## Situation Report for COVID-19: Afghanistan, 2020-06-21

**Download the report for Afghanistan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 28,424 | 546 | 569 | 21 | 0.85 (95% CI: 0.75-0.96) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

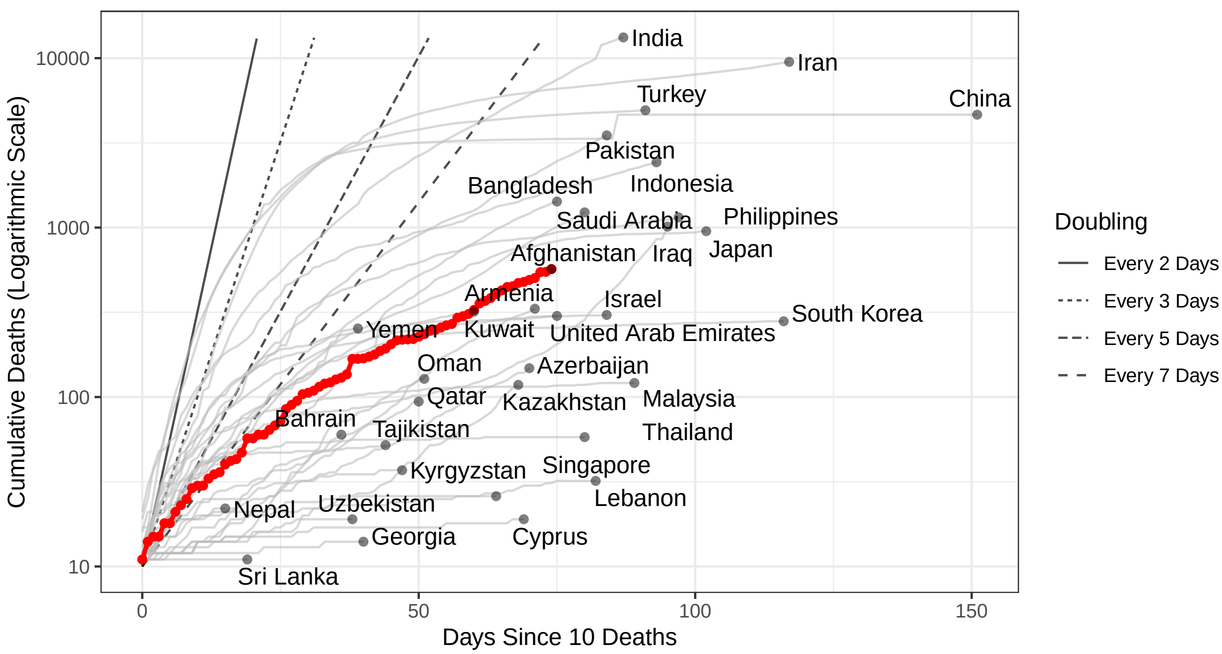


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 161,783 (95% CI: 156,670-166,895) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

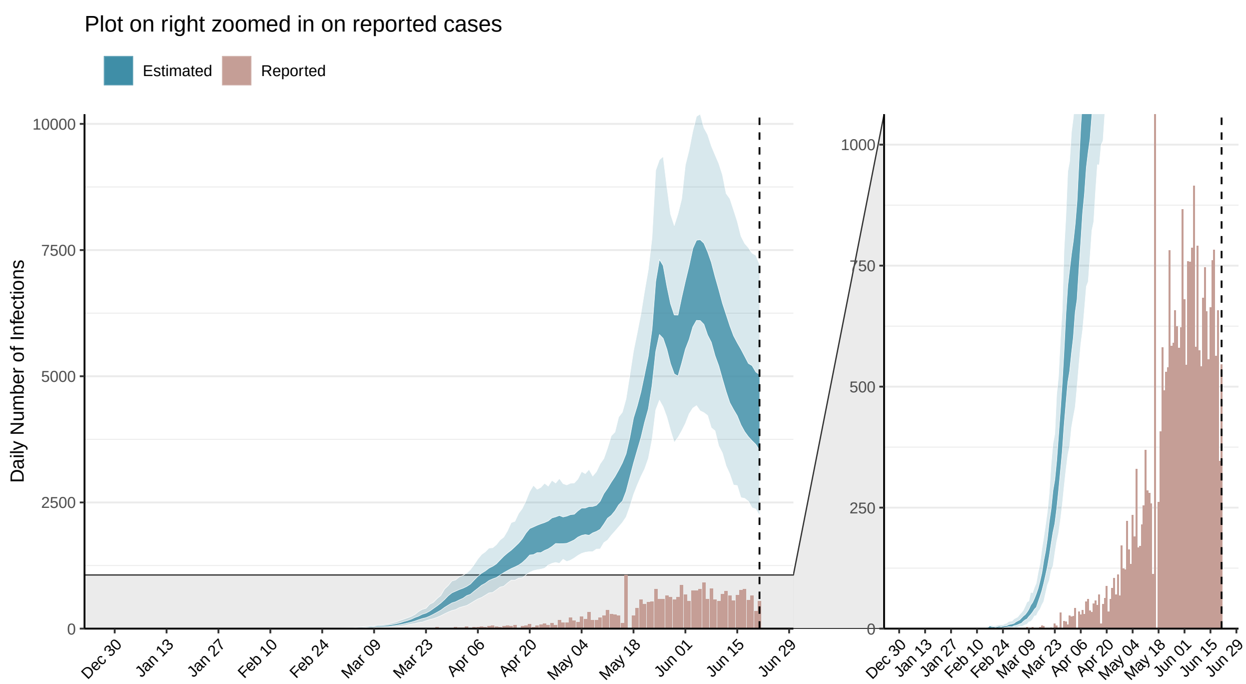


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

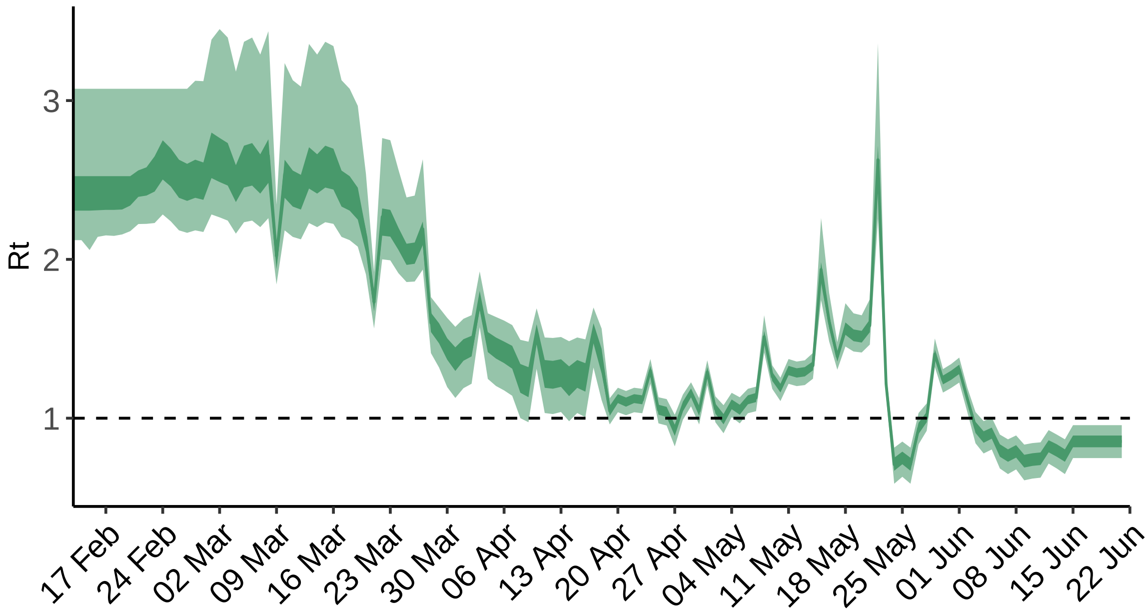


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

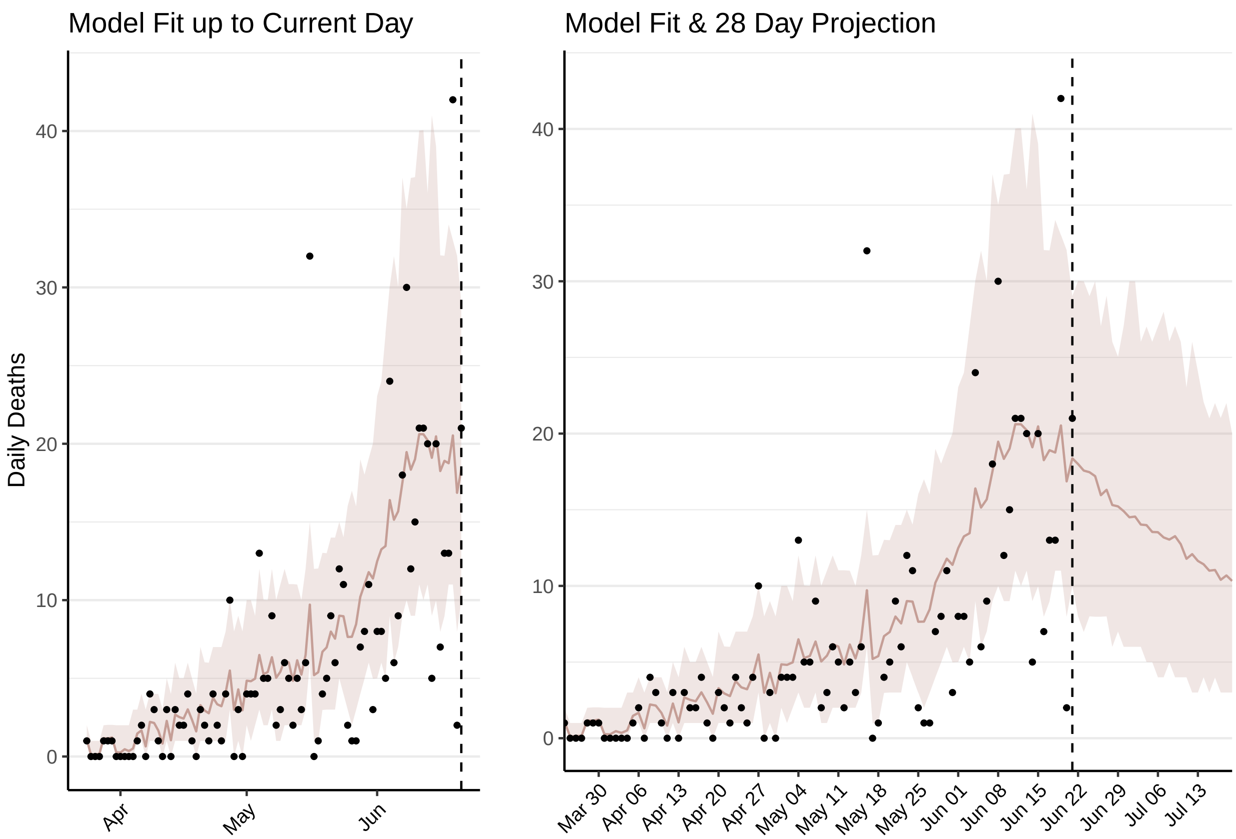


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 862 (95% CI: 834-890) patients requiring treatment with high-pressure oxygen at the current date to 489 (95% CI: 461-517) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 240 (95% CI: 234-245) patients requiring treatment with mechanical ventilation at the current date to 143 (95% CI: 135-150) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

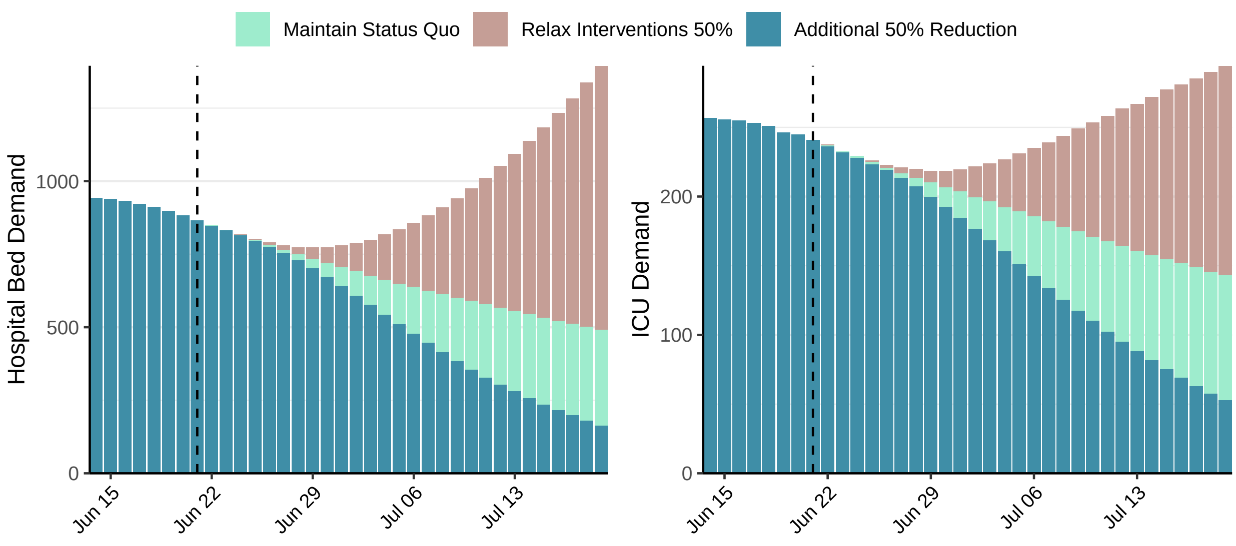


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 4,352 (95% CI: 4,170-4,535) at the current date to 239 (95% CI: 223-254) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 4,352 (95% CI: 4,170-4,535) at the current date to 14,294 (95% CI: 13,230-15,359) by 2020-07-19.

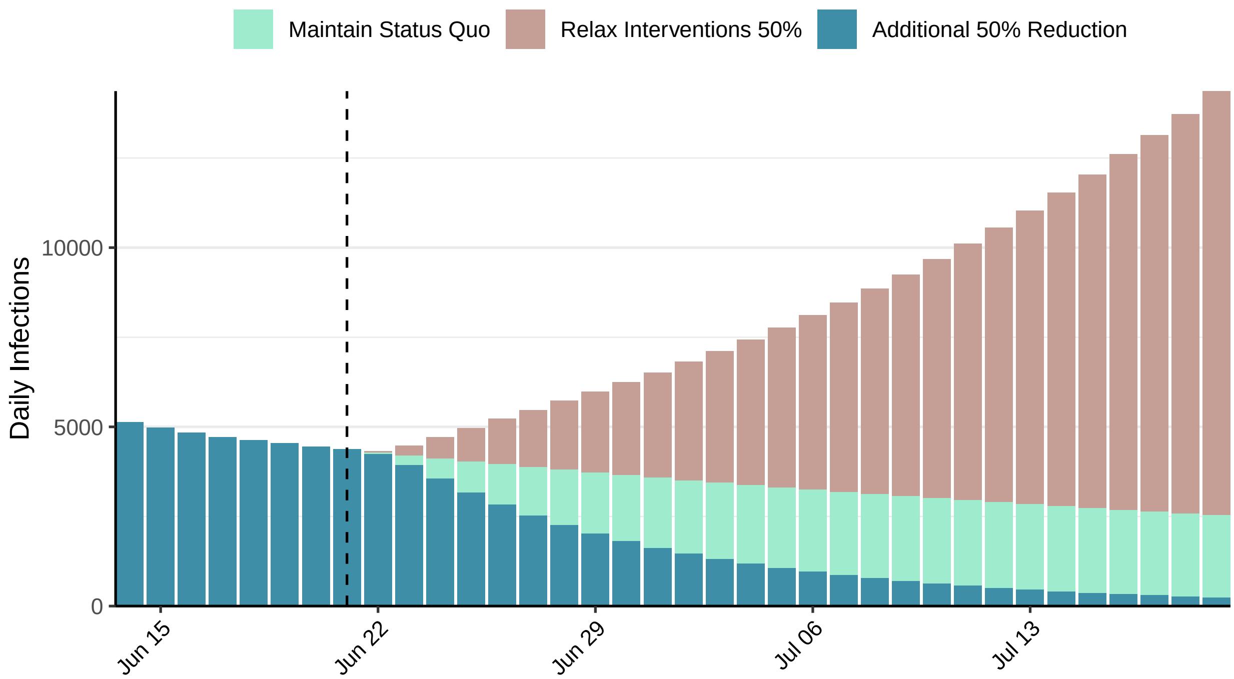


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Angola, 2020-06-21

**Download the report for Angola, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 172 | 6 | 8 | 0 | 1.85 (95% CI: 1.48-2.35) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Angola is not shown in the following plot as only 8 deaths have been reported to date**

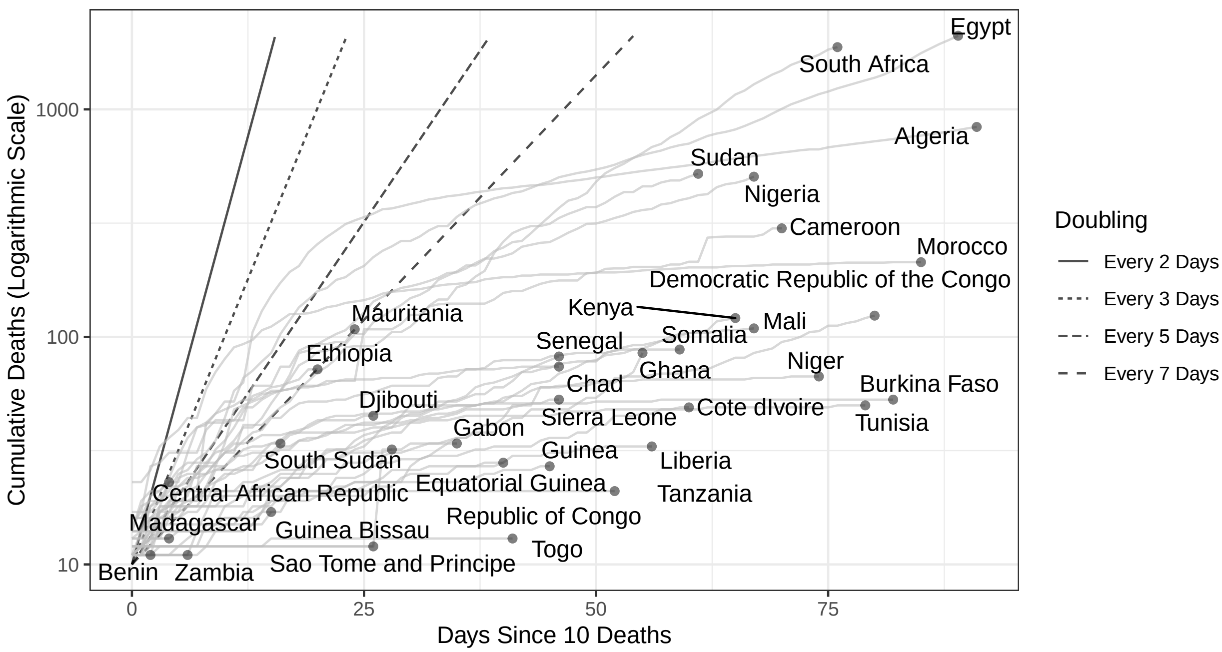


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 8,626 (95% CI: 7,672-9,579) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

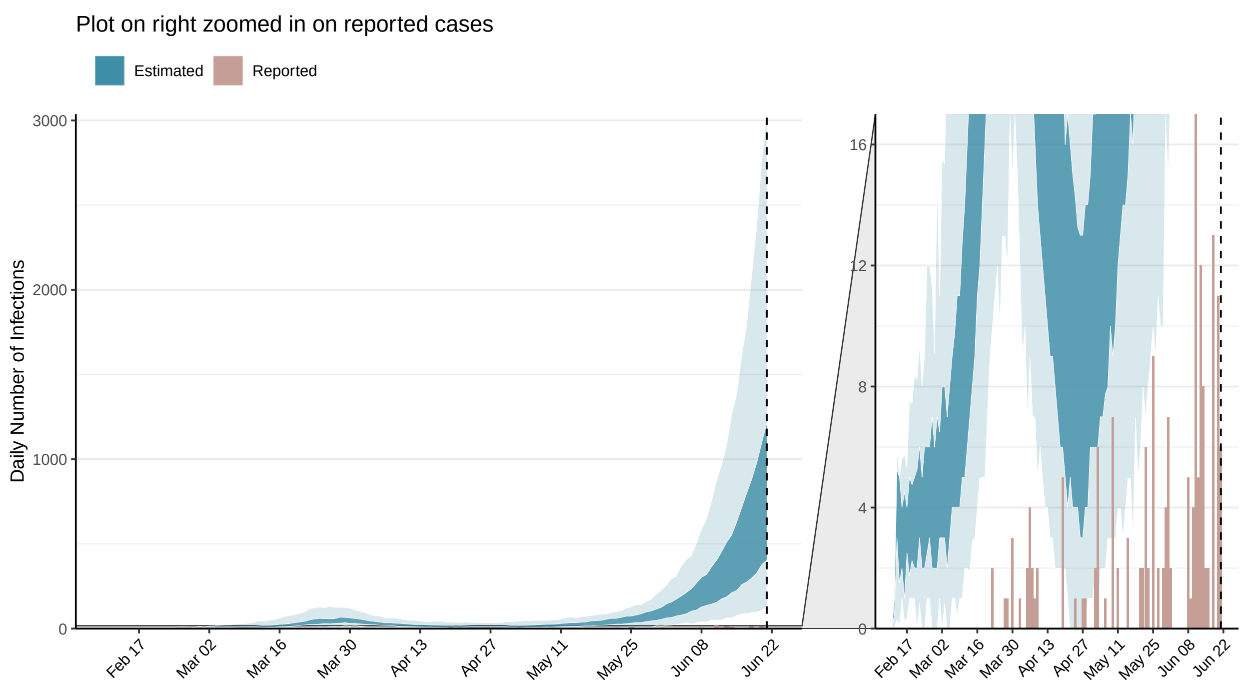


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

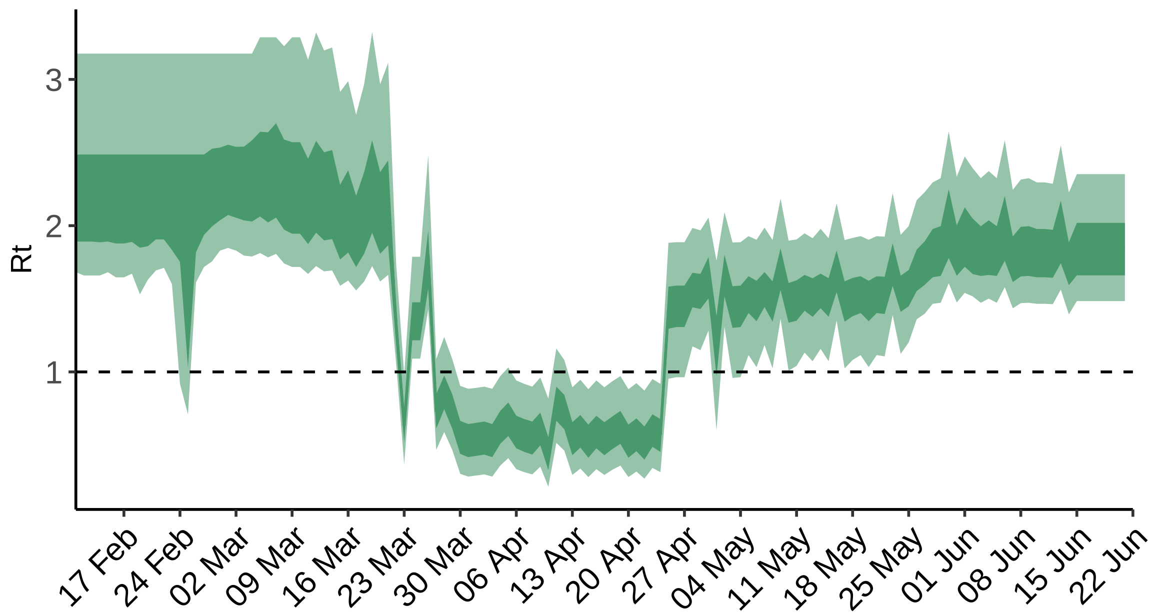


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

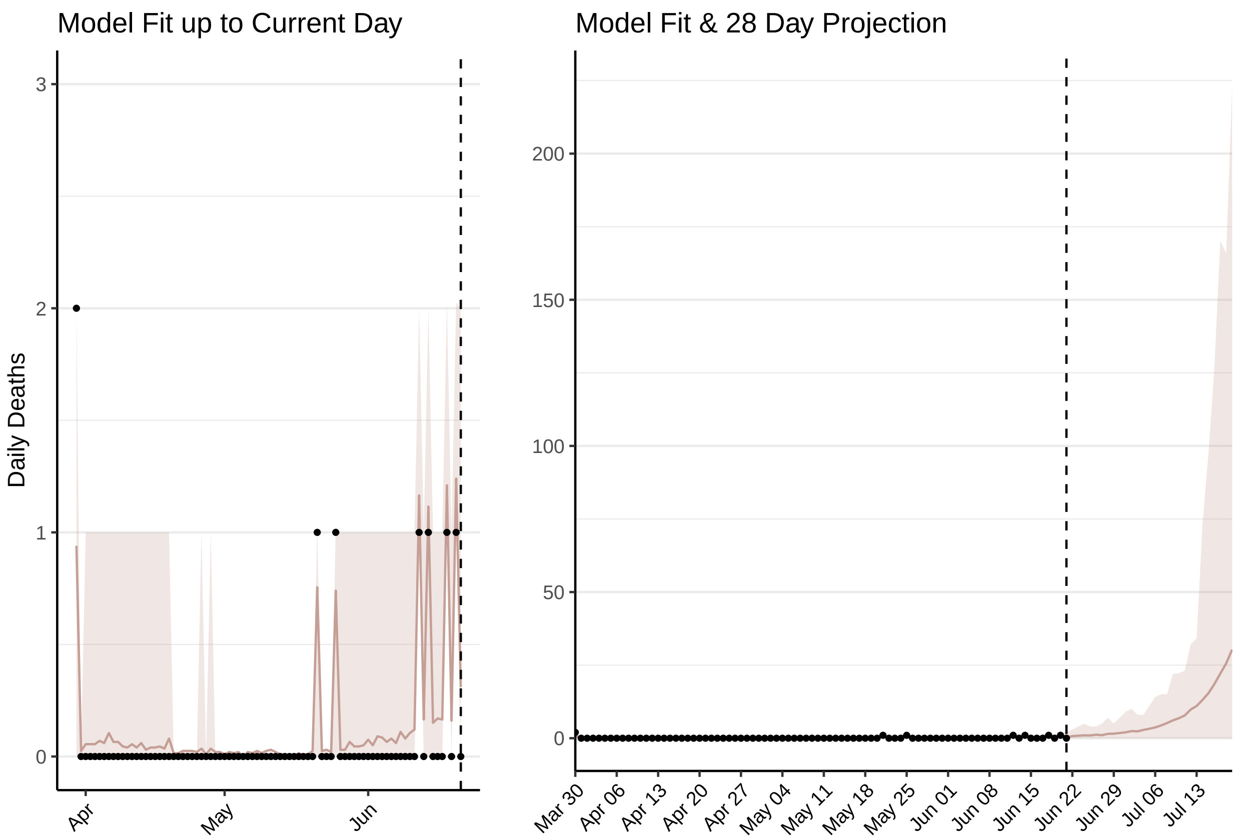


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 47 (95% CI: 42-52) patients requiring treatment with high-pressure oxygen at the current date to 1,201 (95% CI: 906-1,497) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 12 (95% CI: 11-14) patients requiring treatment with mechanical ventilation at the current date to 247 (95% CI: 211-283) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

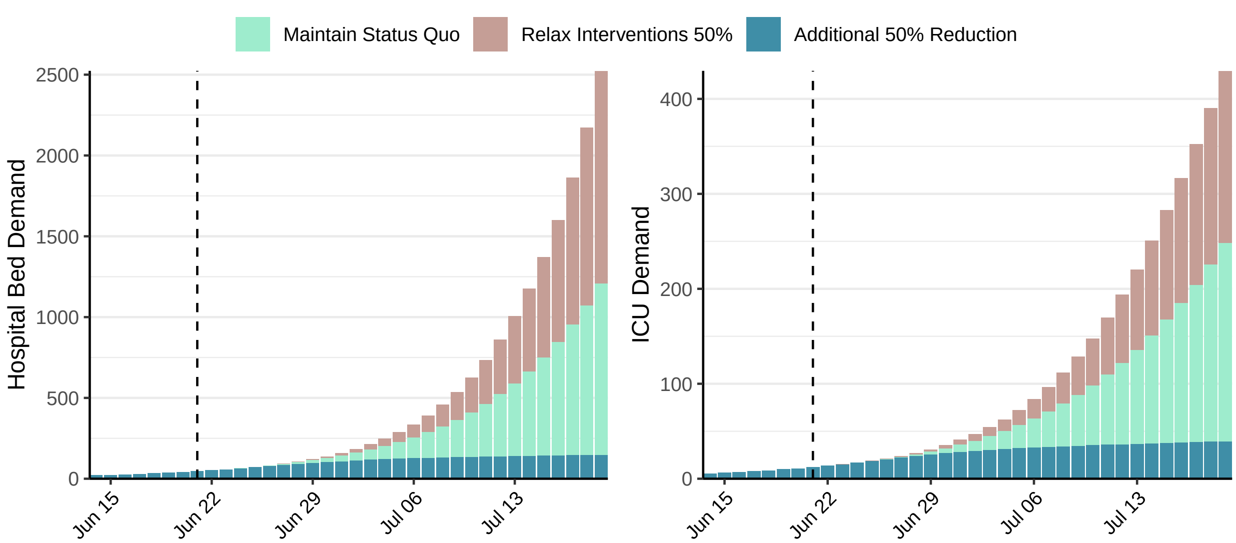


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 941 (95% CI: 811-1,071) at the current date to 1,164 (95% CI: 846-1,482) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 941 (95% CI: 811-1,071) at the current date to 68,447 (95% CI: 51,184-85,710) by 2020-07-19.

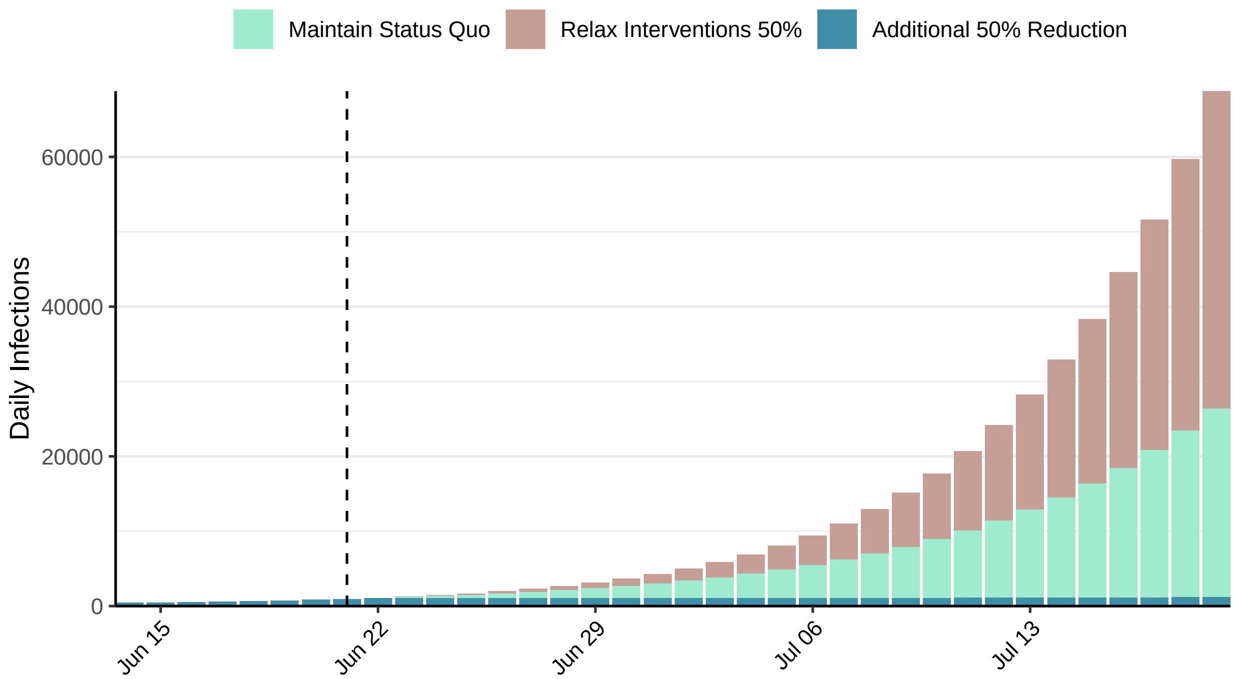


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Albania, 2020-06-21

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### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,891 | 53 | 43 | 1 | 2.49 (95% CI: 2.01-3.04) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

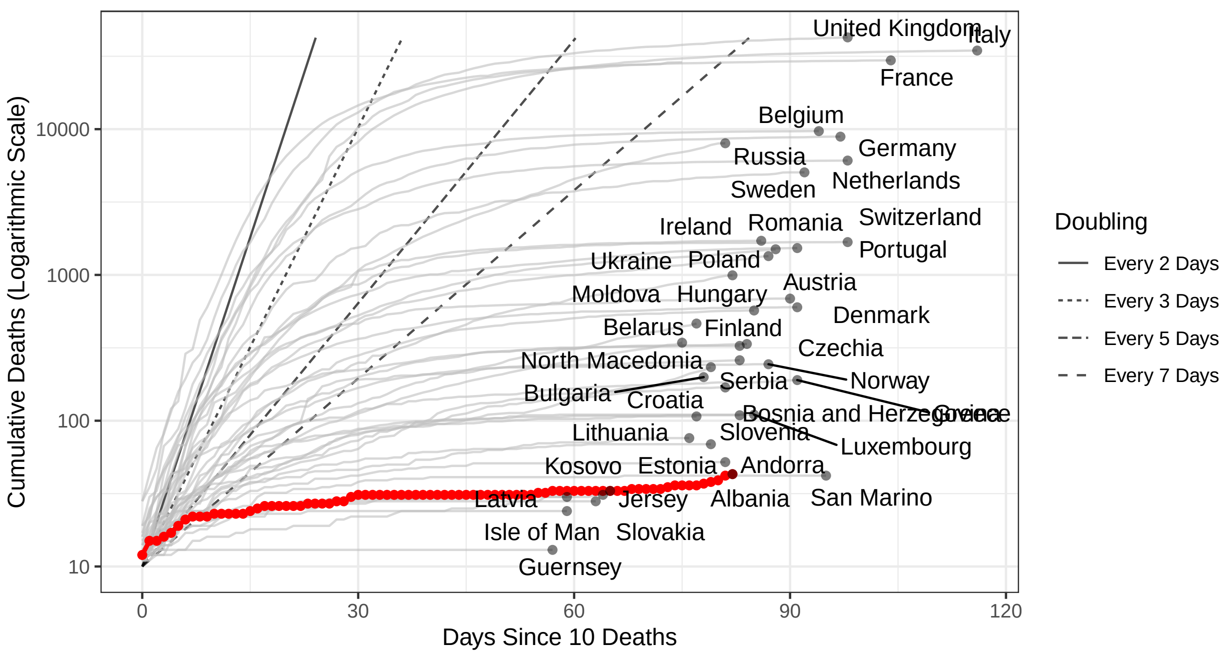


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 18,892 (95% CI: 17,358-20,426) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

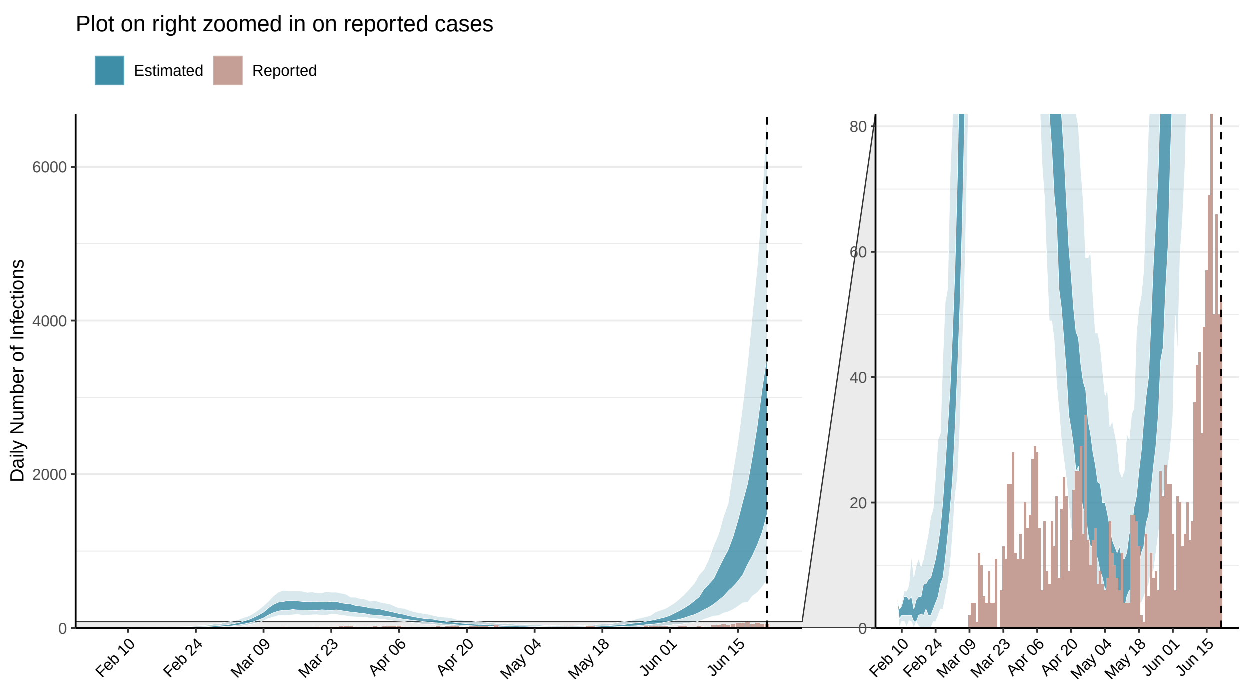


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

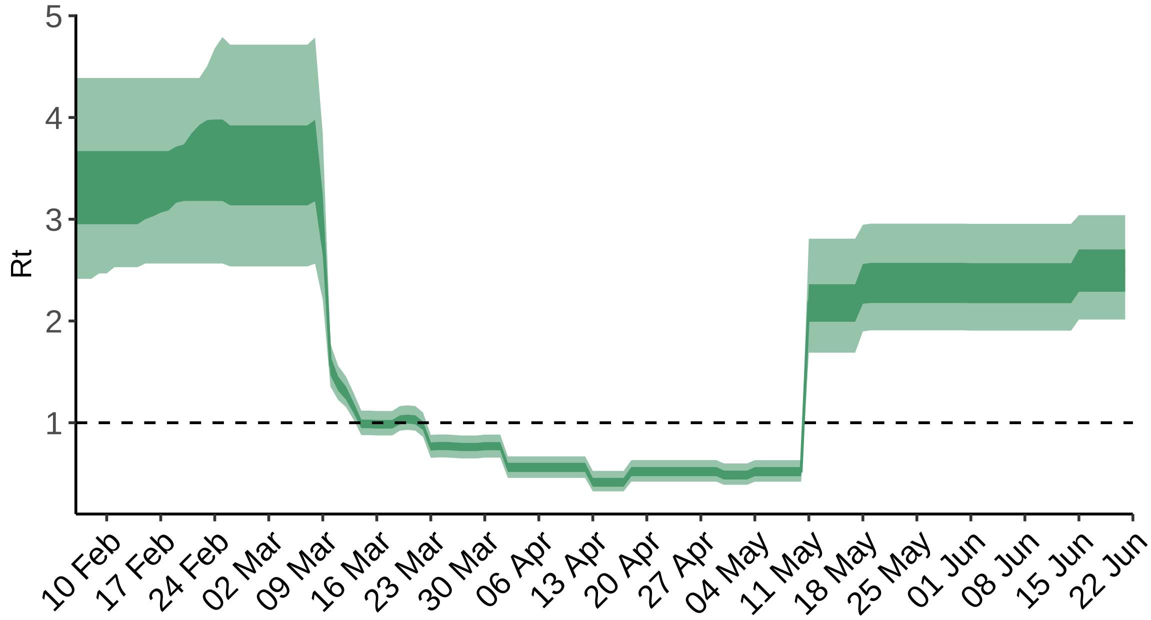


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Albania is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

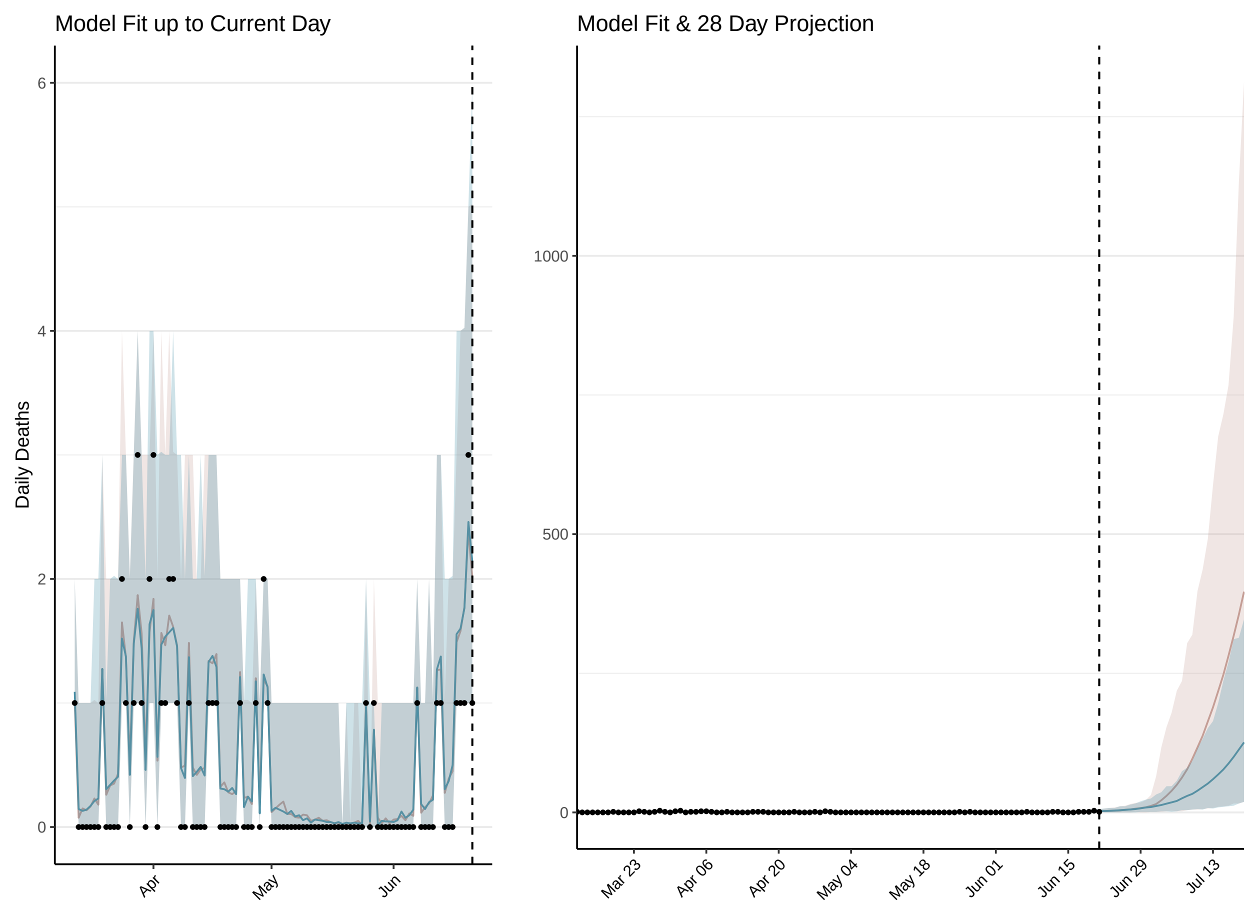


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 143 (95% CI: 132-154) patients requiring treatment with high-pressure oxygen at the current date to 7,670 (95% CI: 6,988-8,351) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 40 (95% CI: 37-43) patients requiring treatment with mechanical ventilation at the current date to 843 (95% CI: 798-887) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

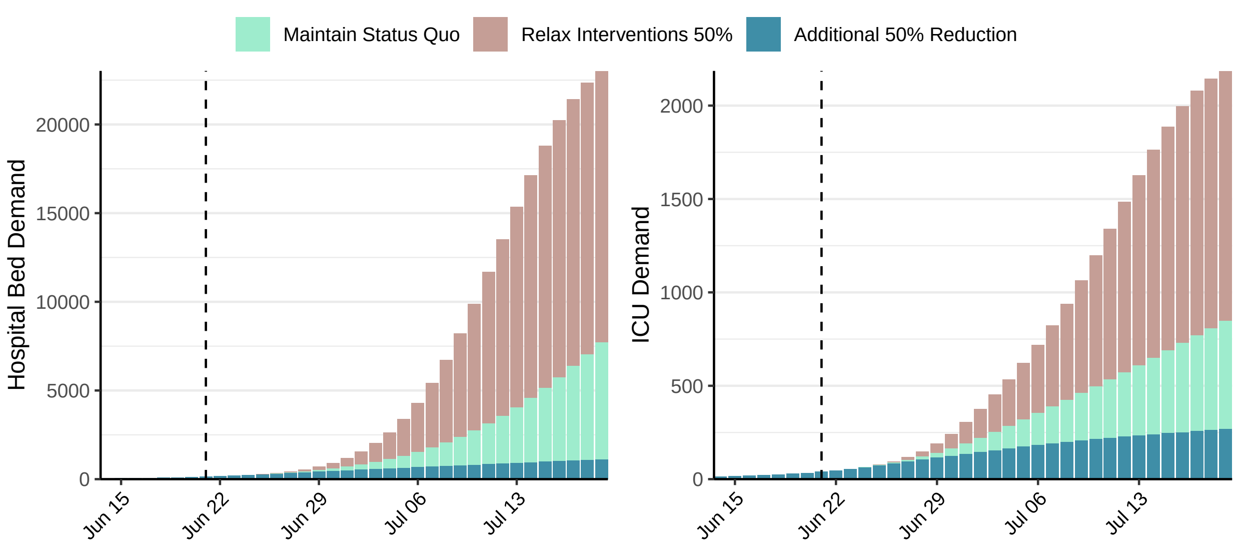


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,763 (95% CI: 2,507-3,018) at the current date to 7,072 (95% CI: 6,253-7,890) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,763 (95% CI: 2,507-3,018) at the current date to 89,995 (95% CI: 85,204-94,787) by 2020-07-19.

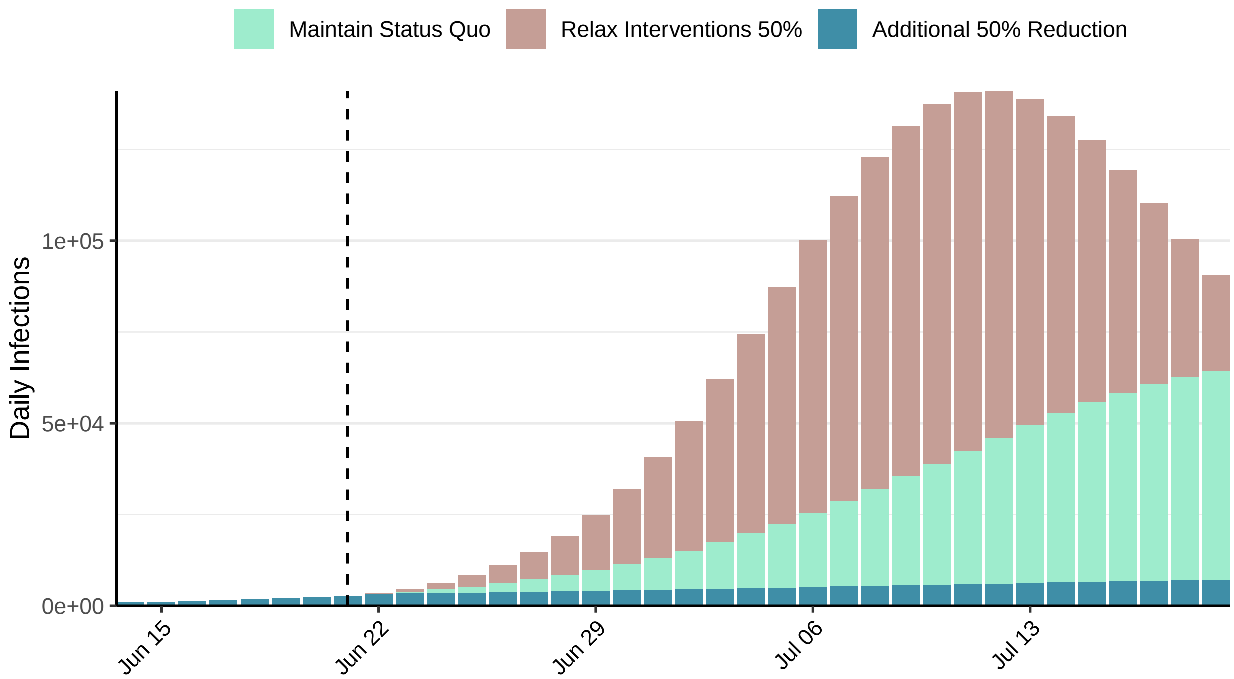


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our [COVID-19 Scenario Analysis Tool - https://covidsim.org/](https://covidsim.org/), which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Argentina, 2020-06-21

**Download the report for Argentina, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 41,191 | 1,634 | 992 | 13 | 1.45 (95% CI: 1.38-1.55) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

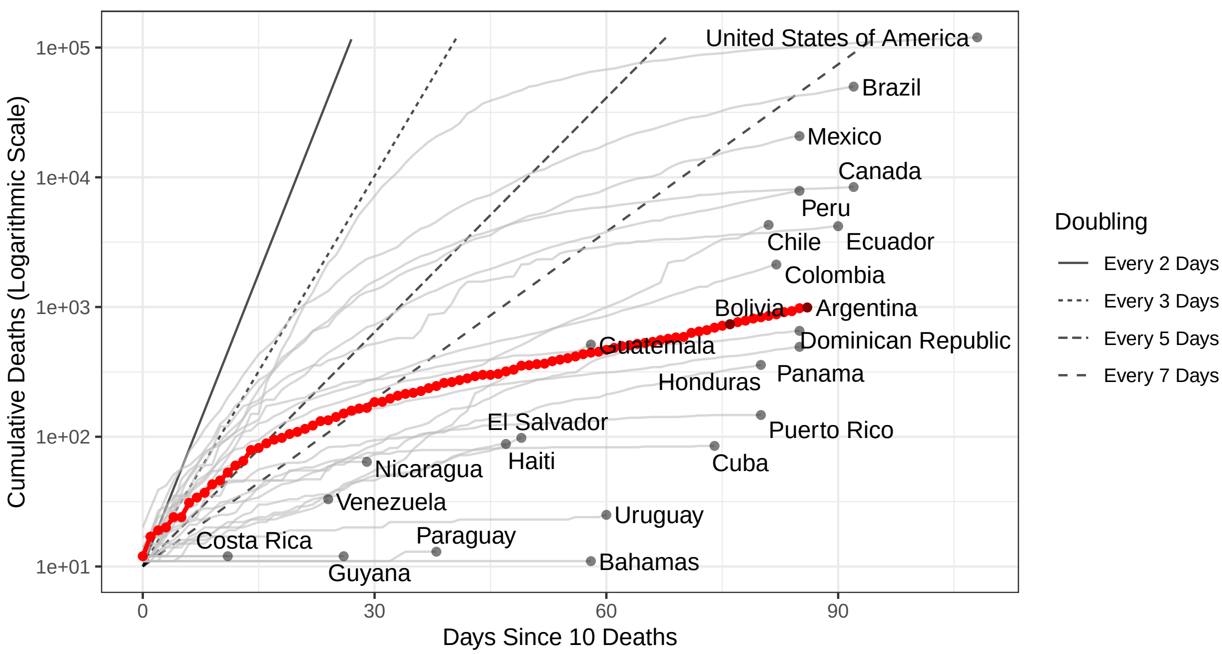


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

### COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 329,755 (95% CI: 318,827-340,684) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

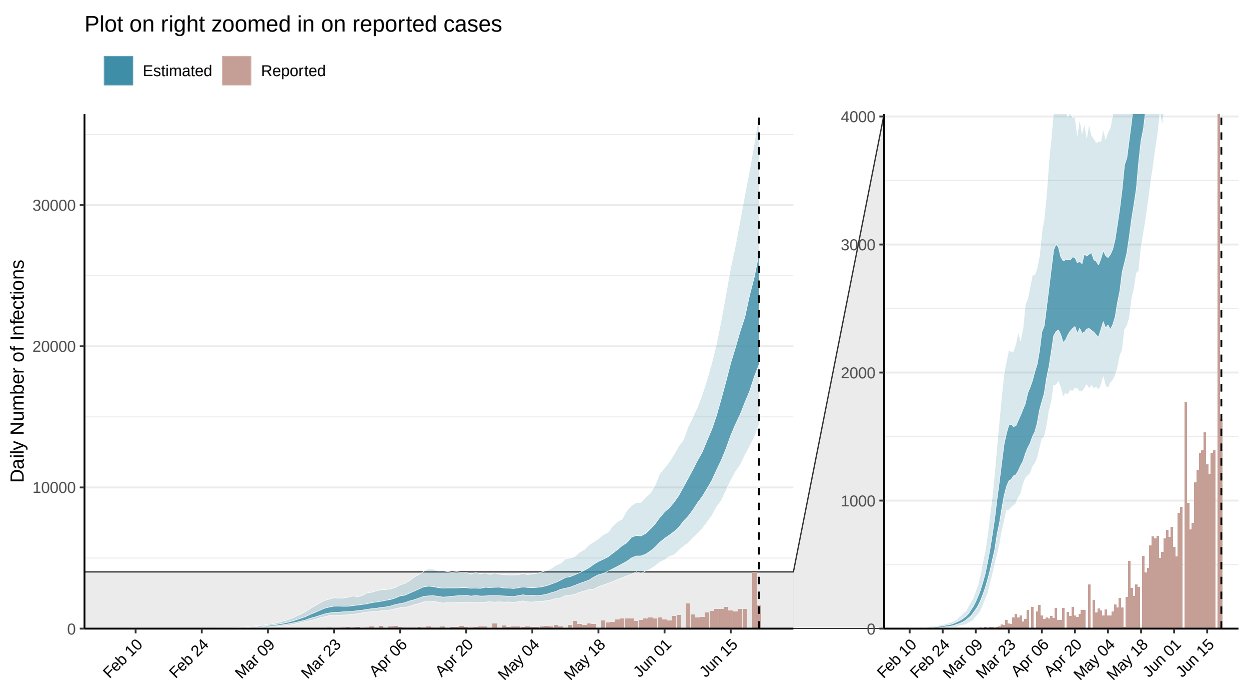


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

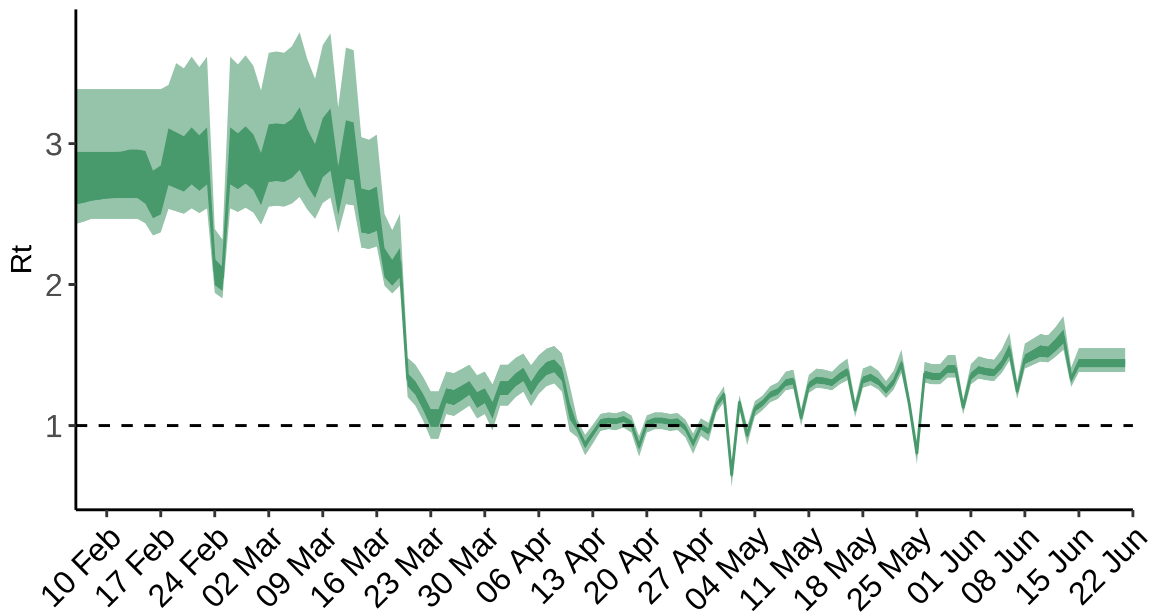


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

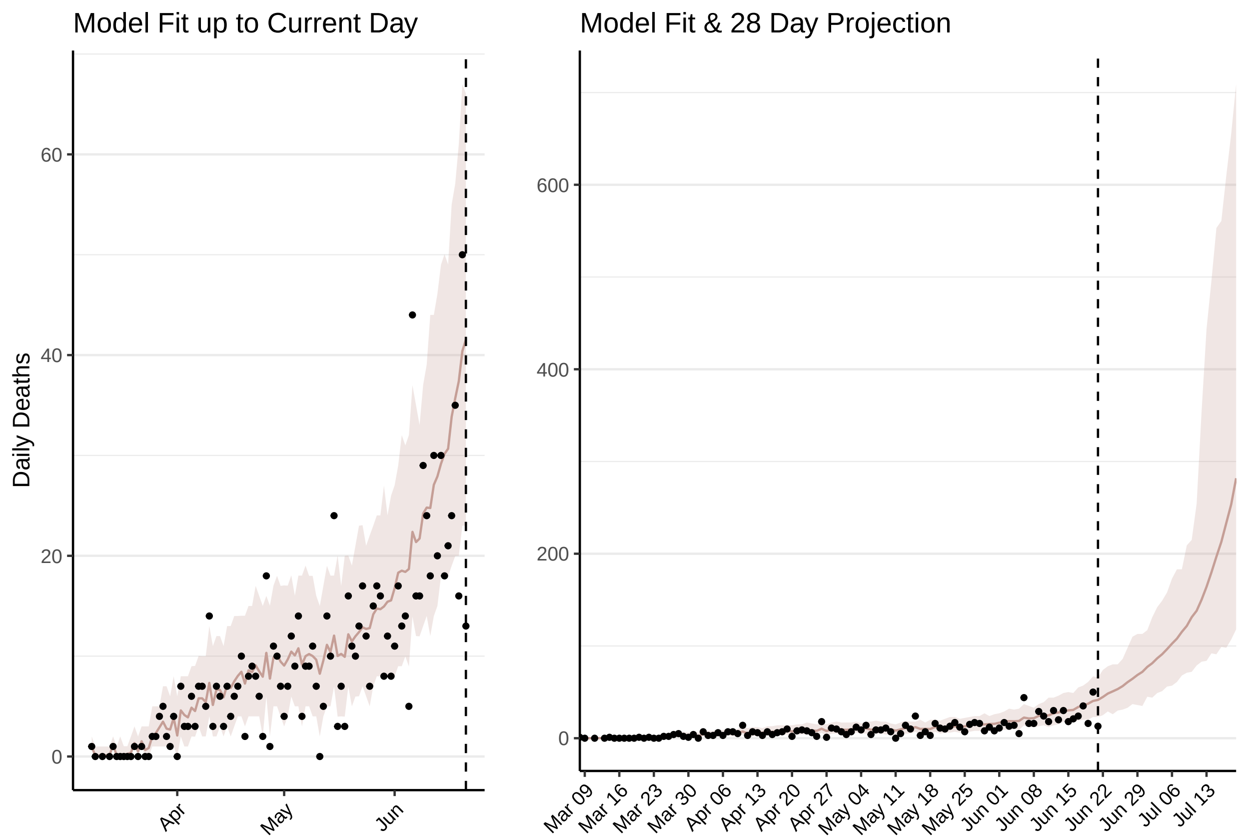


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 2,045 (95% CI: 1,975-2,115) patients requiring treatment with high-pressure oxygen at the current date to 9,916 (95% CI: 9,475-10,356) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 690 (95% CI: 667-714) patients requiring treatment with mechanical ventilation at the current date to 3,122 (95% CI: 3,025-3,219) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

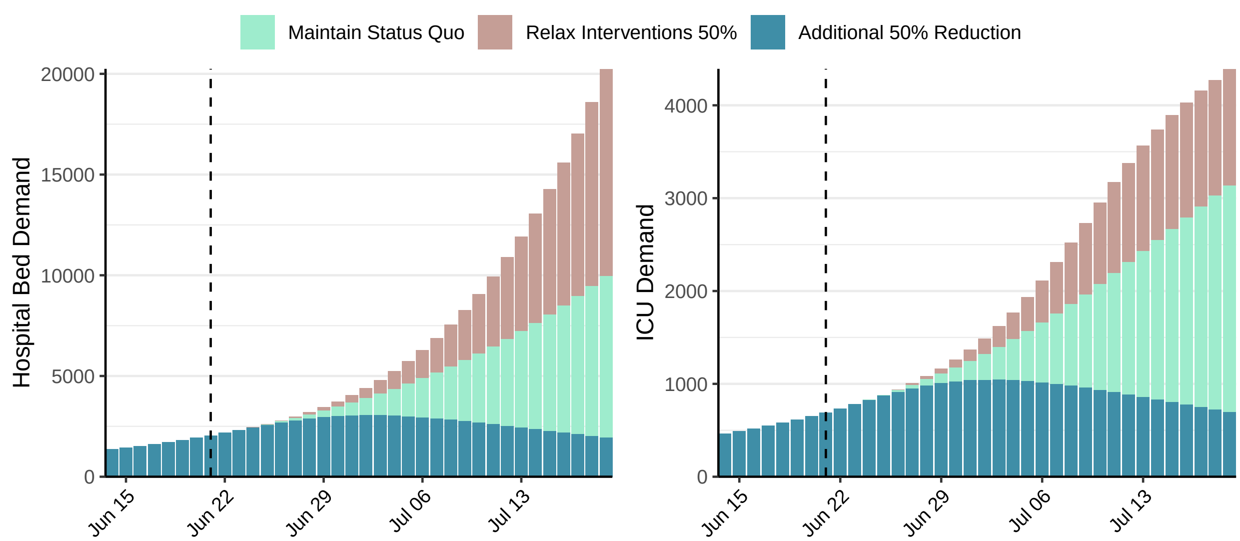


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 23,093 (95% CI: 22,245-23,941) at the current date to 6,828 (95% CI: 6,508-7,148) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 23,093 (95% CI: 22,245-23,941) at the current date to 268,094 (95% CI: 256,697-279,491) by 2020-07-19.

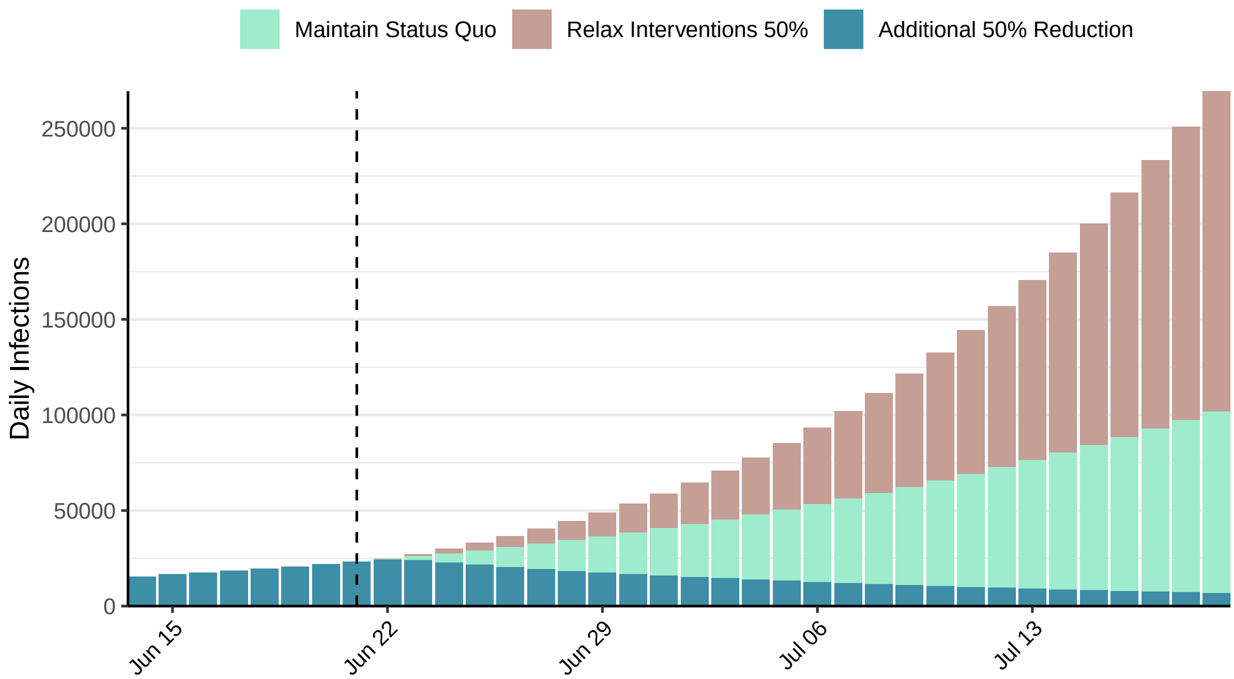


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Armenia, 2020-06-21

**Download the report for Armenia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 19,708 | 551 | 332 | 13 | 1.53 (95% CI: 1.46-1.61) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

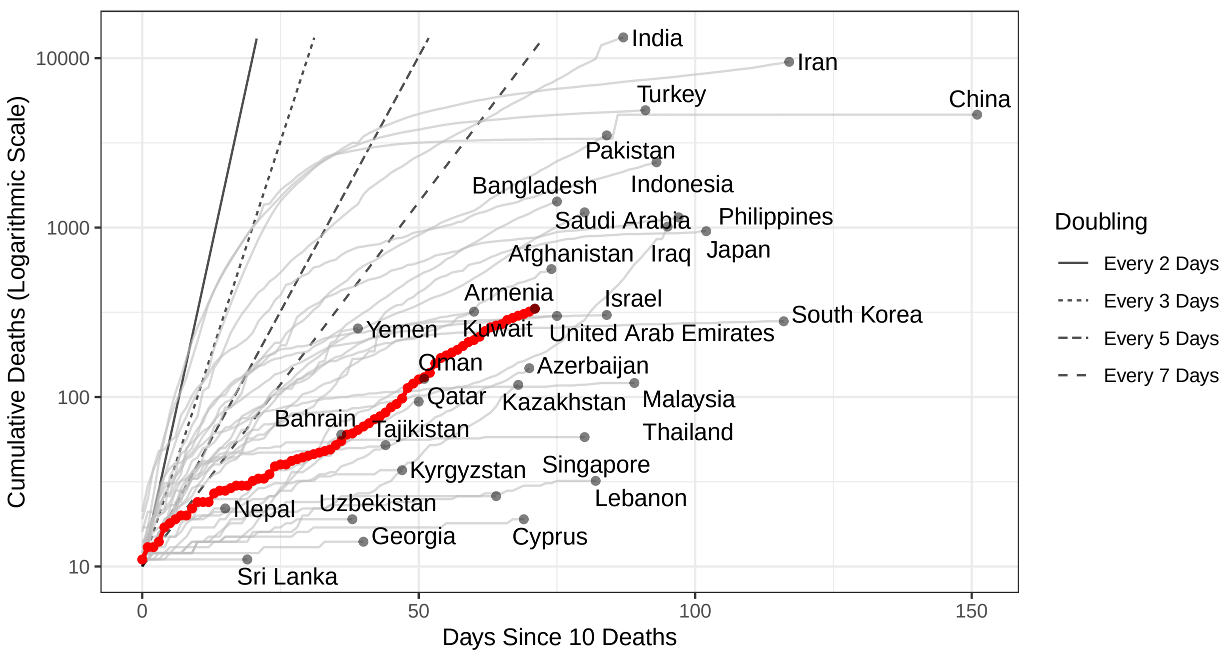


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 158,449 (95% CI: 154,721-162,176) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

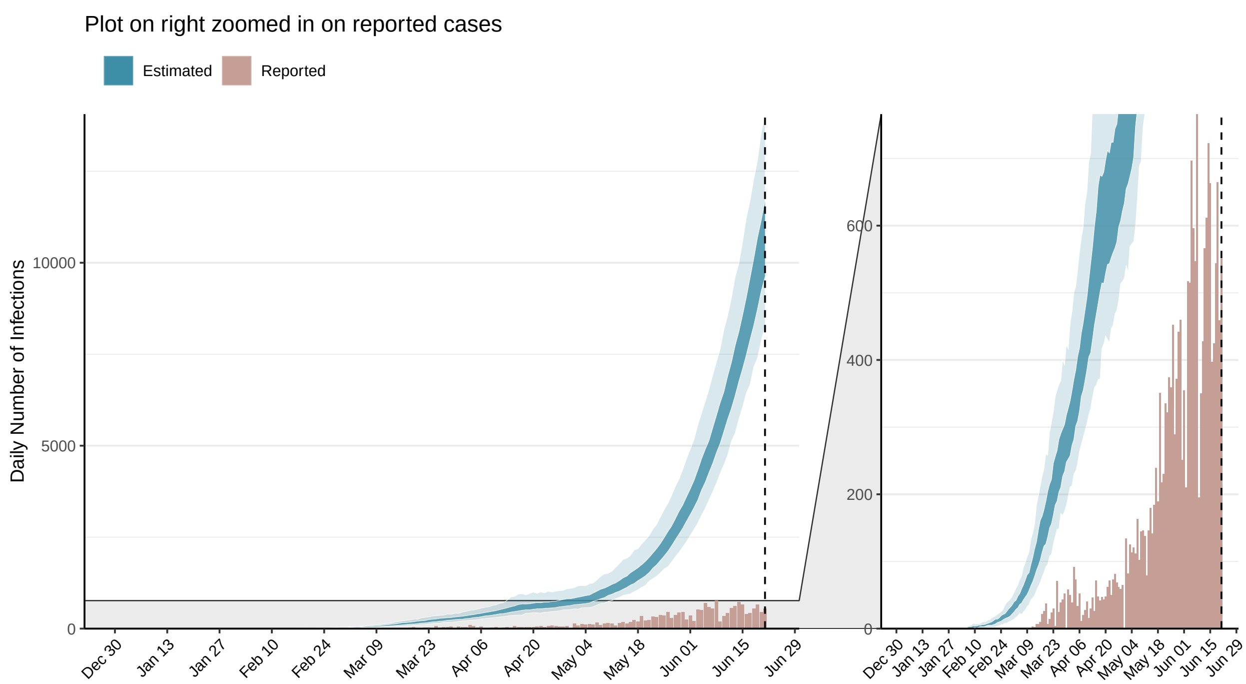


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

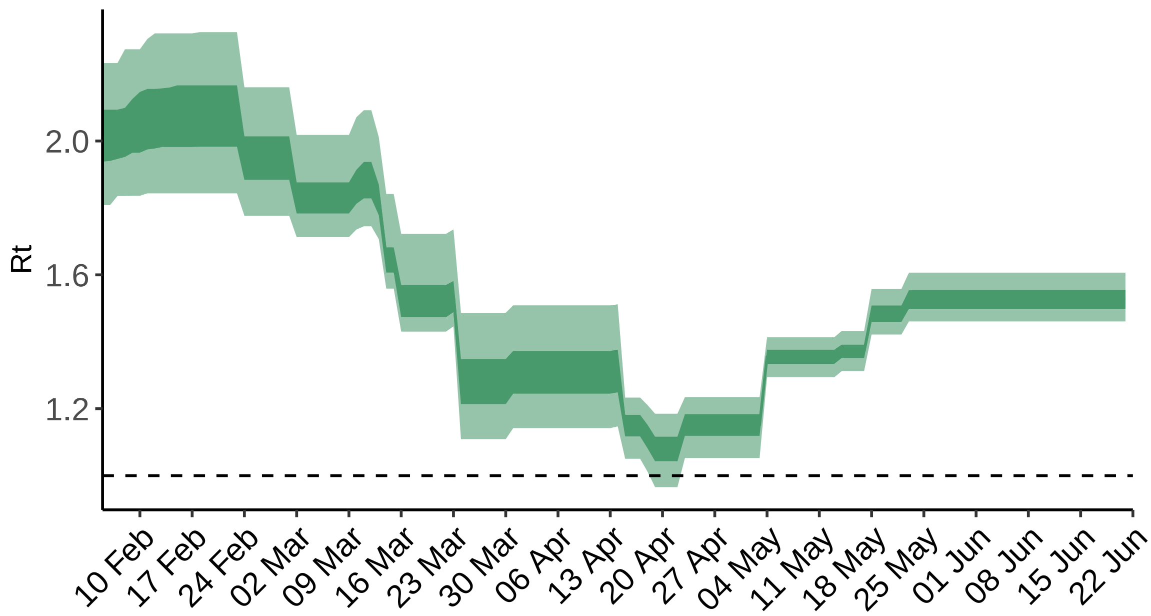


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Armenia is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

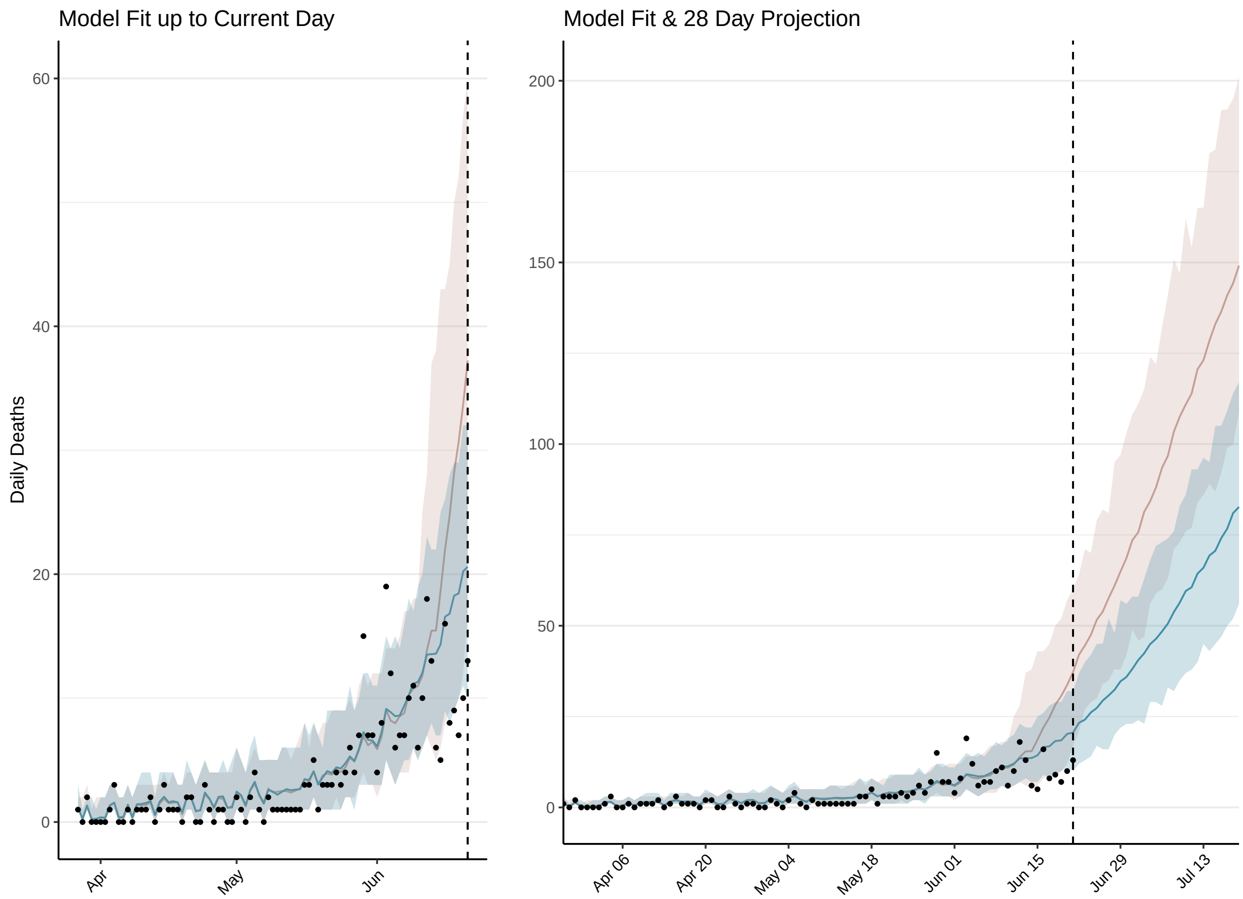


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,235 (95% CI: 1,205-1,265) patients requiring treatment with high-pressure oxygen at the current date to 4,129 (95% CI: 4,040-4,219) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 251 (95% CI: 248-254) patients requiring treatment with mechanical ventilation at the current date to 373 (95% CI: 367-379) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

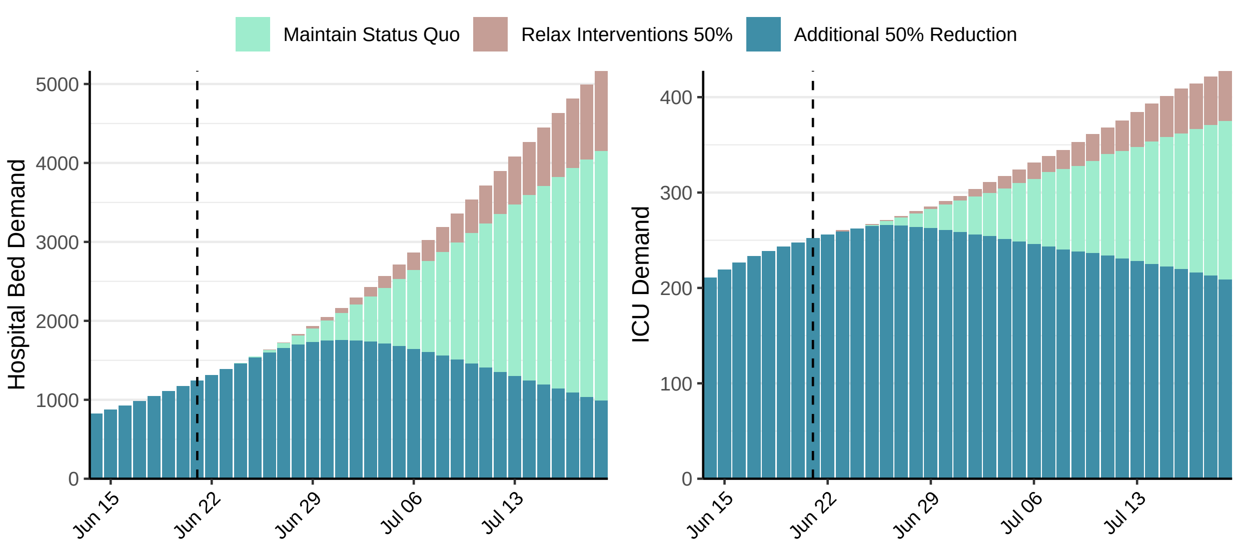


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 10,733 (95% CI: 10,483-10,983) at the current date to 2,302 (95% CI: 2,249-2,354) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 10,733 (95% CI: 10,483-10,983) at the current date to 30,147 (95% CI: 29,655-30,640) by 2020-07-19.

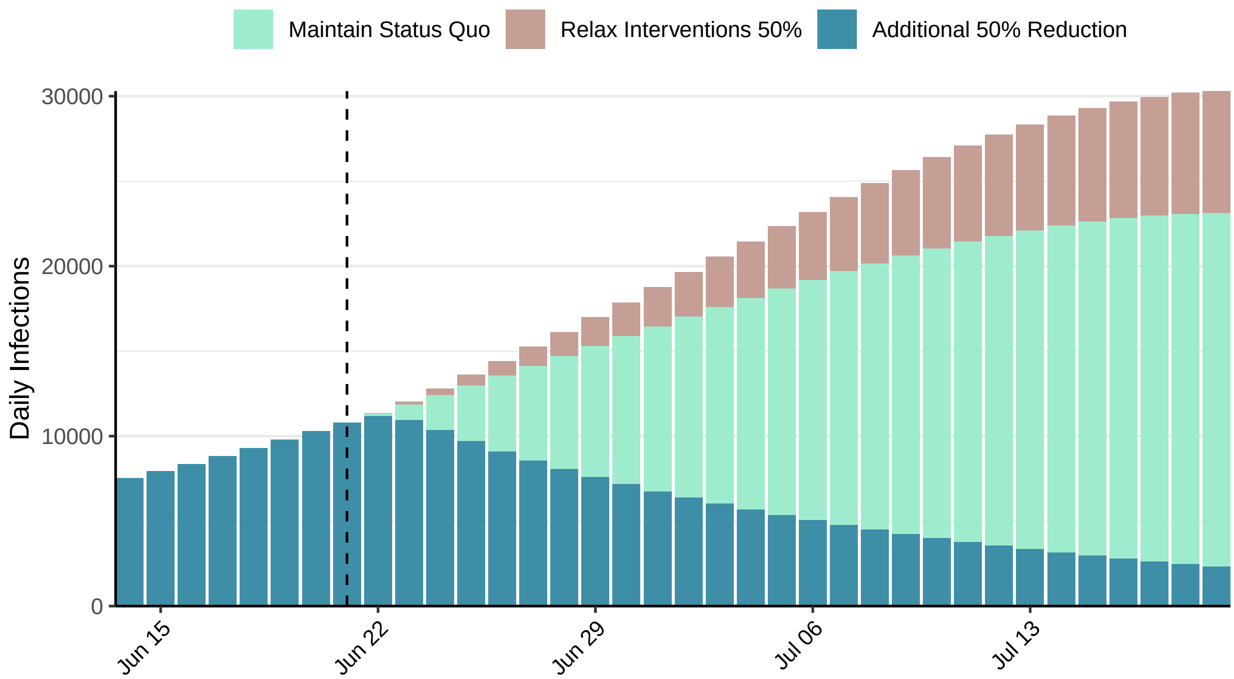


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Azerbaijan, 2020-06-21

**Download the report for Azerbaijan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 12,238 | 909 | 148 | 9 | 1.42 (95% CI: 1.27-1.53) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

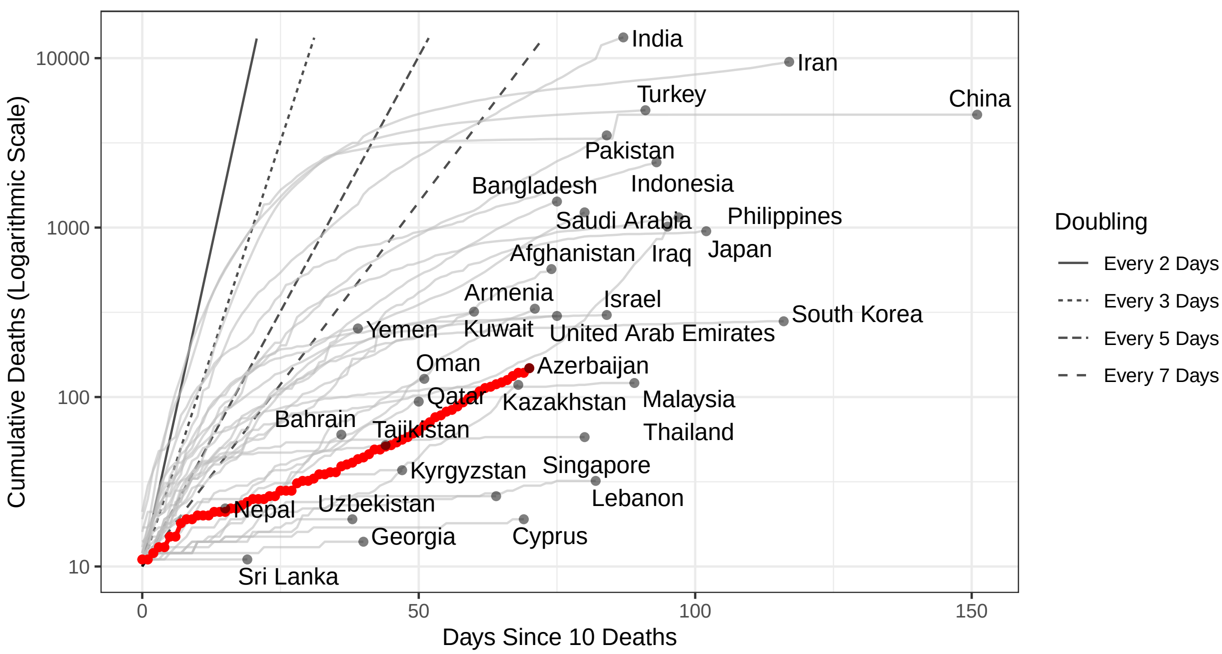


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 94,860 (95% CI: 91,399-98,321) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

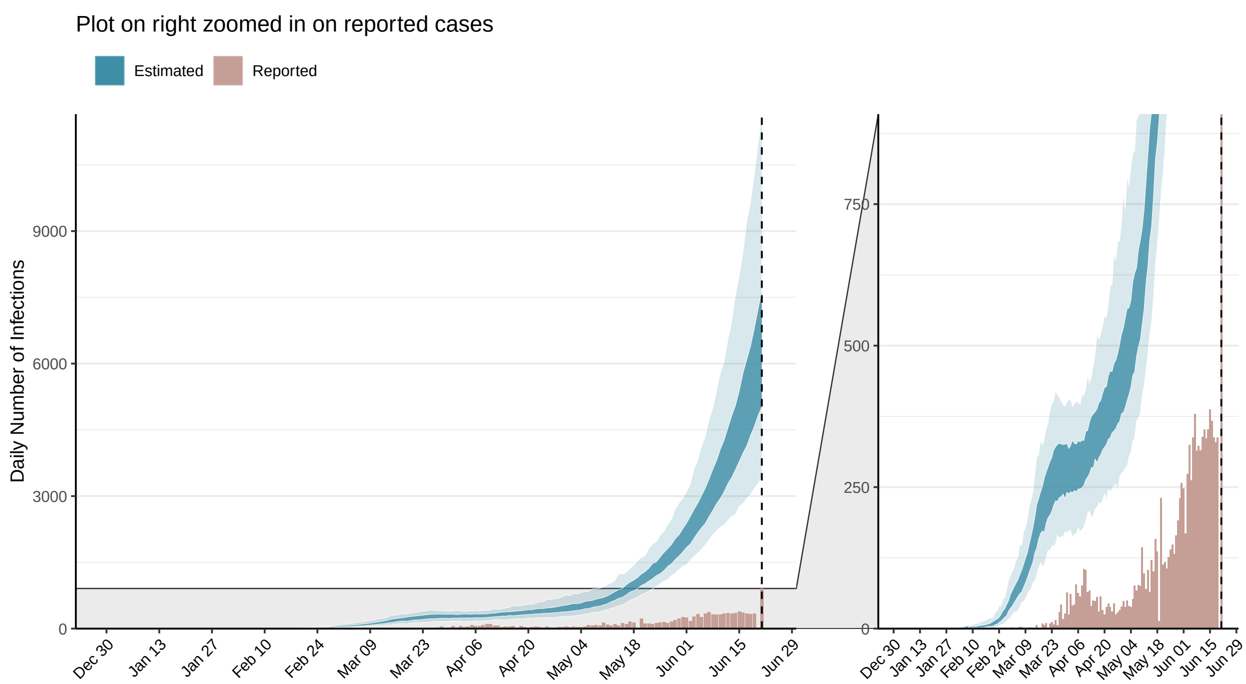


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

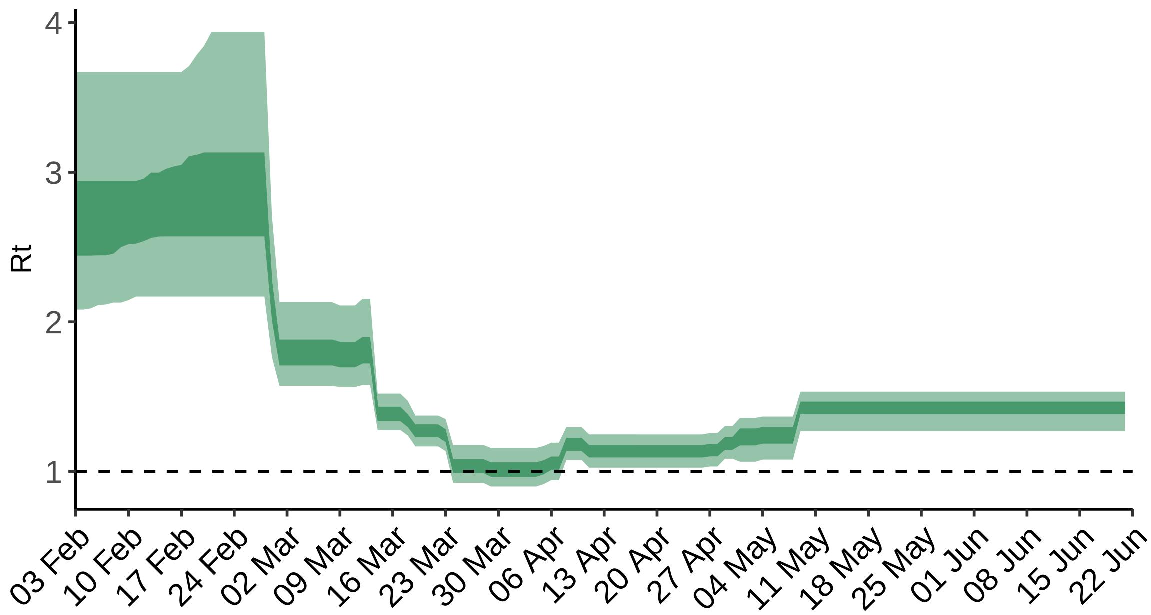


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

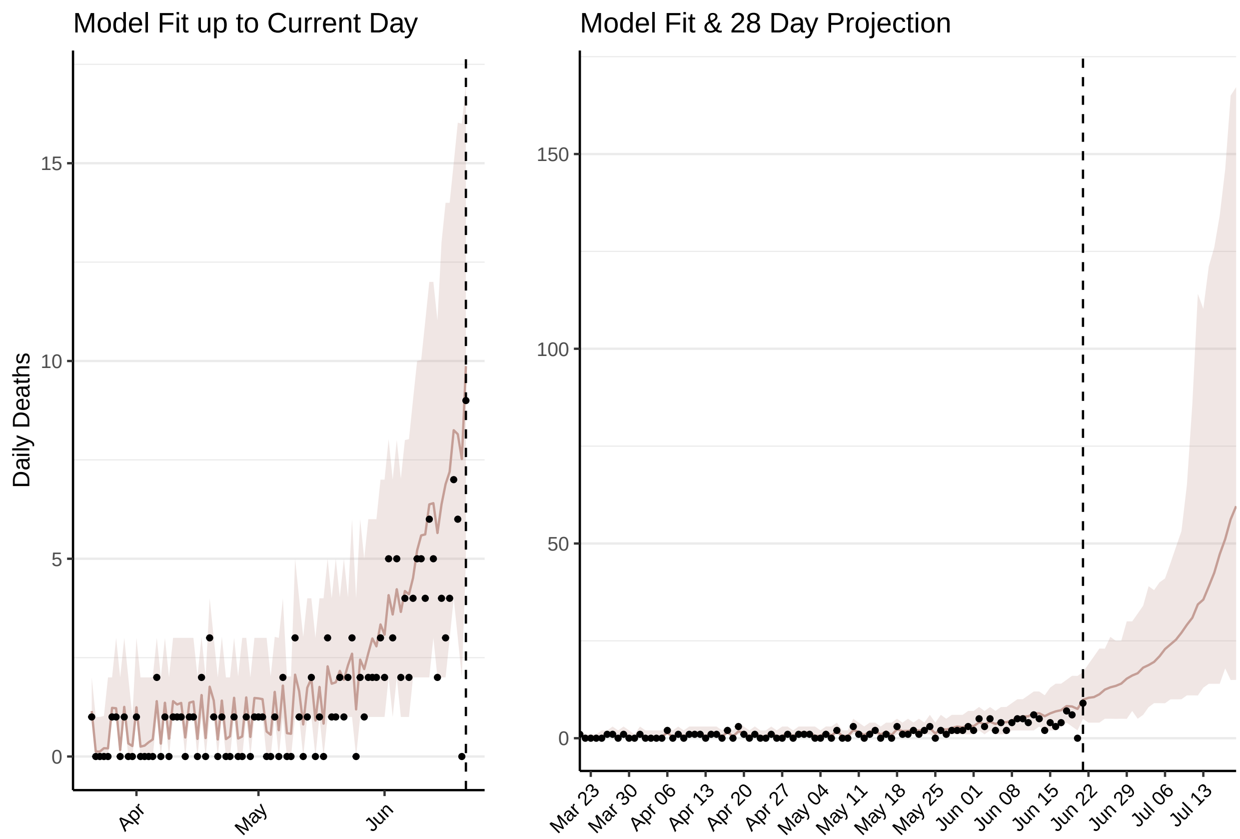


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 672 (95% CI: 646-698) patients requiring treatment with high-pressure oxygen at the current date to 3,015 (95% CI: 2,847-3,183) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 155 (95% CI: 149-161) patients requiring treatment with mechanical ventilation at the current date to 644 (95% CI: 617-670) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

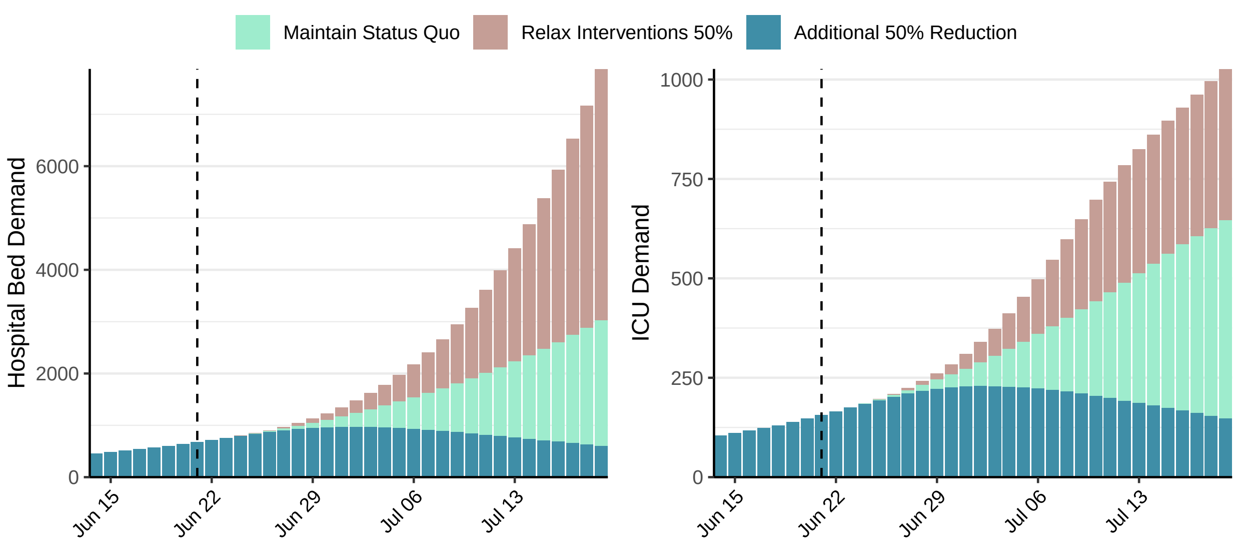


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 6,472 (95% CI: 6,190-6,754) at the current date to 1,827 (95% CI: 1,718-1,937) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 6,472 (95% CI: 6,190-6,754) at the current date to 95,383 (95% CI: 90,523-100,243) by 2020-07-19.

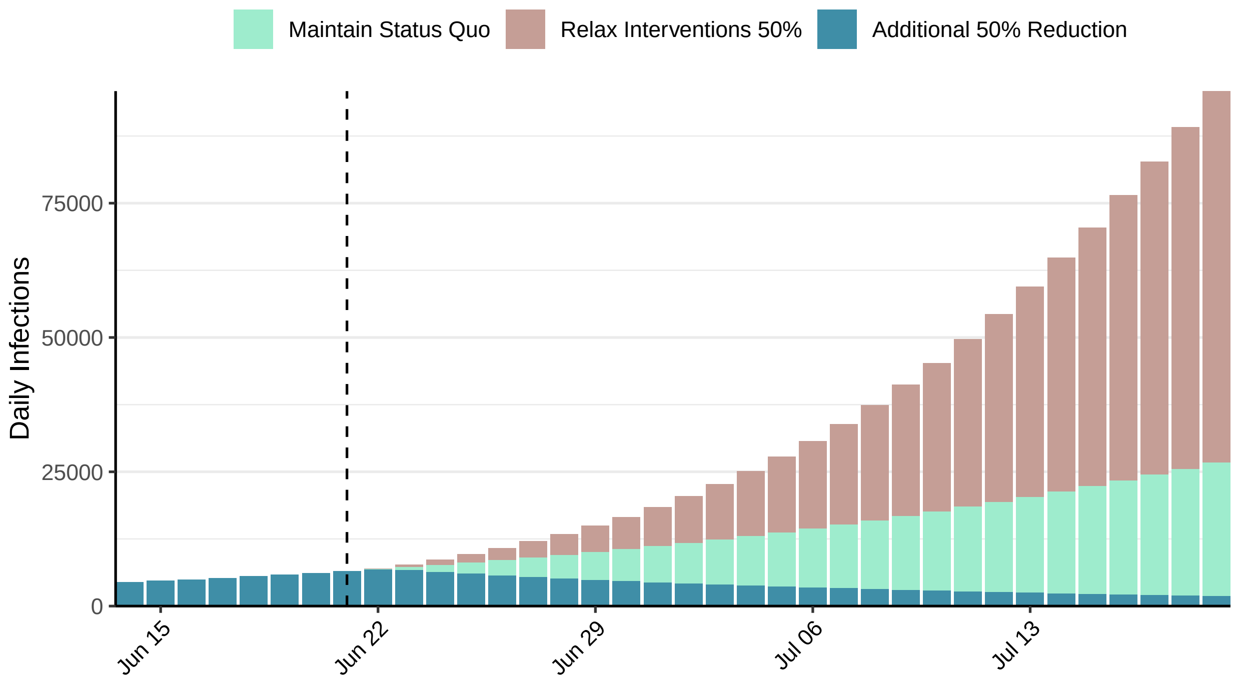


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Burundi, 2020-06-21

**Download the report for Burundi, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 144 | 40 | 1 | 0 | 1.48 (95% CI: 1.42-1.54) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Burundi is not shown in the following plot as only 1 deaths have been reported to date**

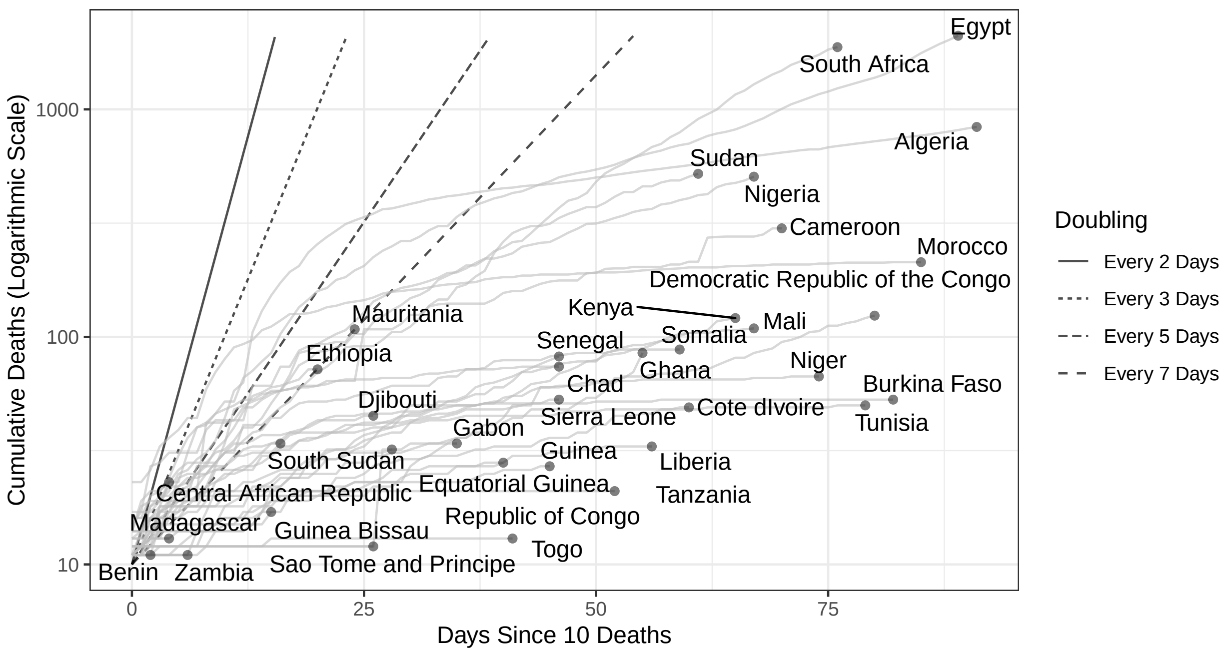


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,049 (95% CI: 2,785-3,314) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

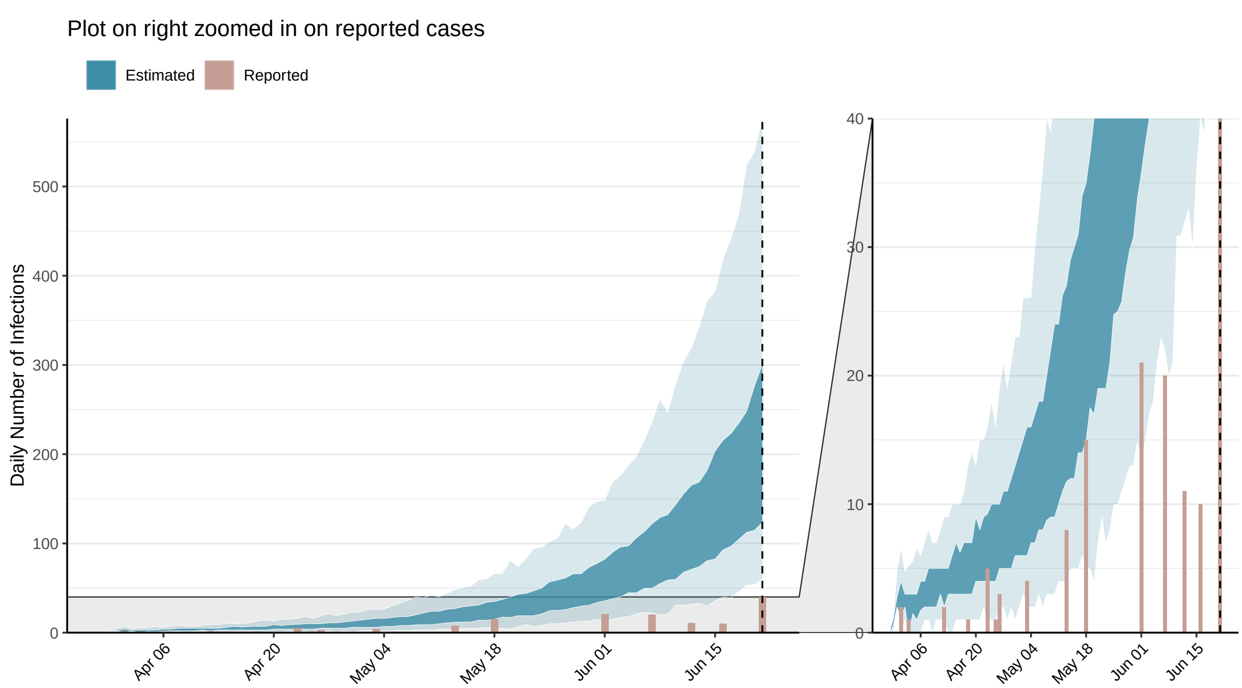


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

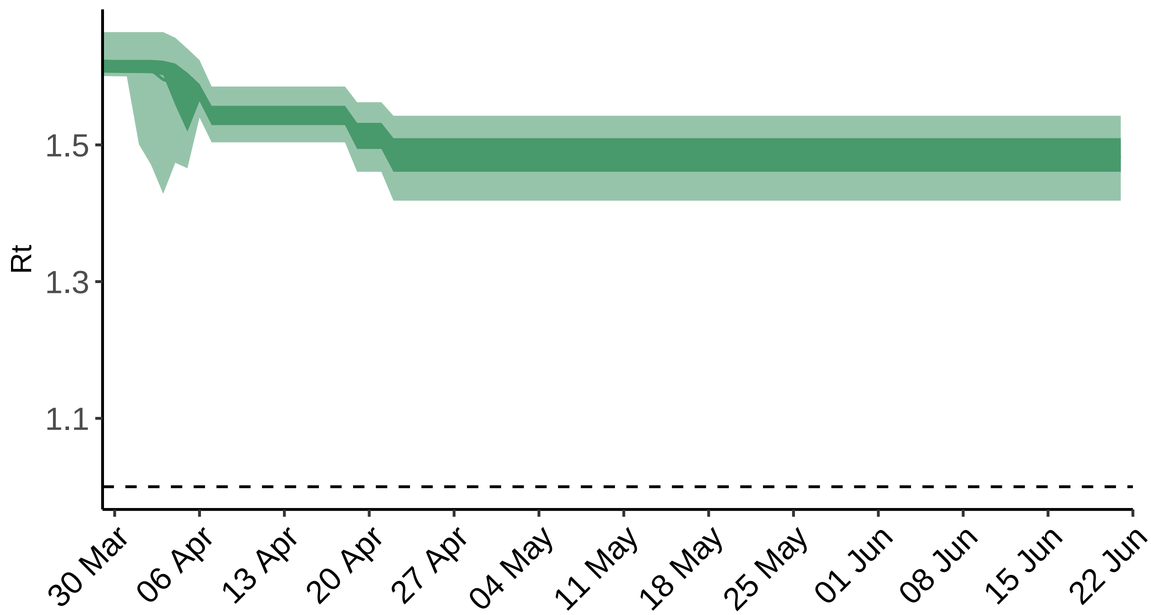


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

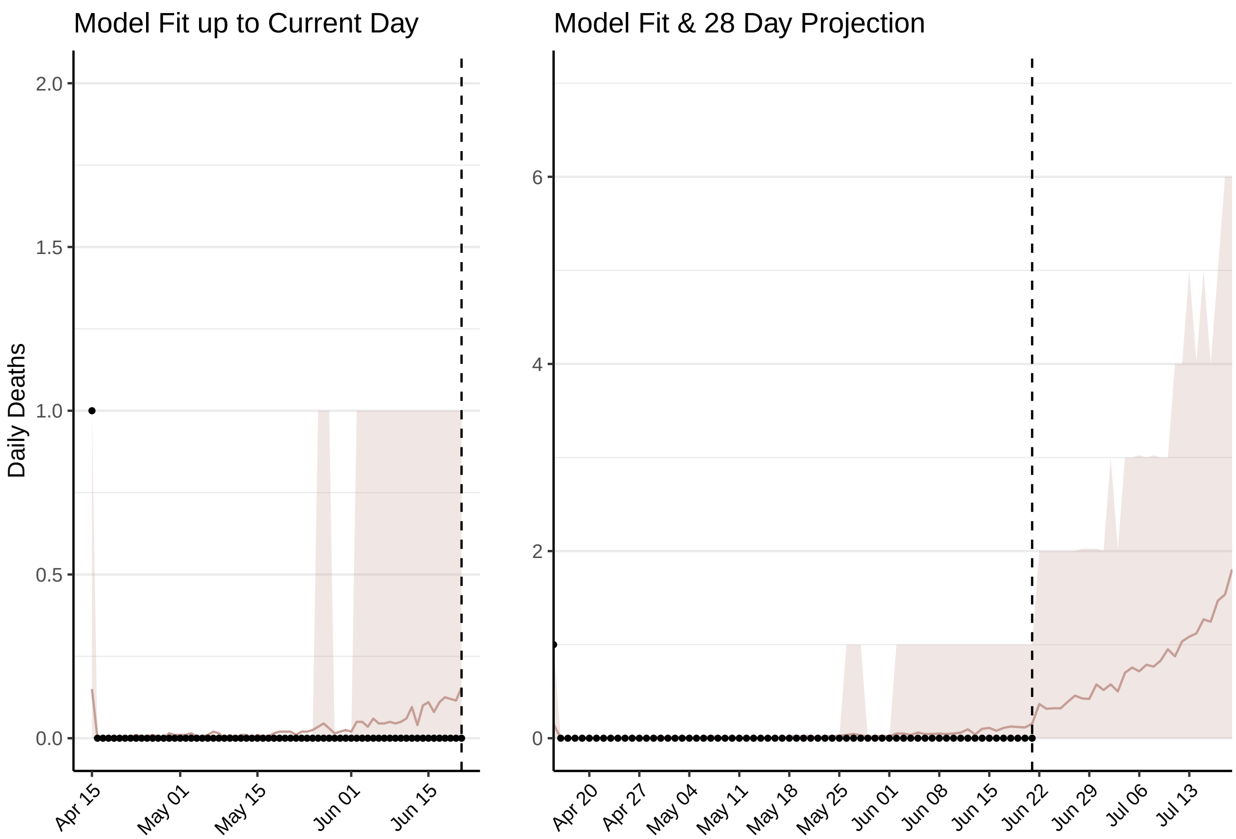


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 17 (95% CI: 15-18) patients requiring treatment with high-pressure oxygen at the current date to 99 (95% CI: 90-109) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4 (95% CI: 4-5) patients requiring treatment with mechanical ventilation at the current date to 25 (95% CI: 23-28) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

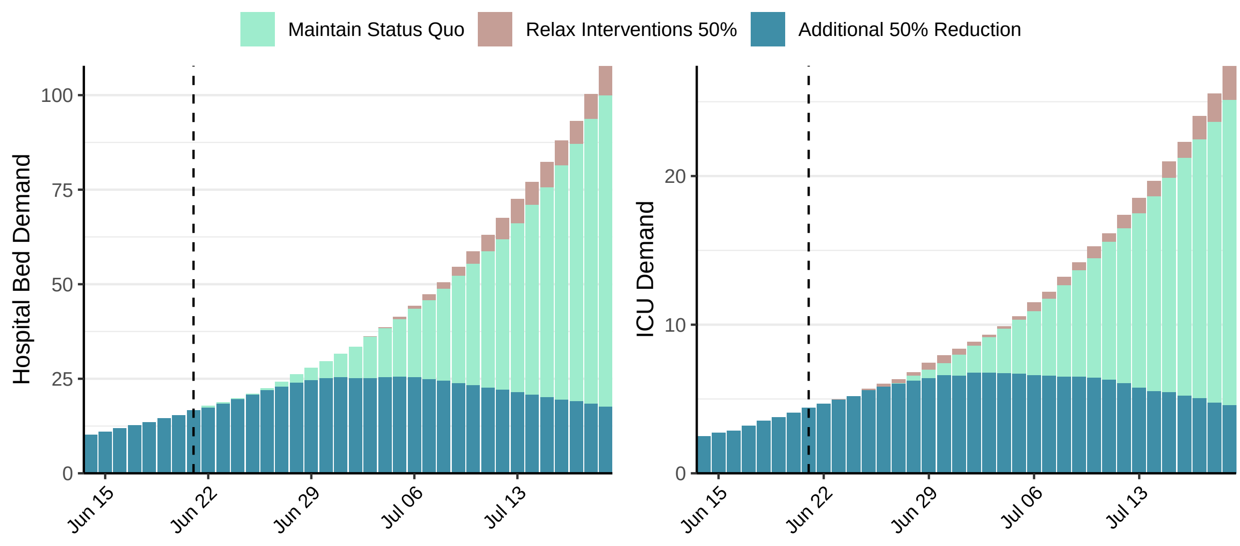


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 226 (95% CI: 205-246) at the current date to 82 (95% CI: 74-90) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 226 (95% CI: 205-246) at the current date to 1,513 (95% CI: 1,364-1,663) by 2020-07-19.

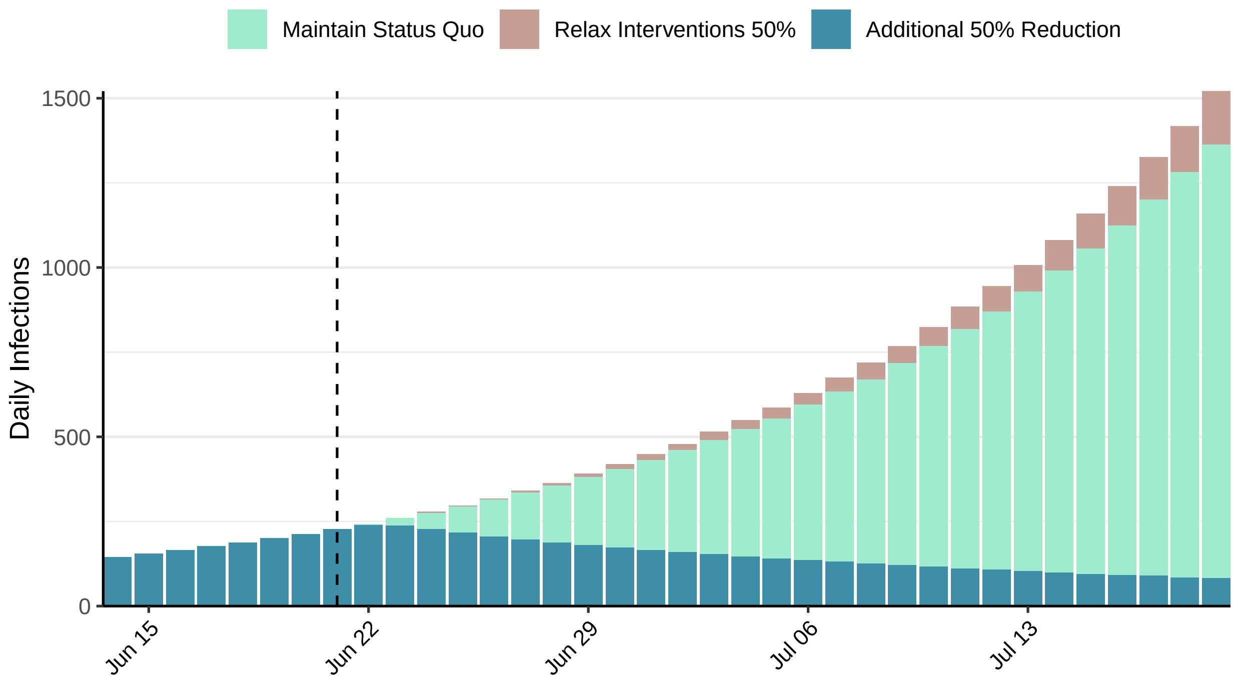


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our [COVID-19 Scenario Analysis Tool - https://covidsim.org/](https://covidsim.org/), which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Benin, 2020-06-21

**Download the report for Benin, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 650 | 0 | 11 | 0 | 1.77 (95% CI: 1.43-2.3) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

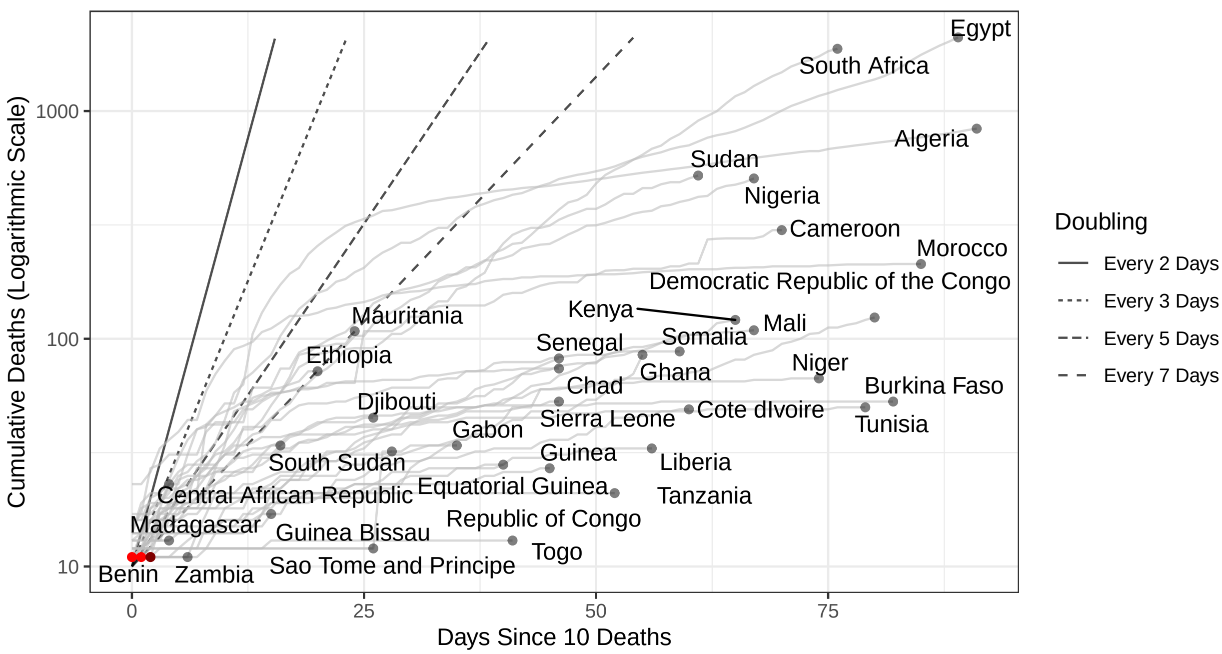


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 11,073 (95% CI: 10,117-12,029) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match). **N.B. Benin has revised their historic reported cases and thus have reported negative cases.**

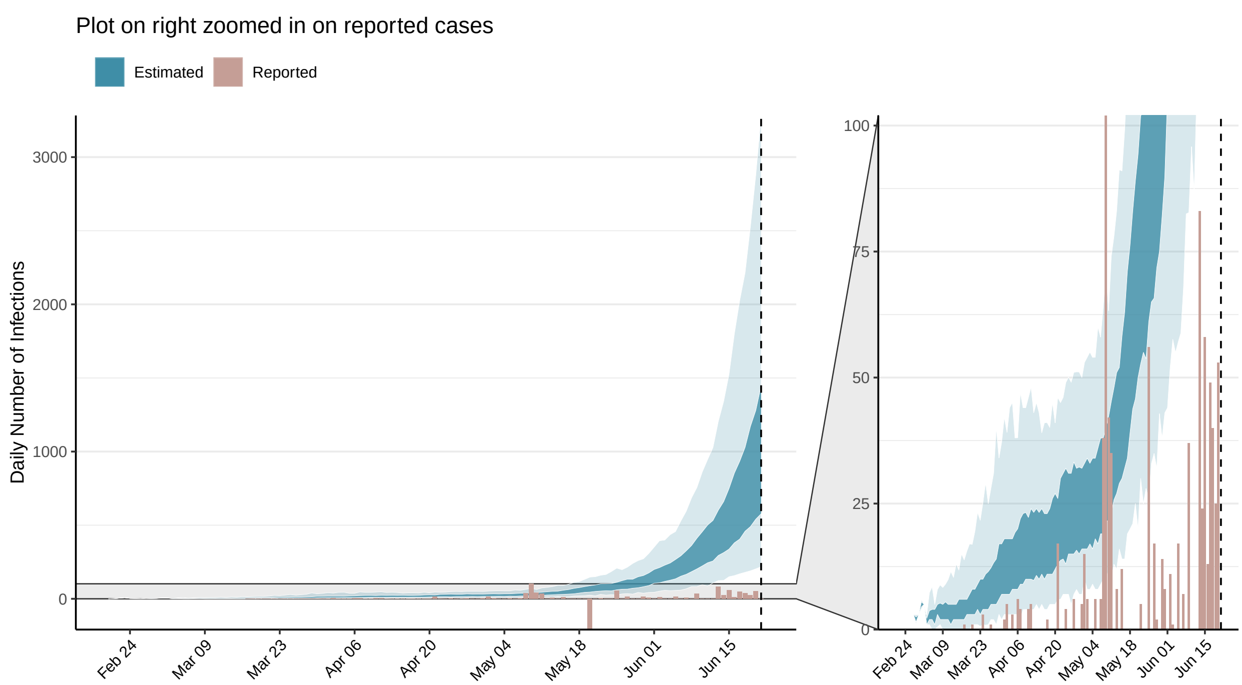


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

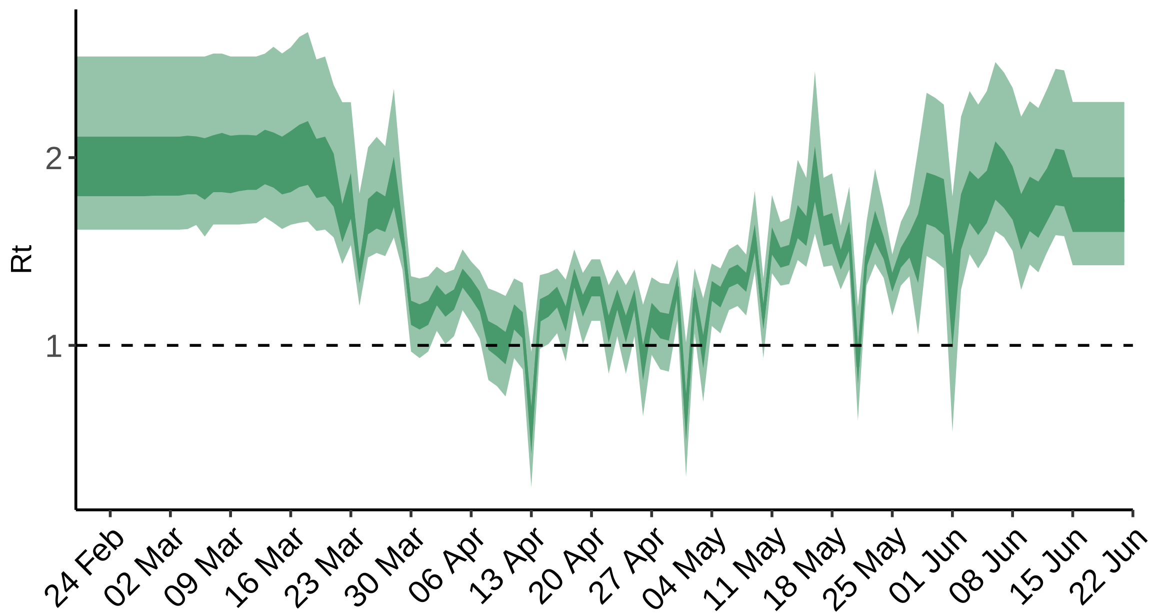


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

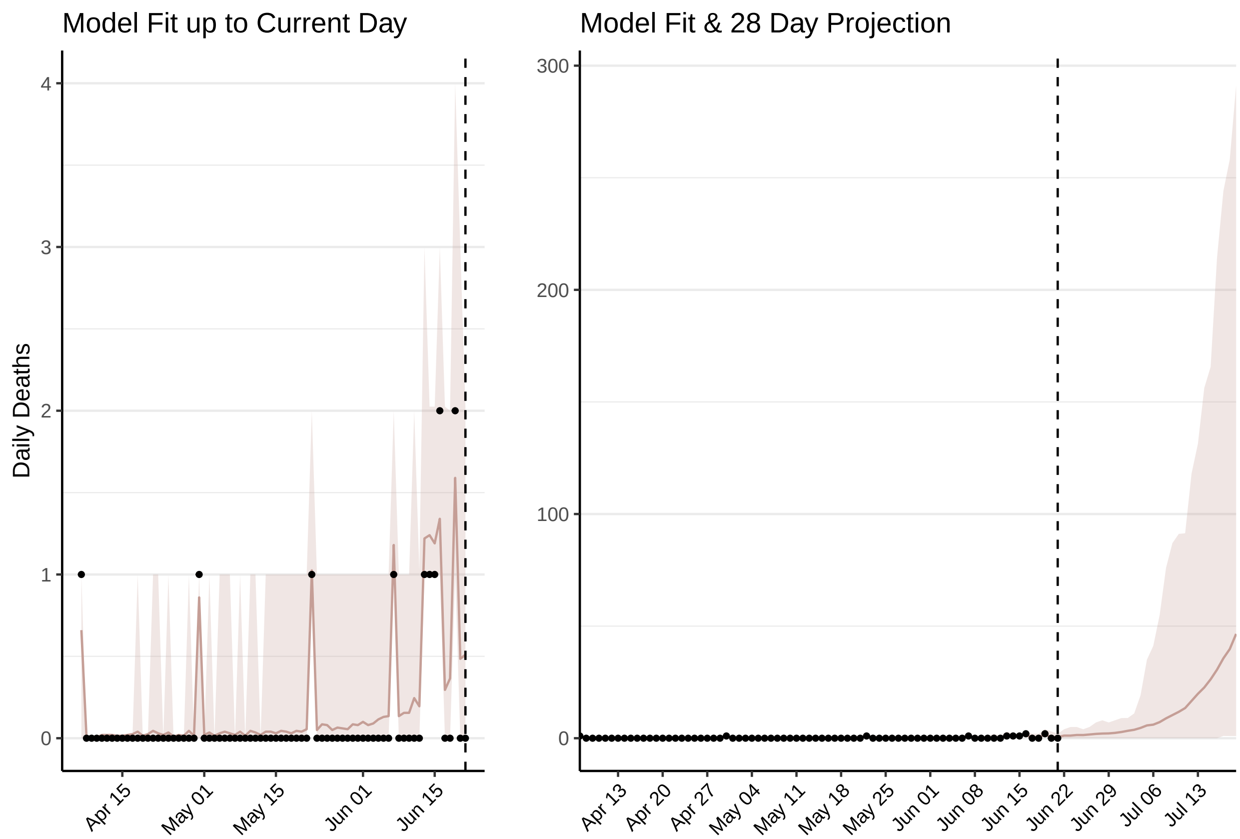


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 64 (95% CI: 59-70) patients requiring treatment with high-pressure oxygen at the current date to 1,253 (95% CI: 1,031-1,476) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 17 (95% CI: 16-19) patients requiring treatment with mechanical ventilation at the current date to 208 (95% CI: 188-227) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

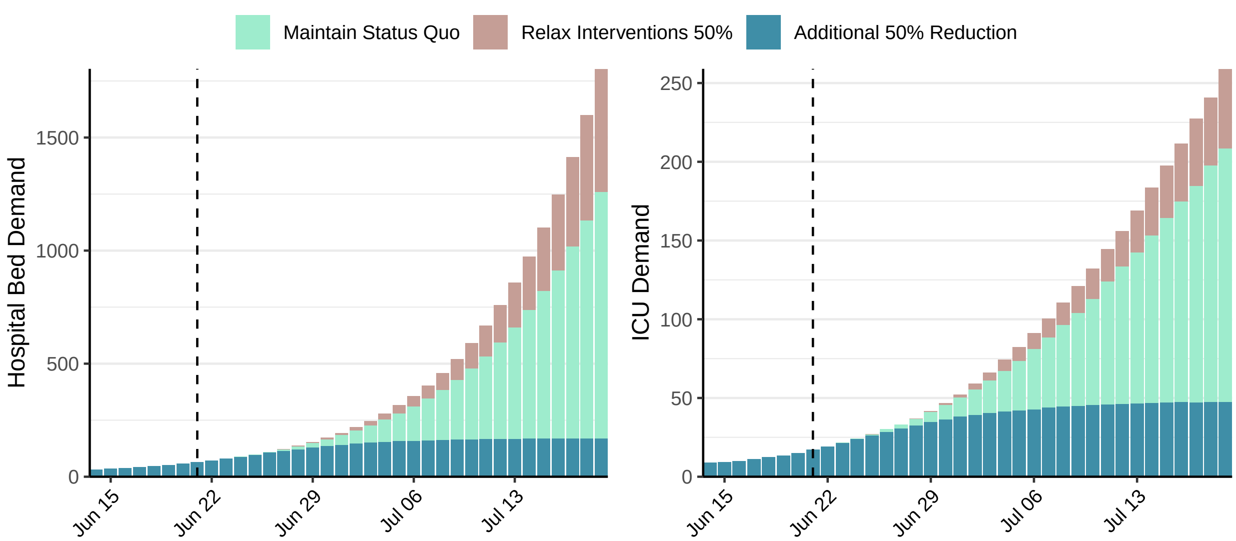


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 1,147 (95% CI: 1,025-1,269) at the current date to 1,125 (95% CI: 904-1,347) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 1,147 (95% CI: 1,025-1,269) at the current date to 36,550 (95% CI: 29,390-43,709) by 2020-07-19.

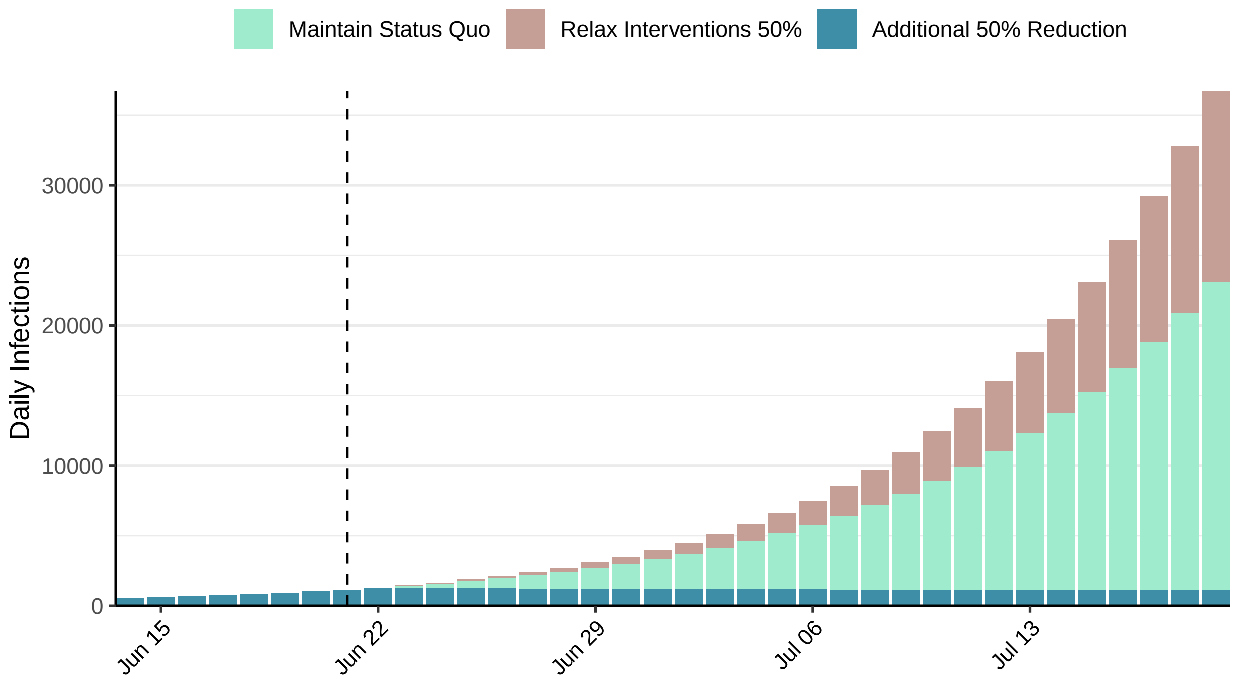


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Burkina Faso, 2020-06-21

**Download the report for Burkina Faso, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 902 | 2 | 53 | 0 | 1.7 (95% CI: 1.59-1.86) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

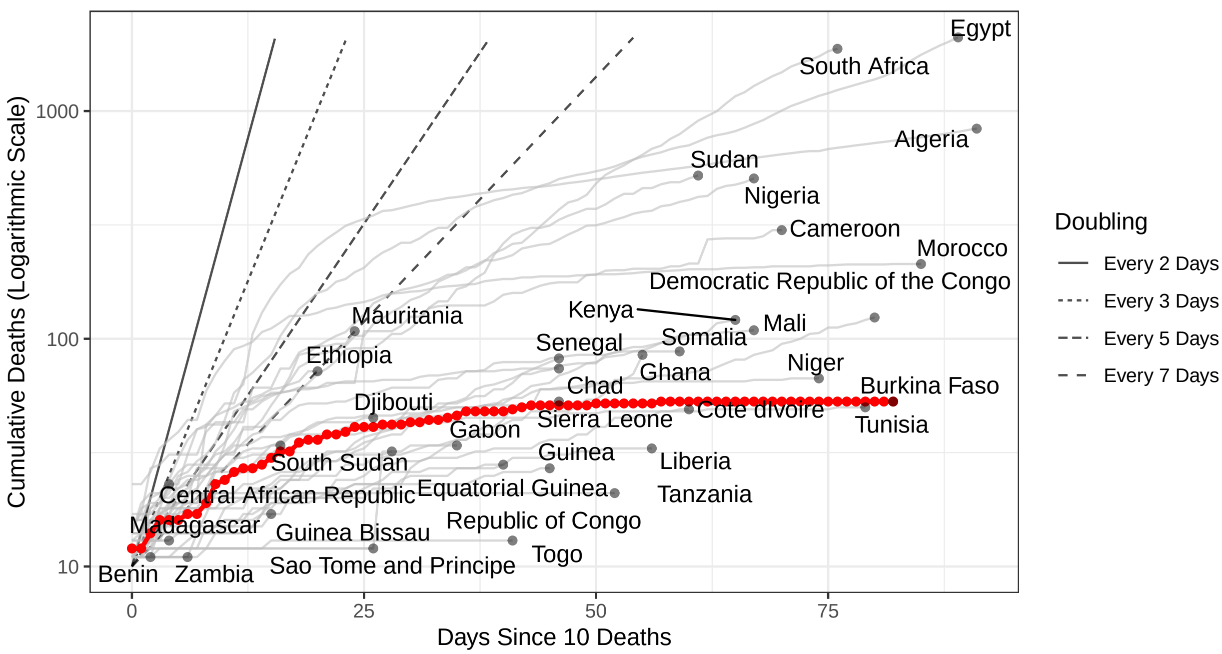


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 4,908 (95% CI: 4,586-5,231) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

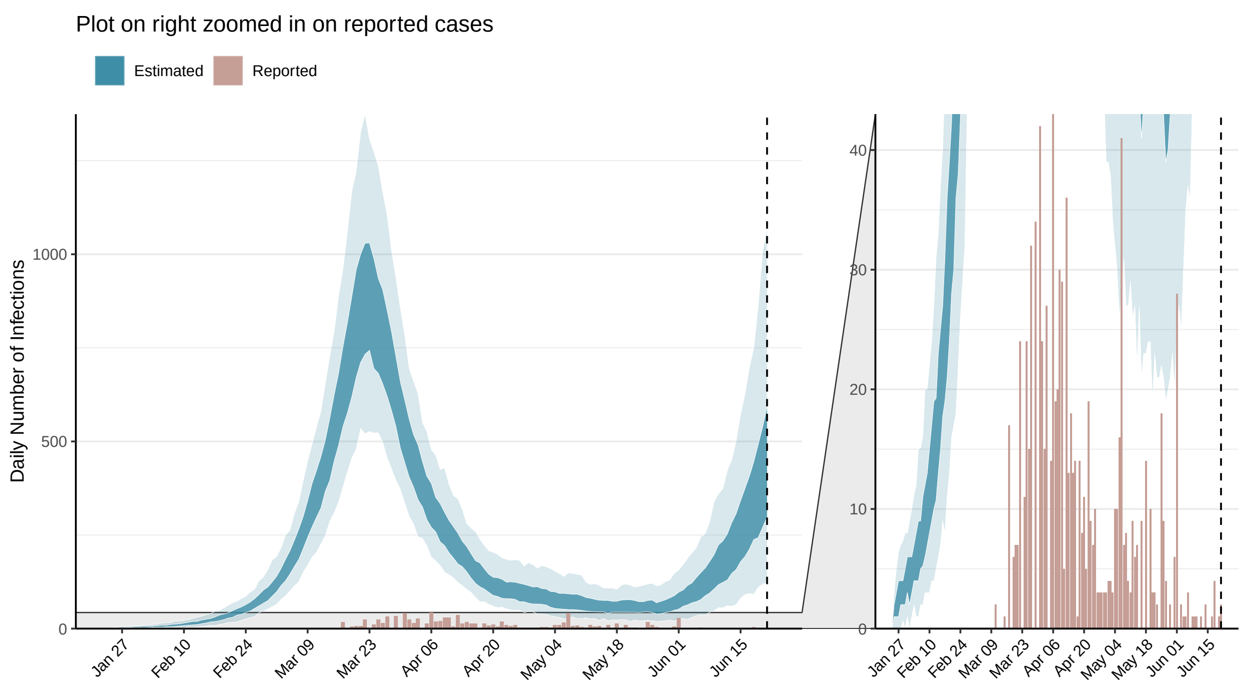


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

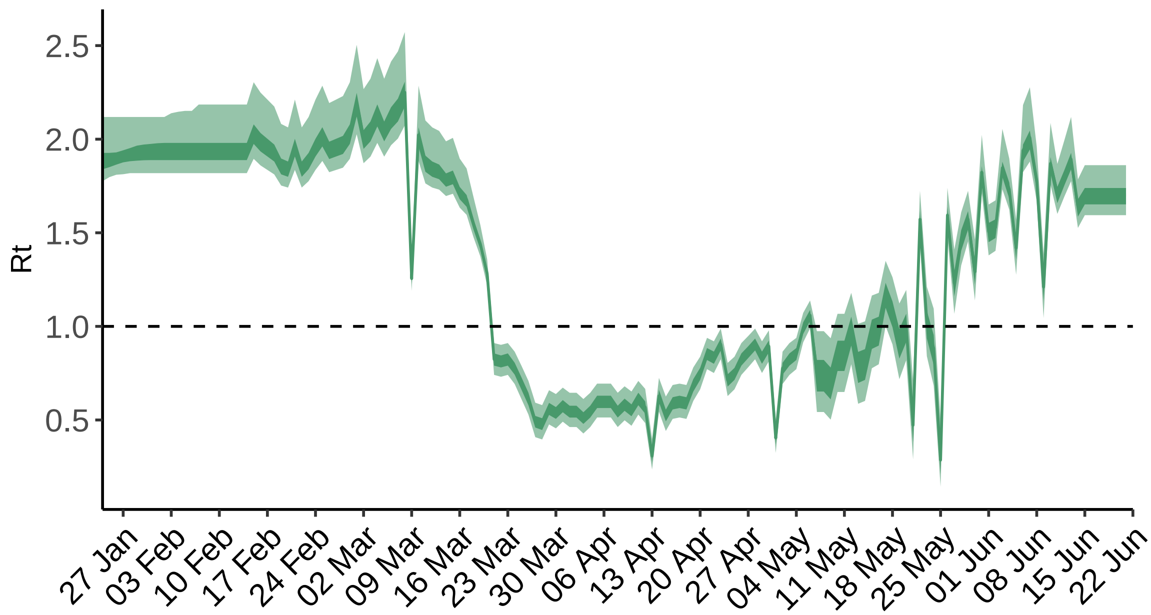


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

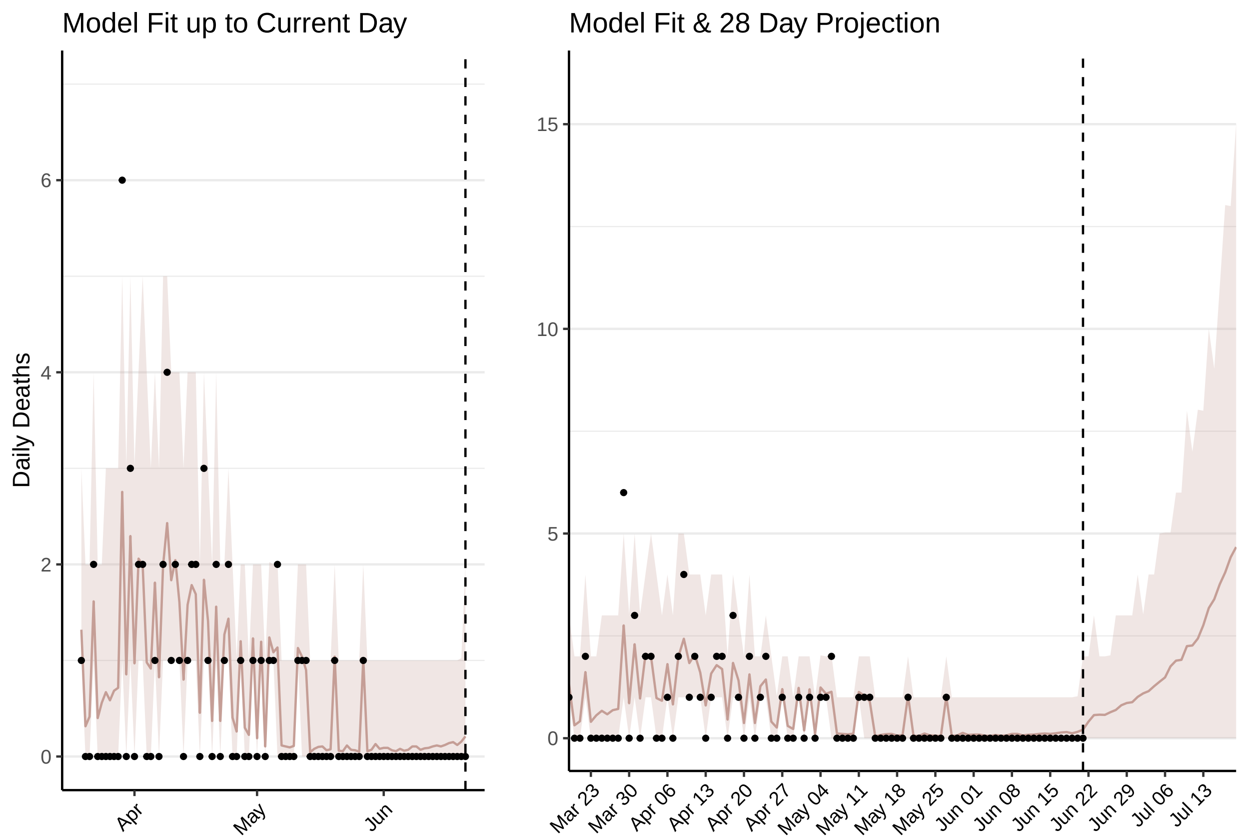


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 27 (95% CI: 25-29) patients requiring treatment with high-pressure oxygen at the current date to 327 (95% CI: 299-355) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 7 (95% CI: 6-8) patients requiring treatment with mechanical ventilation at the current date to 83 (95% CI: 76-90) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

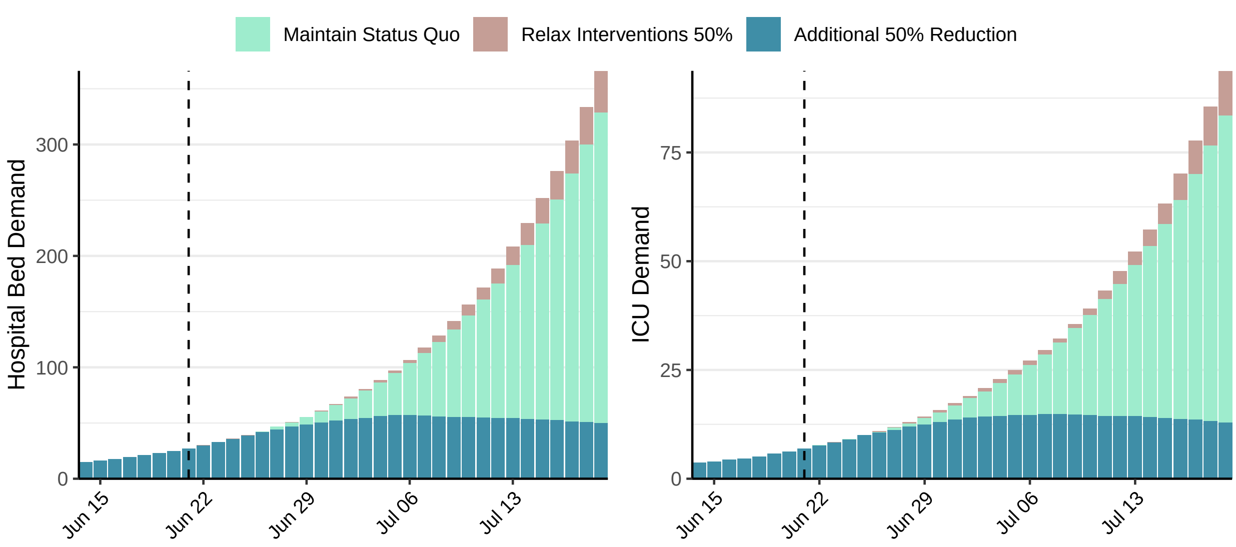


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 450 (95% CI: 418-481) at the current date to 283 (95% CI: 258-309) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 450 (95% CI: 418-481) at the current date to 6,408 (95% CI: 5,794-7,022) by 2020-07-19.

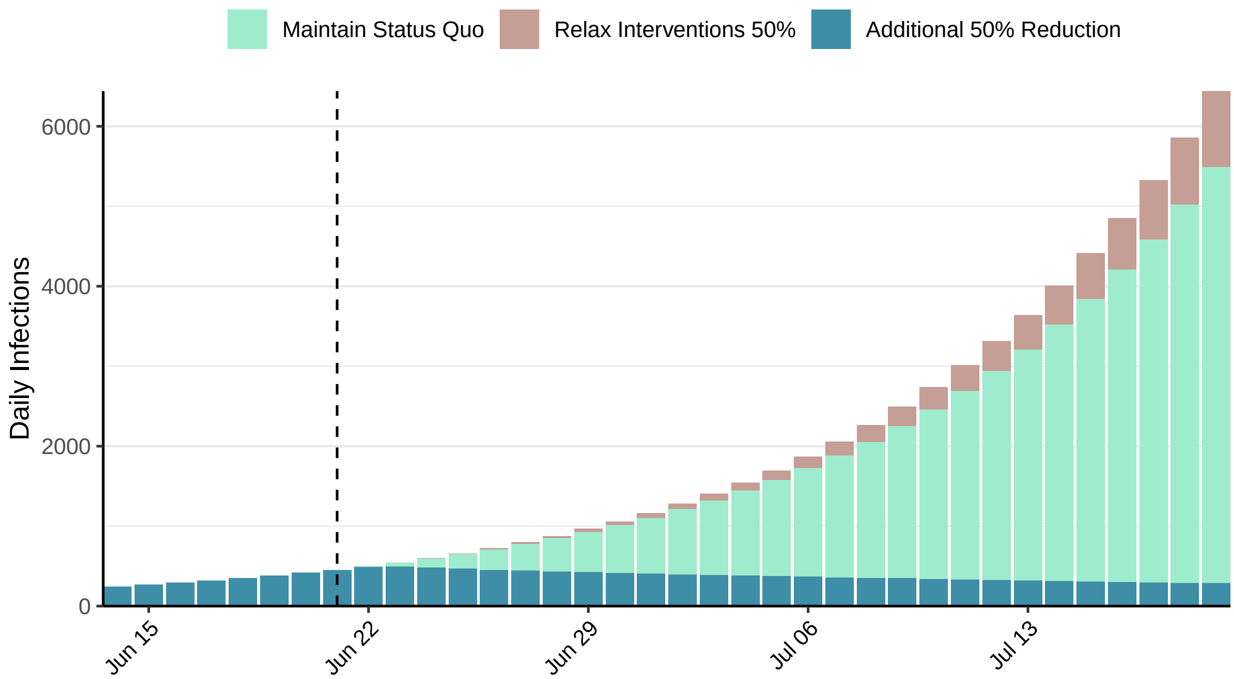


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Bangladesh, 2020-06-21

**Download the report for Bangladesh, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 108,775 | 3,240 | 1,425 | 37 | 1.6 (95% CI: 1.48-1.73) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

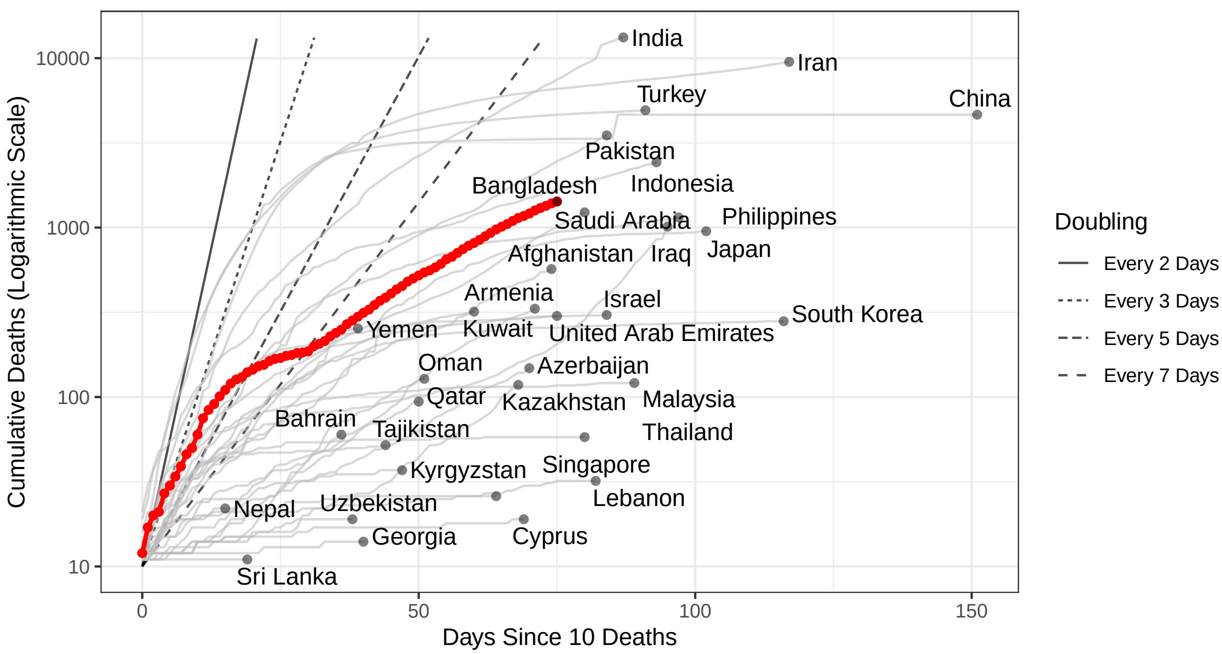


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 654,135 (95% CI: 634,499-673,771) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

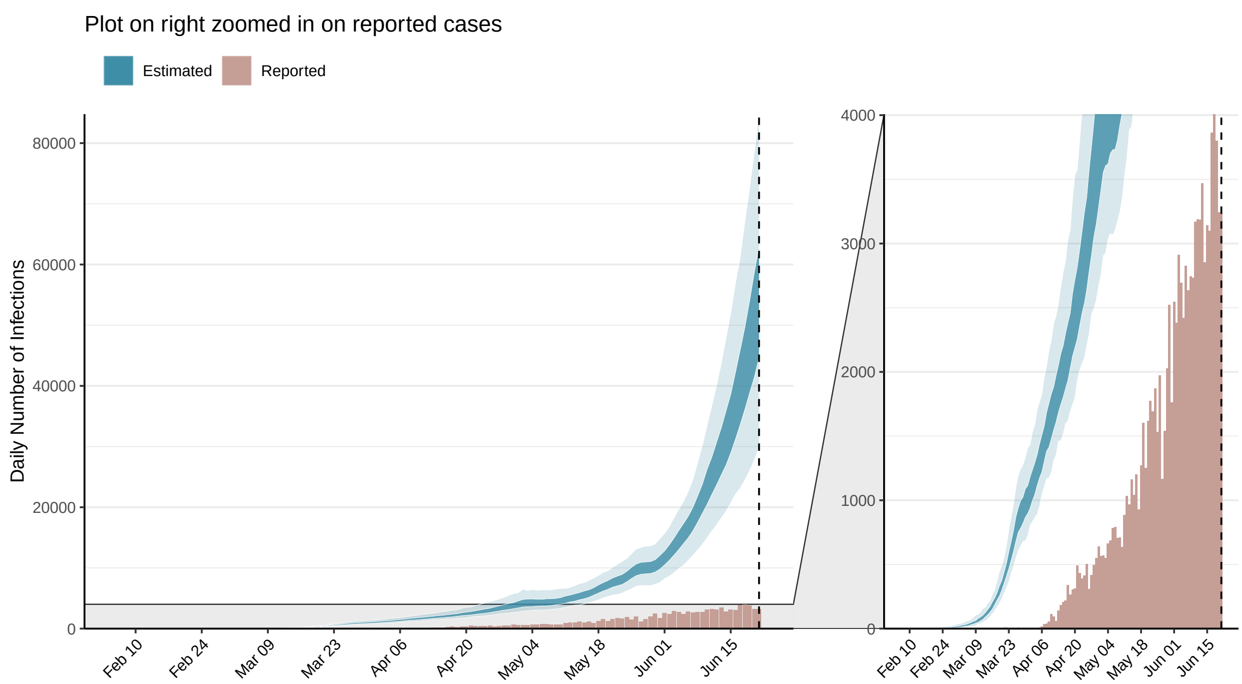


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

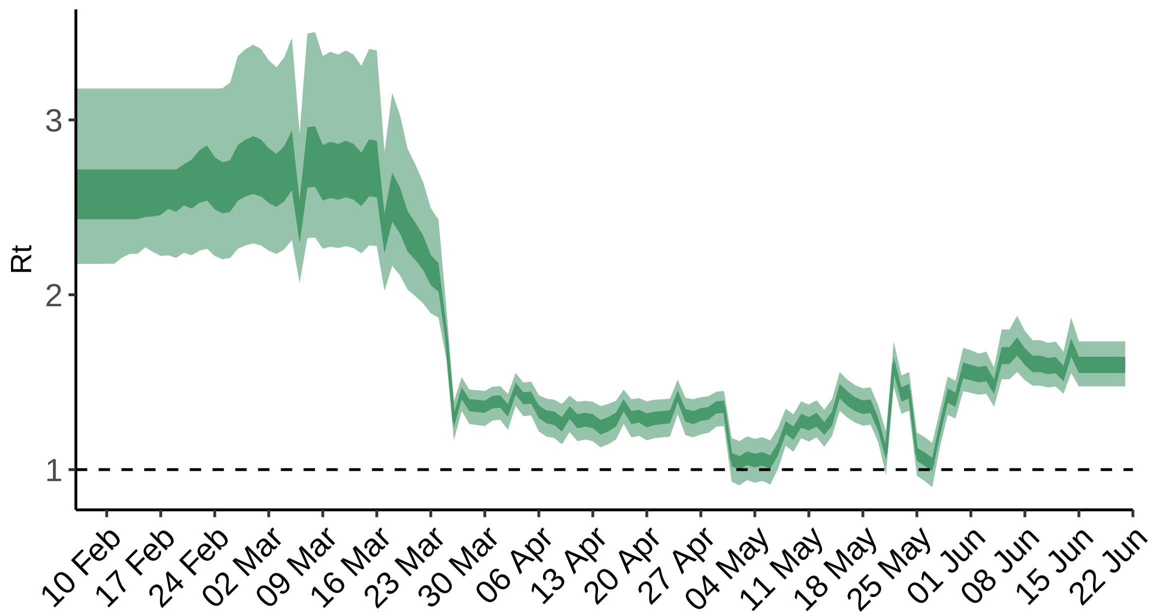


Figure 3: **Time-varying reproduction number,** $R_t$**.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Bangladesh is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

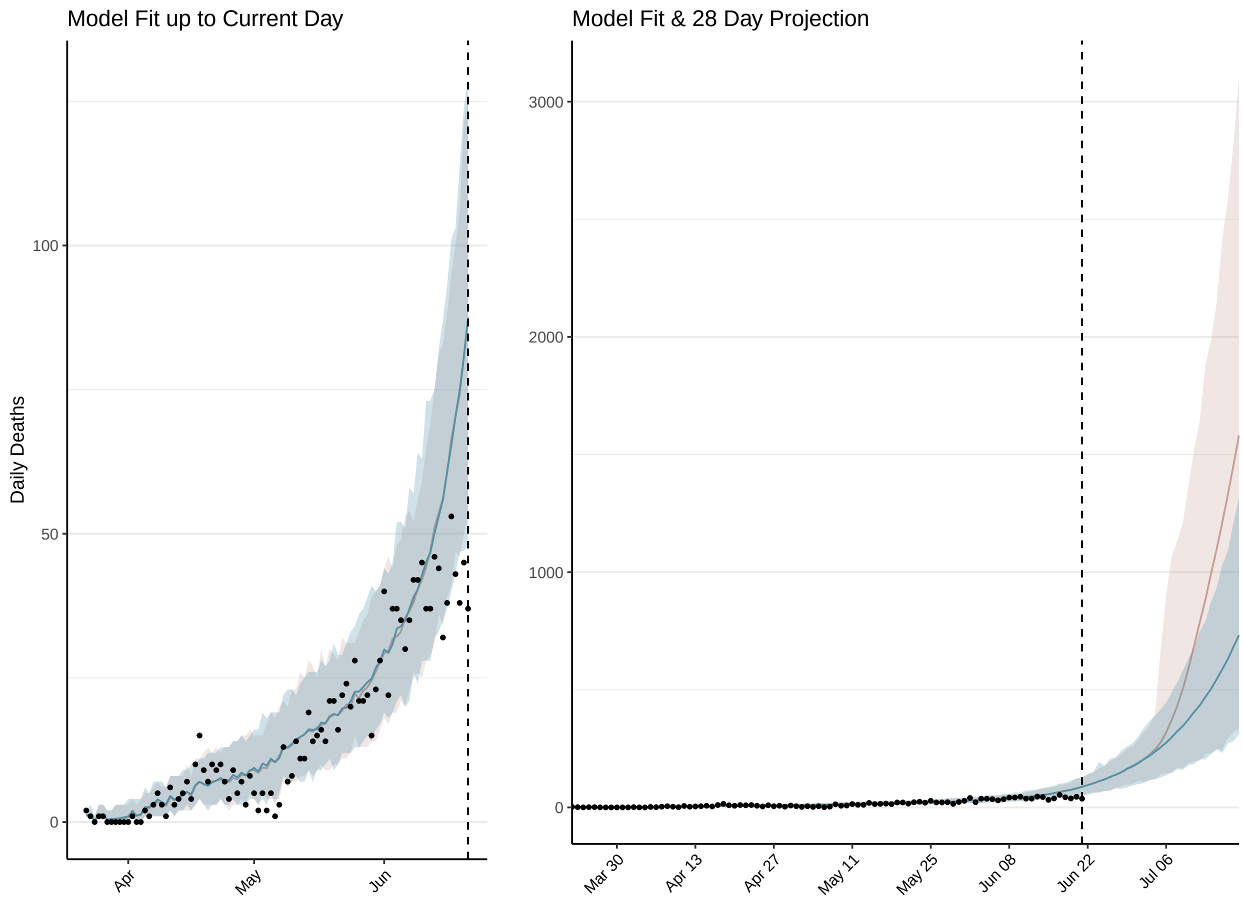


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4,917 (95% CI: 4,768-5,067) patients requiring treatment with high-pressure oxygen at the current date to 40,481 (95% CI: 38,407-42,555) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1,470 (95% CI: 1,426-1,515) patients requiring treatment with mechanical ventilation at the current date to 7,279 (95% CI: 7,129-7,429) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

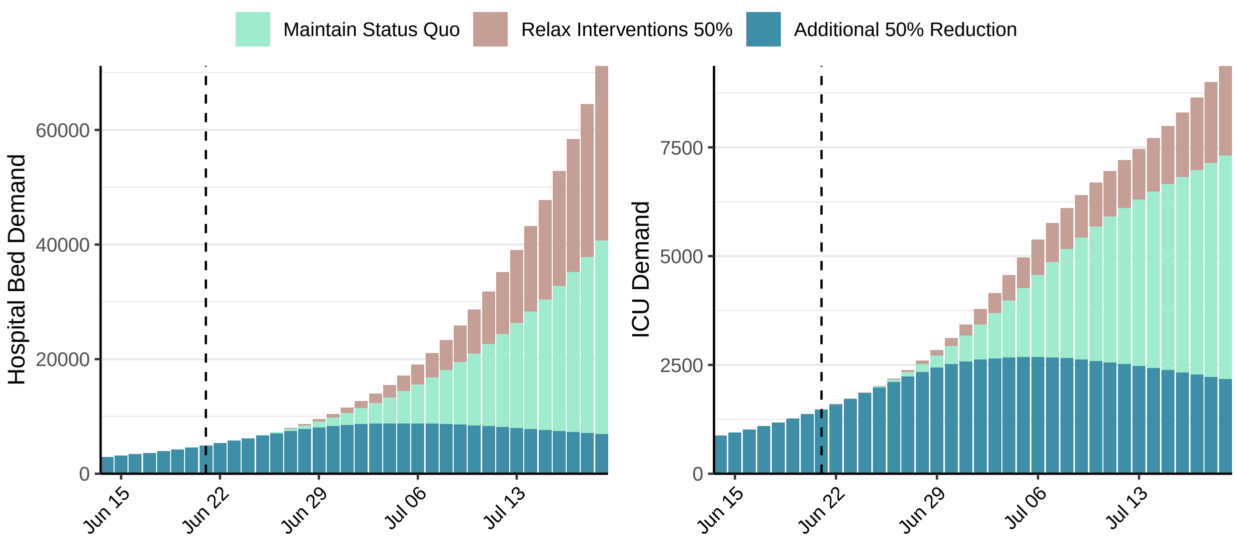


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 54,187 (95% CI: 52,218-56,157) at the current date to 25,628 (95% CI: 24,194-27,063) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 54,187 (95% CI: 52,218-56,157) at the current date to 936,095 (95% CI: 883,775-988,416) by 2020-07-19.

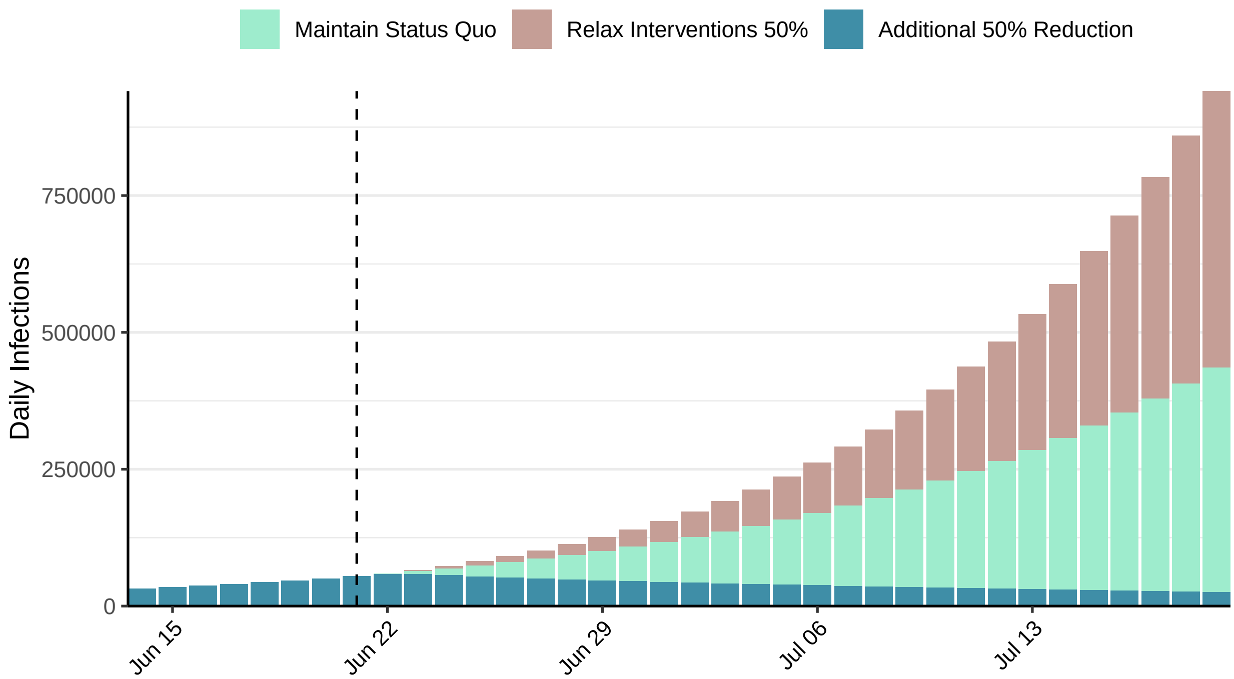


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Bulgaria, 2020-06-21

**Download the report for Bulgaria, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 3,872 | 117 | 199 | 6 | 1.58 (95% CI: 1.44-1.8) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

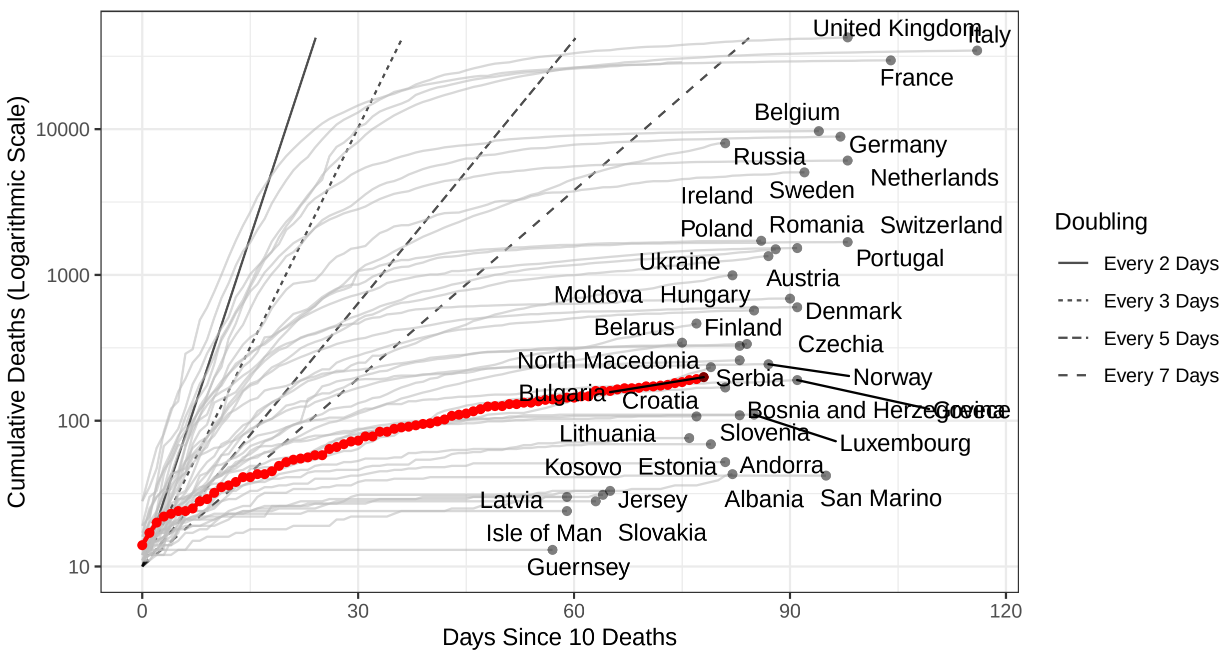


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 37,411 (95% CI: 35,935-38,888) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

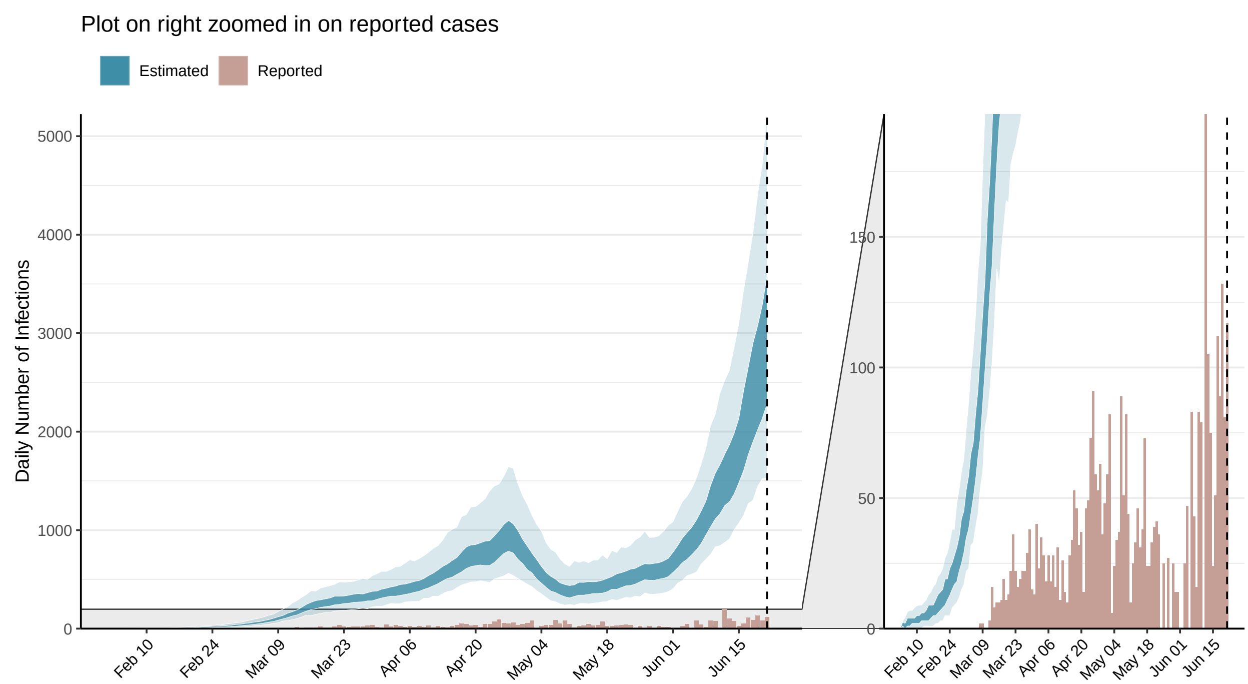


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

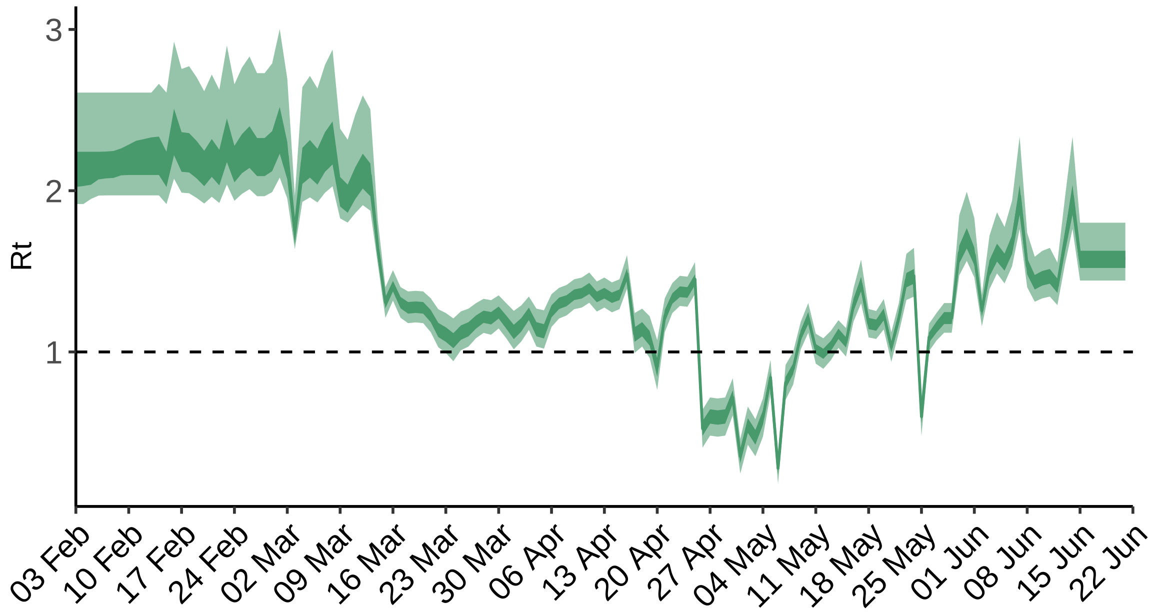


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

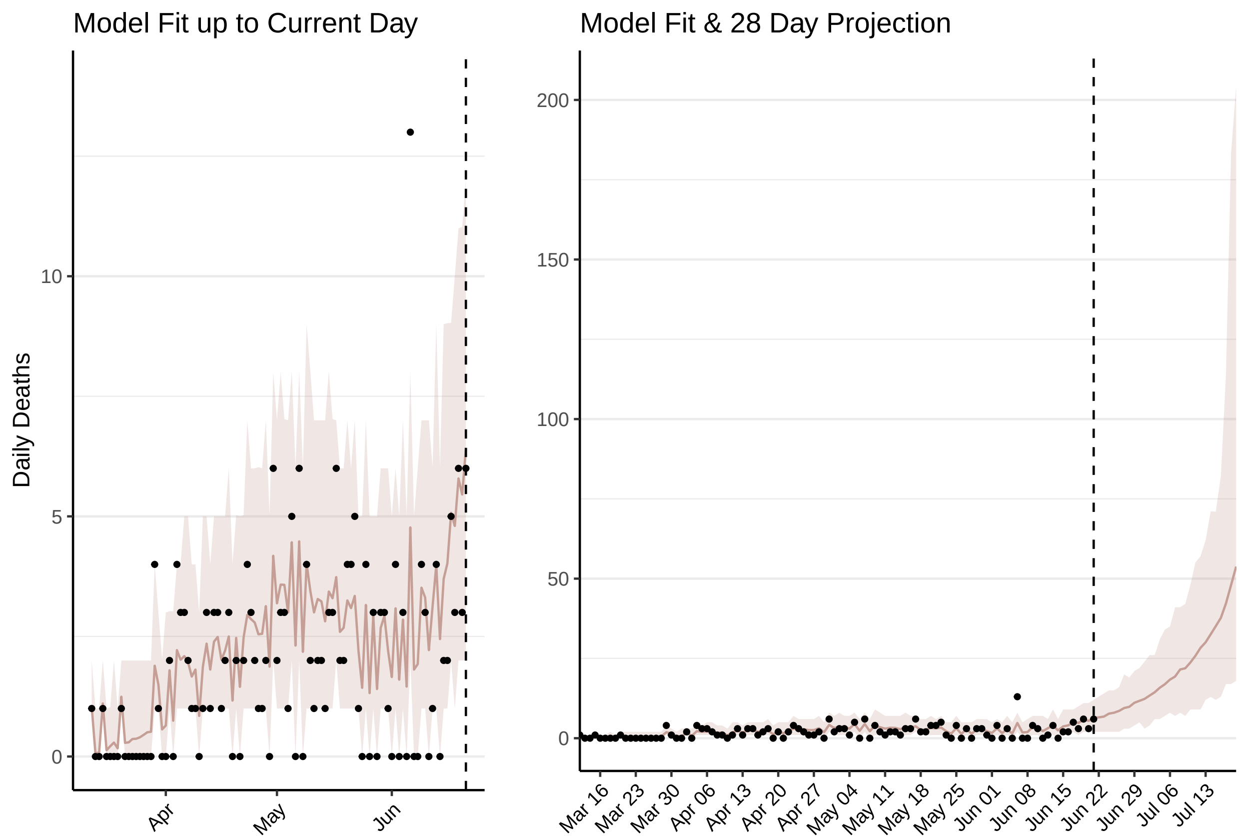


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 329 (95% CI: 315-342) patients requiring treatment with high-pressure oxygen at the current date to 2,470 (95% CI: 2,311-2,629) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 100 (95% CI: 95-104) patients requiring treatment with mechanical ventilation at the current date to 747 (95% CI: 703-792) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

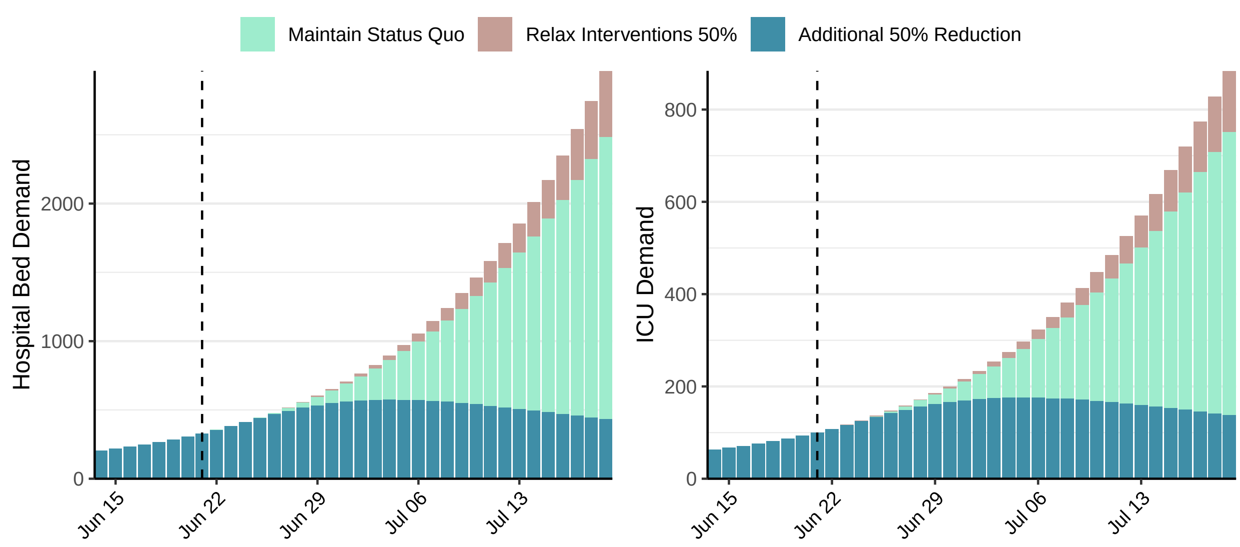


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 3,022 (95% CI: 2,884-3,161) at the current date to 1,276 (95% CI: 1,188-1,364) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 3,022 (95% CI: 2,884-3,161) at the current date to 25,757 (95% CI: 24,032-27,483) by 2020-07-19.

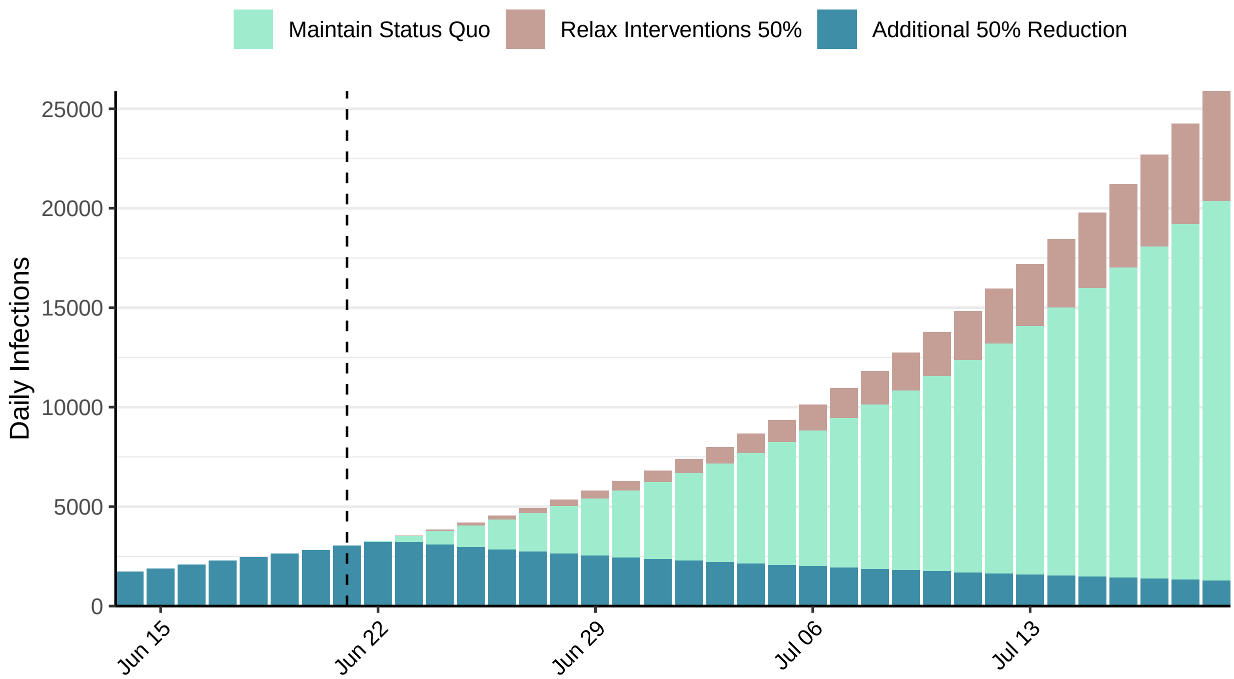


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Bosnia and Herzegovina, 2020-06-21

**Download the report for Bosnia and Herzegovina, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 3,288 | 15 | 169 | 0 | 1.86 (95% CI: 1.75-2.03) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

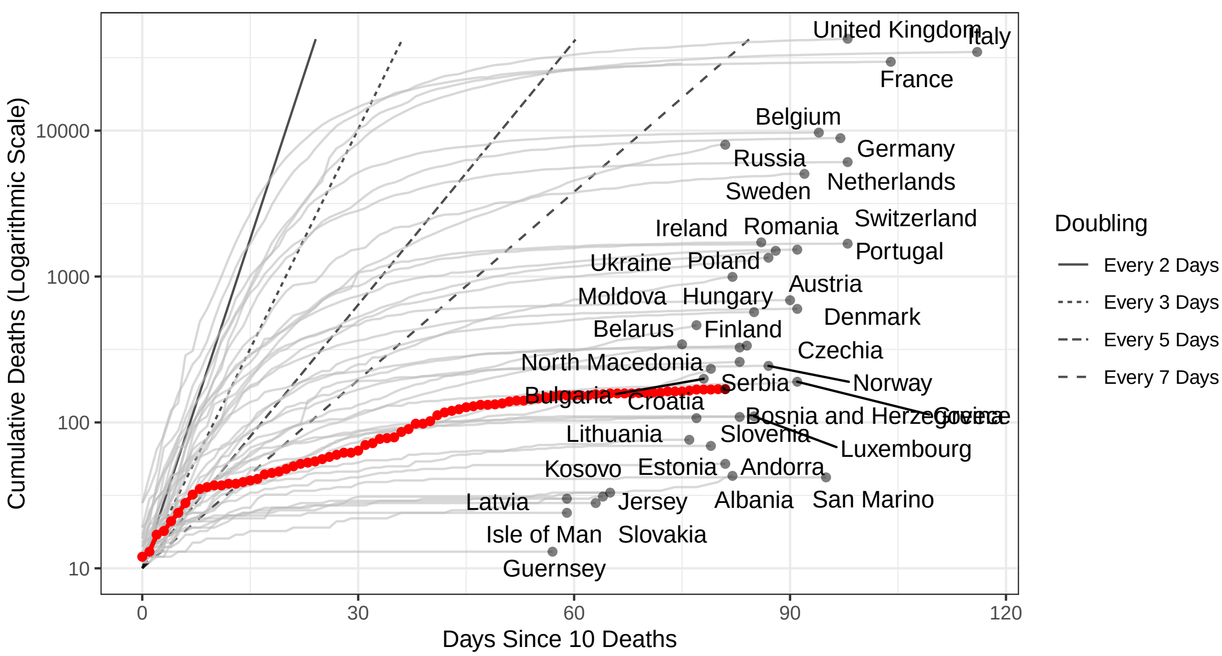


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 17,550 (95% CI: 16,853-18,247) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

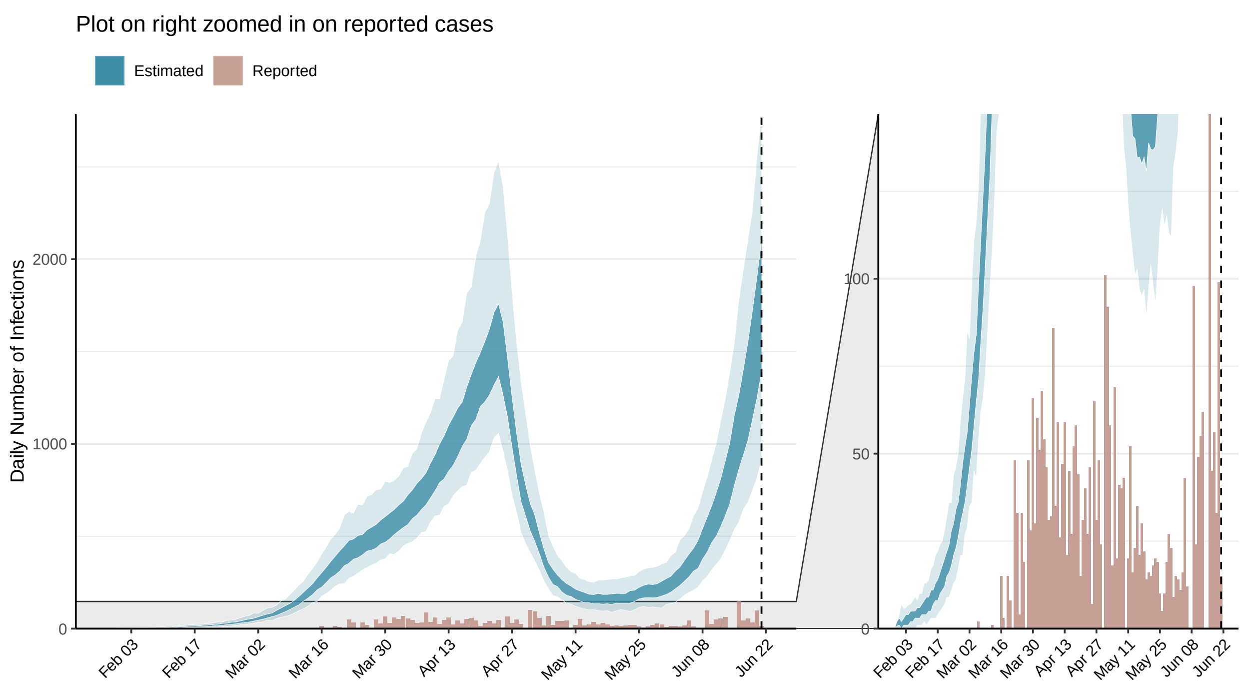


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

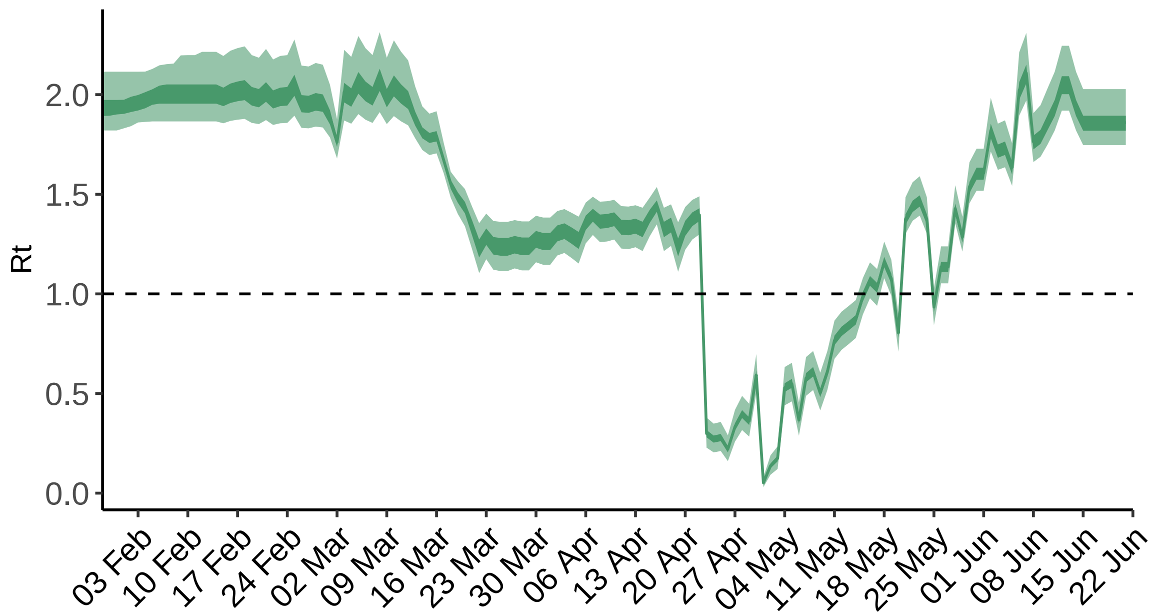


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Bosnia and Herzegovina is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

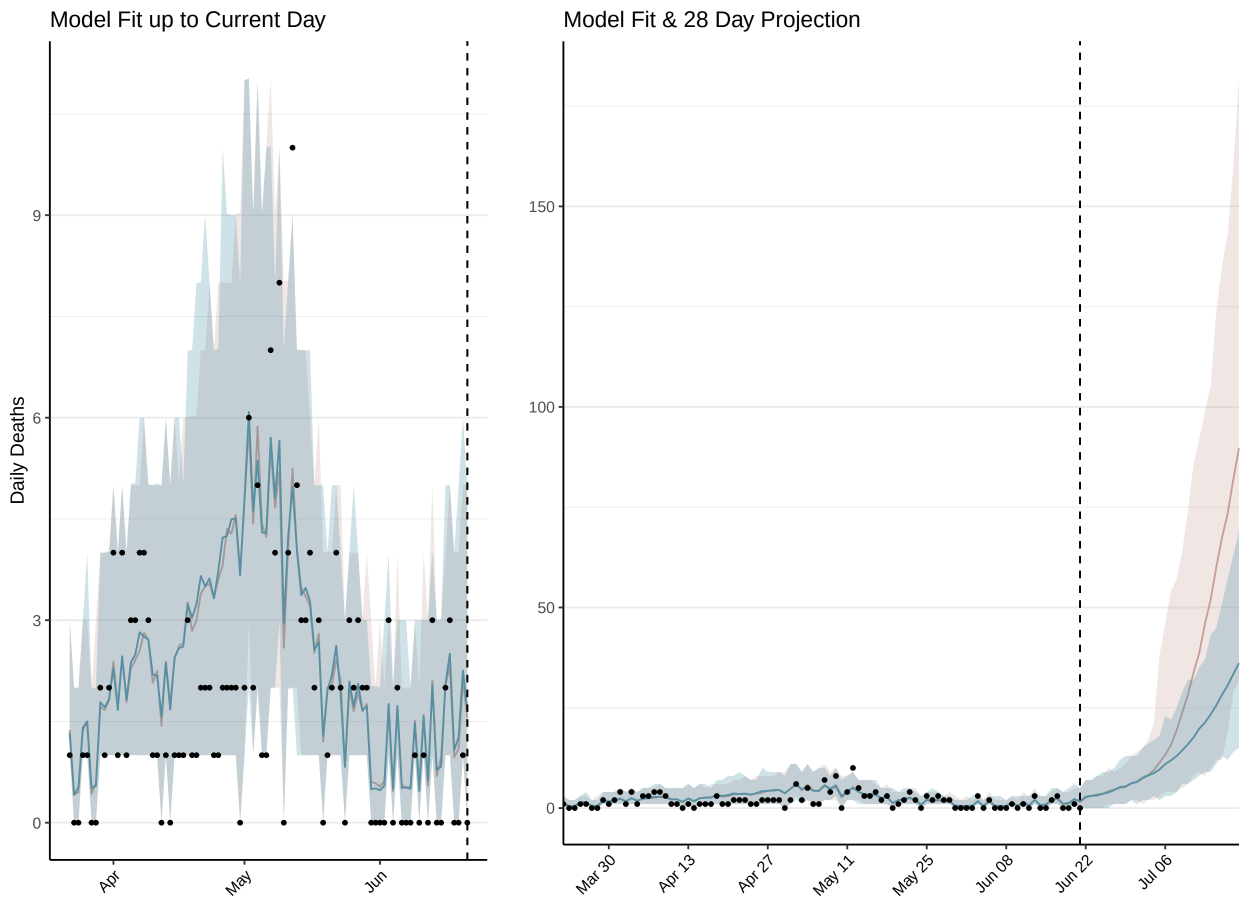


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 155 (95% CI: 149-162) patients requiring treatment with high-pressure oxygen at the current date to 2,165 (95% CI: 2,062-2,268) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 43 (95% CI: 41-45) patients requiring treatment with mechanical ventilation at the current date to 335 (95% CI: 329-342) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

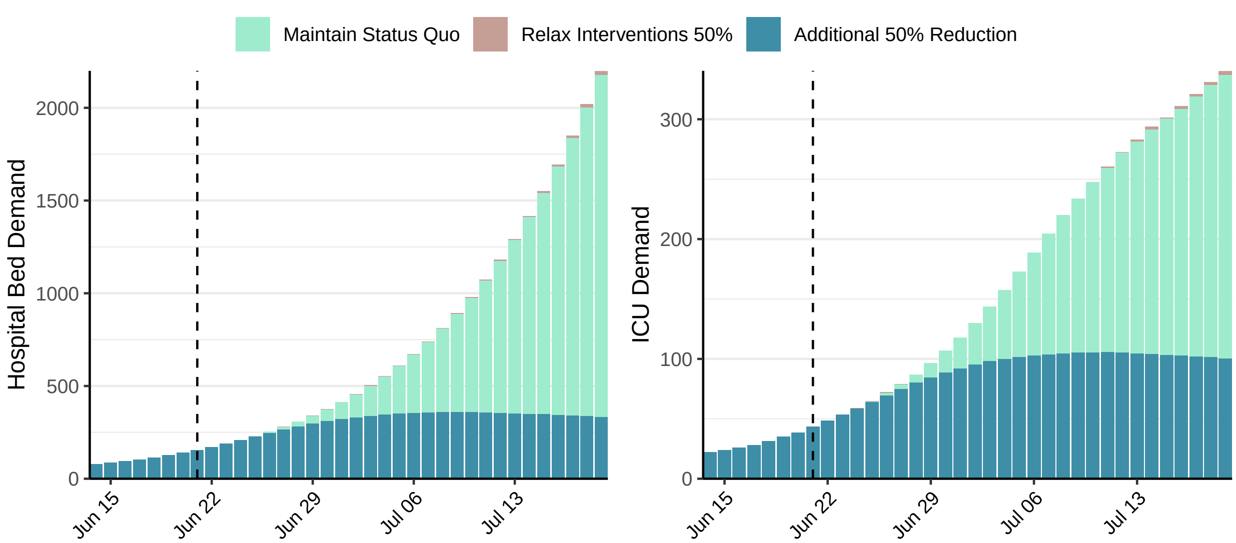


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 1,746 (95% CI: 1,673-1,819) at the current date to 1,248 (95% CI: 1,185-1,311) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 1,746 (95% CI: 1,673-1,819) at the current date to 20,863 (95% CI: 19,939-21,787) by 2020-07-19.

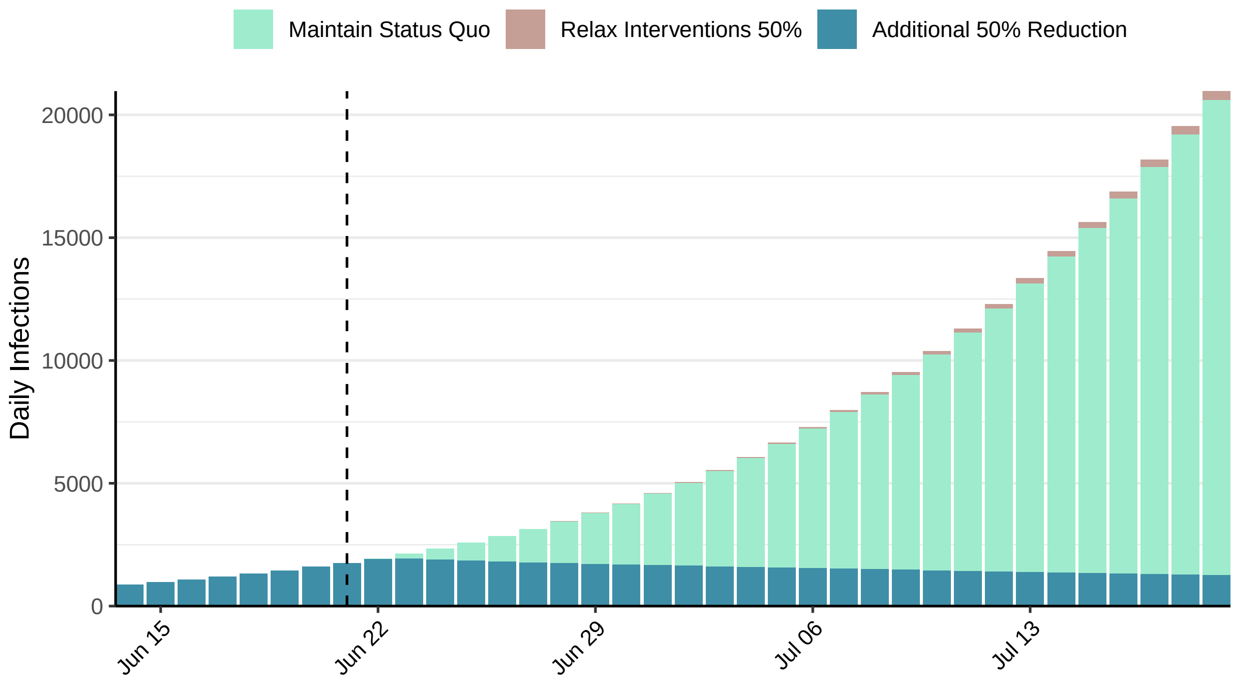


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our [COVID-19 Scenario Analysis Tool - https://covidsim.org/](https://covidsim.org/), which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Belarus, 2020-06-21

**Download the report for Belarus, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 57,936 | 603 | 343 | 10 | 1.4 (95% CI: 1.35-1.46) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

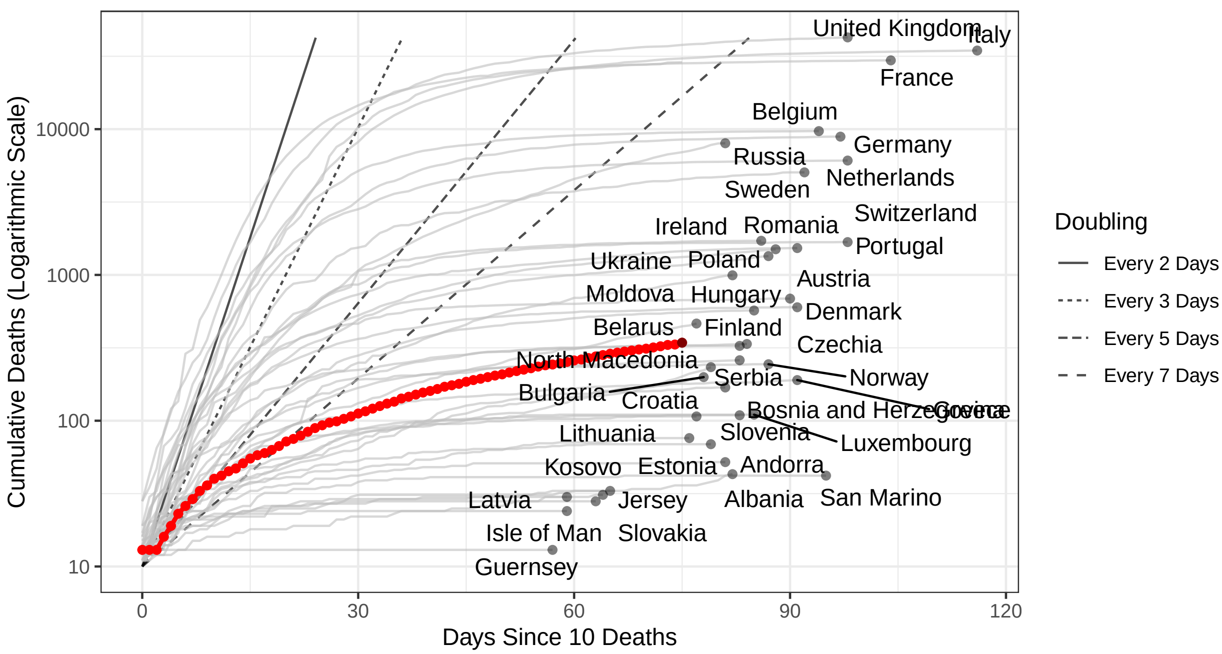


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 78,159 (95% CI: 76,146-80,172) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

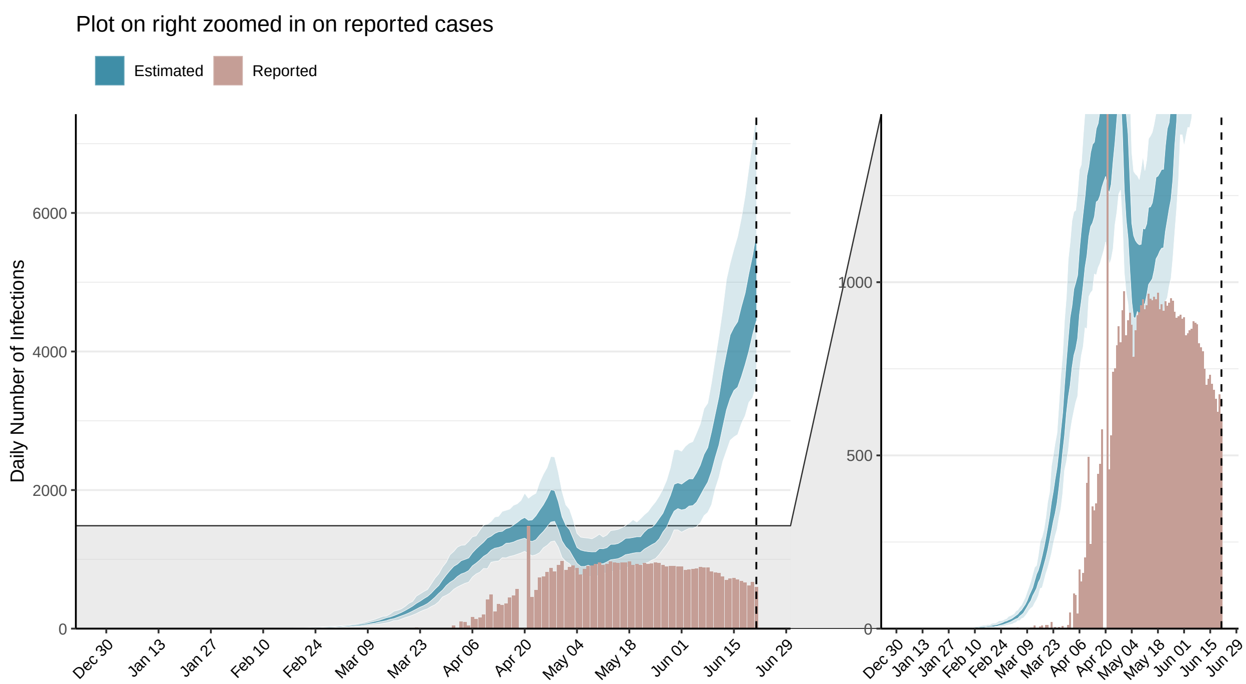


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

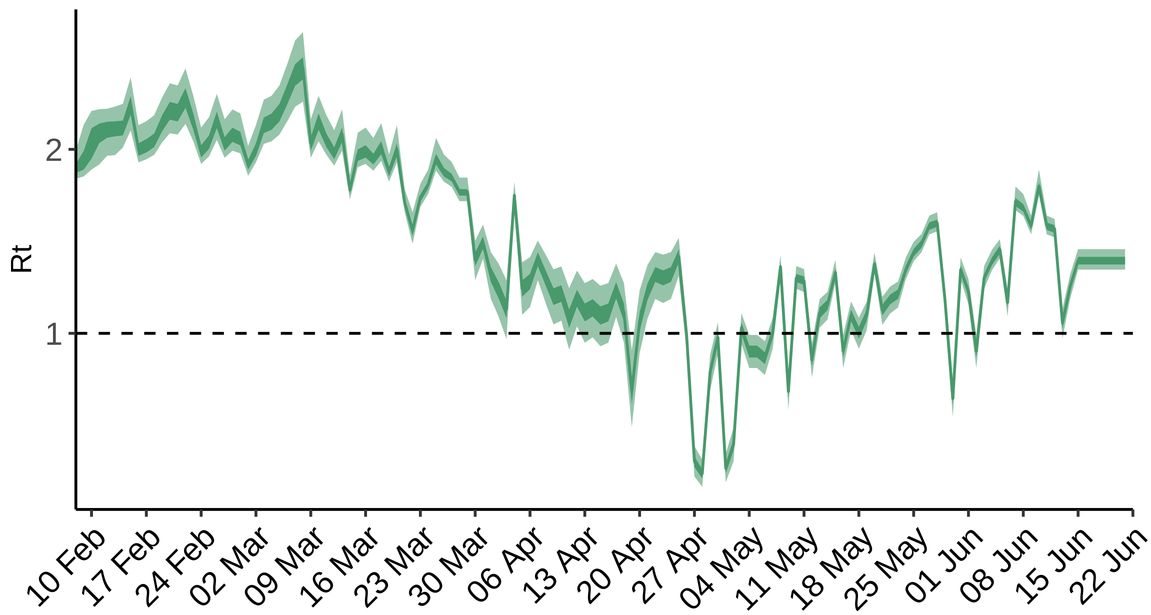


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

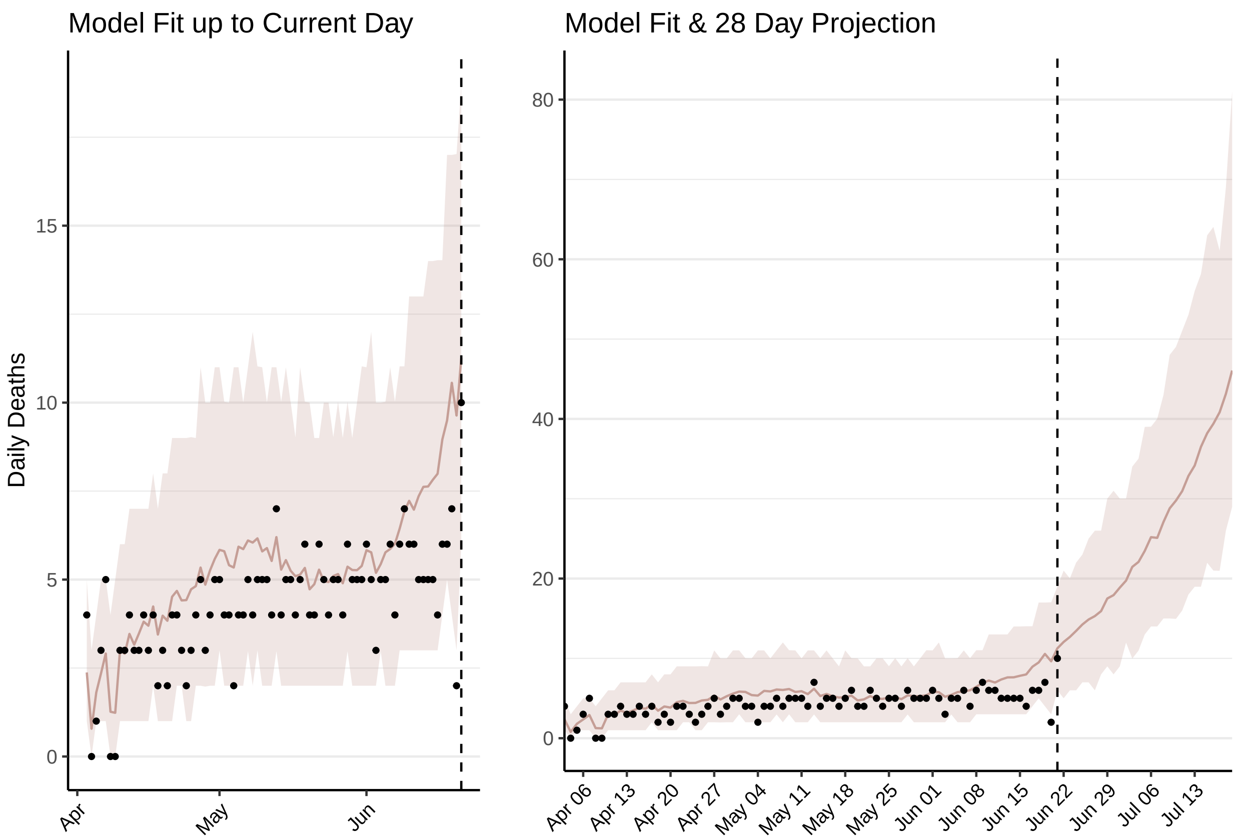


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 648 (95% CI: 630-665) patients requiring treatment with high-pressure oxygen at the current date to 2,540 (95% CI: 2,454-2,625) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 183 (95% CI: 178-188) patients requiring treatment with mechanical ventilation at the current date to 725 (95% CI: 701-750) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

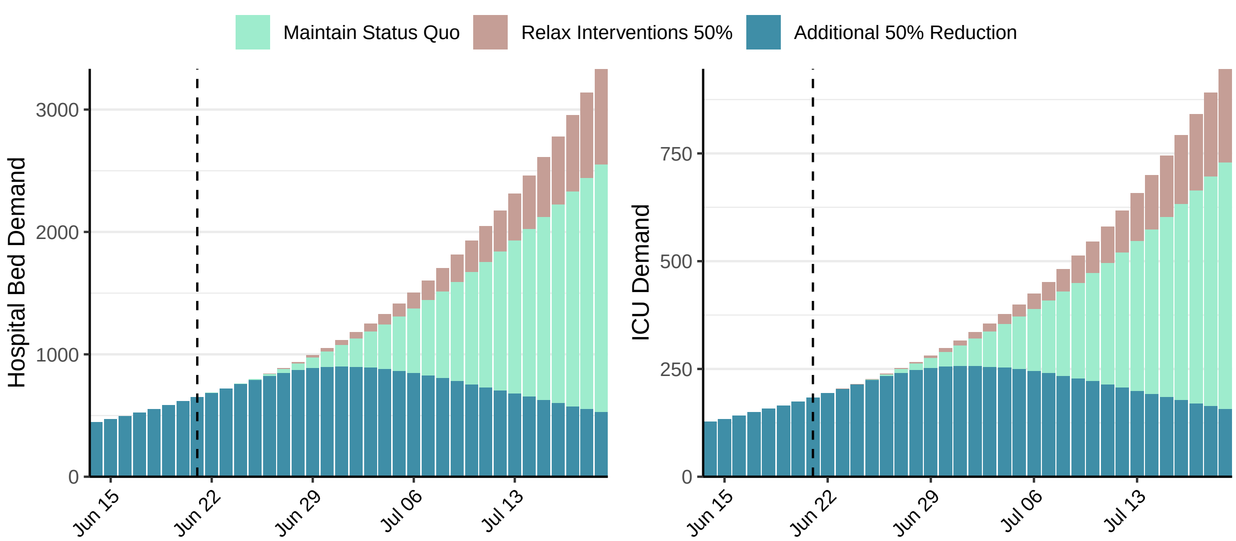


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 5,085 (95% CI: 4,939-5,232) at the current date to 1,279 (95% CI: 1,233-1,325) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 5,085 (95% CI: 4,939-5,232) at the current date to 26,904 (95% CI: 25,998-27,809) by 2020-07-19.

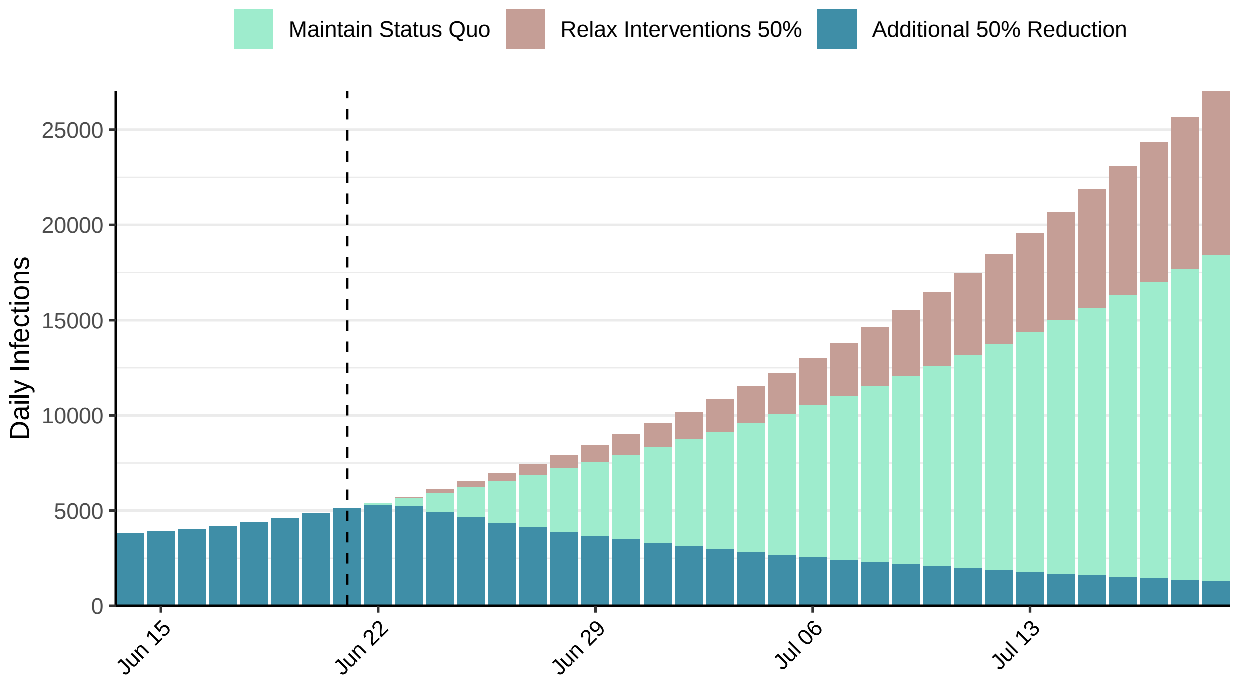


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Belize, 2020-06-21

**Download the report for Belize, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 22 | 0 | 2 | 0 | 1.35 (95% CI: 0.6-2.24) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Belize is not shown in the following plot as only 2 deaths have been reported to date**

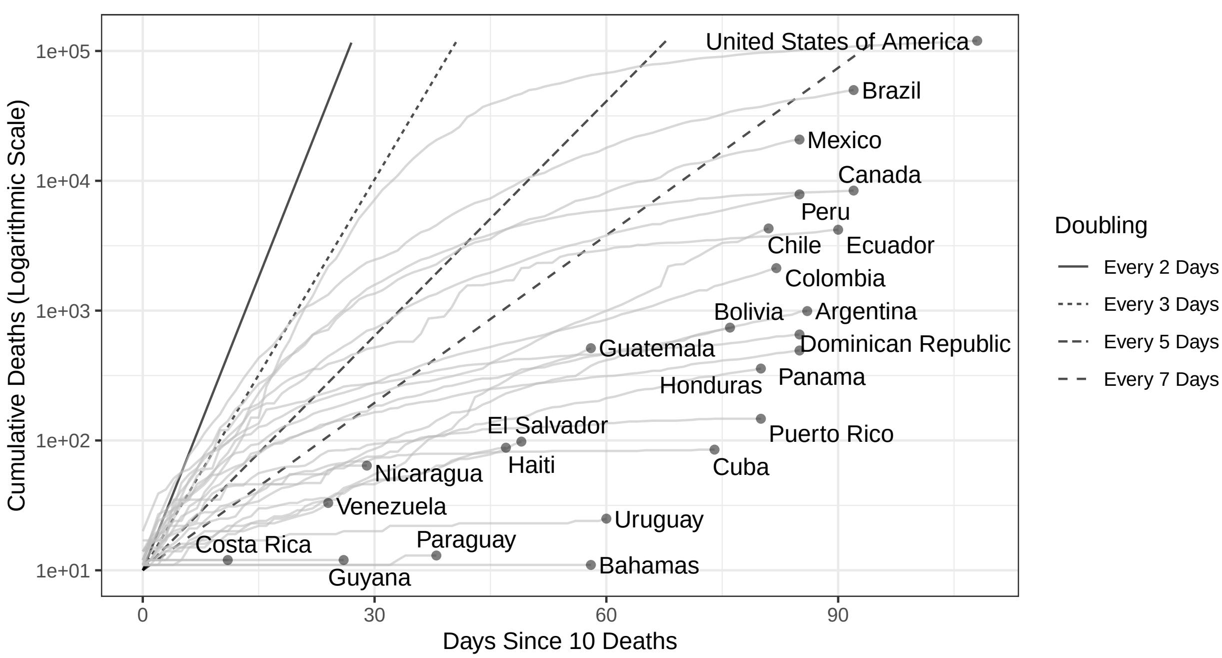


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 56 (95% CI: 20-91) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

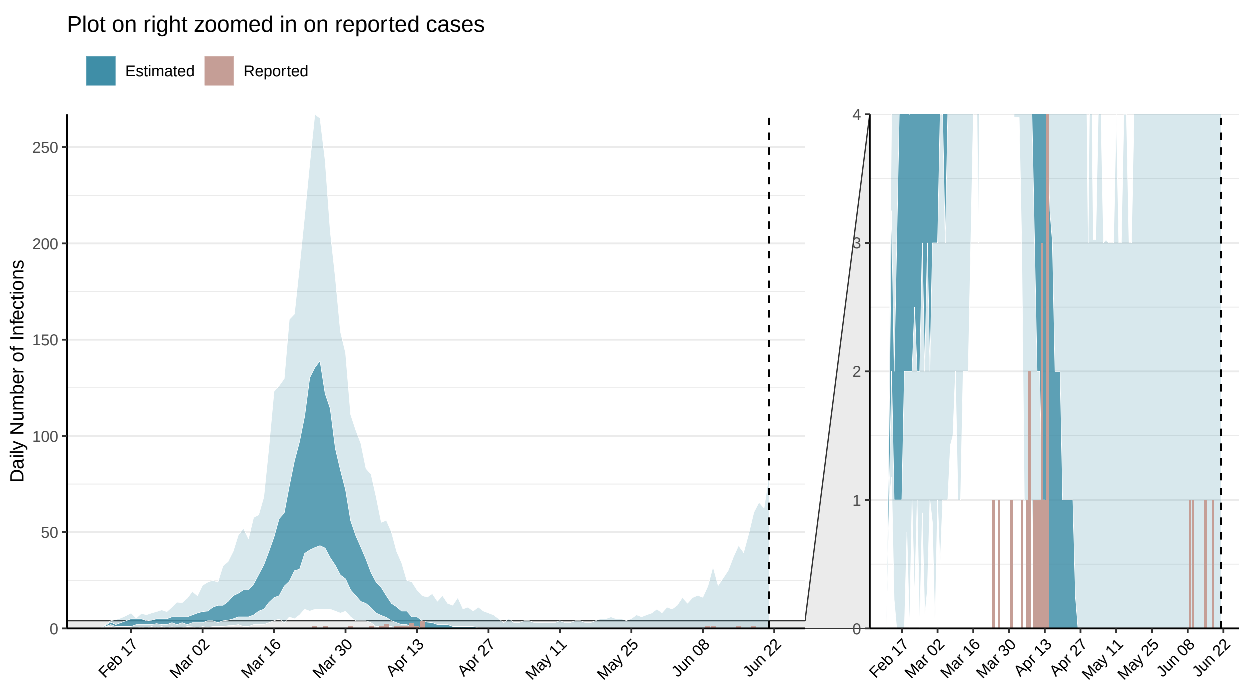


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

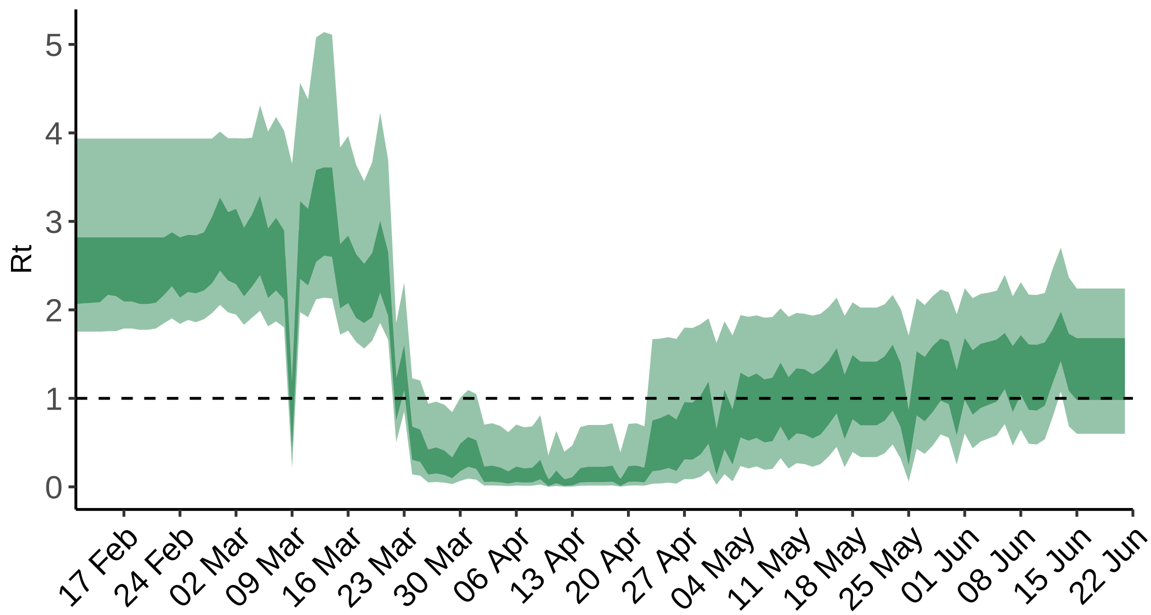


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

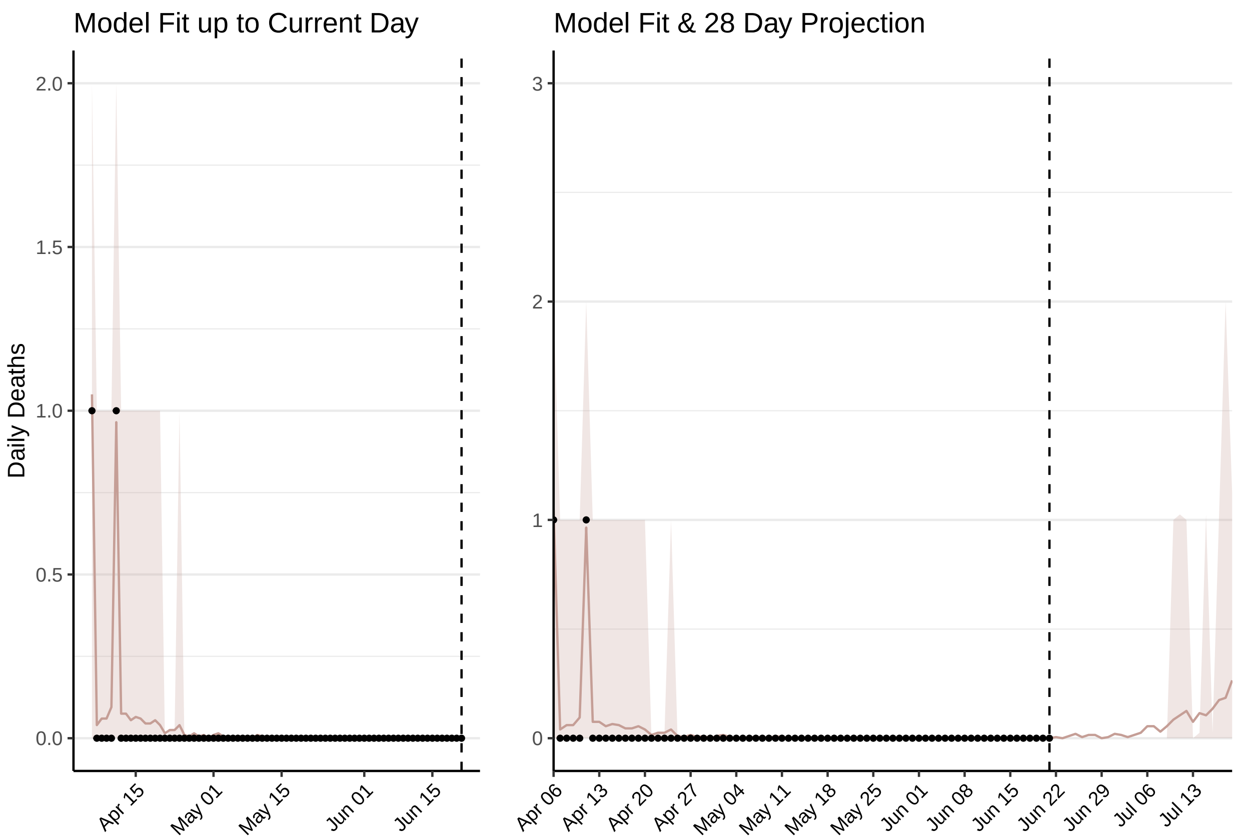


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 0 (95% CI: 0-1) patients requiring treatment with high-pressure oxygen at the current date to 7 (95% CI: 1-12) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 0-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

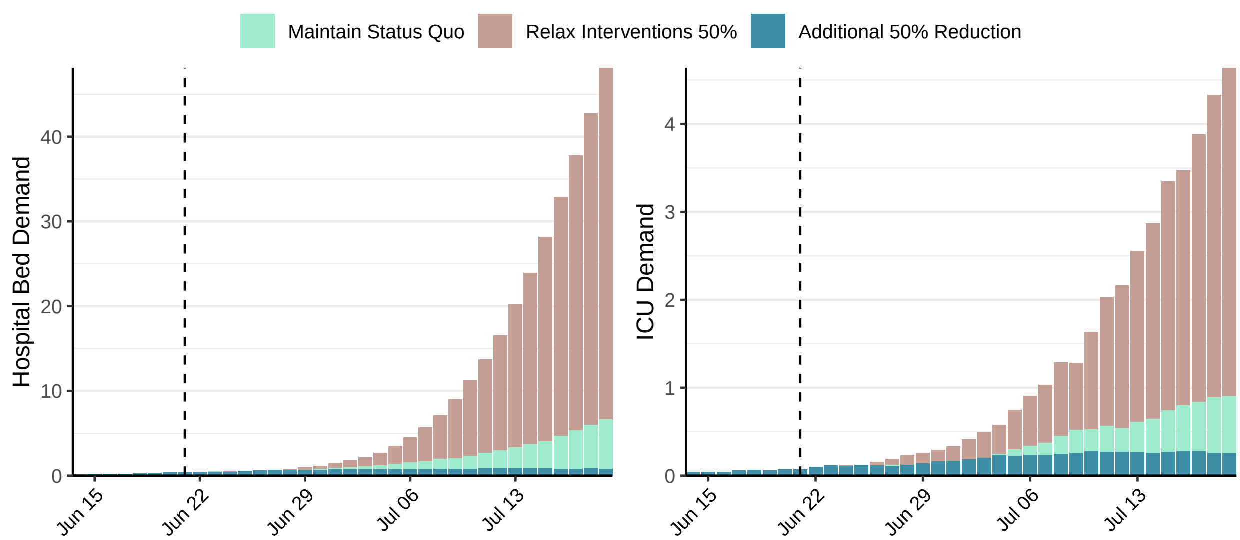


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 6 (95% CI: 2-10) at the current date to 7 (95% CI: 1-12) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 6 (95% CI: 2-10) at the current date to 925 (95% CI: 443-1,407) by 2020-07-19.

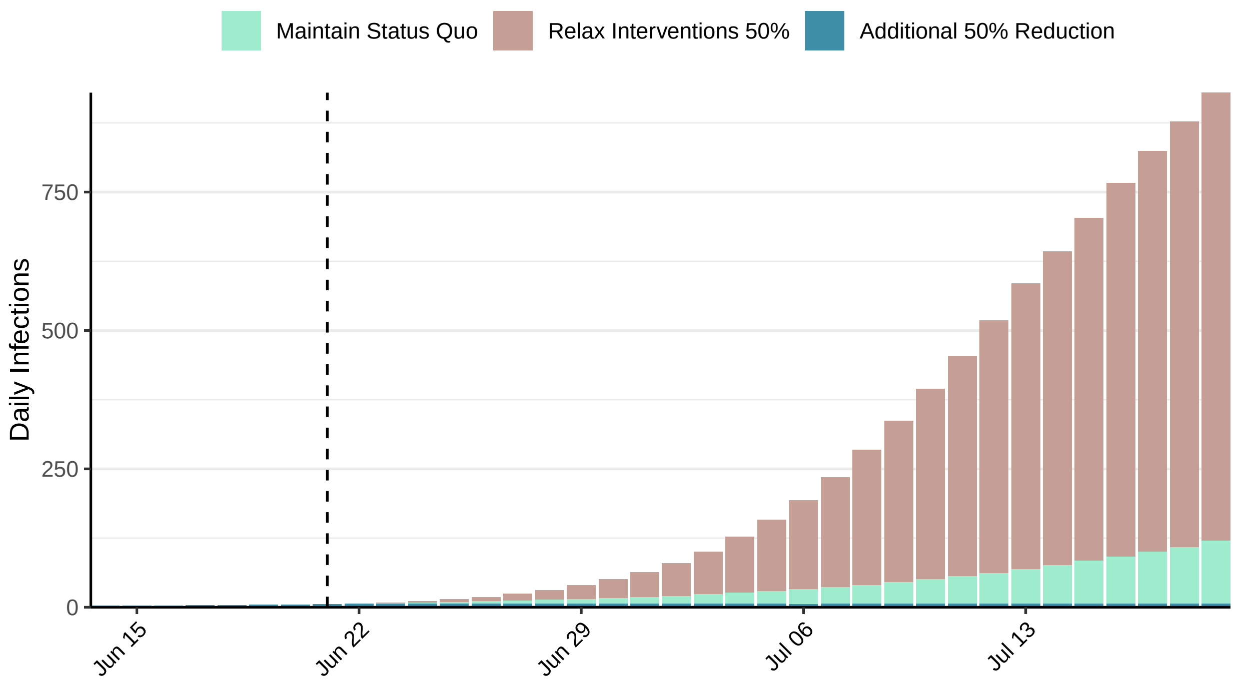


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Bolivia, 2020-06-21

**Download the report for Bolivia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 23,512 | 1,036 | 740 | 25 | 1.44 (95% CI: 1.38-1.51) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

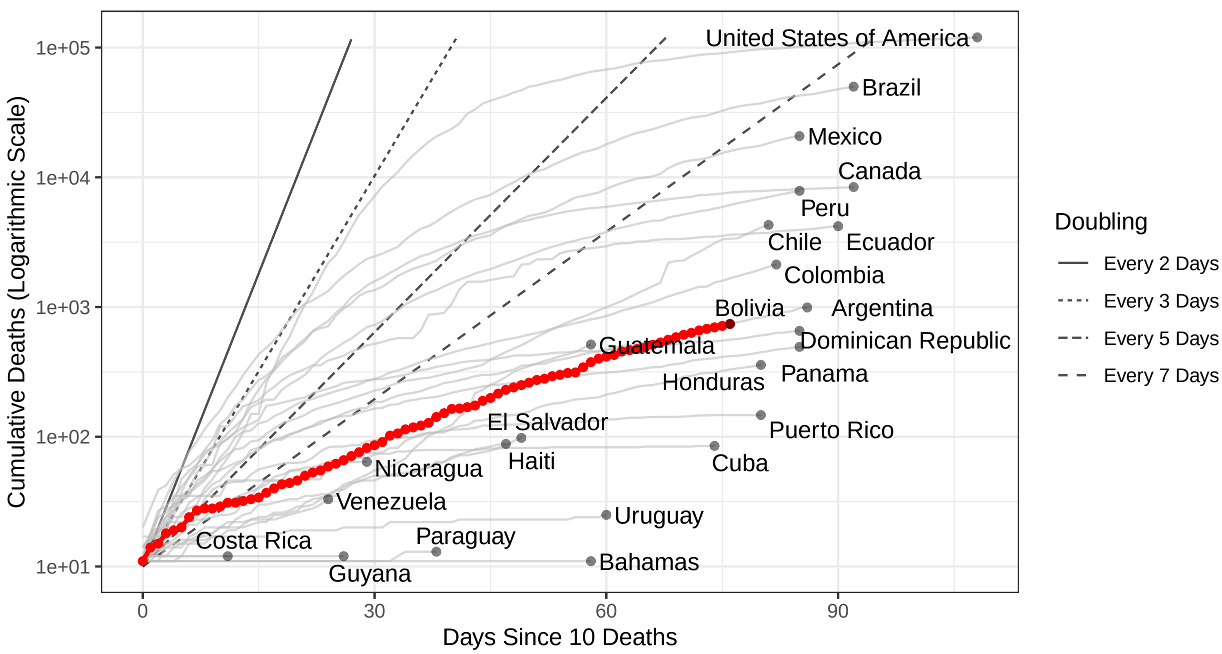


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 325,904 (95% CI: 318,598-333,209) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

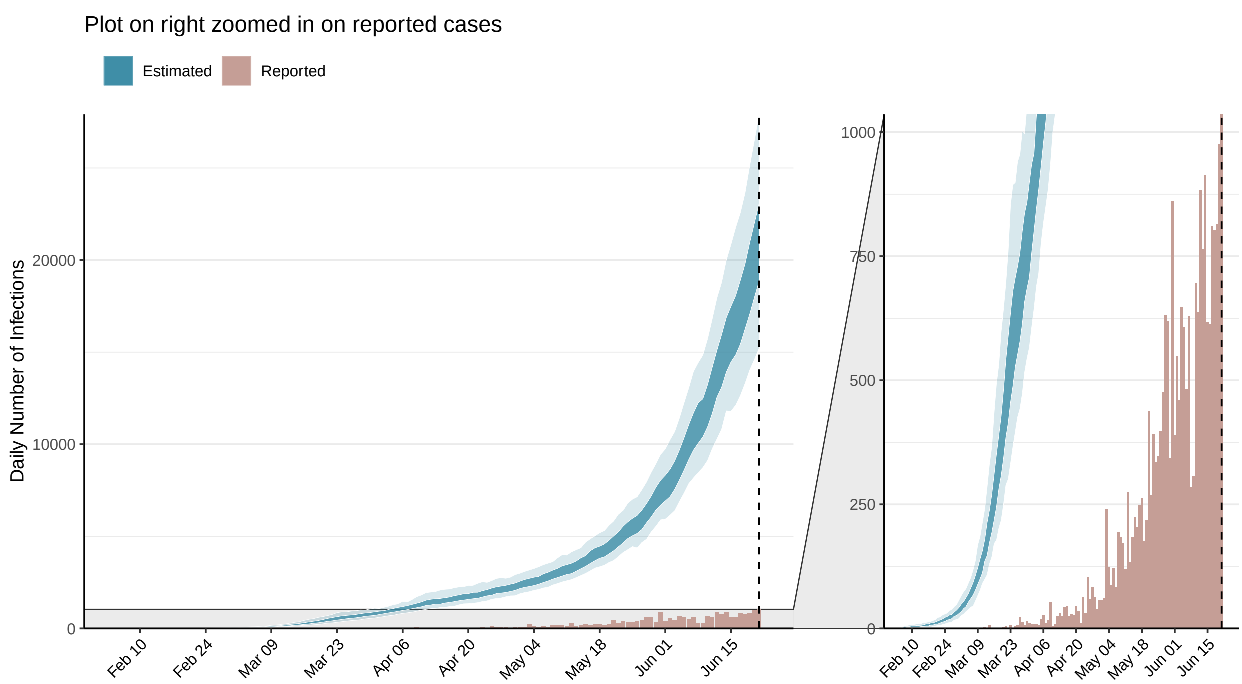


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

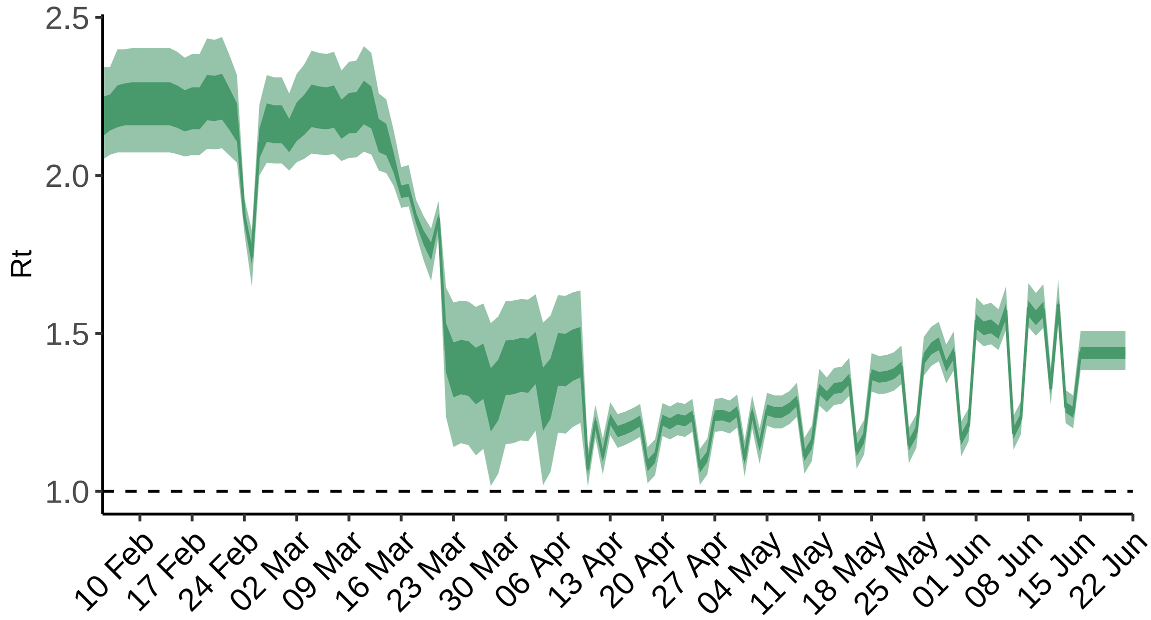


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Bolivia is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

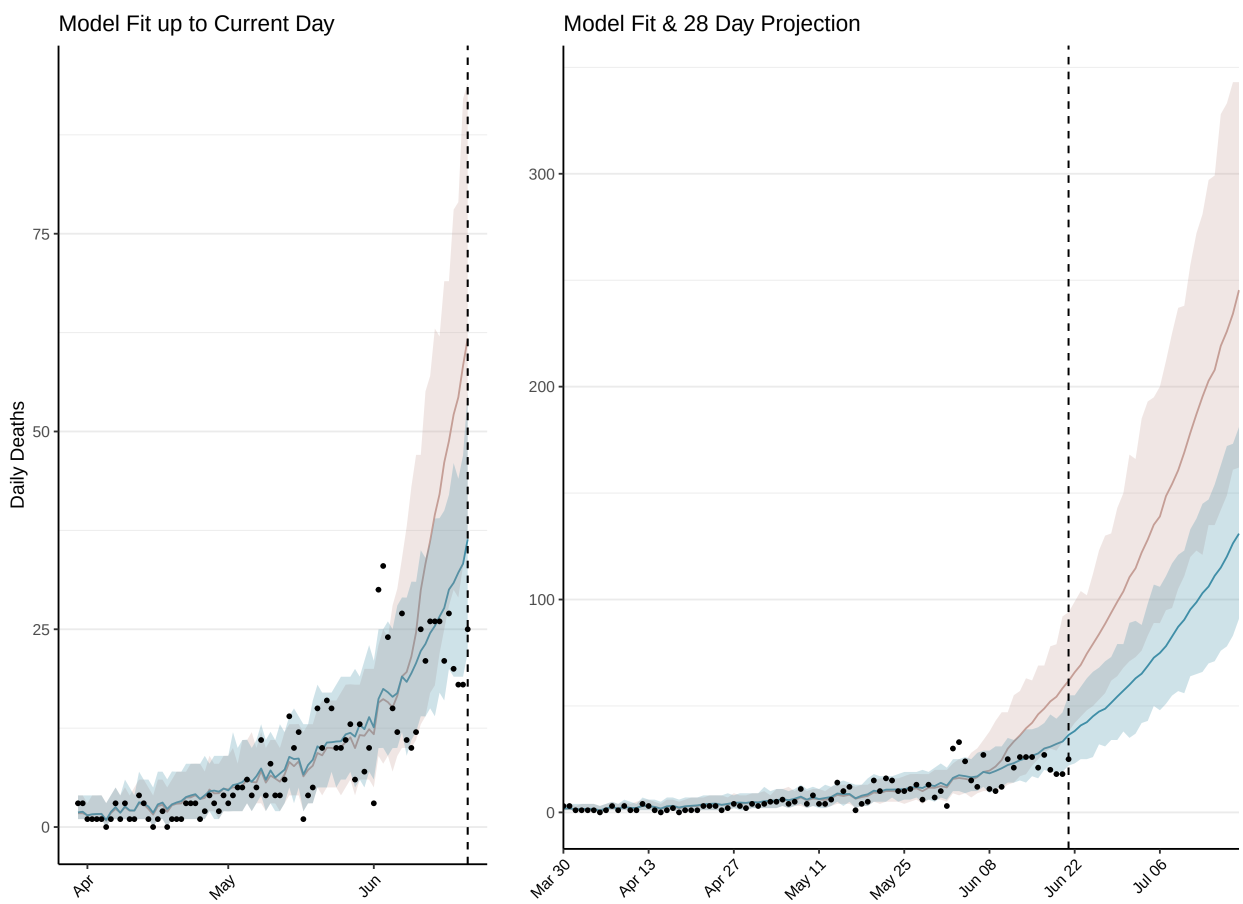


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,732 (95% CI: 1,693-1,771) patients requiring treatment with high-pressure oxygen at the current date to 5,981 (95% CI: 5,824-6,137) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 335 (95% CI: 331-339) patients requiring treatment with mechanical ventilation at the current date to 535 (95% CI: 526-544) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

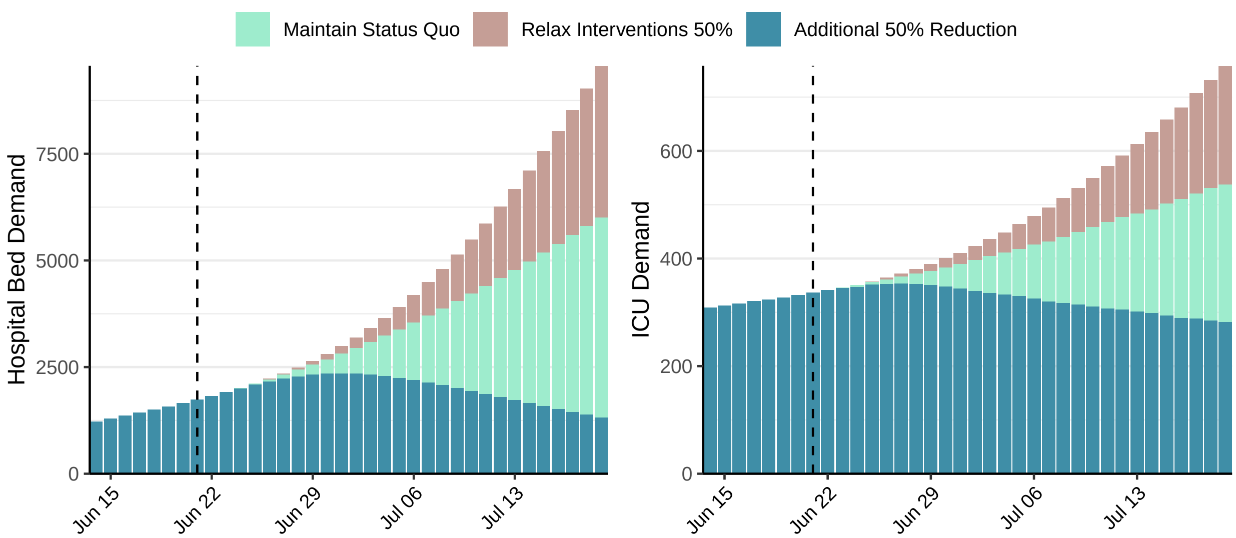


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 20,930 (95% CI: 20,417-21,444) at the current date to 4,780 (95% CI: 4,647-4,913) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 20,930 (95% CI: 20,417-21,444) at the current date to 107,351 (95% CI: 105,110-109,591) by 2020-07-19.

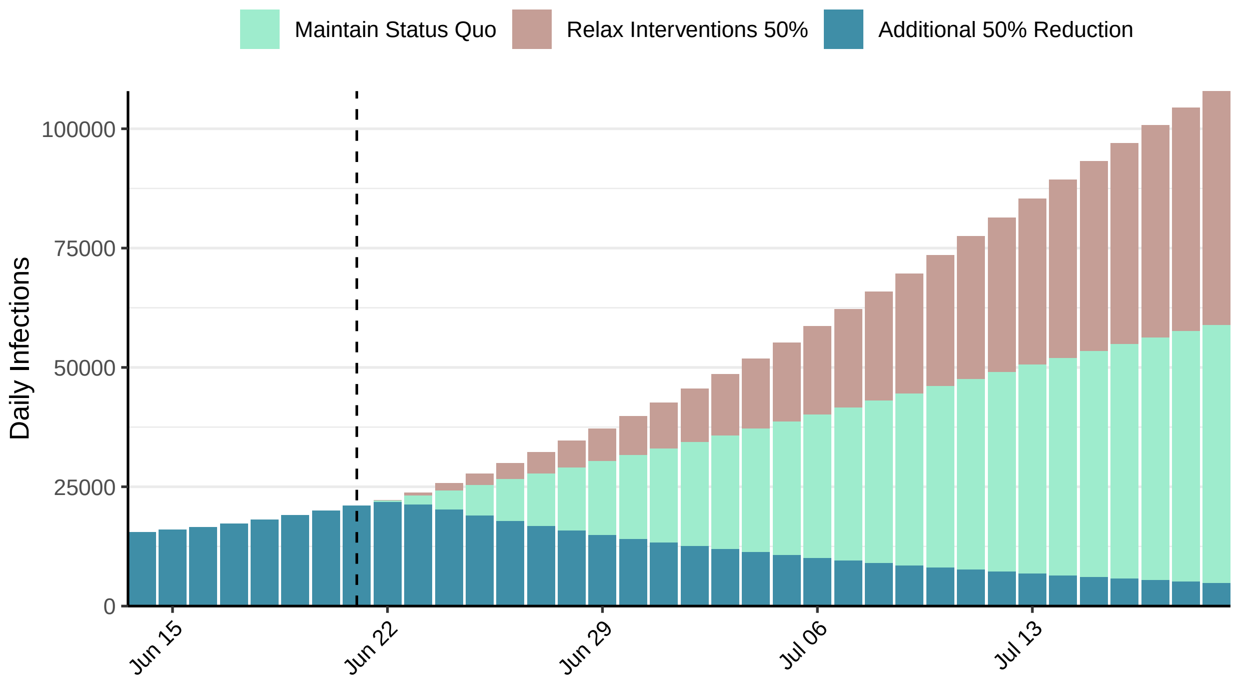


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Brazil, 2020-06-21

**Download the report for Brazil, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,067,579 | 34,666 | 49,976 | 1,022 | 1.43 (95% CI: 1.38-1.5) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

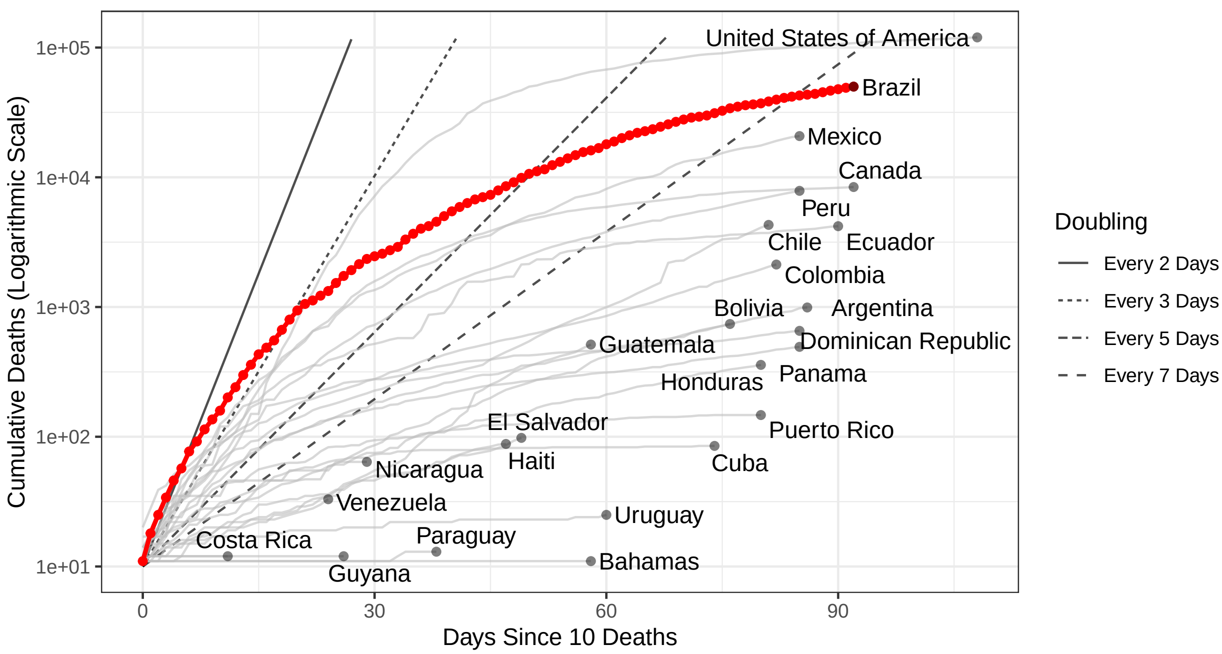


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 10,321,805 (95% CI: 10,135,397-10,508,212) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

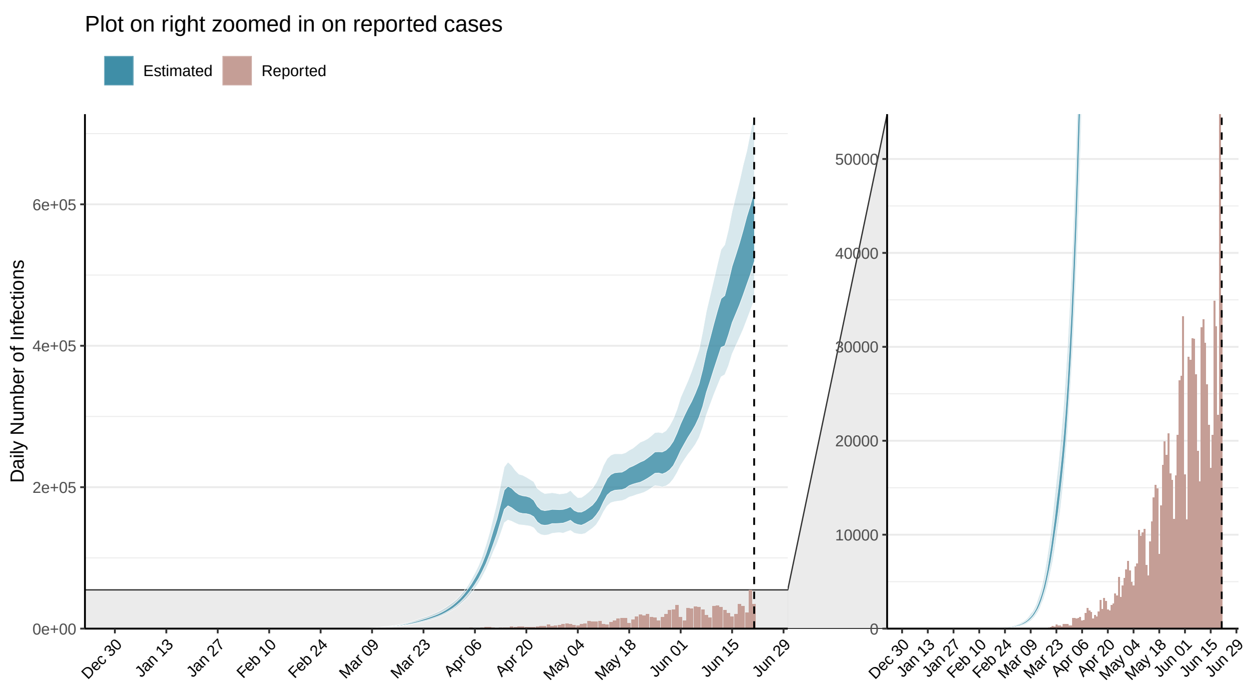


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

**For sub-national estimates of $R_t$, and further analysis of Brazil, please see Report 21**

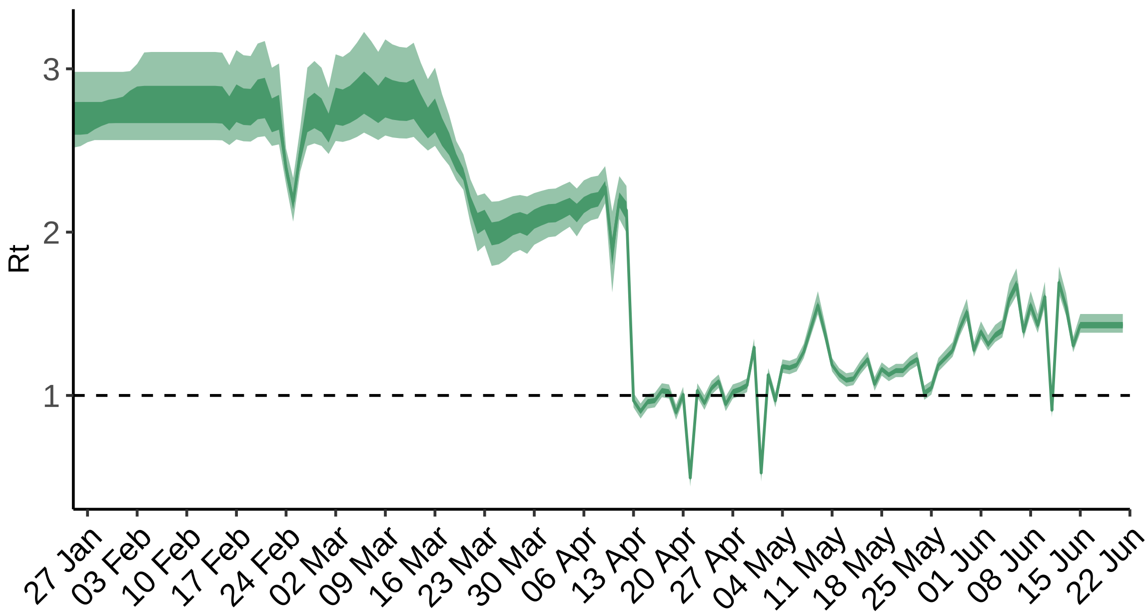


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Brazil is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

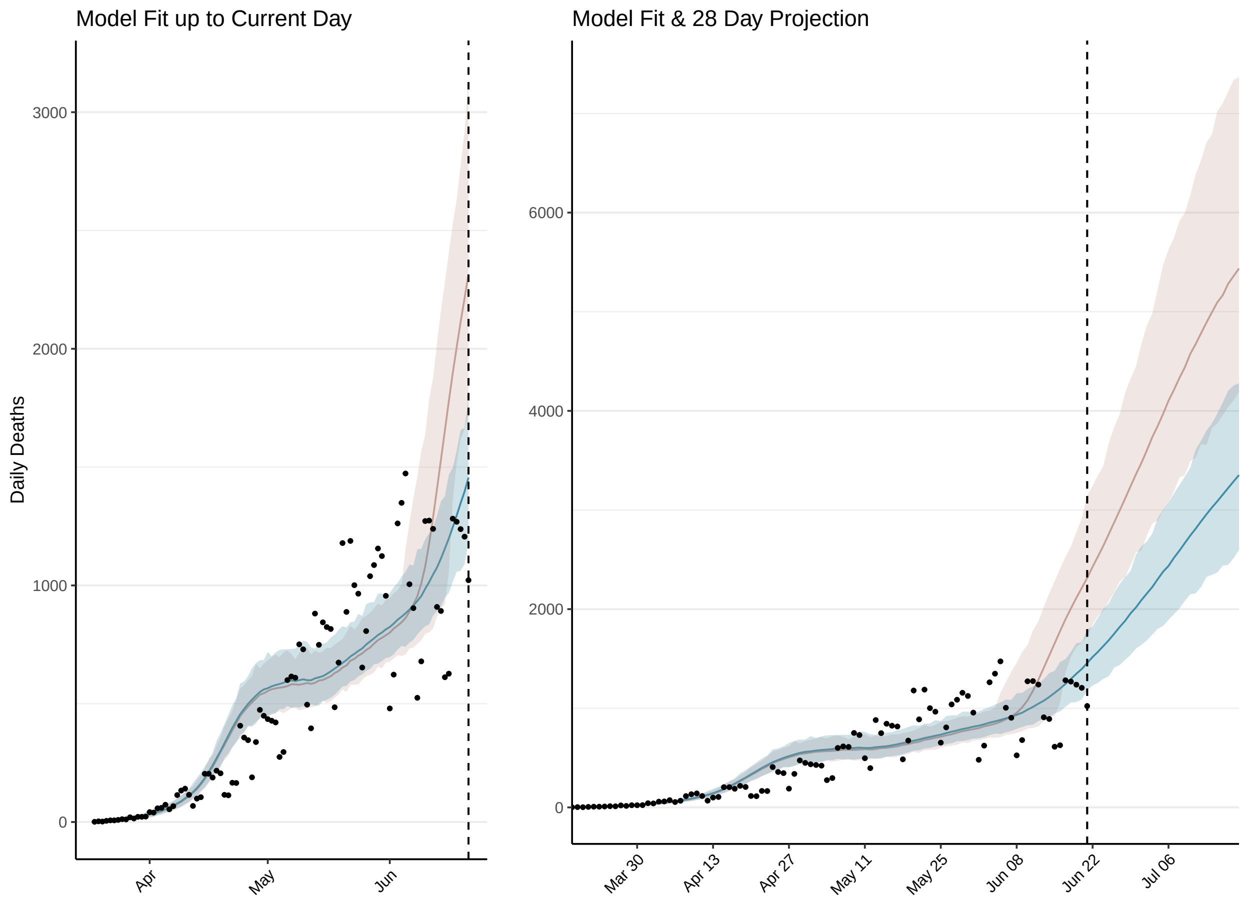


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 69,498 (95% CI: 68,216-70,780) patients requiring treatment with high-pressure oxygen at the current date to 149,722 (95% CI: 146,499-152,944) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 16,320 (95% CI: 16,150-16,490) patients requiring treatment with mechanical ventilation at the current date to 19,656 (95% CI: 19,423-19,890) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

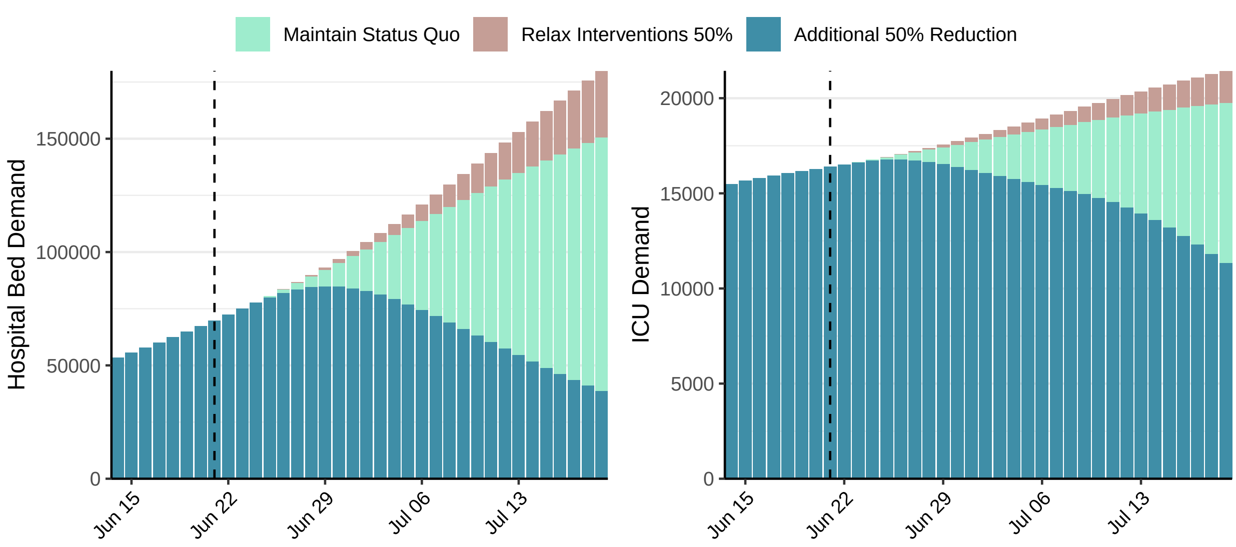


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 570,929 (95% CI: 559,457-582,402) at the current date to 84,015 (95% CI: 82,124-85,906) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 570,929 (95% CI: 559,457-582,402) at the current date to 1,136,095 (95% CI: 1,115,356-1,156,833) by 2020-07-19.

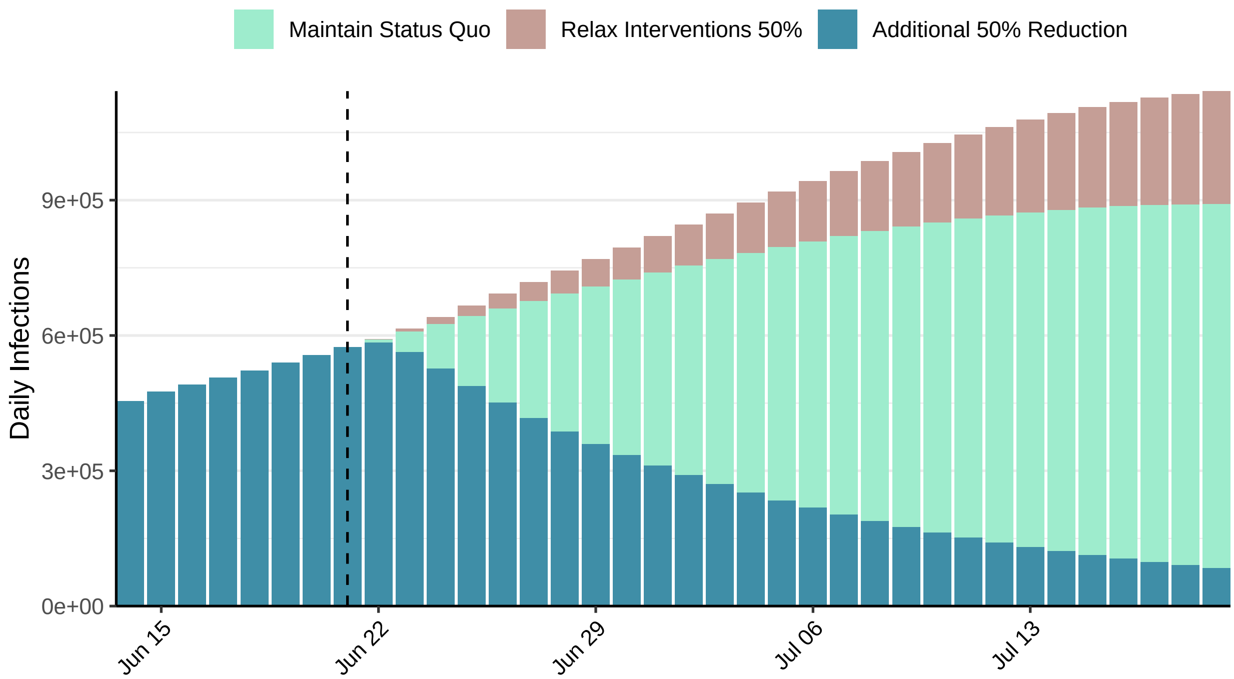


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Botswana, 2020-06-21

**Download the report for Botswana, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 89 | 0 | 1 | 0 | 1.95 (95% CI: 1.43-2.93) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Botswana is not shown in the following plot as only 1 deaths have been reported to date**

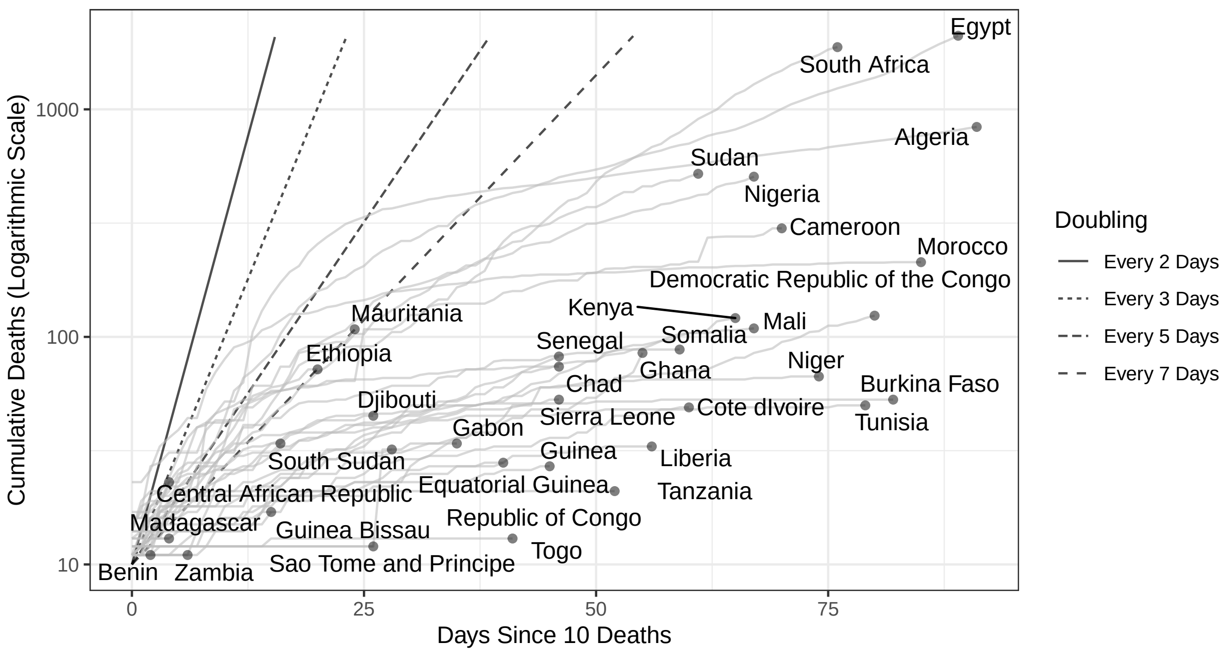


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 36 (95% CI: 13-59) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

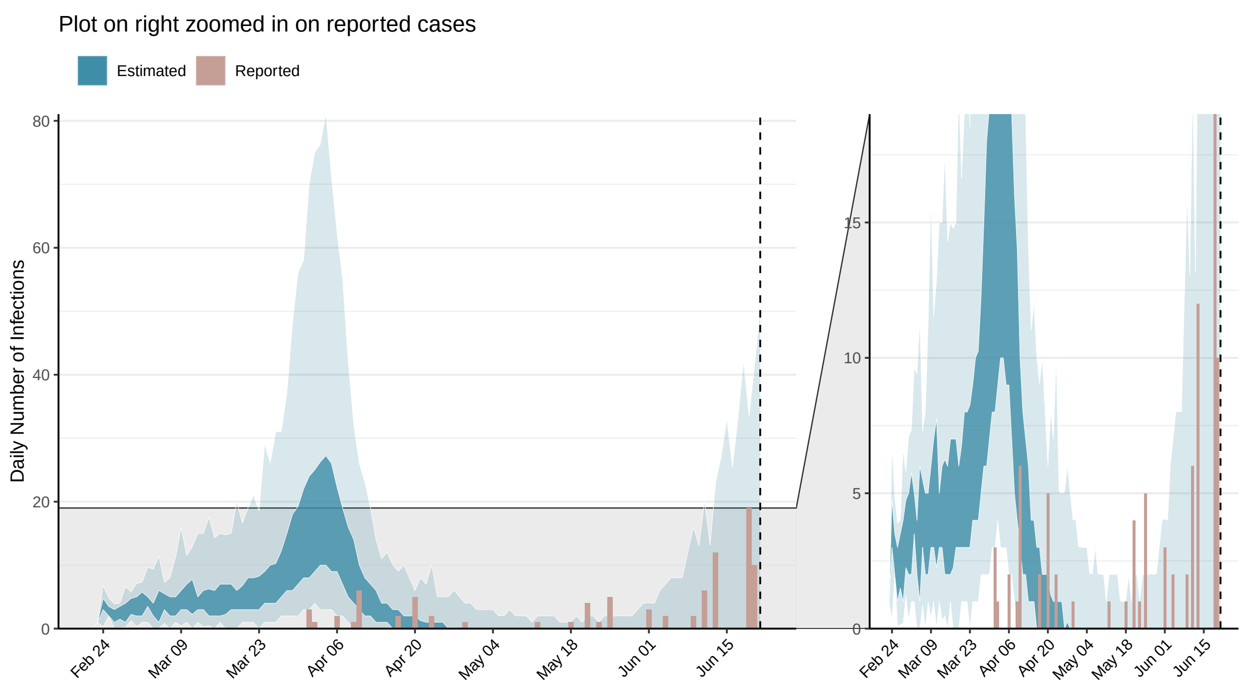


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

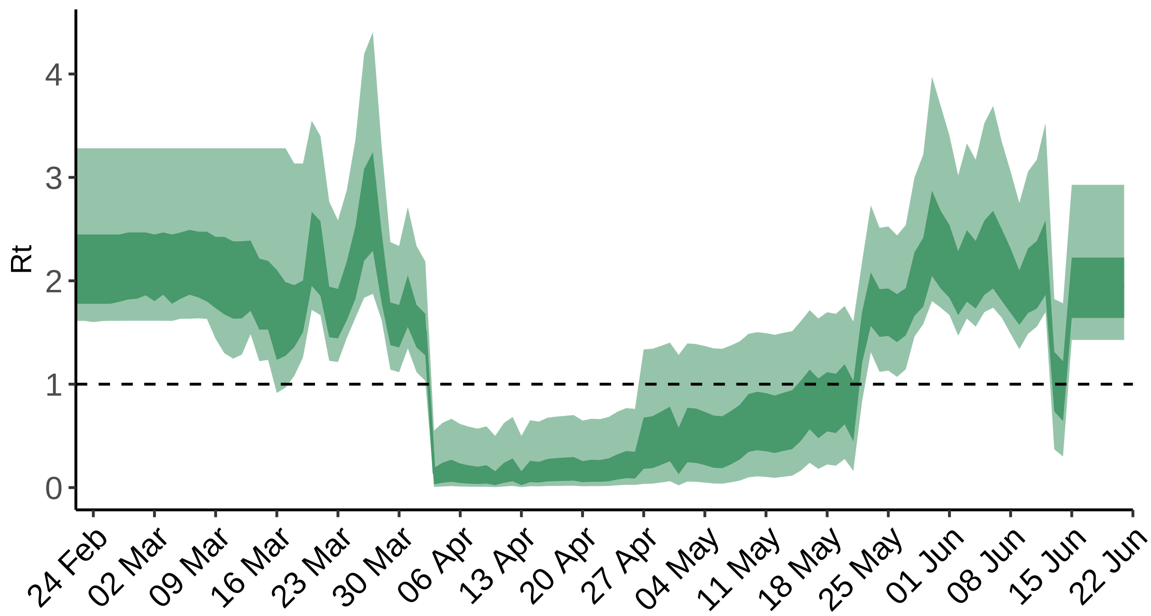


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

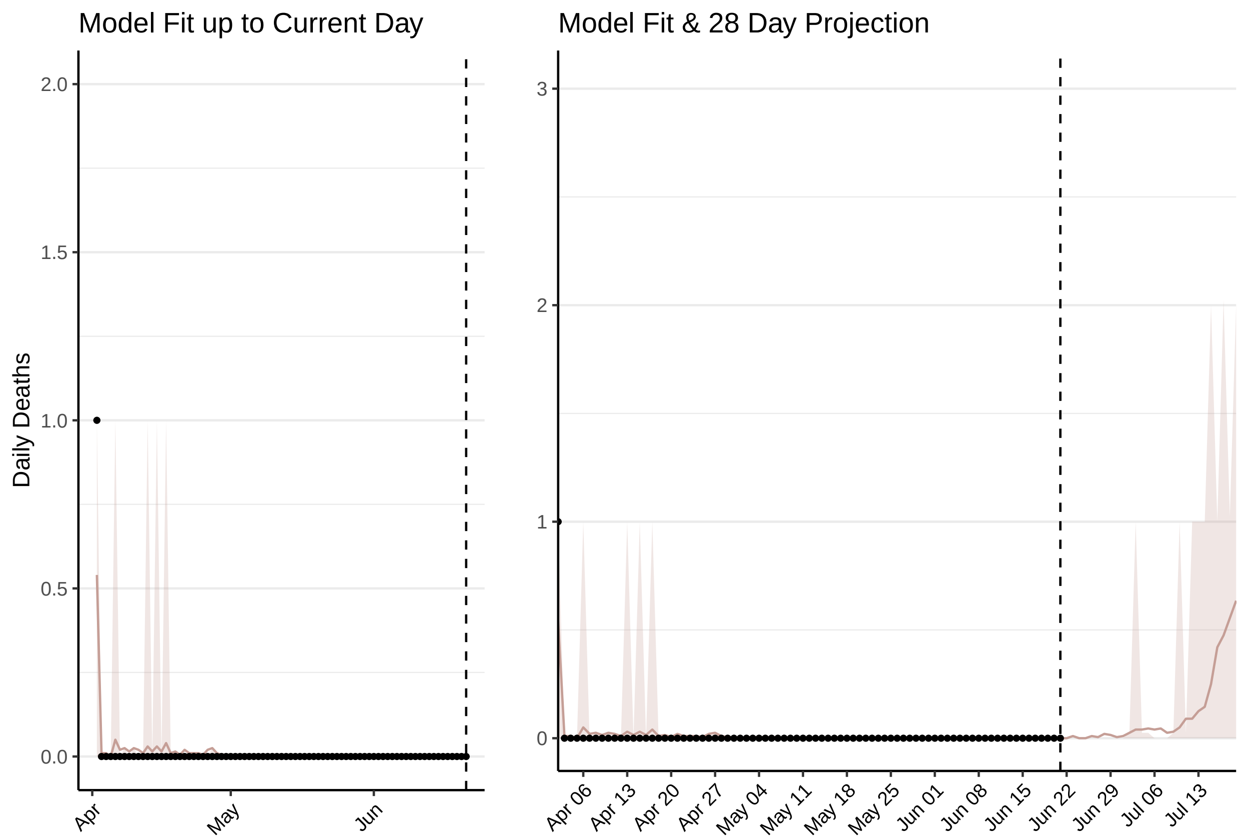


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 0 (95% CI: 0-1) patients requiring treatment with high-pressure oxygen at the current date to 20 (95% CI: -3-42) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 4 (95% CI: 1-7) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

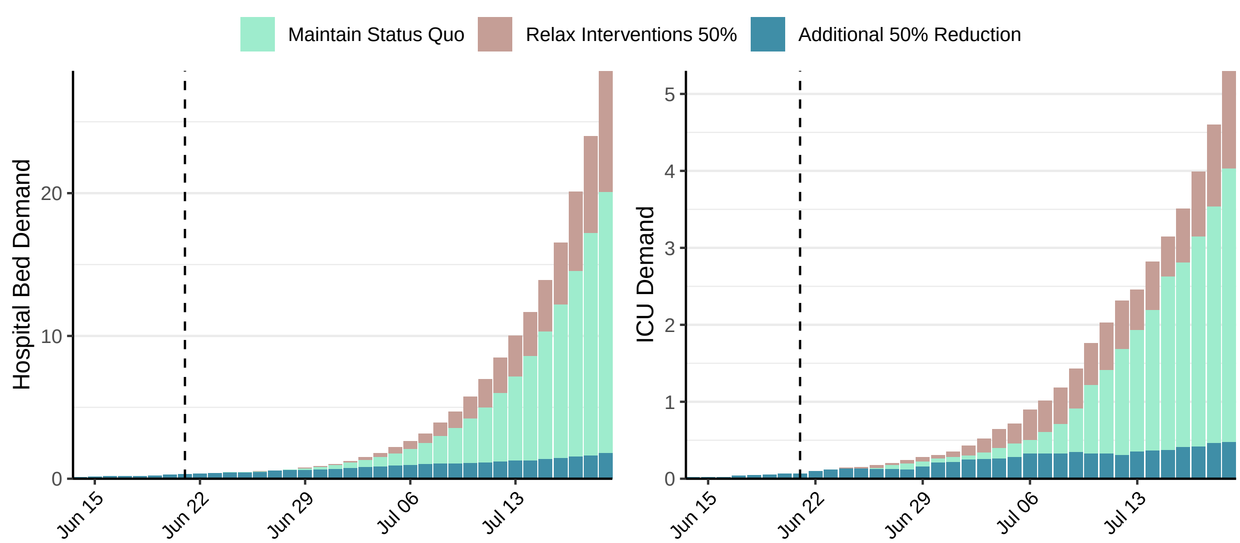


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 5 (95% CI: 1-8) at the current date to 17 (95% CI: -3-37) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 5 (95% CI: 1-8) at the current date to 721 (95% CI: -152-1,593) by 2020-07-19.

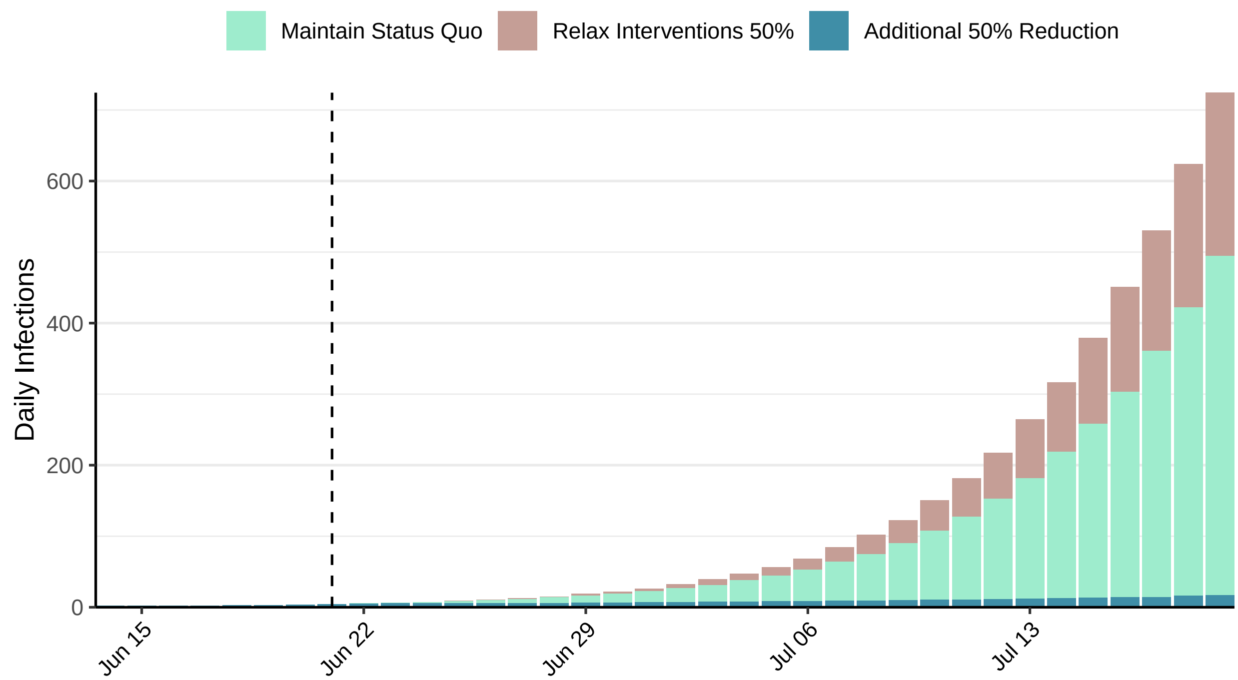


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Central African Republic, 2020-06-21

**Download the report for Central African Republic, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,808 | 203 | 23 | 4 | 1.95 (95% CI: 1.6-2.36) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

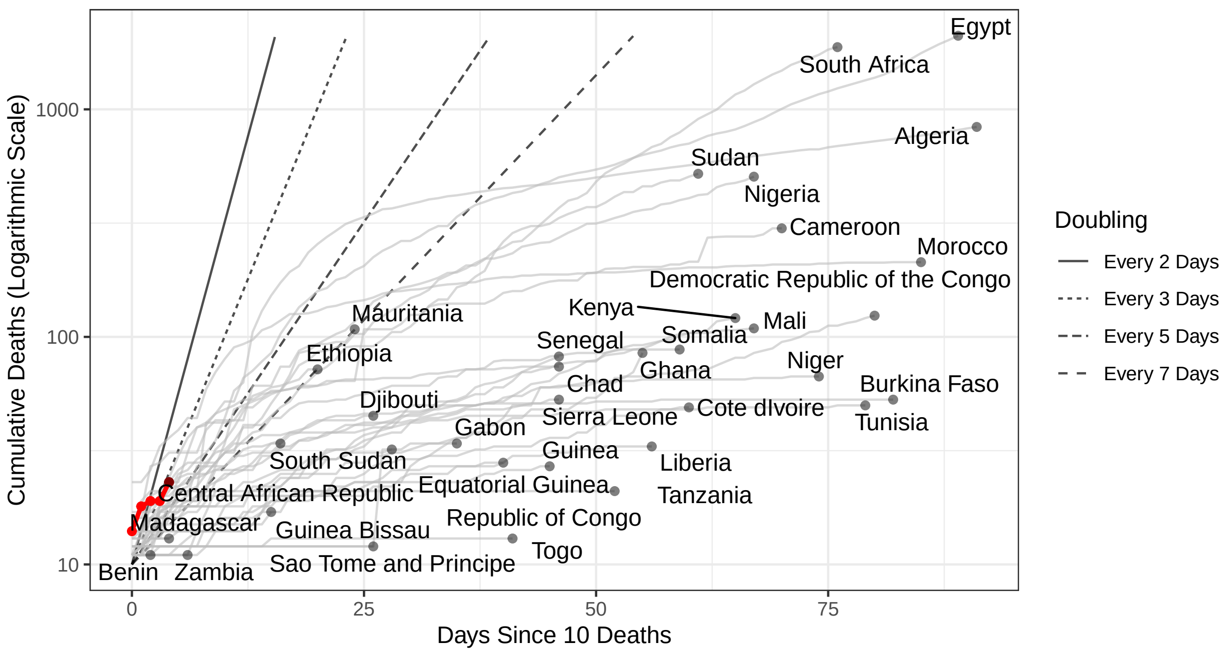


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 32,043 (95% CI: 30,368-33,719) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

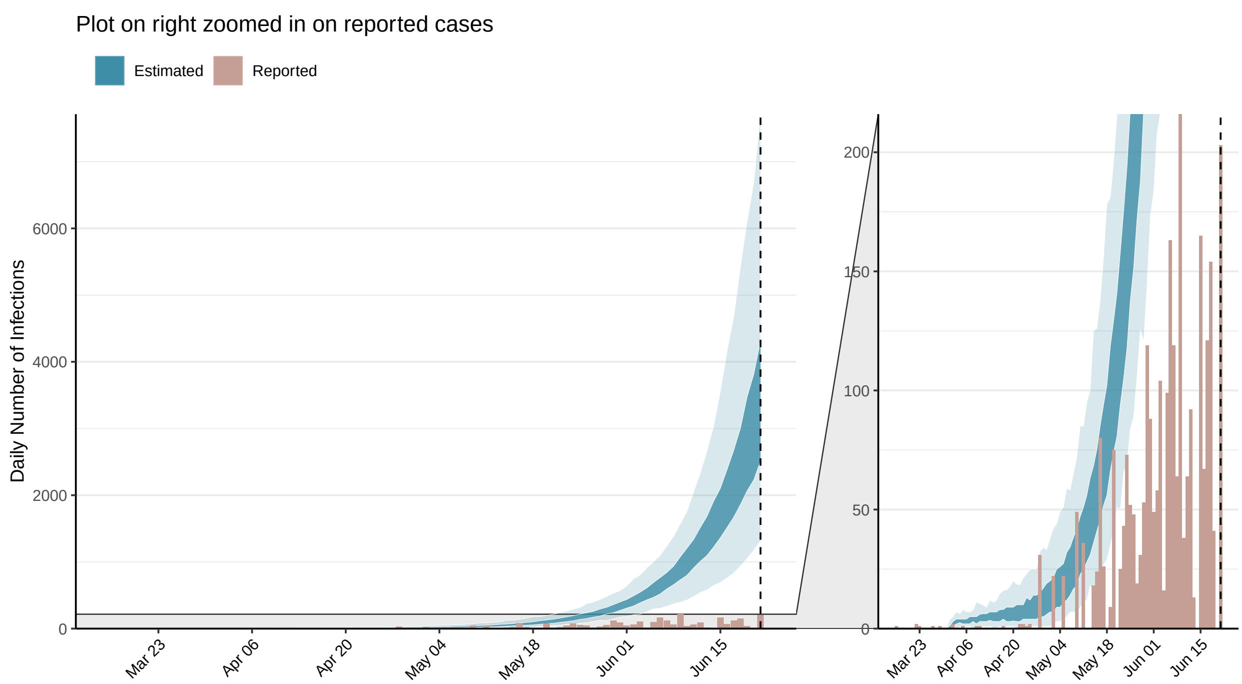


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

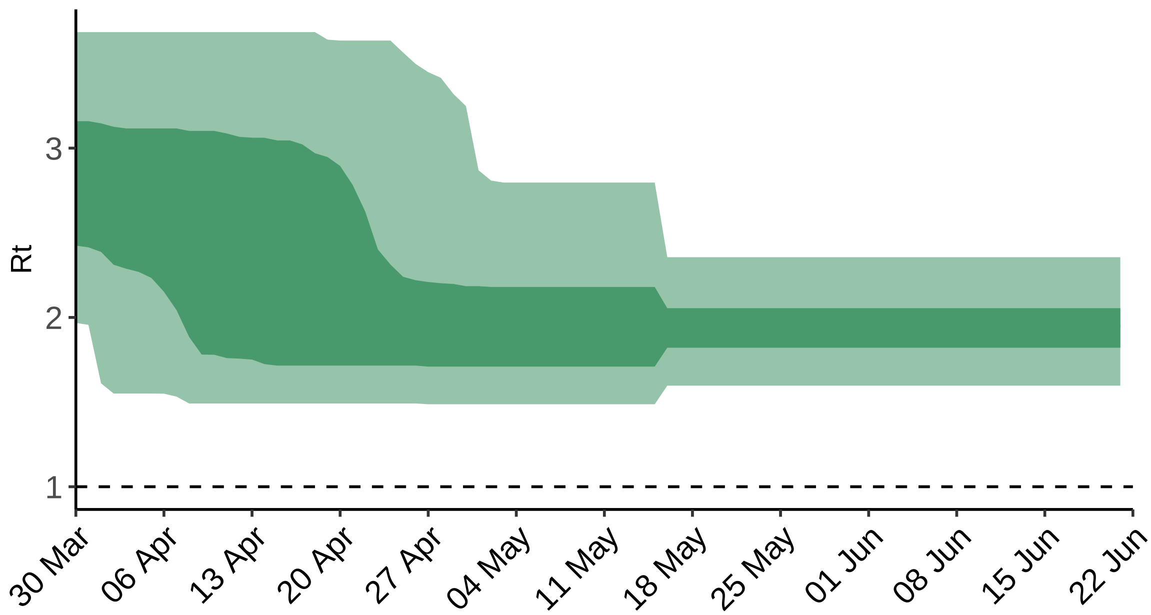


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Central African Republic is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

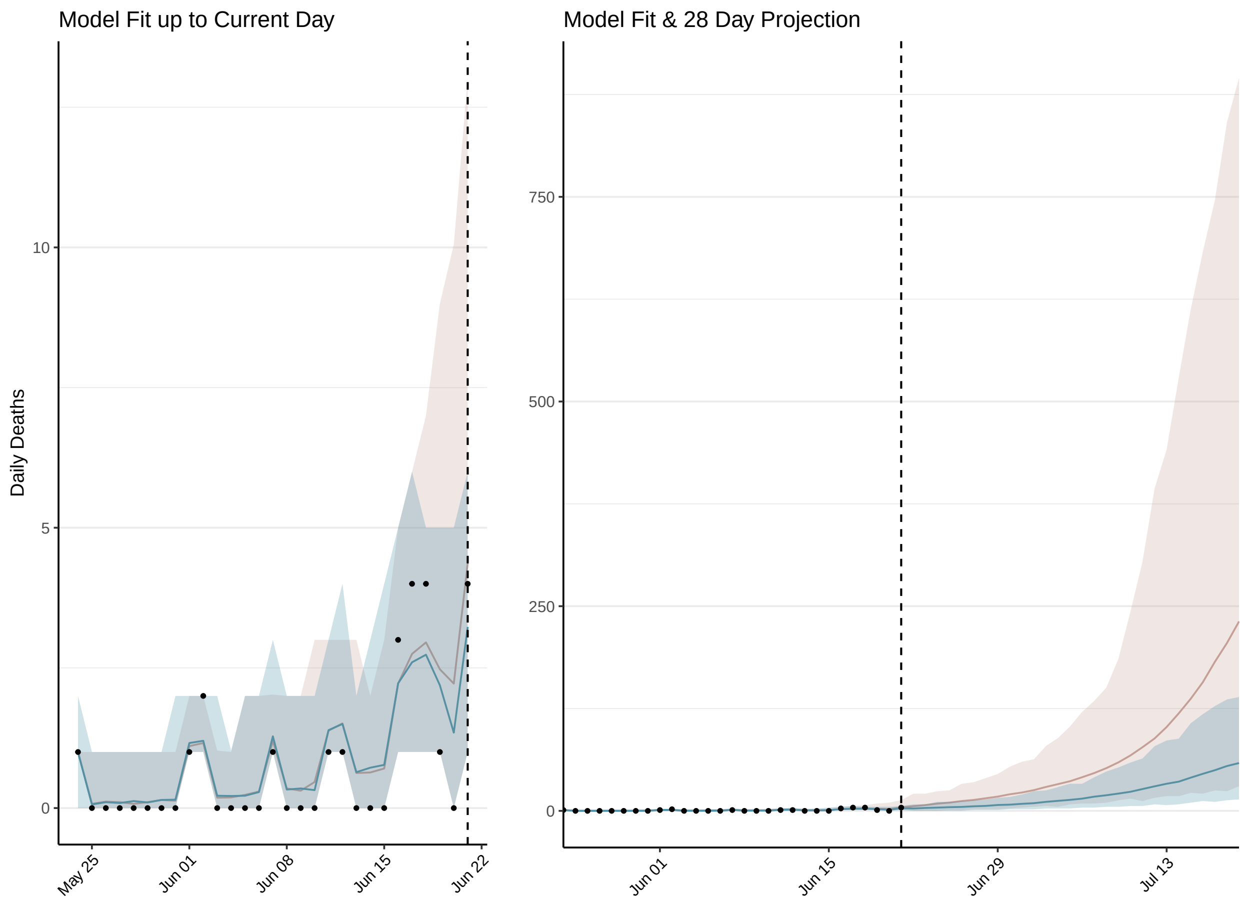


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 177 (95% CI: 167-186) patients requiring treatment with high-pressure oxygen at the current date to 3,268 (95% CI: 3,020-3,516) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 43 (95% CI: 41-45) patients requiring treatment with mechanical ventilation at the current date to 219 (95% CI: 203-235) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

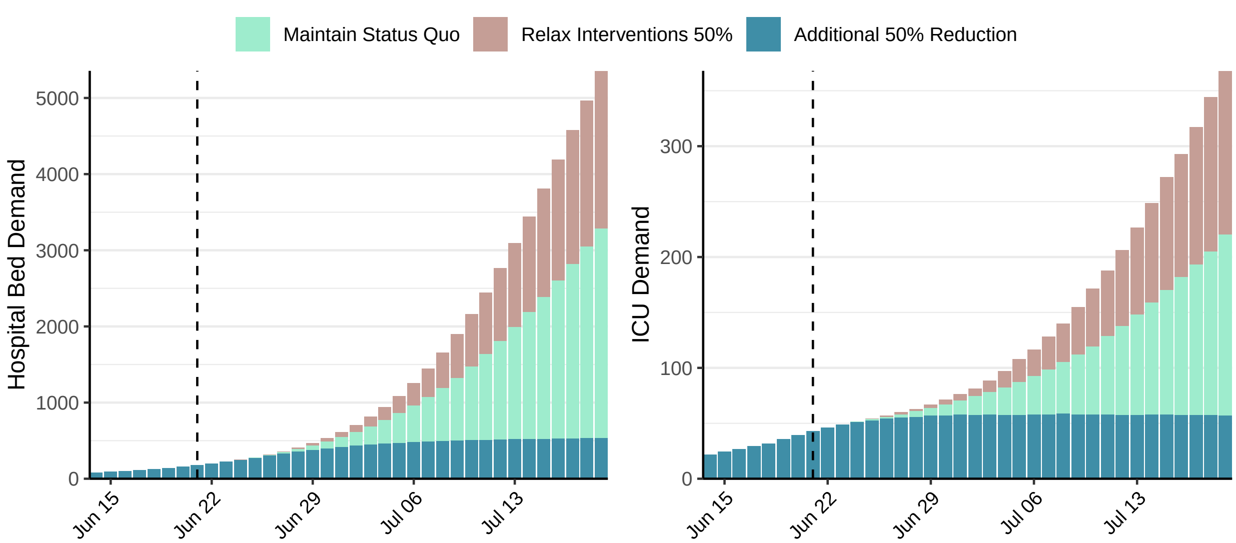


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 3,580 (95% CI: 3,347-3,813) at the current date to 3,957 (95% CI: 3,488-4,425) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 3,580 (95% CI: 3,347-3,813) at the current date to 109,391 (95% CI: 102,839-115,943) by 2020-07-19.

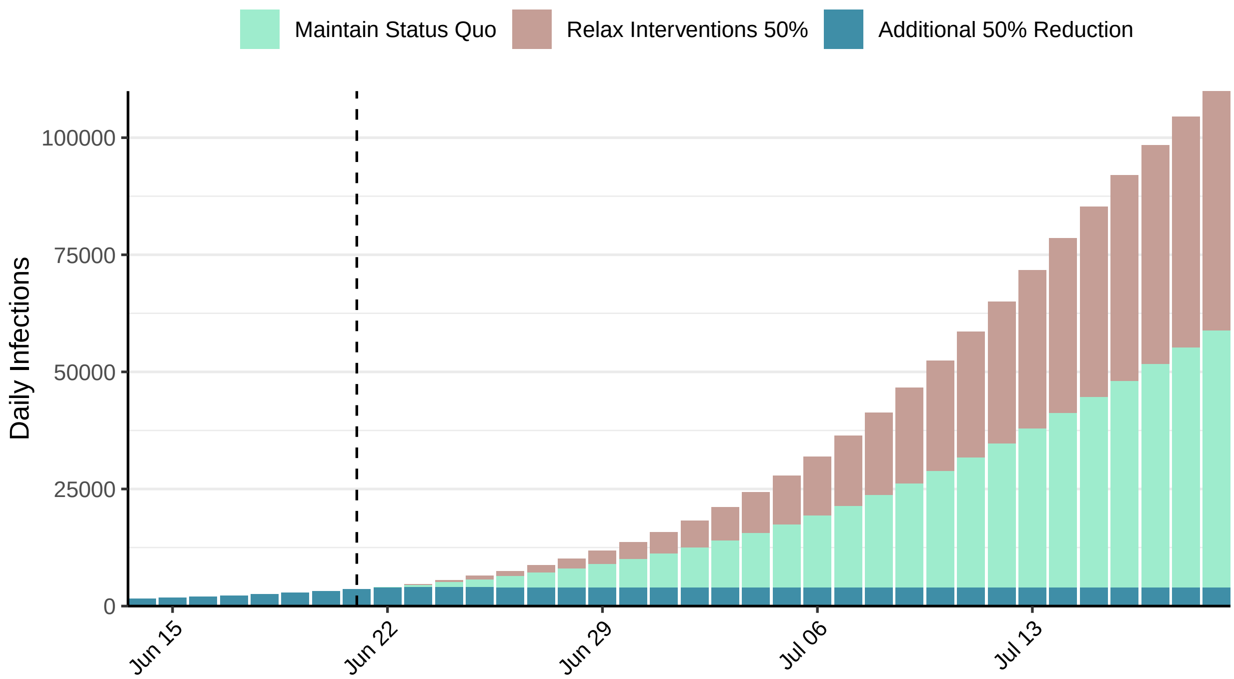


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Chile, 2020-06-21

**Download the report for Chile, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 236,748 | 5,355 | 4,295 | 202 | 1.53 (95% CI: 1.43-1.63) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

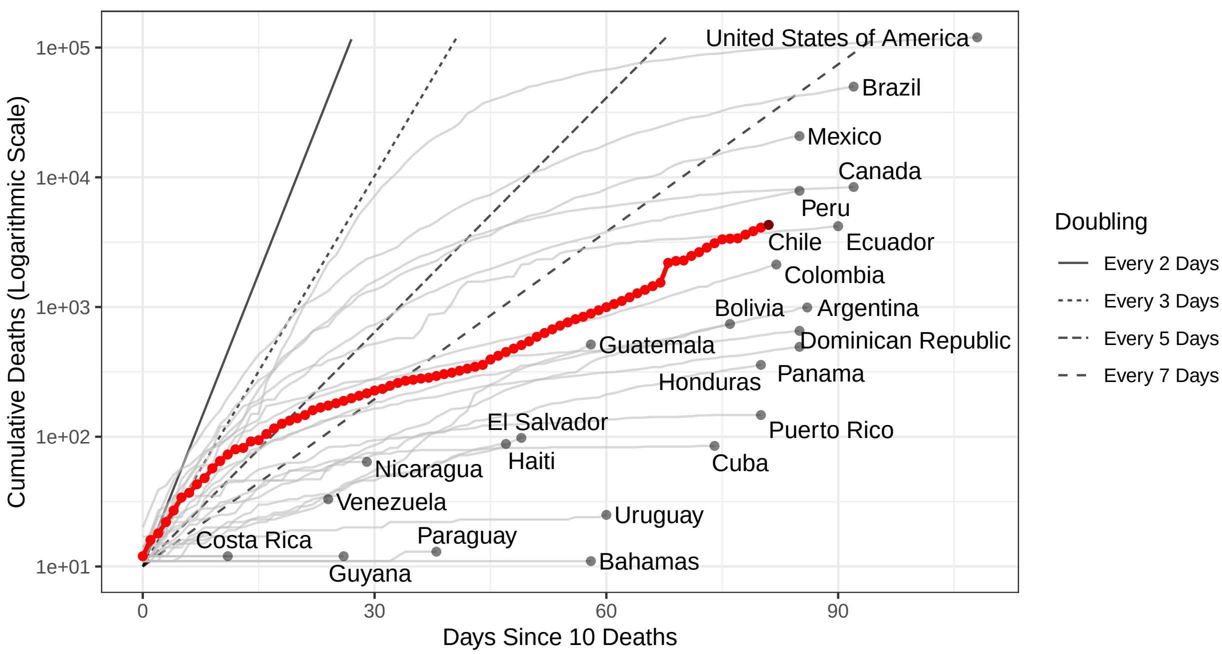


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,474,309 (95% CI: 1,441,626-1,506,992) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

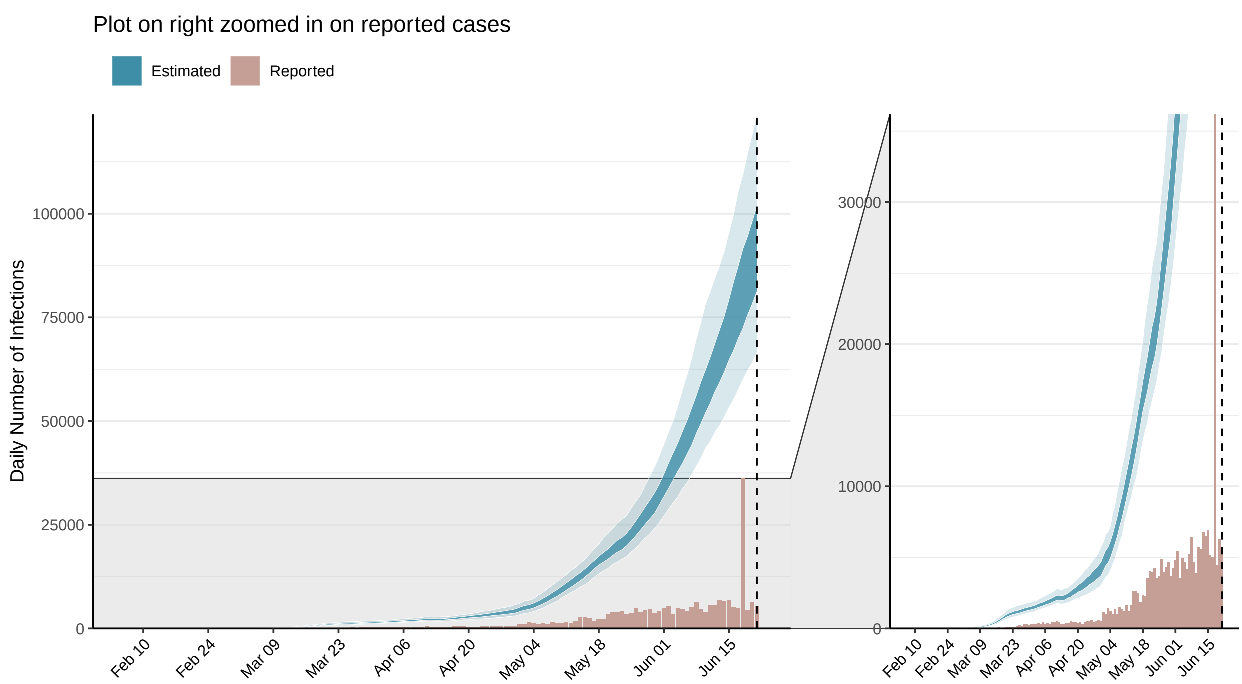


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

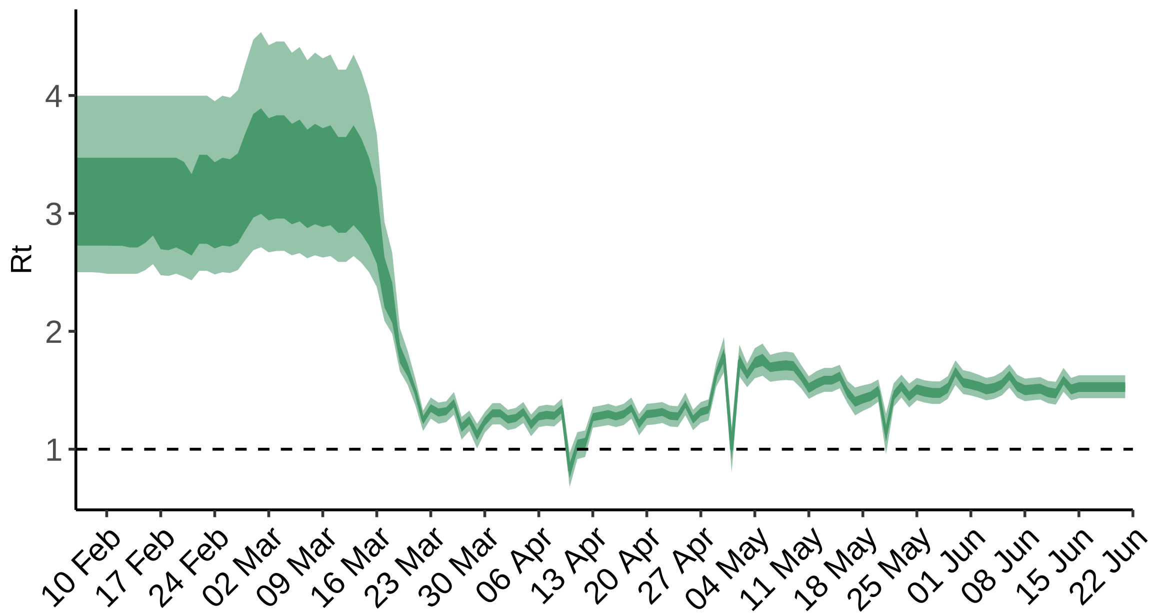


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Chile is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

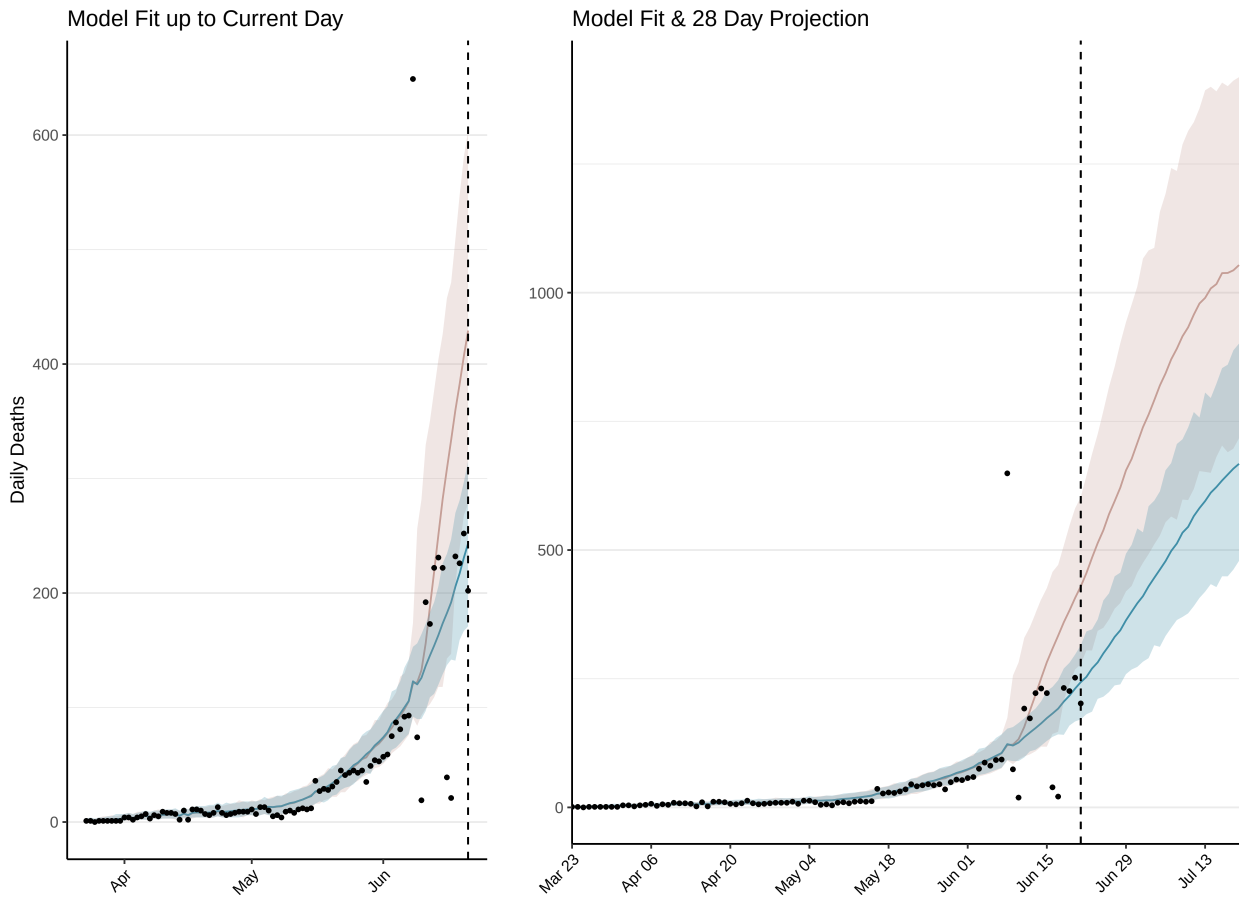


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 10,782 (95% CI: 10,533-11,032) patients requiring treatment with high-pressure oxygen at the current date to 25,783 (95% CI: 25,136-26,430) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2,531 (95% CI: 2,503-2,560) patients requiring treatment with mechanical ventilation at the current date to 3,173 (95% CI: 3,131-3,216) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

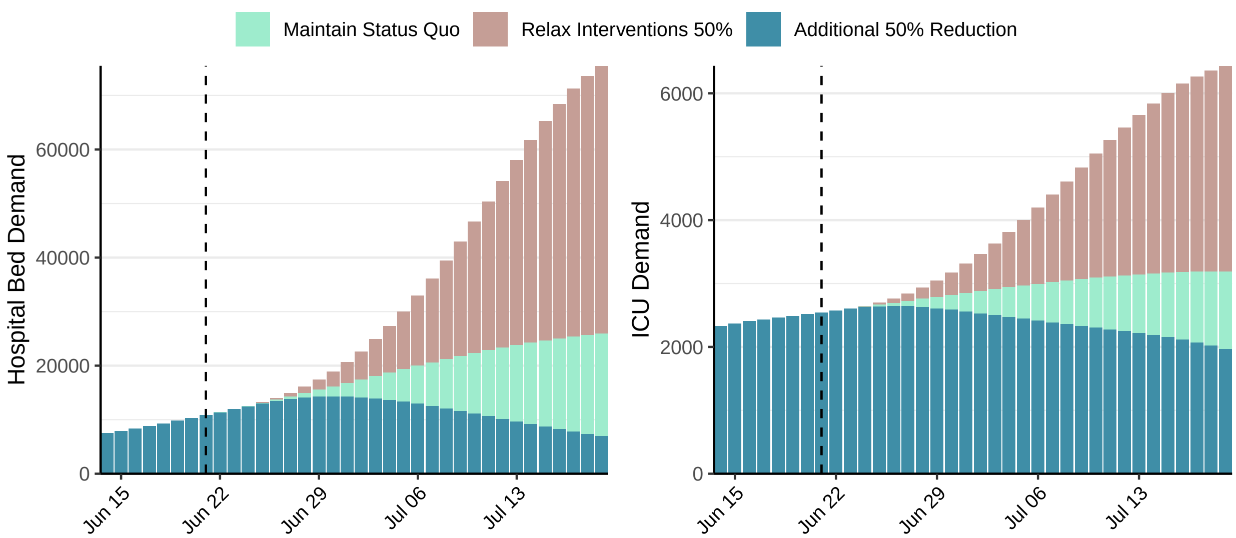


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 91,613 (95% CI: 89,291-93,935) at the current date to 13,745 (95% CI: 13,389-14,102) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 91,613 (95% CI: 89,291-93,935) at the current date to 344,386 (95% CI: 340,355-348,417) by 2020-07-19.

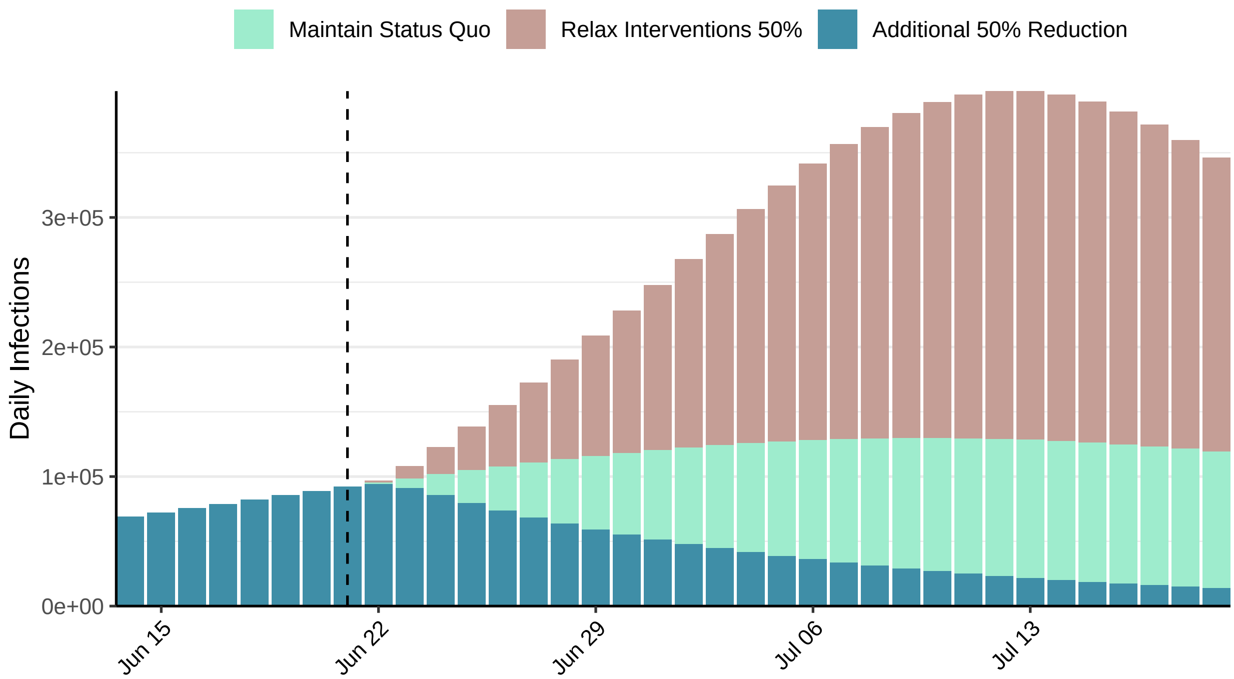


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Cote d'Ivoire, 2020-06-21

**Download the report for Cote d'Ivoire, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 6,874 | 430 | 49 | 0 | 1.52 (95% CI: 1.3-1.79) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

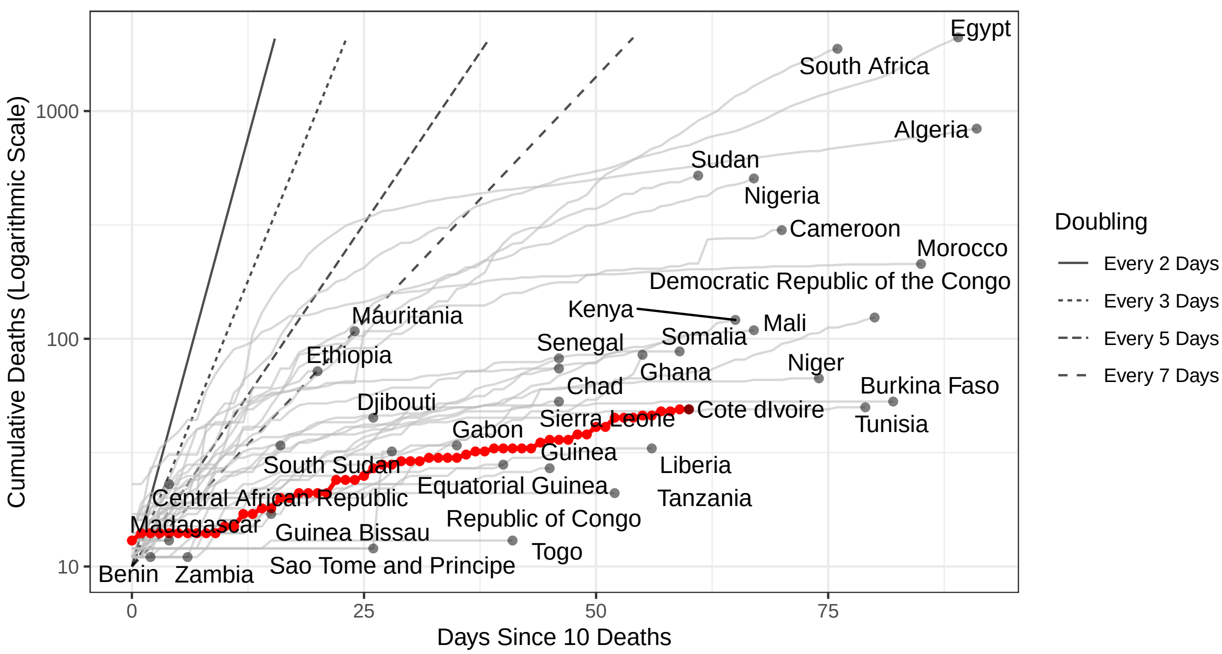


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 28,802 (95% CI: 27,512-30,092) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

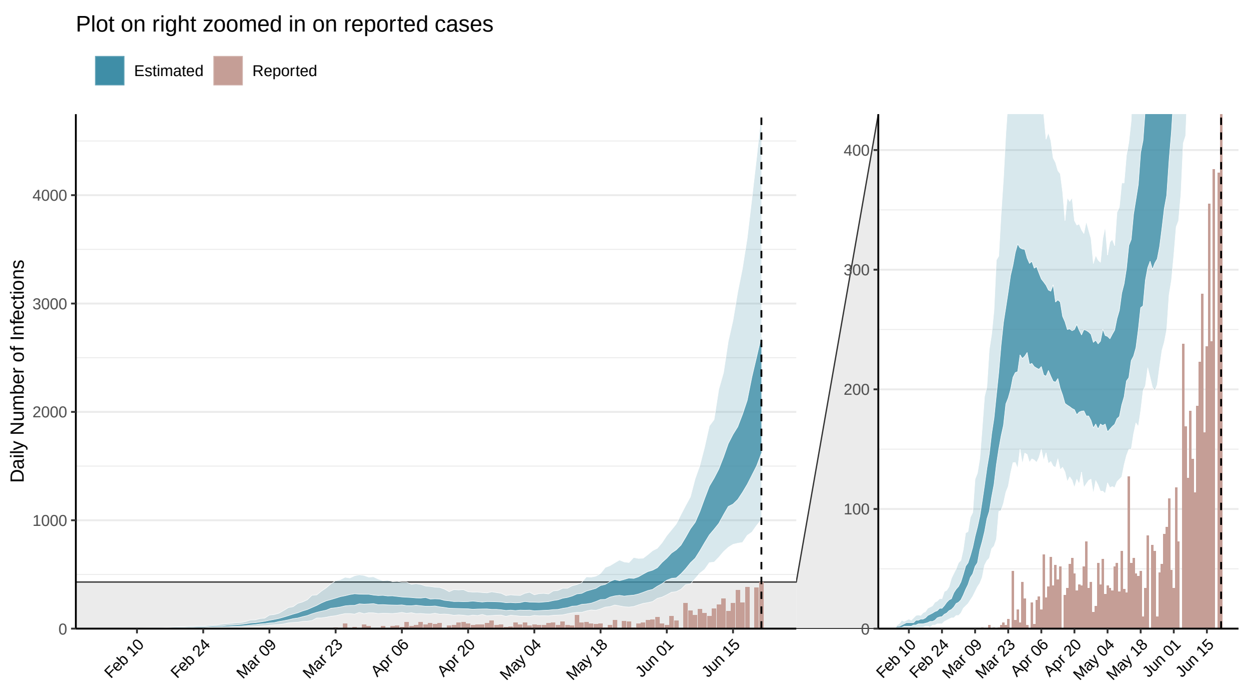


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

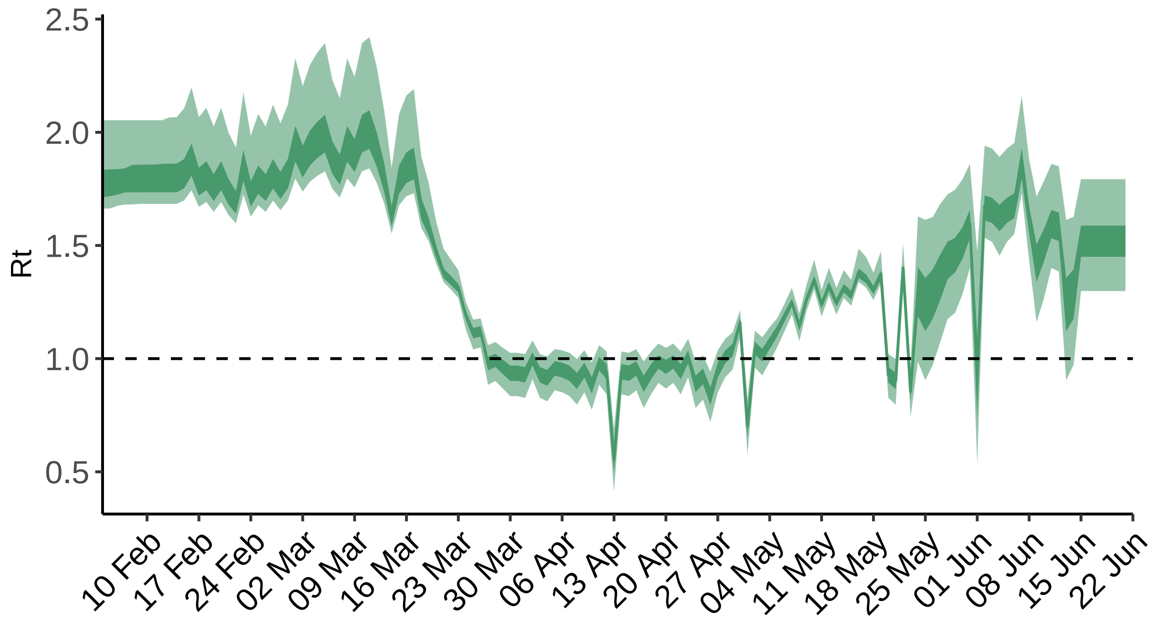


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Cote d'Ivoire is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

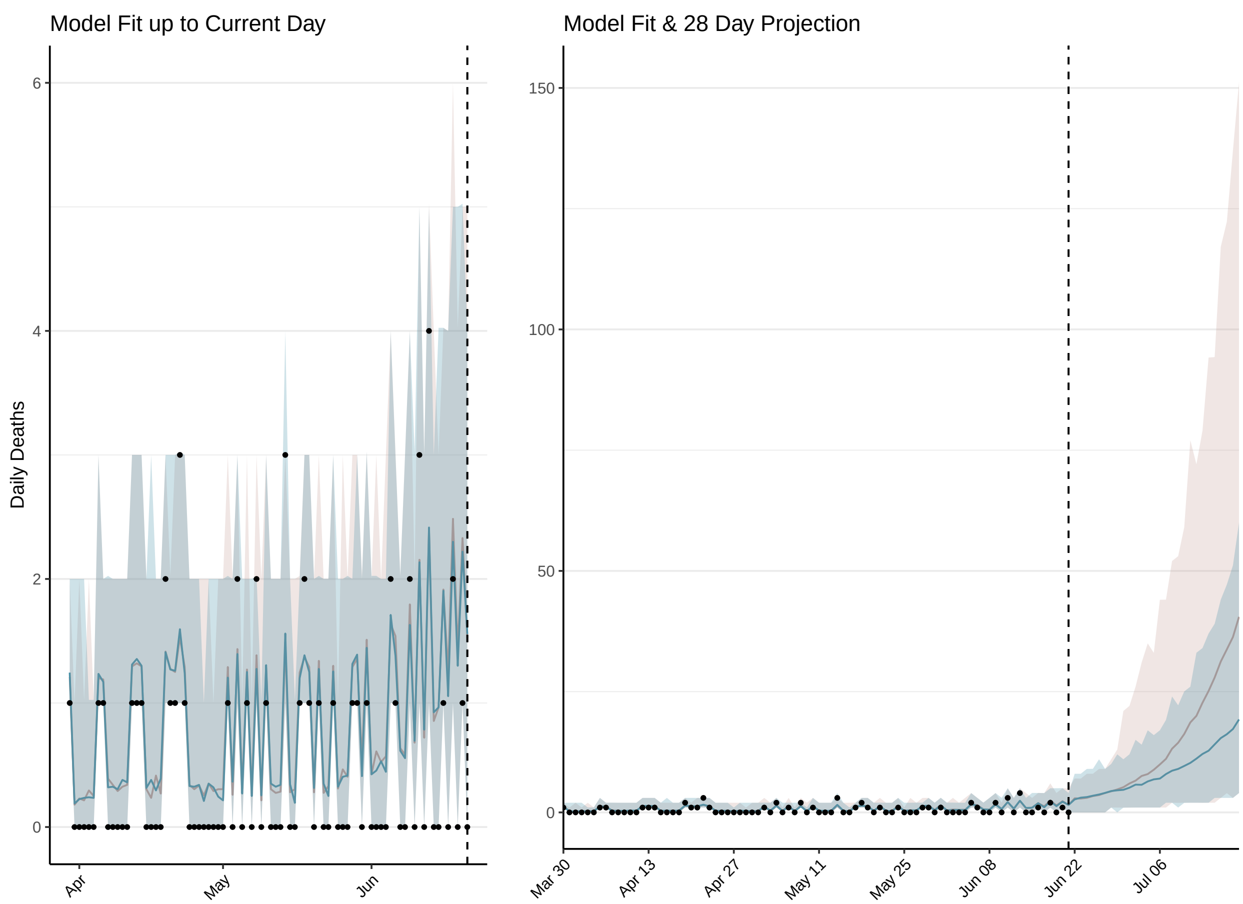


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 167 (95% CI: 160-175) patients requiring treatment with high-pressure oxygen at the current date to 1,193 (95% CI: 1,080-1,307) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 43 (95% CI: 41-45) patients requiring treatment with mechanical ventilation at the current date to 179 (95% CI: 172-186) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

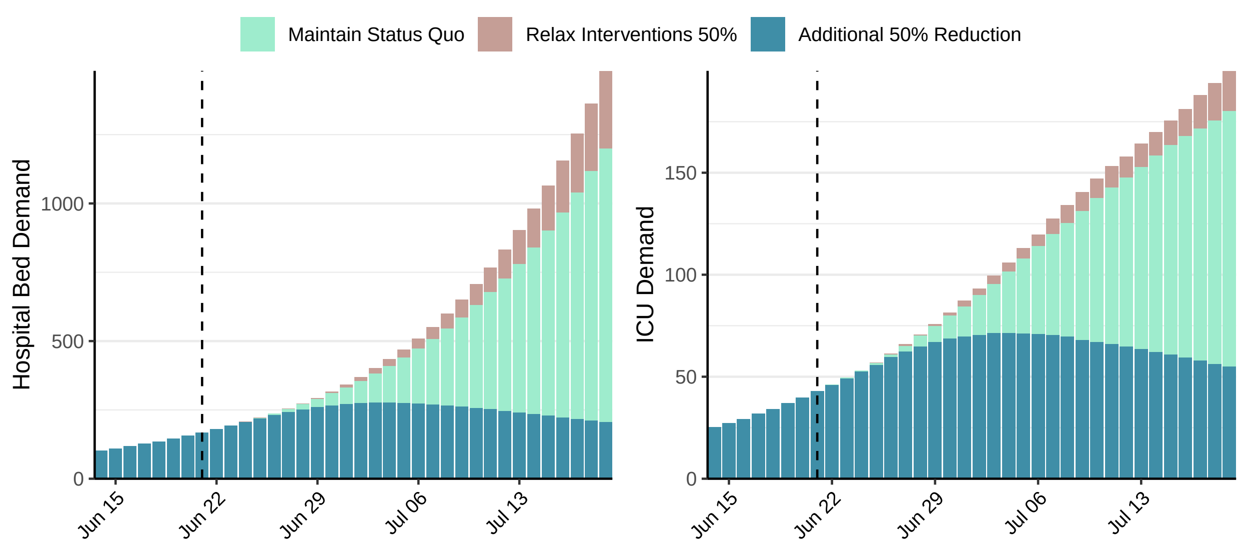


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,234 (95% CI: 2,105-2,362) at the current date to 962 (95% CI: 862-1,061) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,234 (95% CI: 2,105-2,362) at the current date to 23,041 (95% CI: 20,366-25,715) by 2020-07-19.

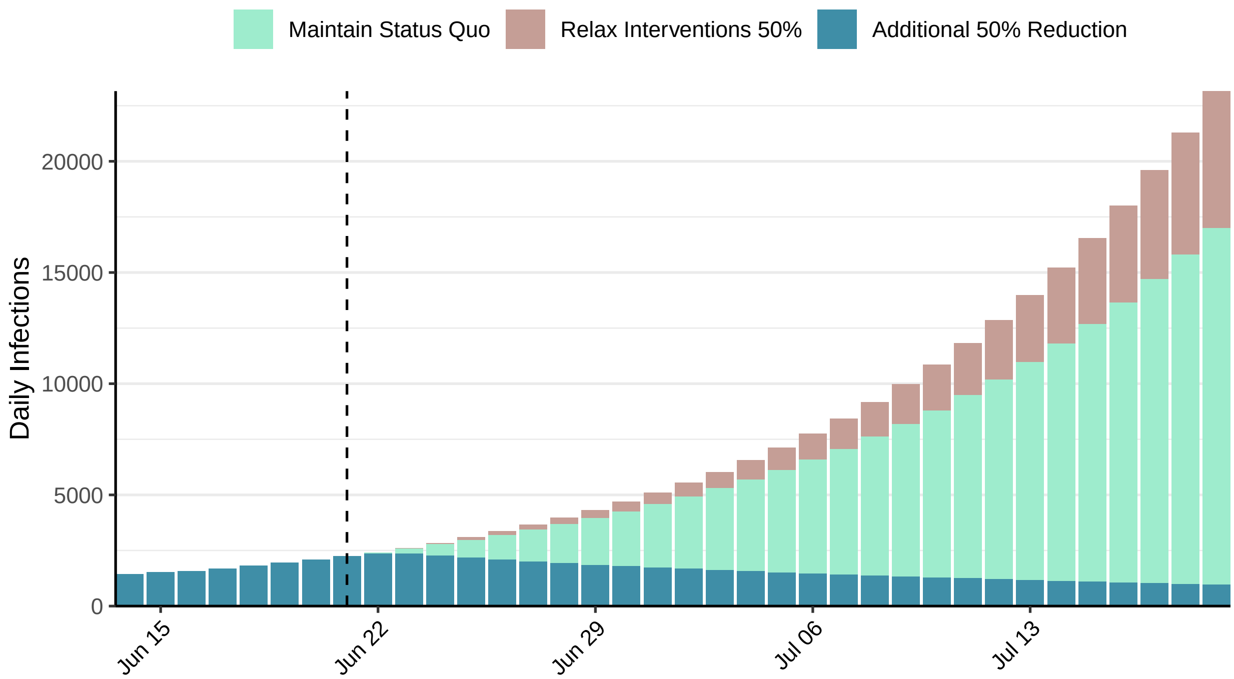


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Cameroon, 2020-06-21

**Download the report for Cameroon, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 11,281 | 0 | 300 | 0 | 1.52 (95% CI: 1.44-1.61) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

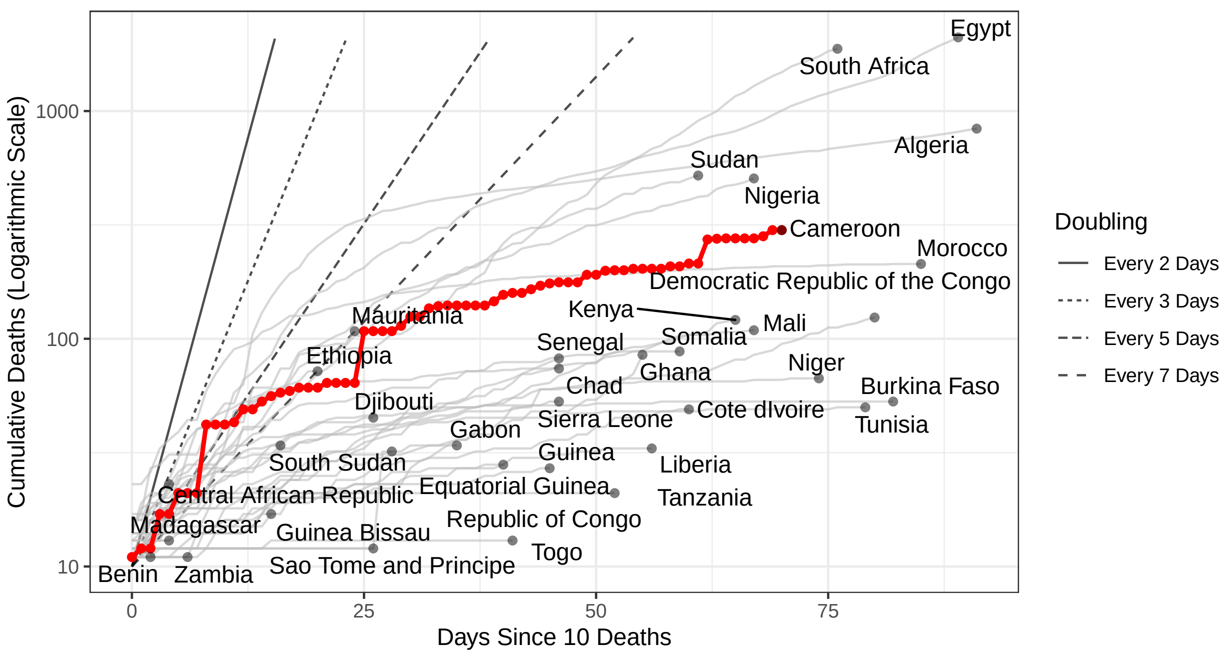


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 105,074 (95% CI: 101,157-108,991) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

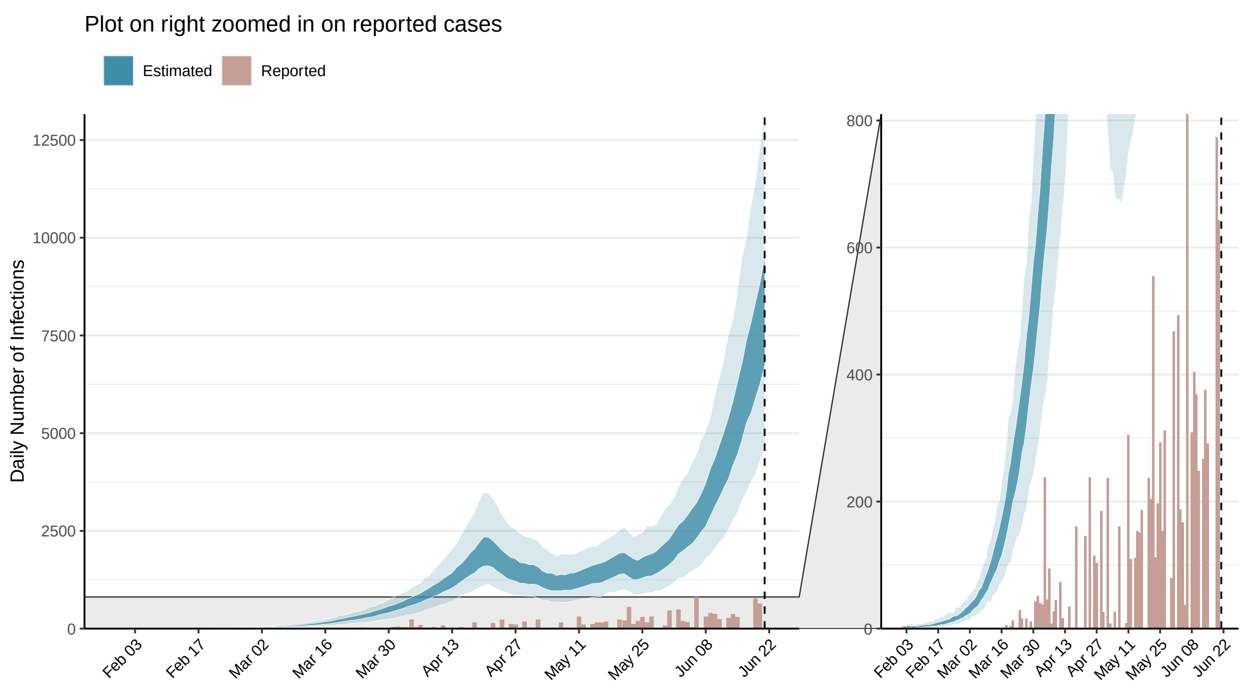


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

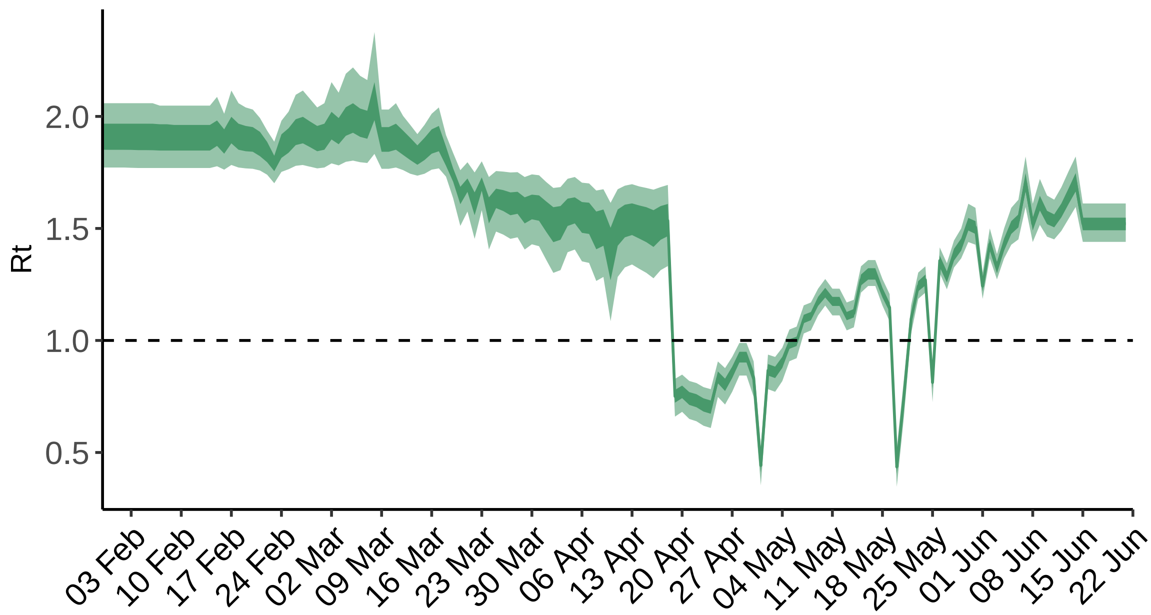


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Cameroon is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

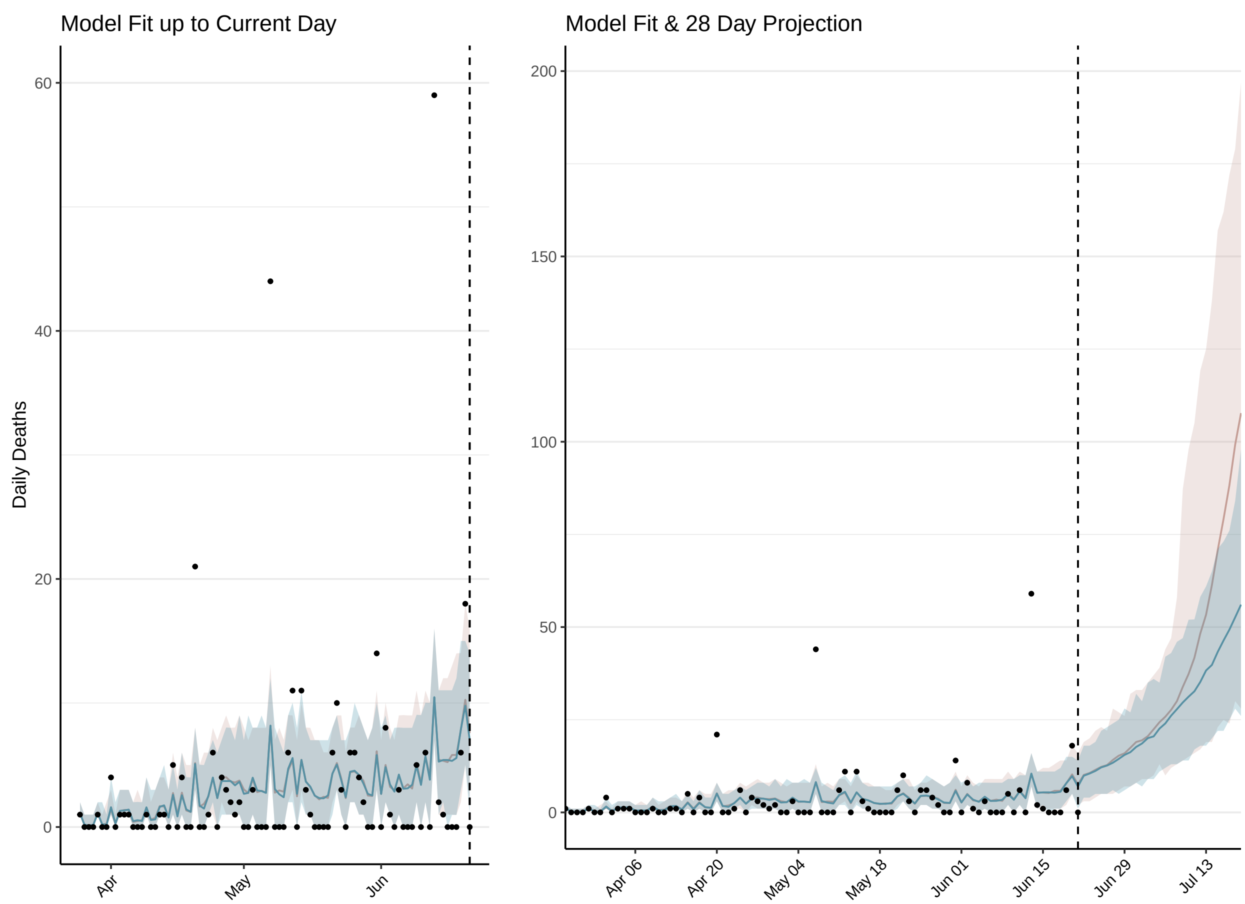


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 593 (95% CI: 570-615) patients requiring treatment with high-pressure oxygen at the current date to 3,792 (95% CI: 3,640-3,944) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 154 (95% CI: 148-160) patients requiring treatment with mechanical ventilation at the current date to 770 (95% CI: 755-786) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

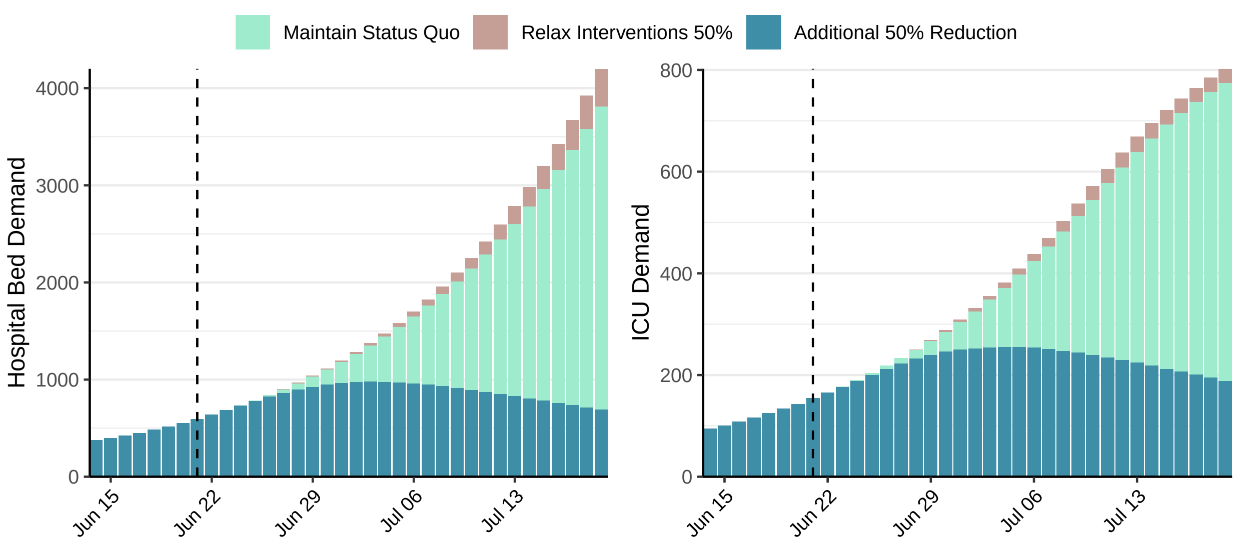


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 8,160 (95% CI: 7,849-8,470) at the current date to 3,047 (95% CI: 2,917-3,177) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 8,160 (95% CI: 7,849-8,470) at the current date to 56,973 (95% CI: 54,573-59,374) by 2020-07-19.

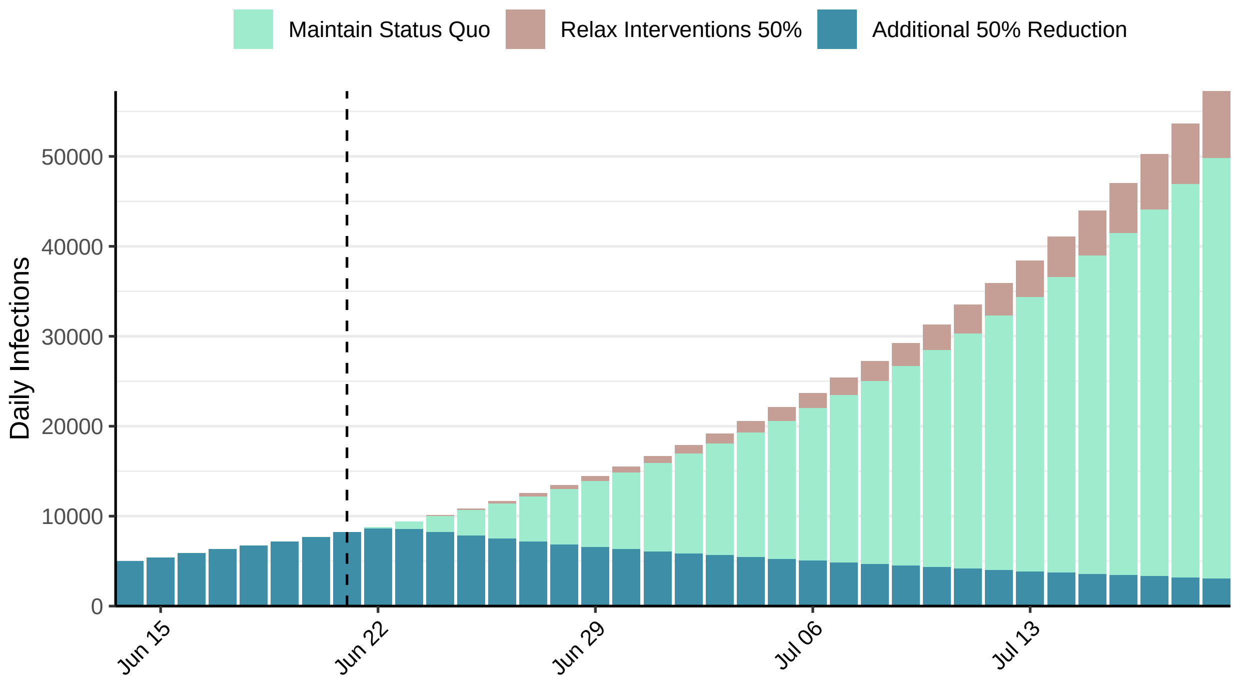


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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# Situation Report for COVID-19: Democratic Republic of Congo, 2020-06-21

**Download the report for Democratic Republic of Congo, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 5,671 | 195 | 124 | 3 | 1.2 (95% CI: 1.1-1.29) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

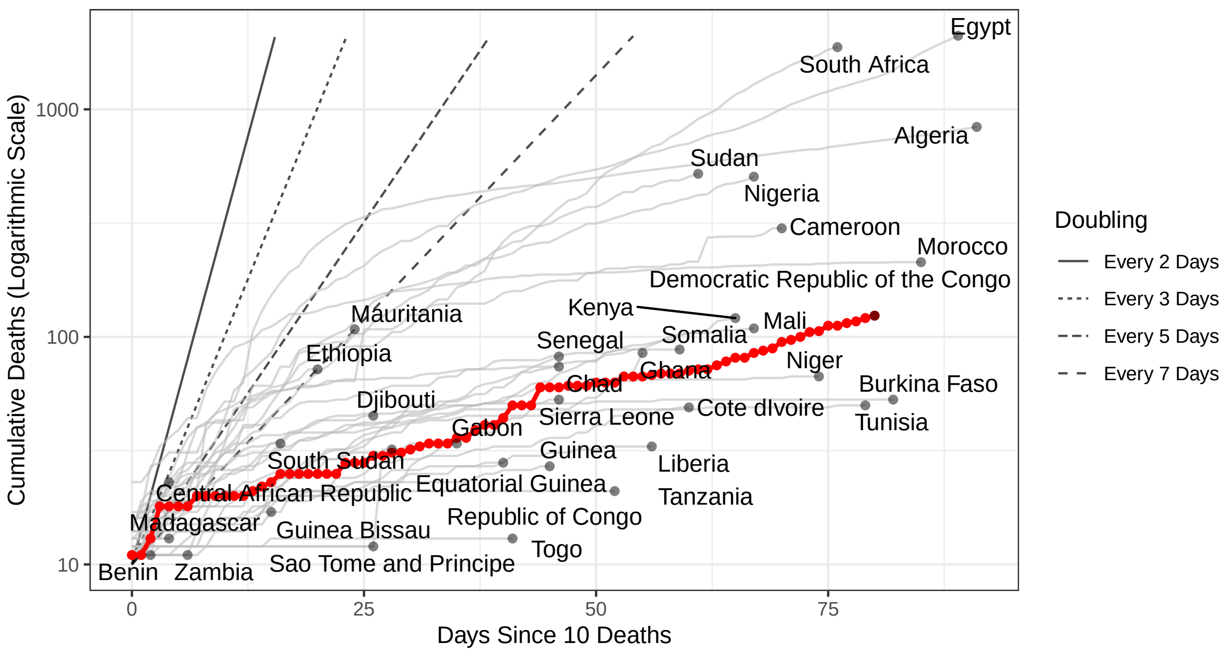


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 43,508 (95% CI: 41,696-45,320) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

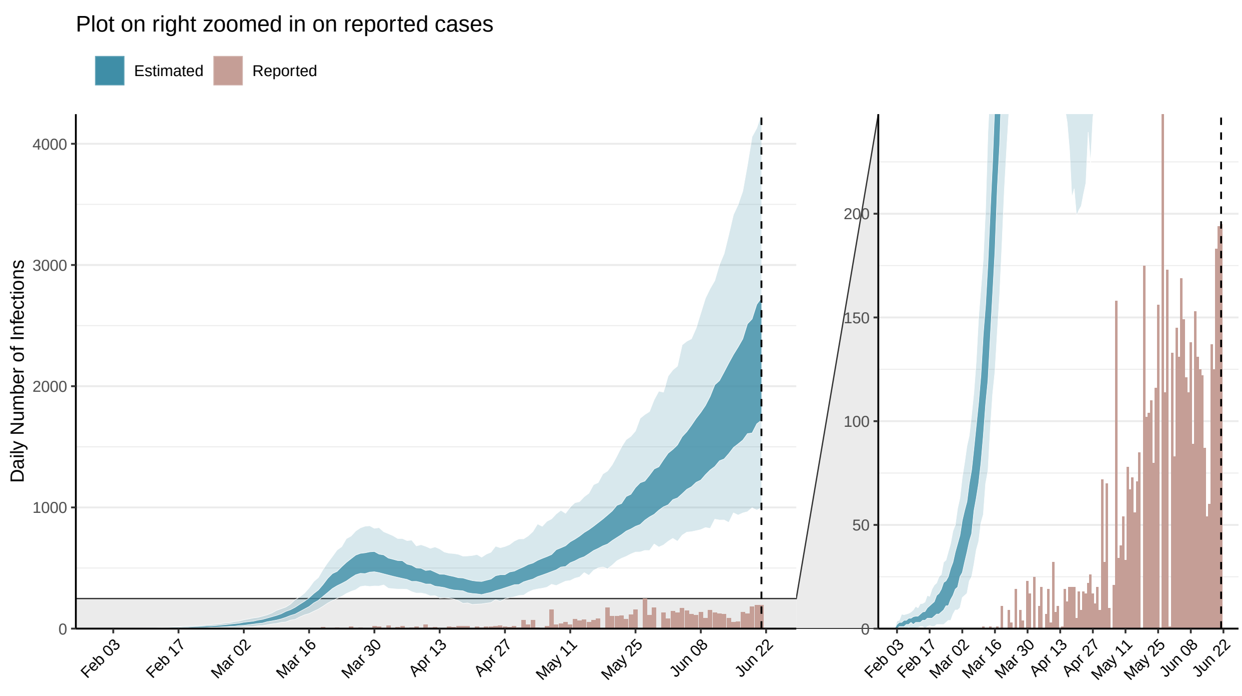


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

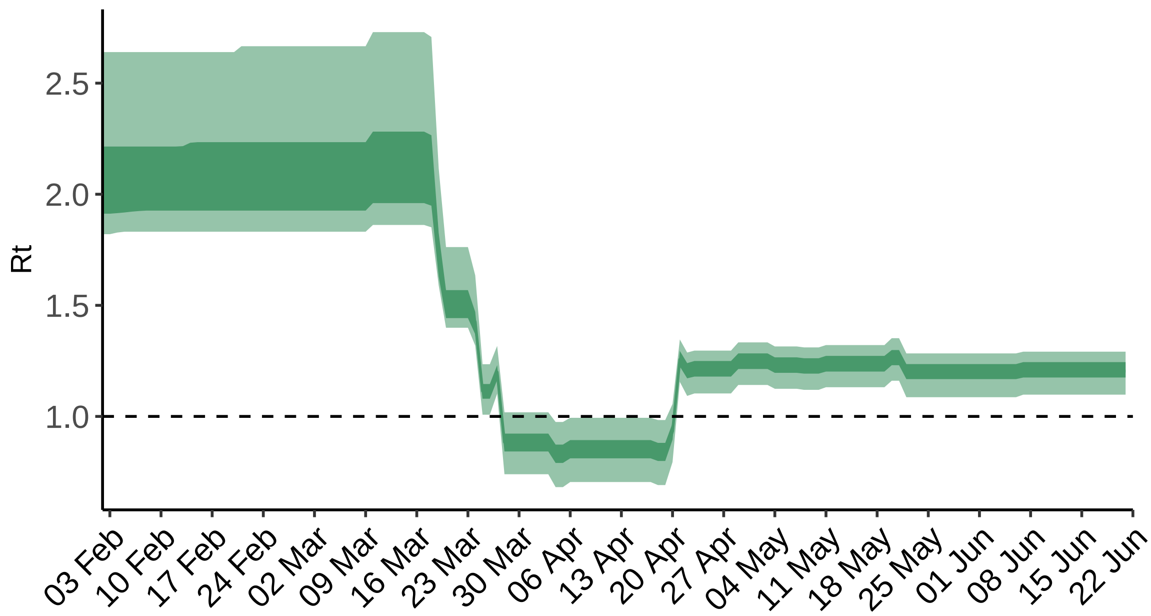


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

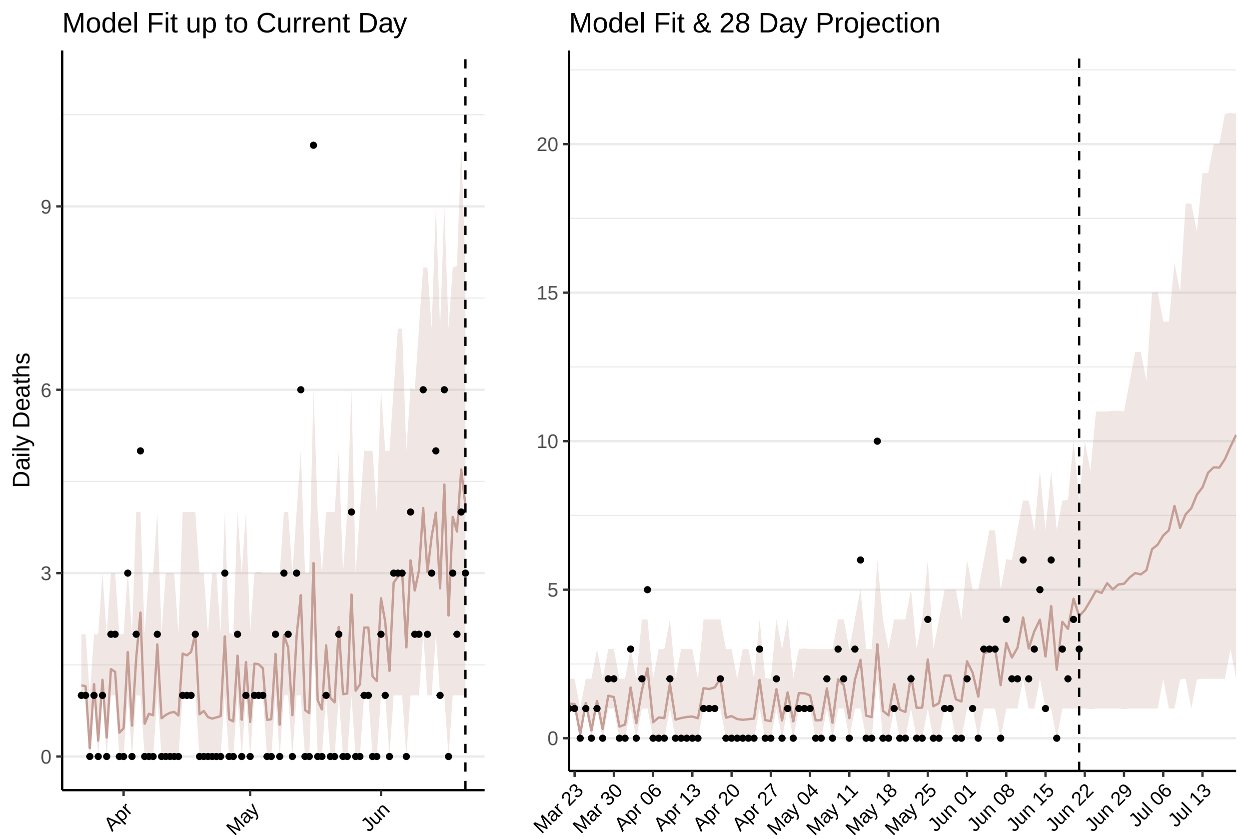


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 234 (95% CI: 223-244) patients requiring treatment with high-pressure oxygen at the current date to 567 (95% CI: 531-602) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 65 (95% CI: 62-68) patients requiring treatment with mechanical ventilation at the current date to 155 (95% CI: 145-165) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

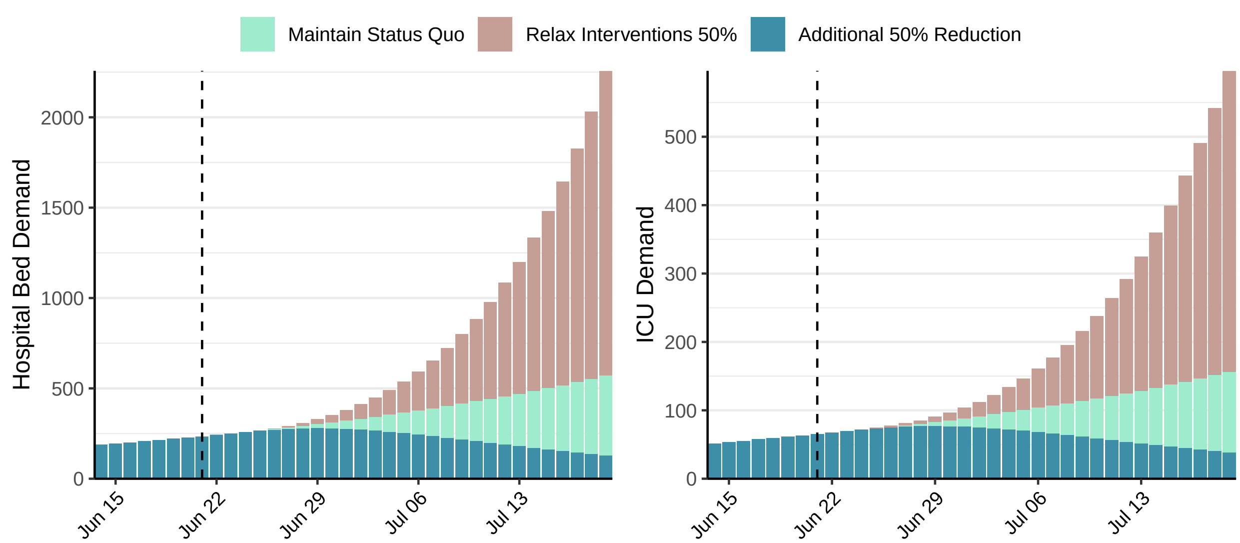


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,281 (95% CI: 2,169-2,393) at the current date to 395 (95% CI: 368-422) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,281 (95% CI: 2,169-2,393) at the current date to 41,862 (95% CI: 38,735-44,988) by 2020-07-19.

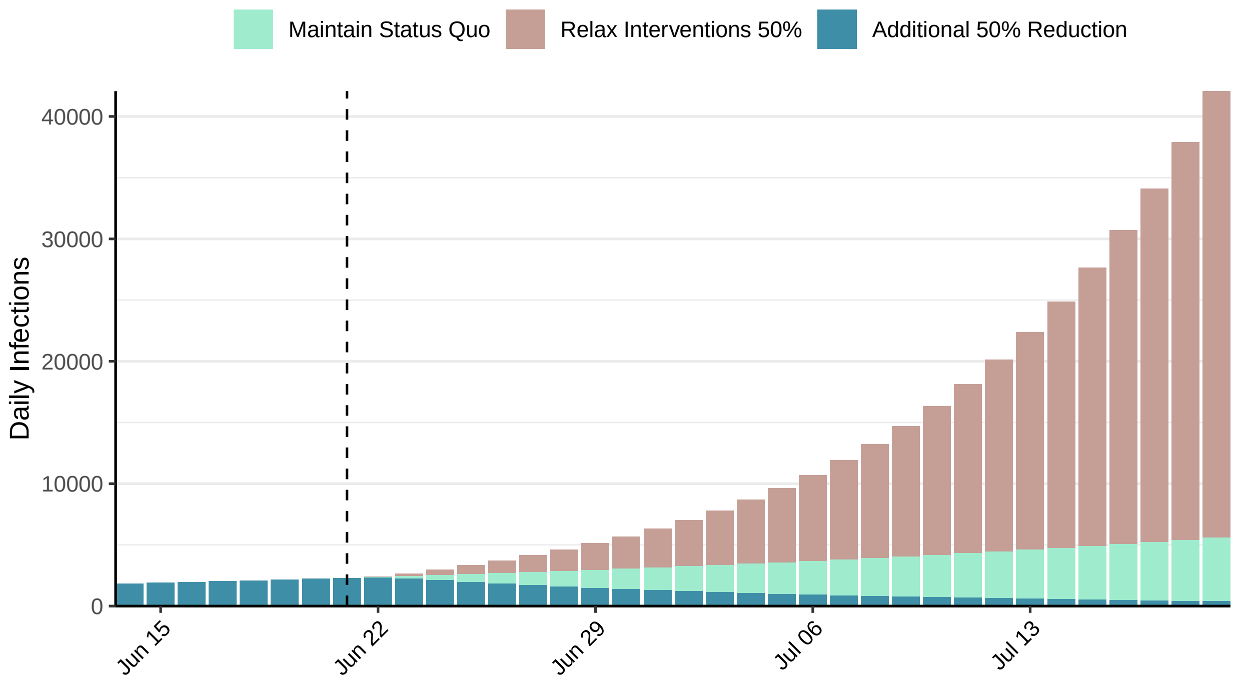


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Republic of the Congo, 2020-06-21

**Download the report for Republic of the Congo, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,013 | 130 | 28 | 1 | 1.15 (95% CI: 0.66-1.62) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

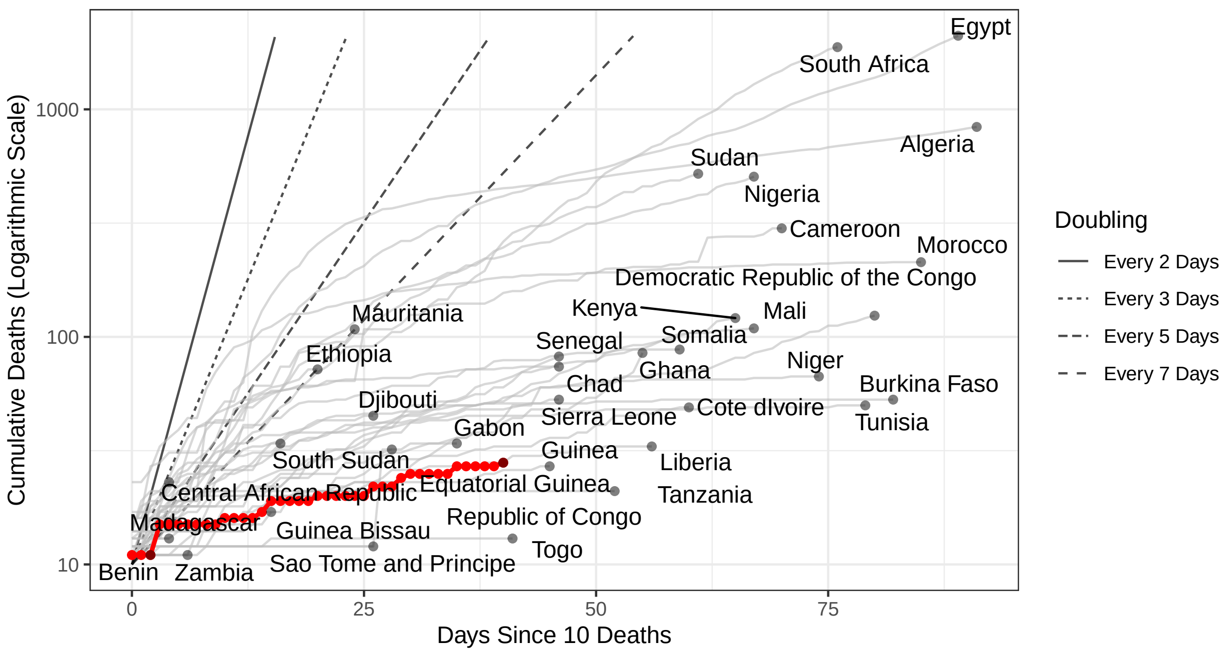


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 6,958 (95% CI: 6,396-7,520) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

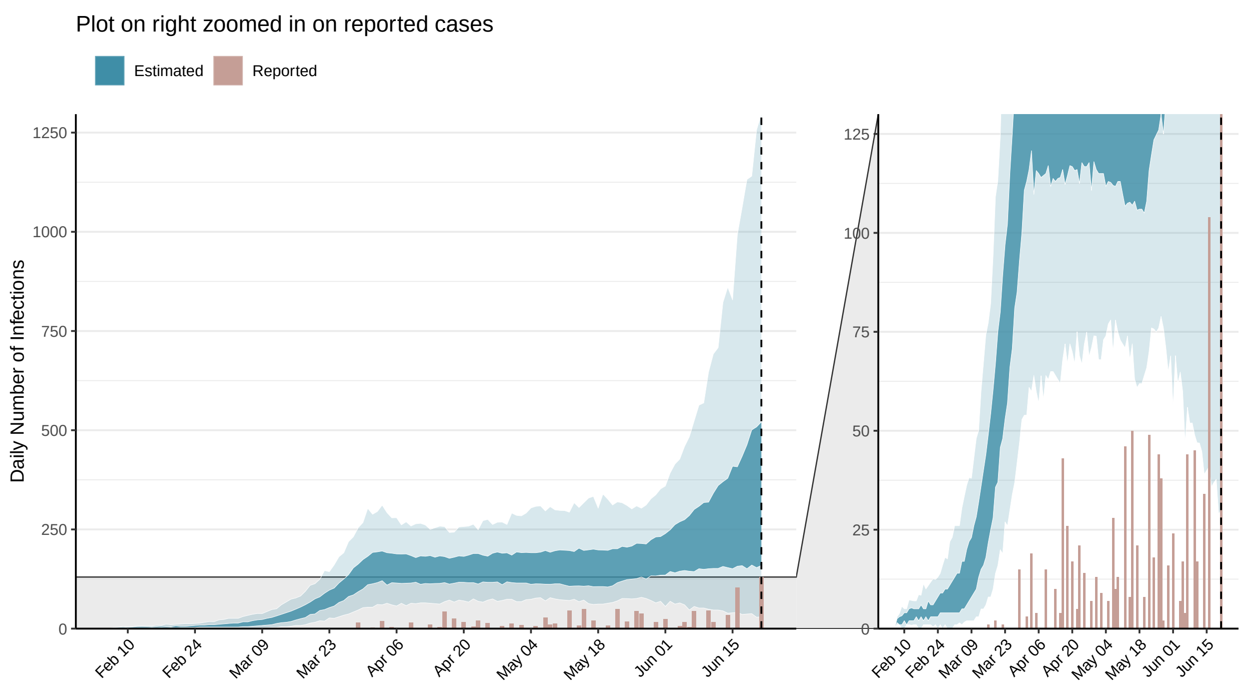


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

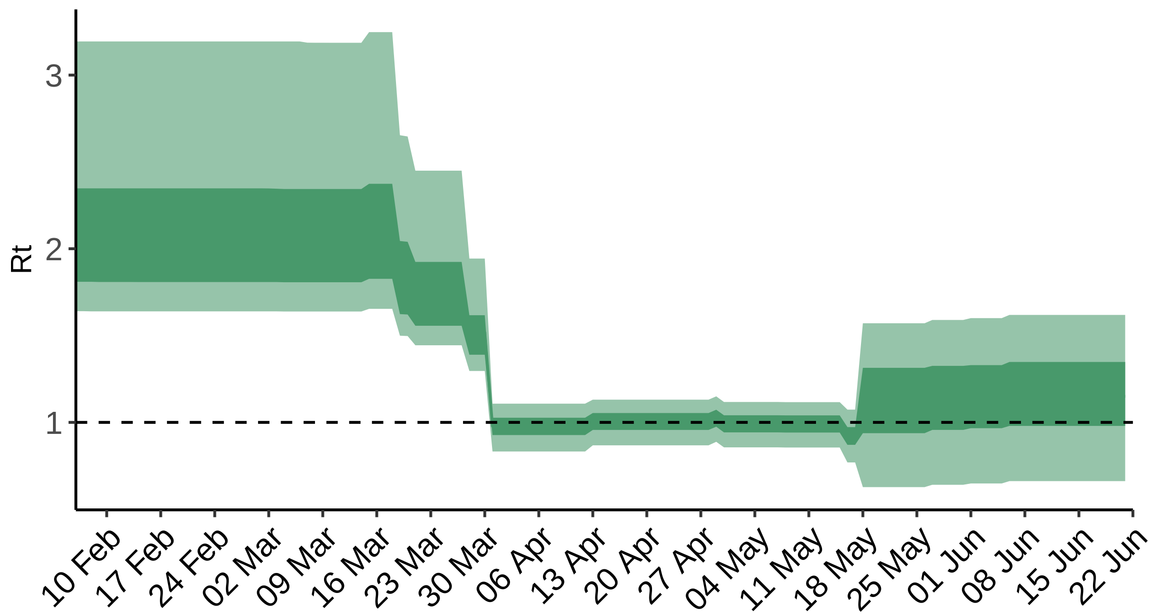


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

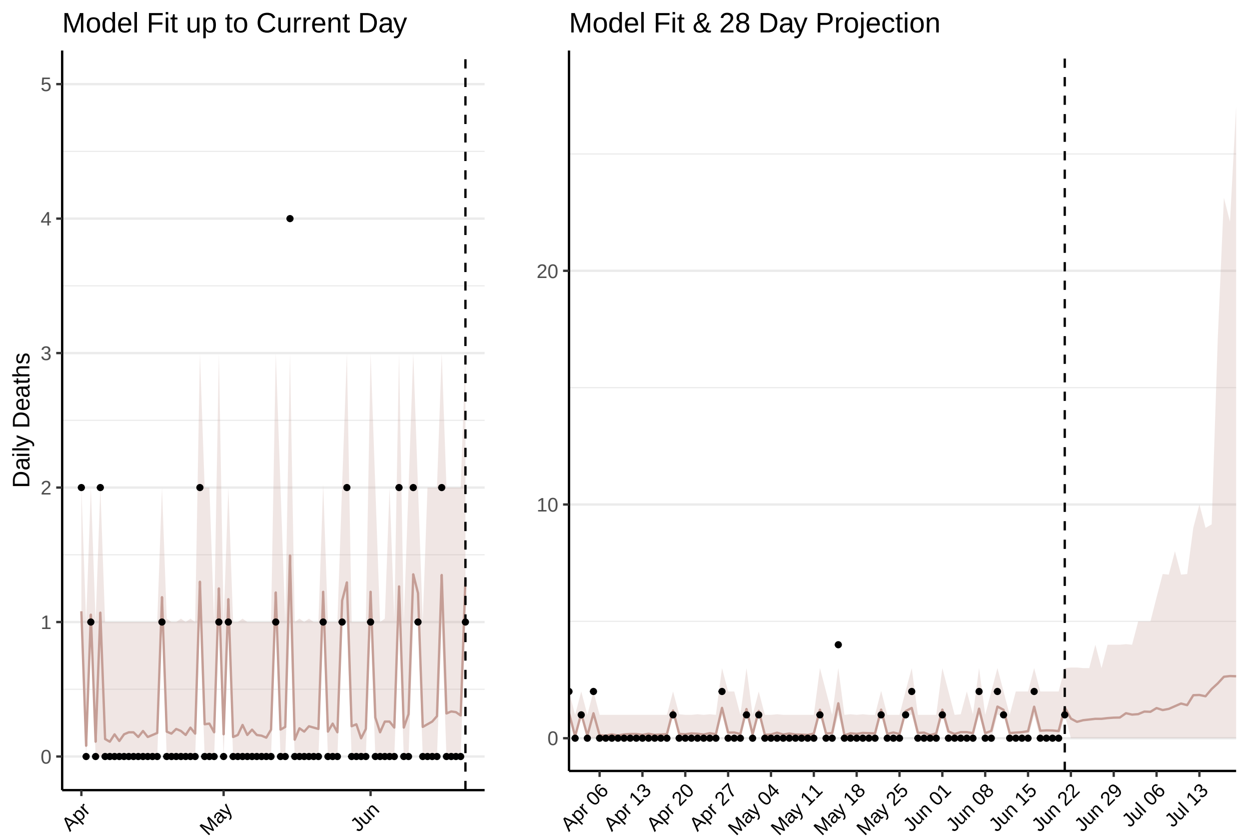


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 39 (95% CI: 36-43) patients requiring treatment with high-pressure oxygen at the current date to 139 (95% CI: 111-166) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 10 (95% CI: 9-11) patients requiring treatment with mechanical ventilation at the current date to 34 (95% CI: 28-40) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

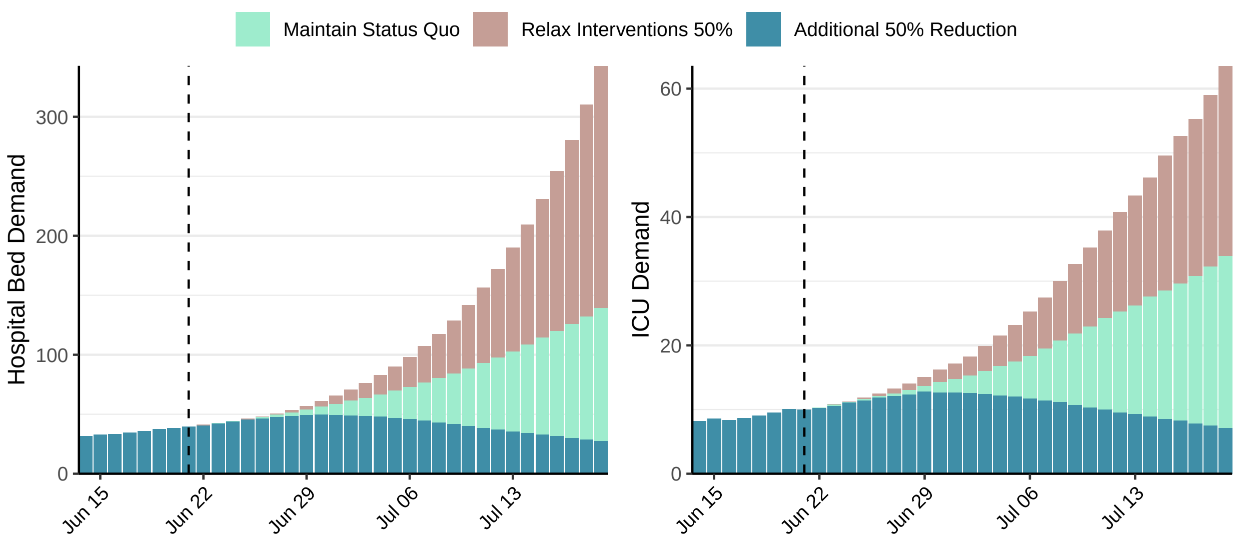


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 389 (95% CI: 340-437) at the current date to 102 (95% CI: 80-124) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 389 (95% CI: 340-437) at the current date to 5,832 (95% CI: 4,416-7,248) by 2020-07-19.

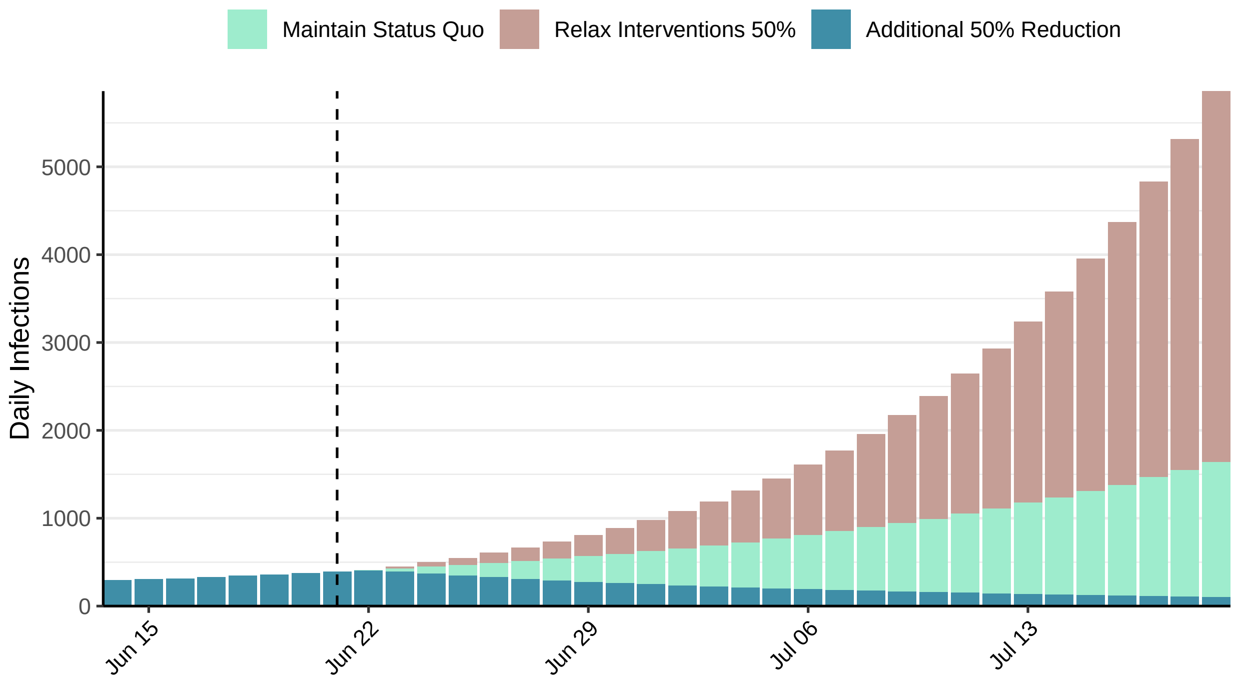


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Colombia, 2020-06-21

**Download the report for Colombia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 65,633 | 2,357 | 2,126 | 81 | 1.64 (95% CI: 1.56-1.75) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

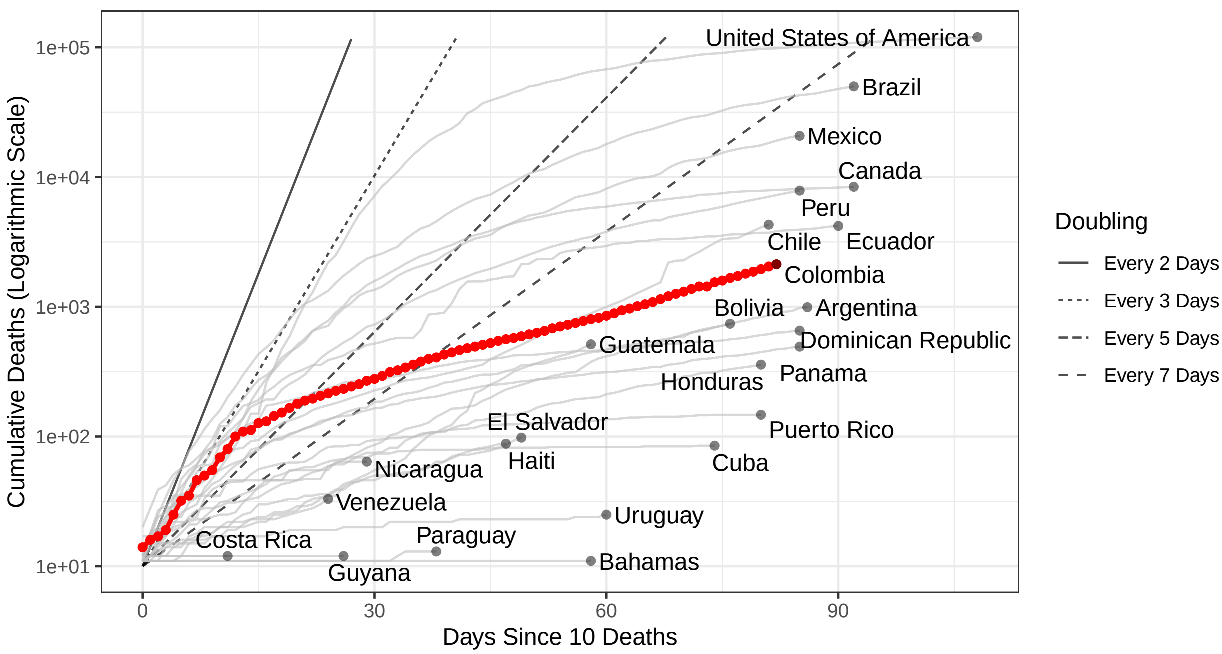


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,111,079 (95% CI: 1,085,064-1,137,094) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

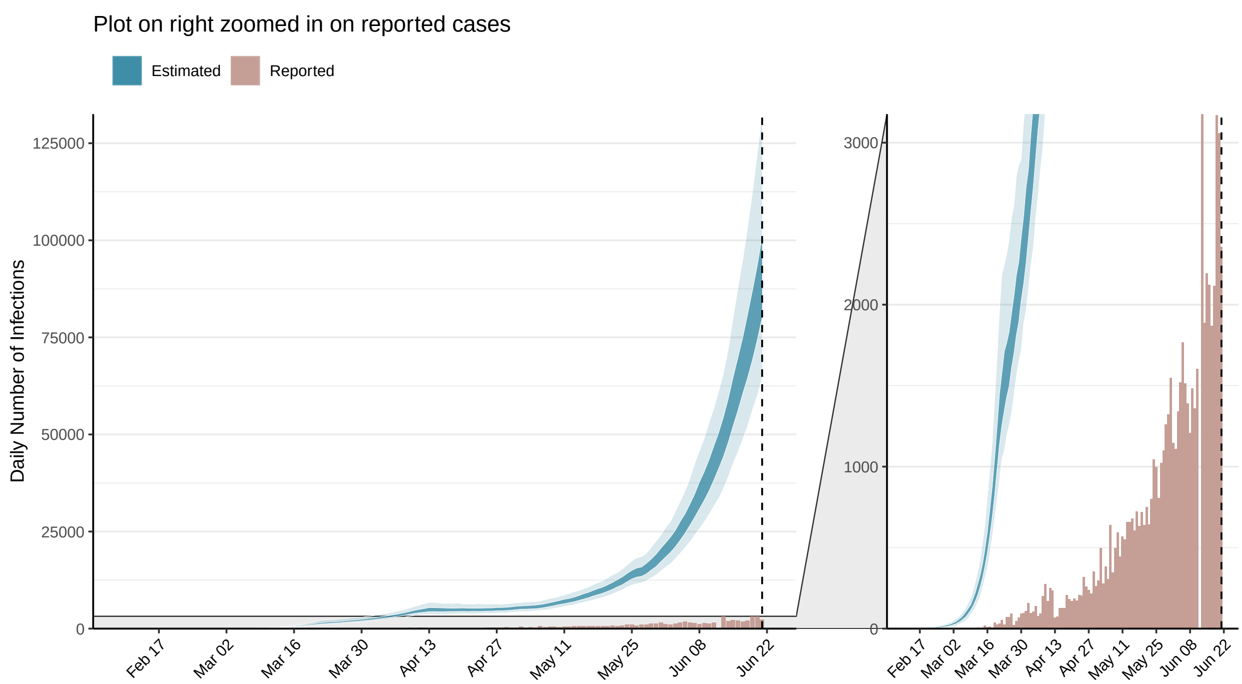


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

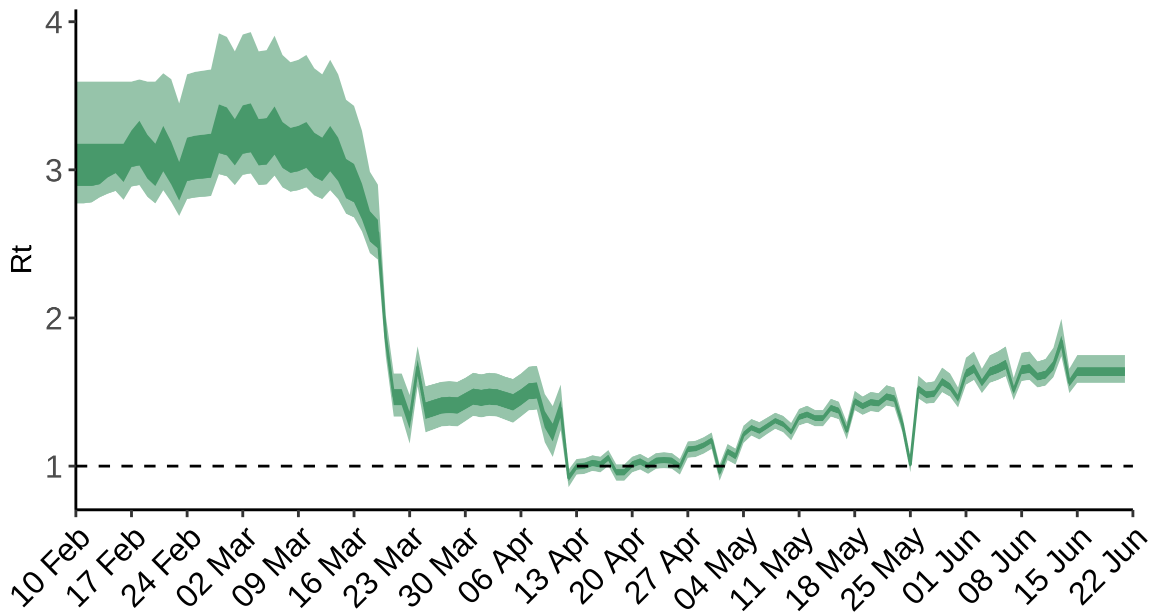


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Colombia is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

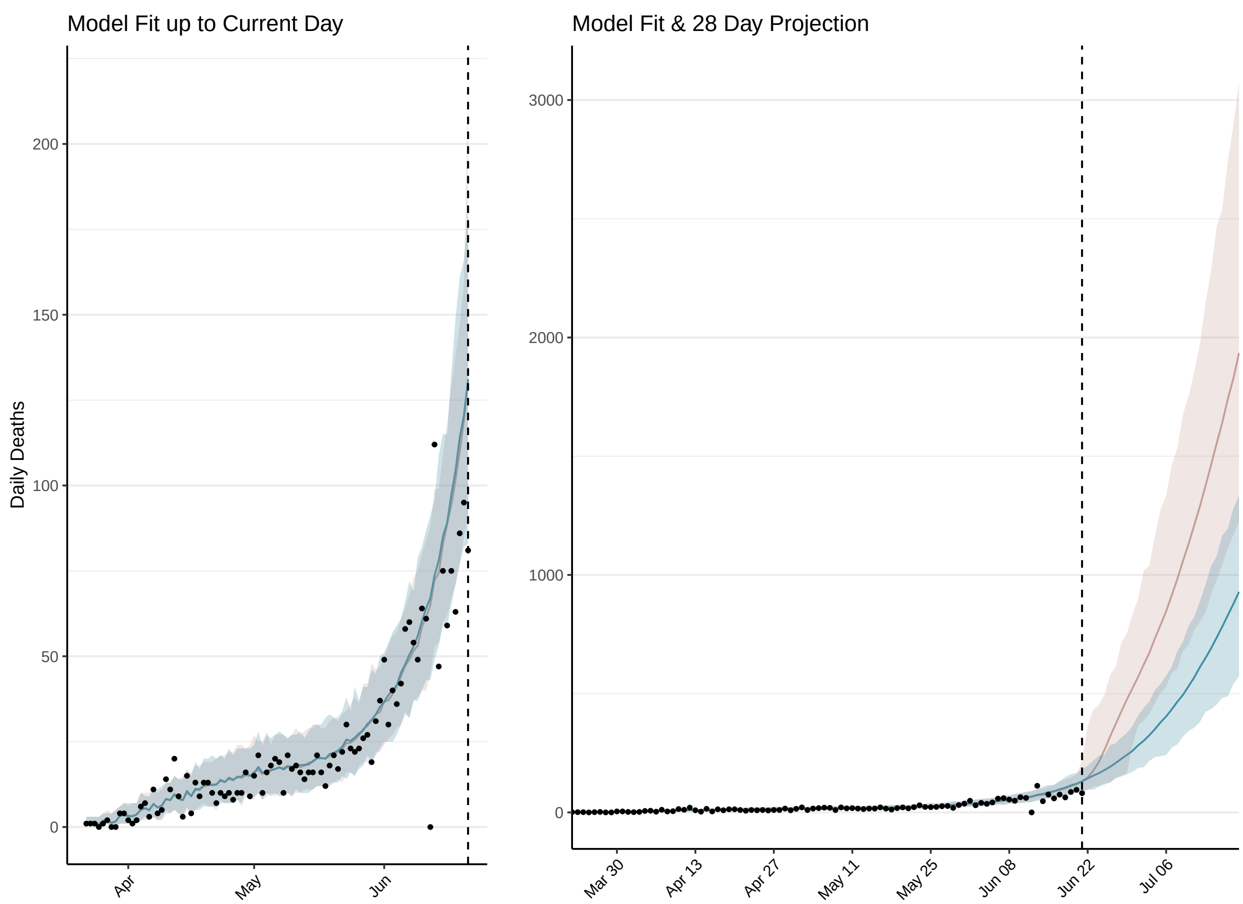


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 6,983 (95% CI: 6,816-7,151) patients requiring treatment with high-pressure oxygen at the current date to 45,033 (95% CI: 43,642-46,424) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2,140 (95% CI: 2,091-2,190) patients requiring treatment with mechanical ventilation at the current date to 4,674 (95% CI: 4,591-4,758) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

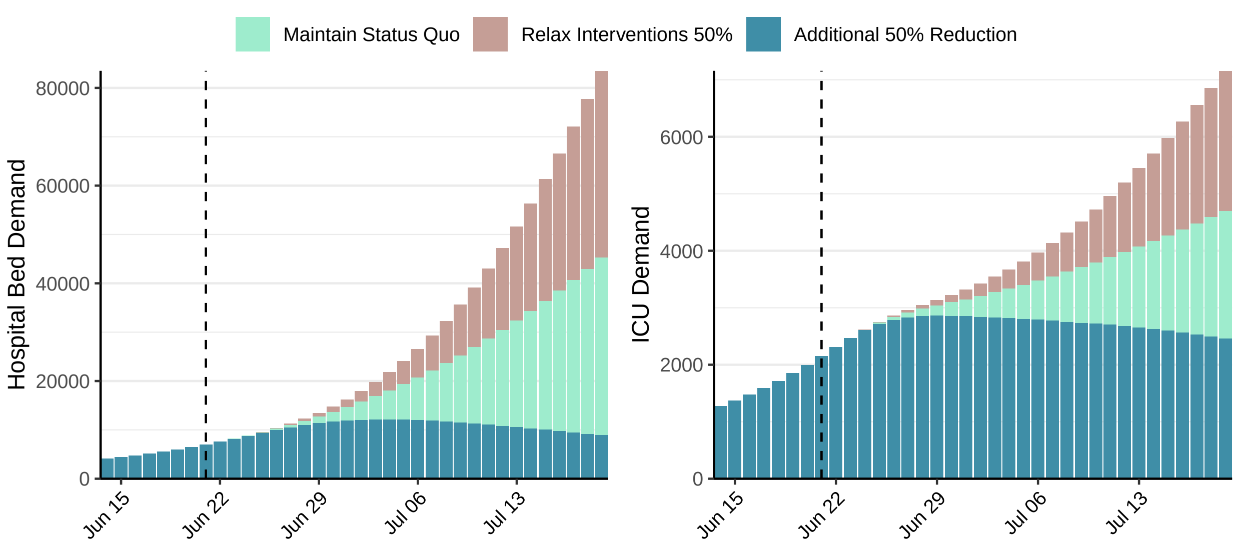


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 91,087 (95% CI: 88,632-93,543) at the current date to 34,167 (95% CI: 33,016-35,317) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 91,087 (95% CI: 88,632-93,543) at the current date to 818,663 (95% CI: 803,444-833,882) by 2020-07-19.

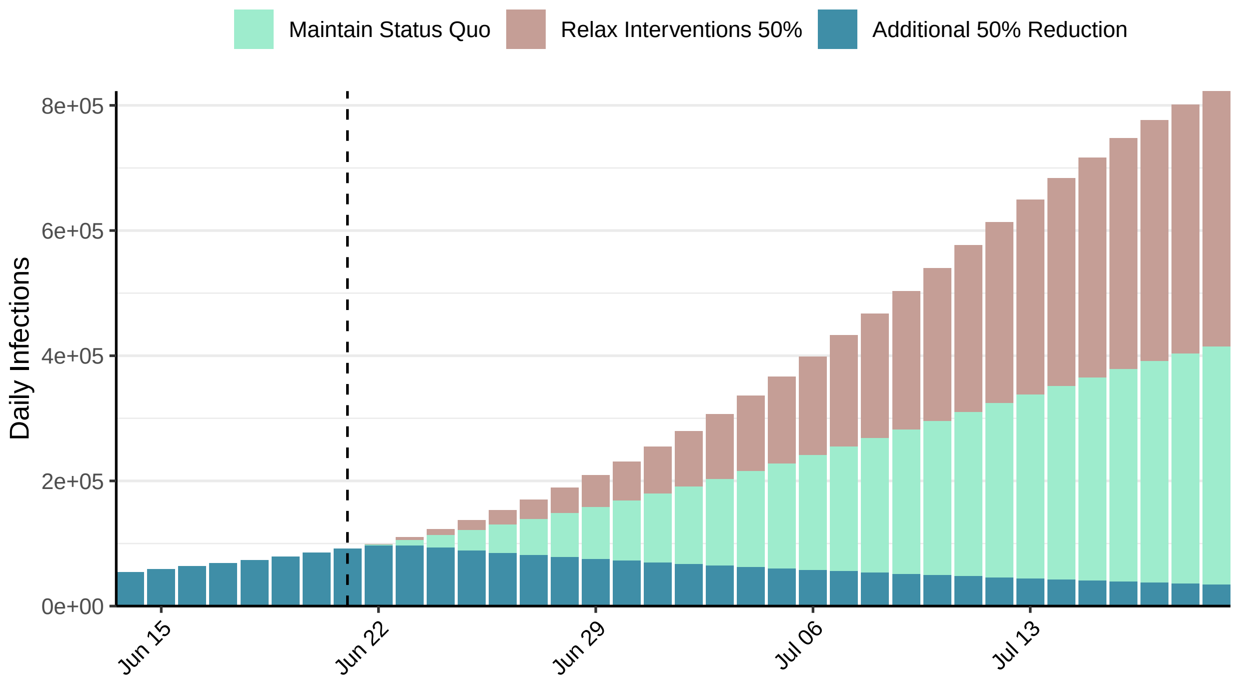


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Comoros, 2020-06-21

**Download the report for Comoros, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 247 | 37 | 5 | 0 | 1.36 (95% CI: 1.02-1.66) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Comoros is not shown in the following plot as only 5 deaths have been reported to date**

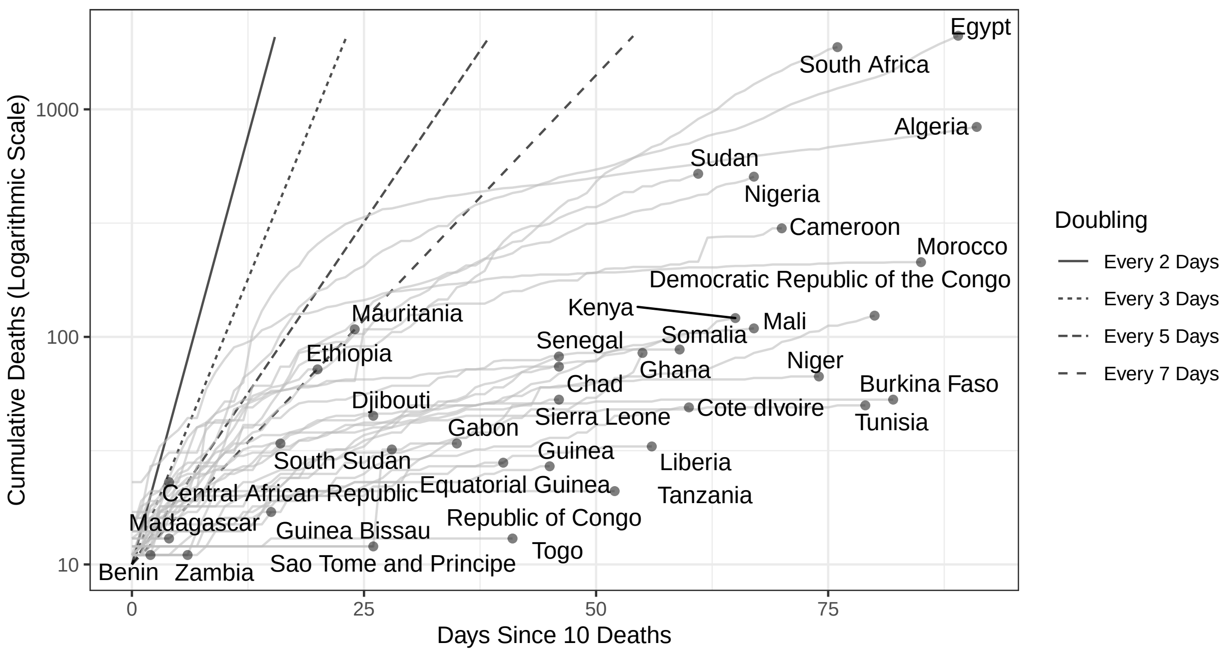


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,427 (95% CI: 3,133-3,721) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

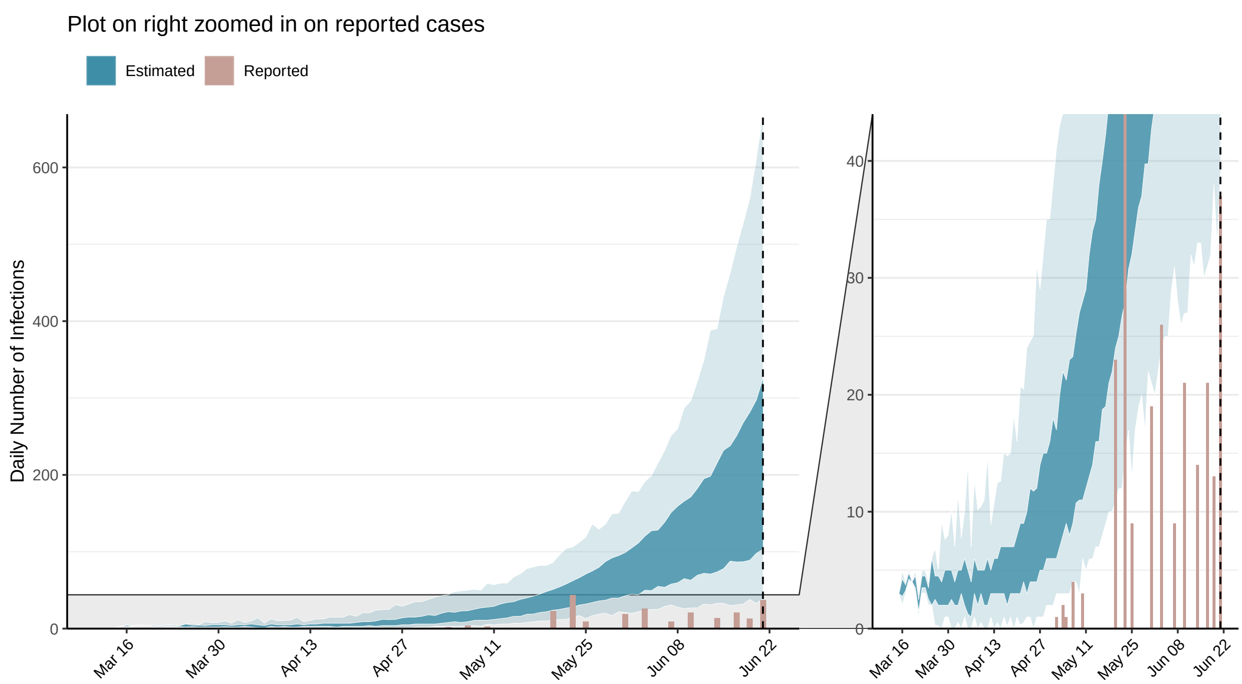


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

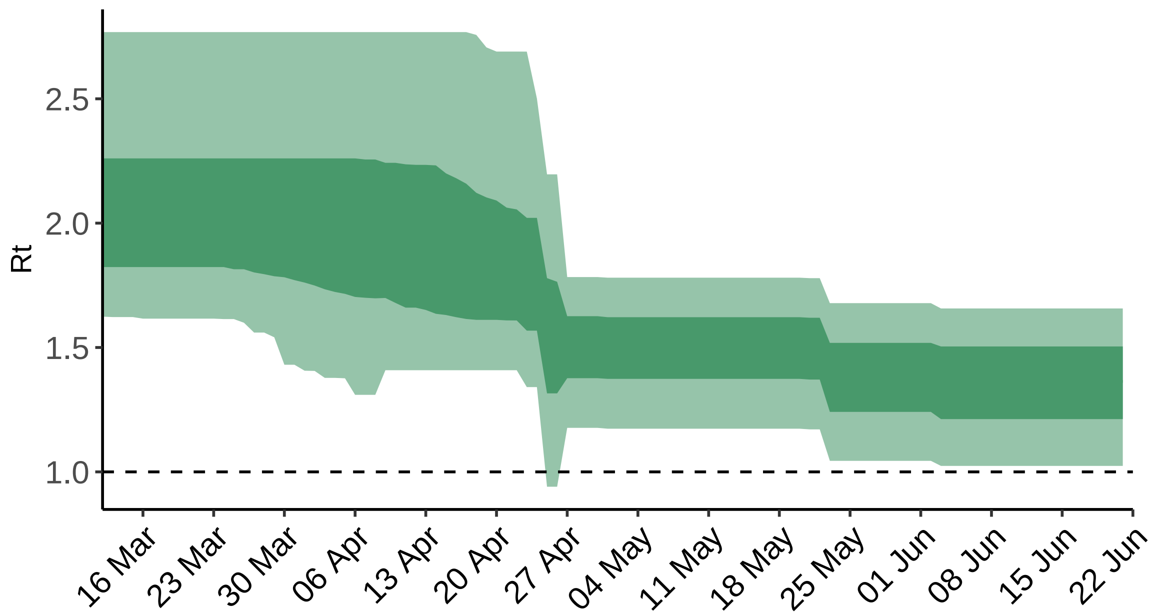


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

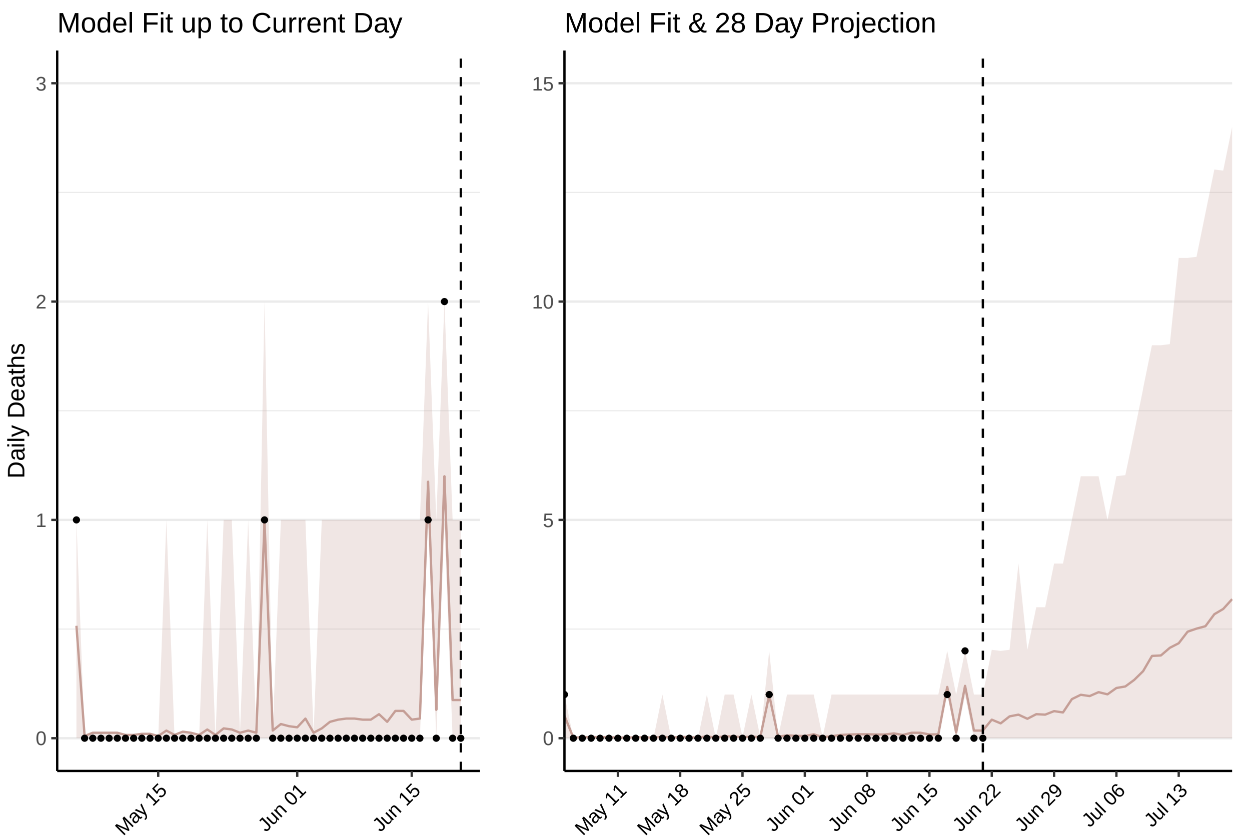


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 20 (95% CI: 19-22) patients requiring treatment with high-pressure oxygen at the current date to 101 (95% CI: 87-114) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 5 (95% CI: 5-6) patients requiring treatment with mechanical ventilation at the current date to 14 (95% CI: 13-15) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

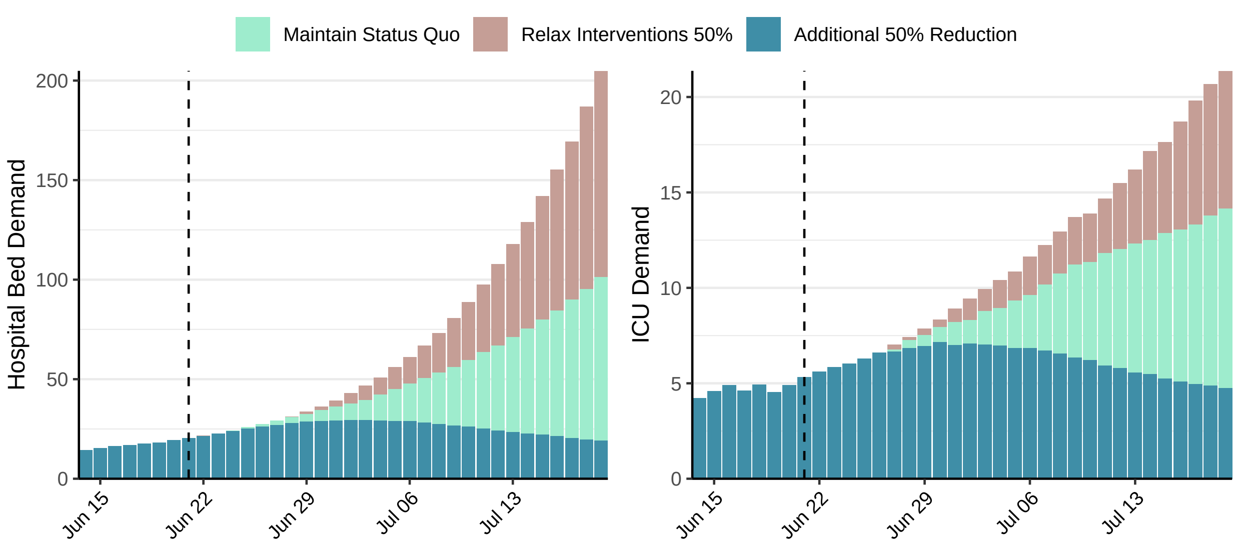


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 235 (95% CI: 211-260) at the current date to 77 (95% CI: 66-89) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 235 (95% CI: 211-260) at the current date to 3,193 (95% CI: 2,739-3,648) by 2020-07-19.

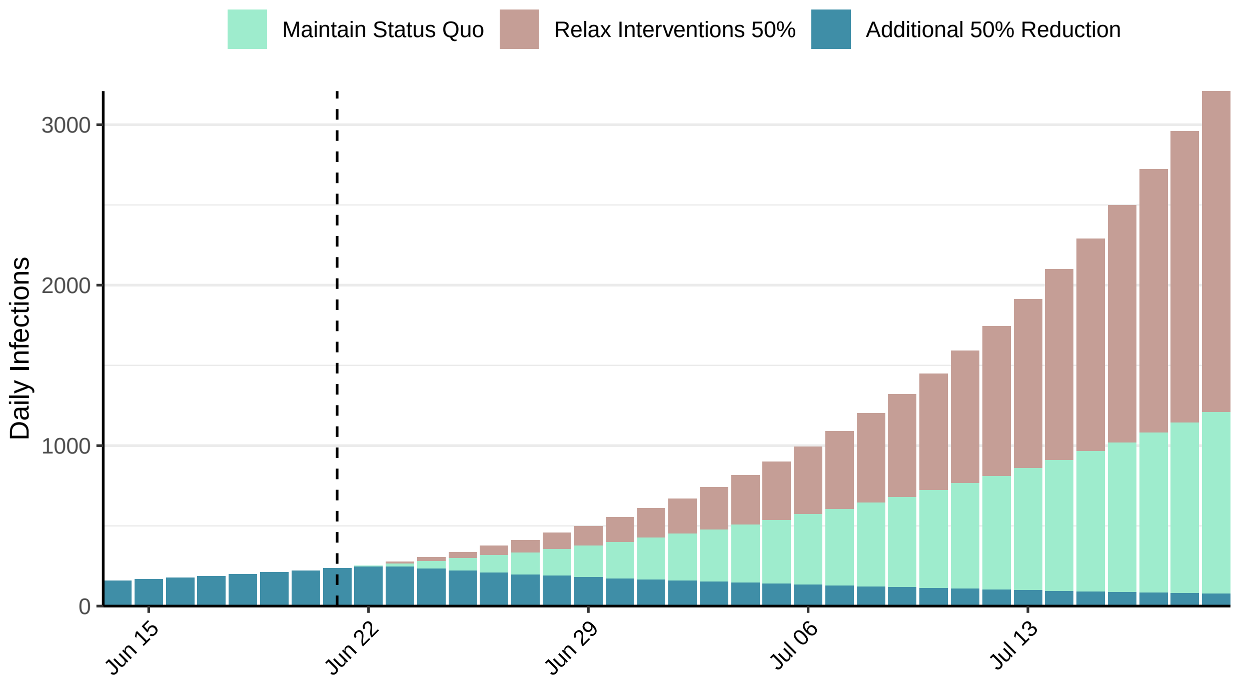


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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# Situation Report for COVID-19: Cabo Verde, 2020-06-21

**Download the report for Cabo Verde, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 863 | 15 | 8 | 0 | 1.47 (95% CI: 1.1-1.82) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Cabo Verde is not shown in the following plot as only 8 deaths have been reported to date**

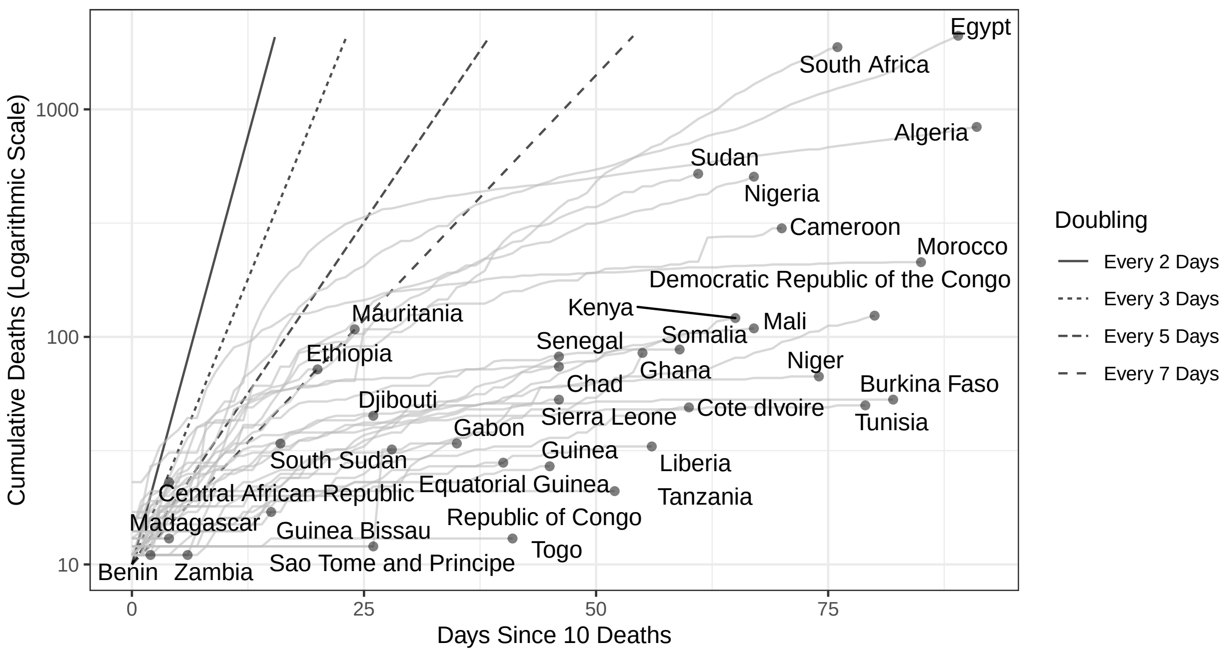


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,418 (95% CI: 3,074-3,762) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

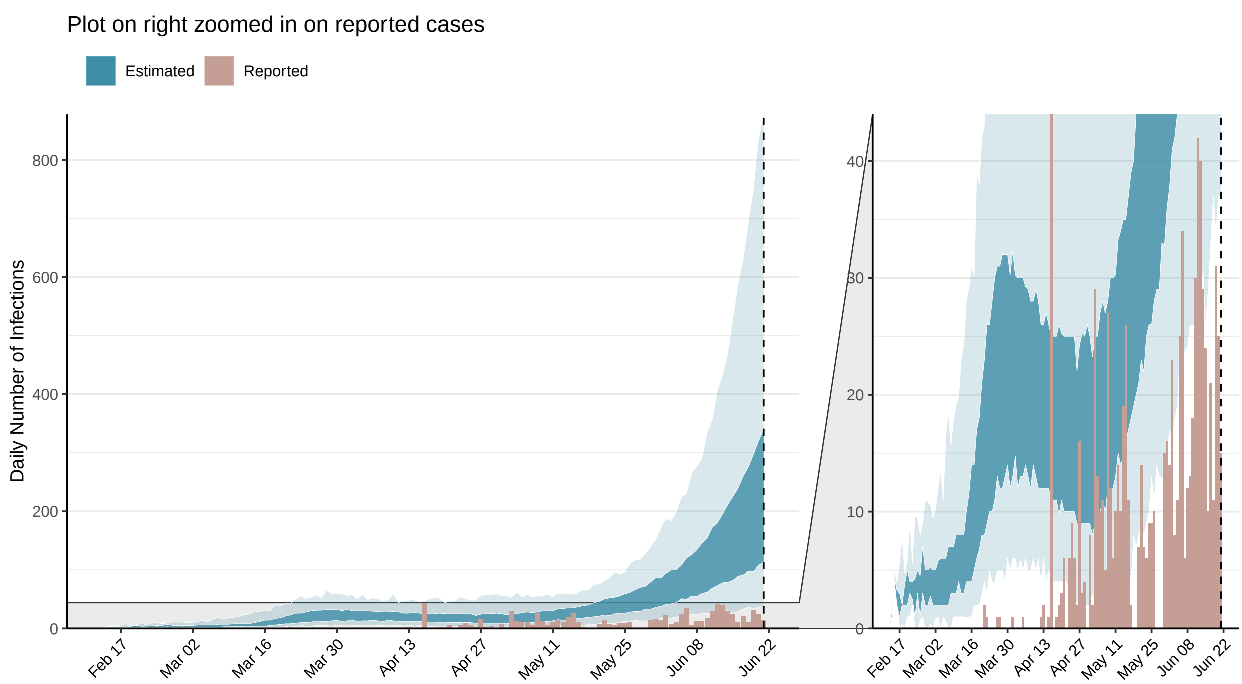


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

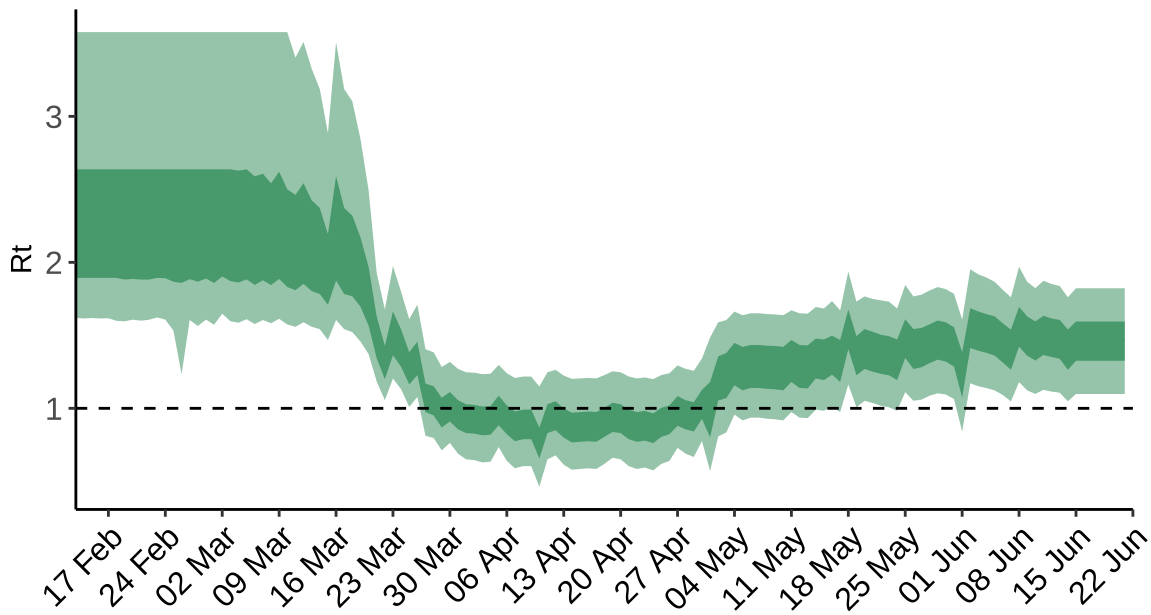


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

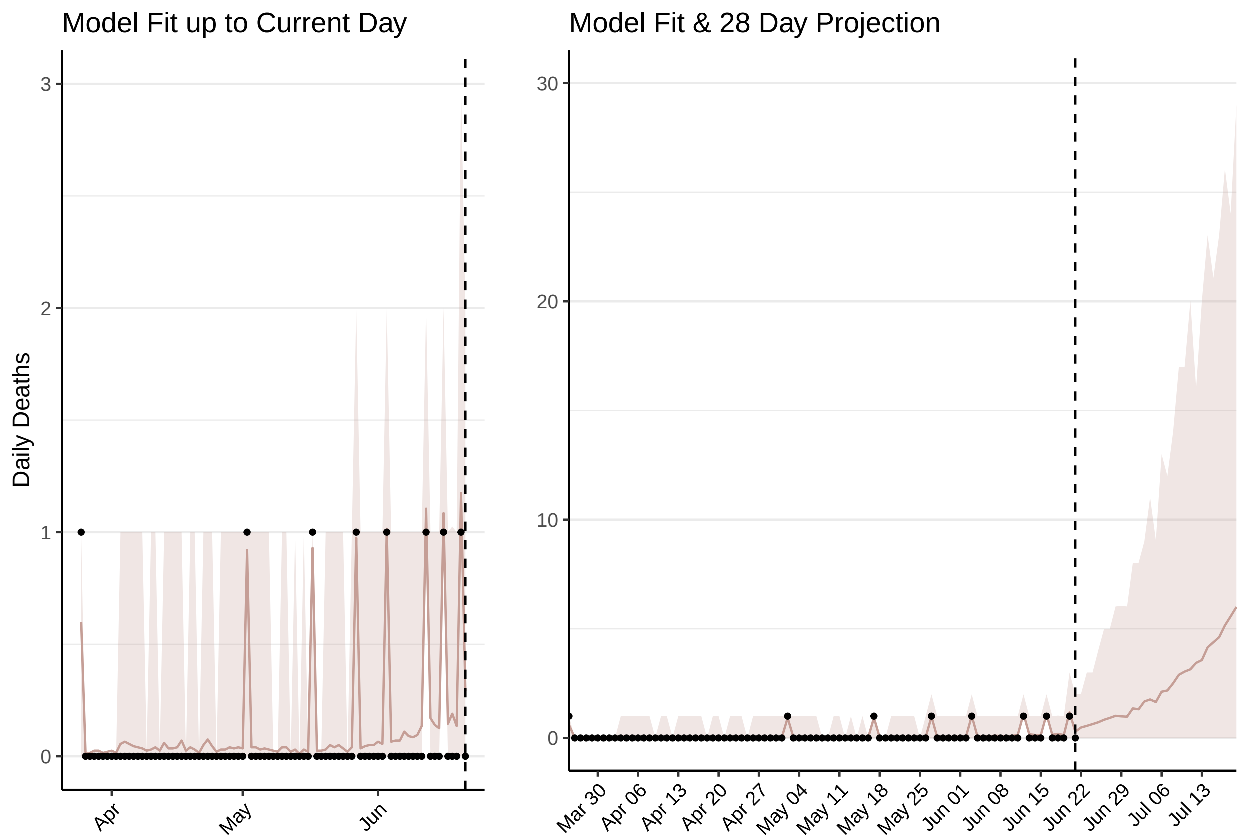


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 24 (95% CI: 22-27) patients requiring treatment with high-pressure oxygen at the current date to 160 (95% CI: 132-187) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 7 (95% CI: 6-8) patients requiring treatment with mechanical ventilation at the current date to 24 (95% CI: 22-27) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

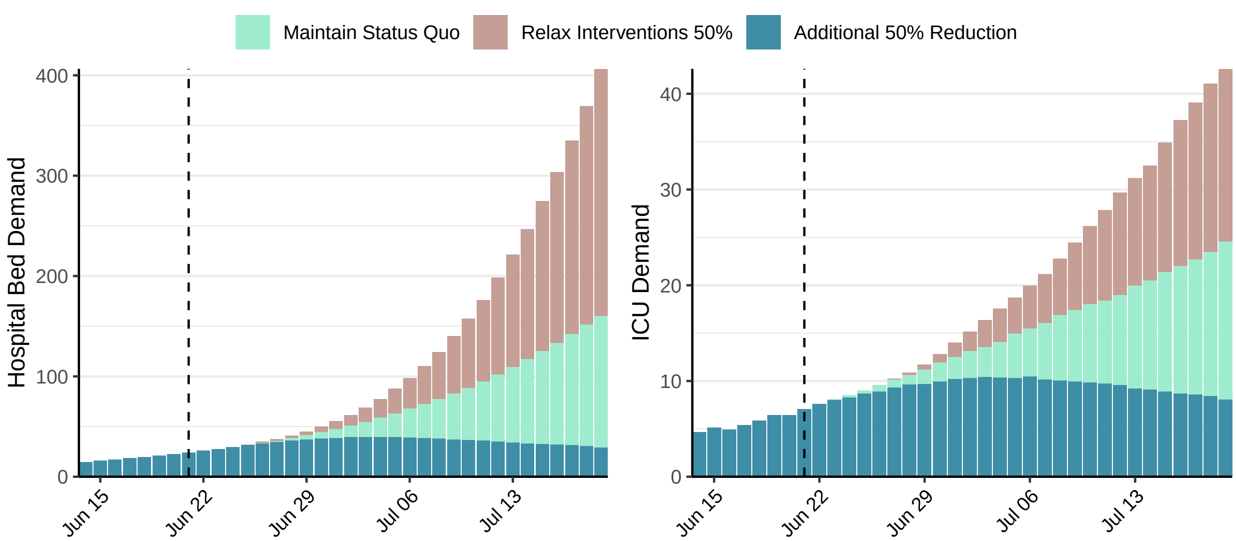


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 267 (95% CI: 233-300) at the current date to 116 (95% CI: 92-139) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 267 (95% CI: 233-300) at the current date to 5,361 (95% CI: 4,685-6,037) by 2020-07-19.

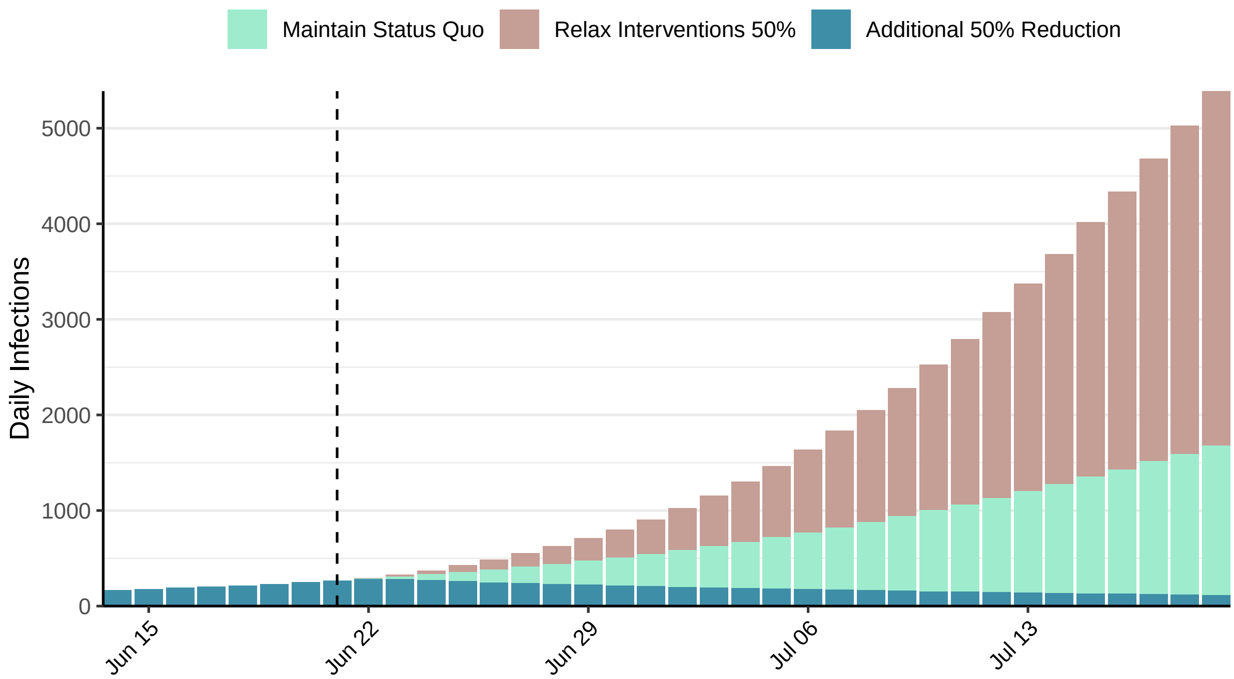


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Costa Rica, 2020-06-21

**Download the report for Costa Rica, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,127 | 69 | 12 | 0 | 1.01 (95% CI: 0.73-1.25) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

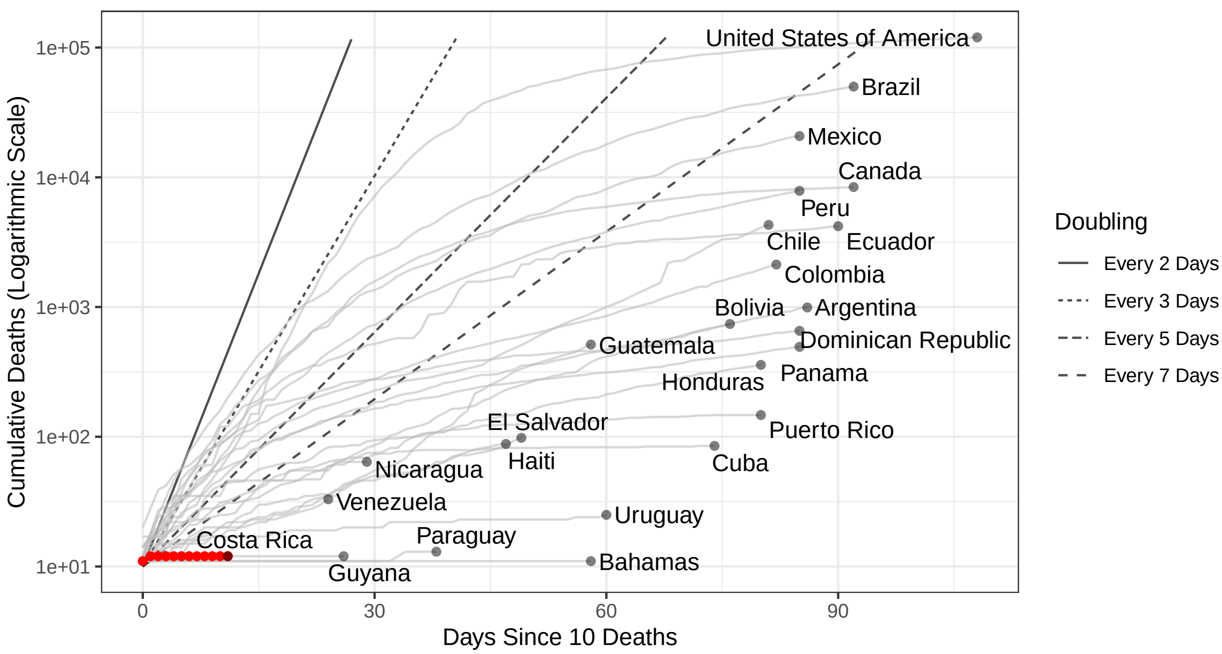


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,102 (95% CI: 972-1,232) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

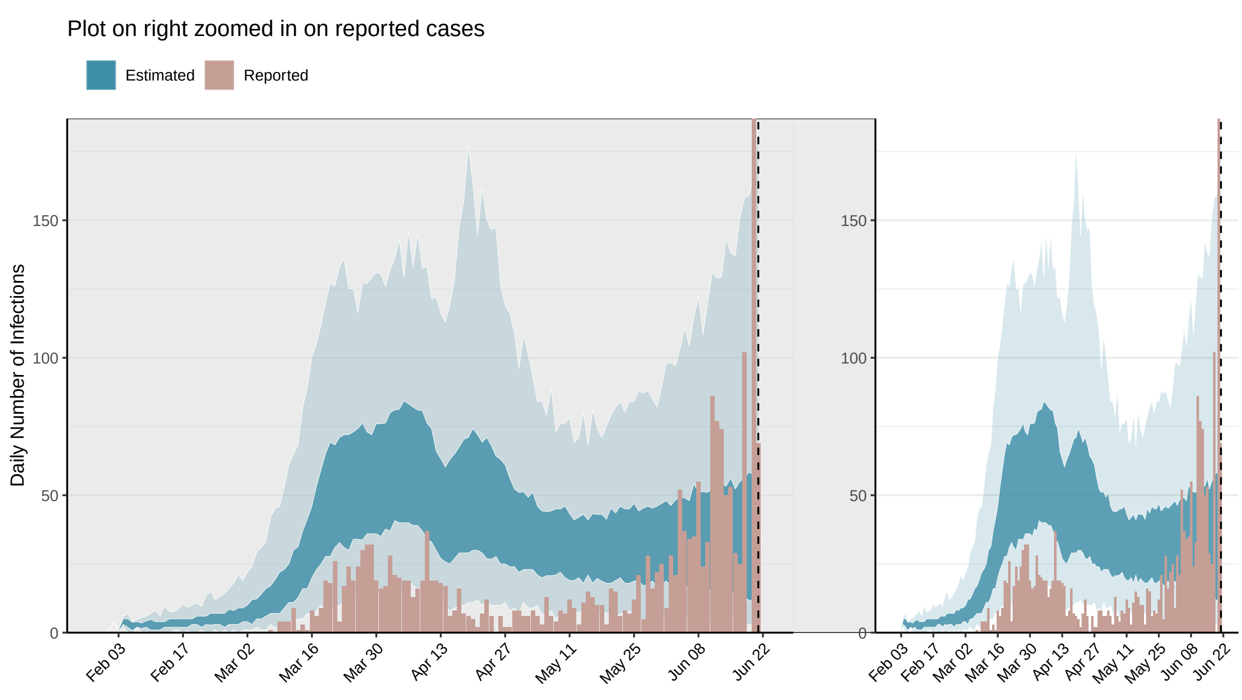


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

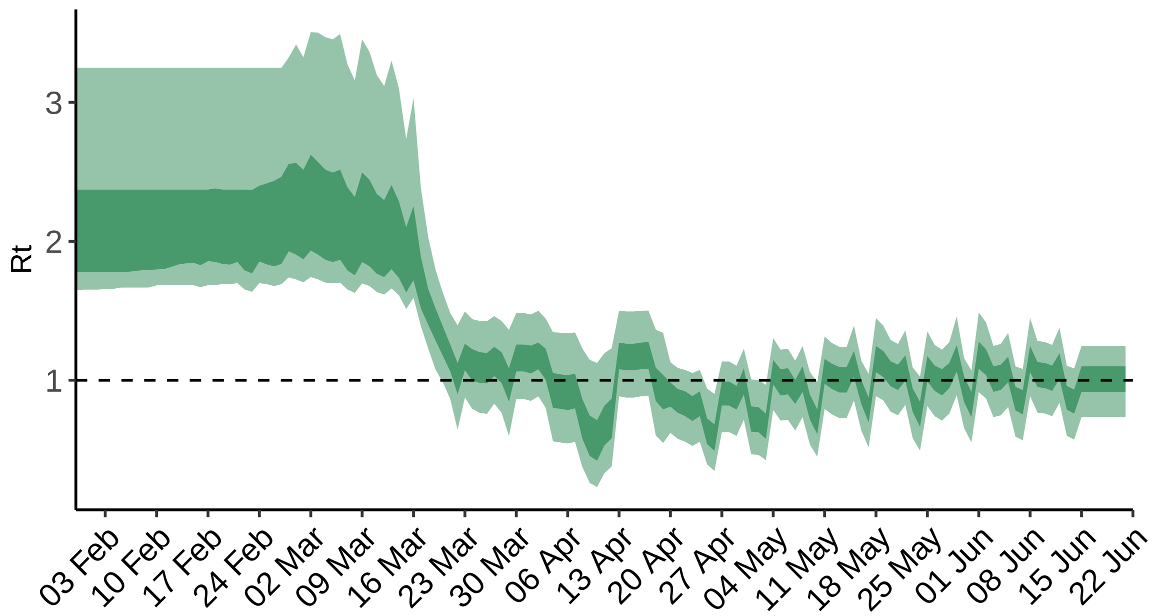


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

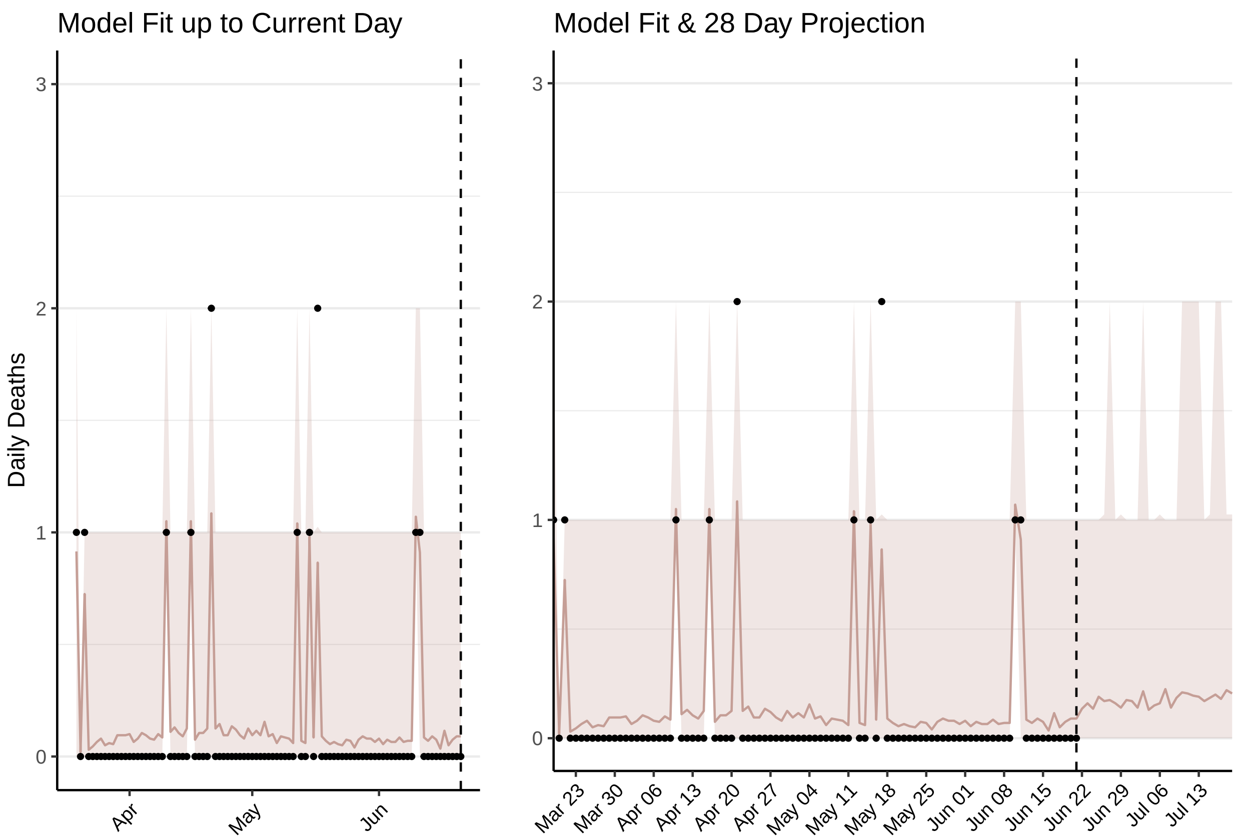


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 7 (95% CI: 6-8) patients requiring treatment with high-pressure oxygen at the current date to 10 (95% CI: 8-12) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2 (95% CI: 2-3) patients requiring treatment with mechanical ventilation at the current date to 3 (95% CI: 3-4) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

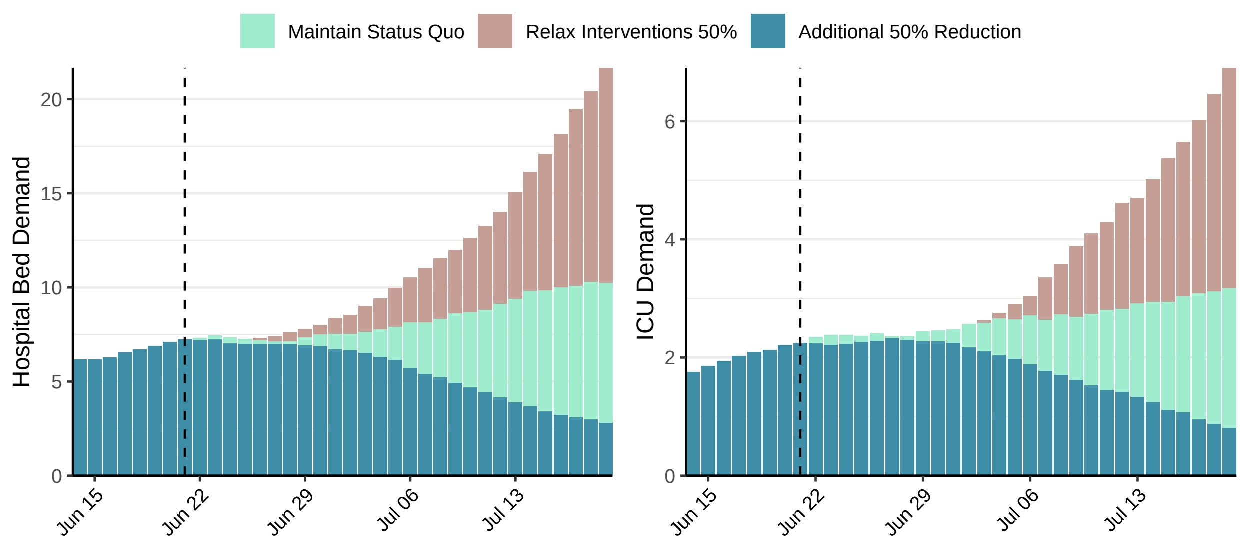


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 46 (95% CI: 39-53) at the current date to 6 (95% CI: 5-7) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 46 (95% CI: 39-53) at the current date to 238 (95% CI: 184-292) by 2020-07-19.

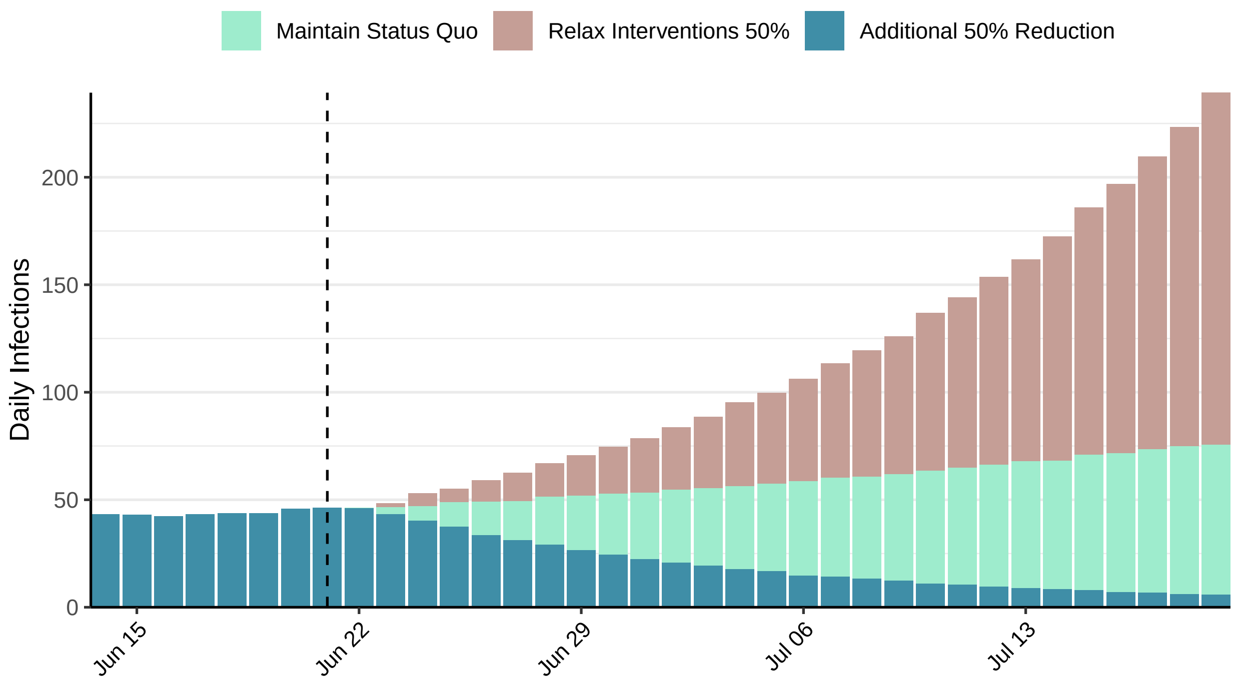


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Cuba, 2020-06-21

**Download the report for Cuba, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,309 | 4 | 85 | 0 | 0.67 (95% CI: 0.26-1.05) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

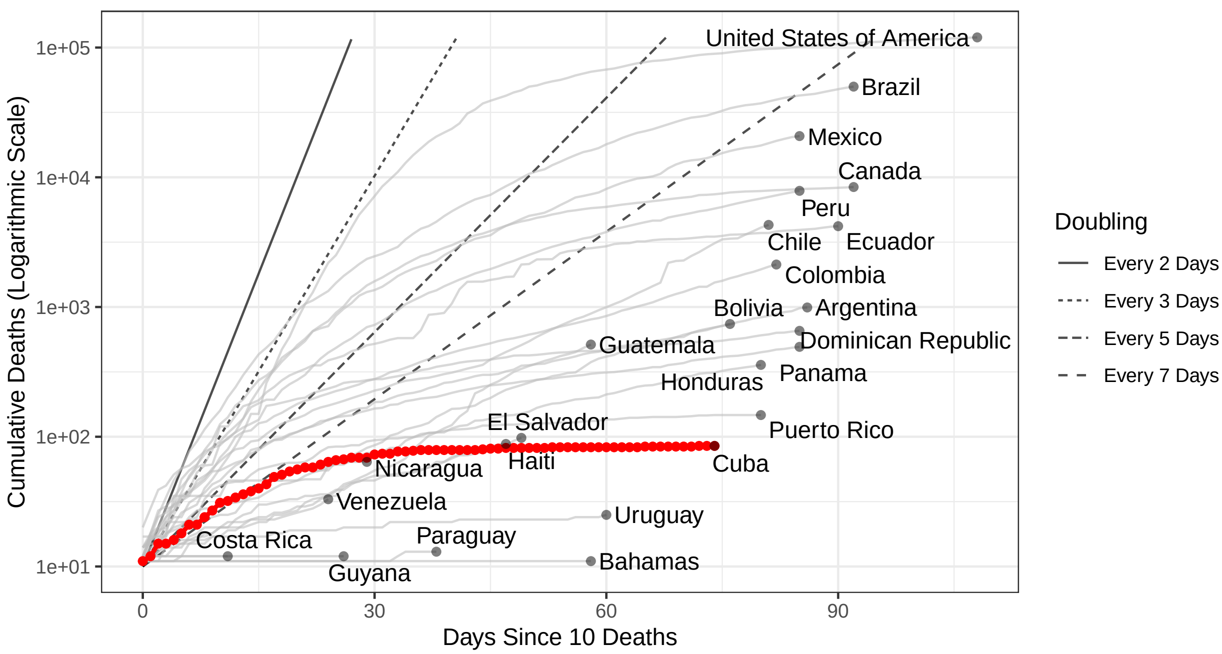


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 646 (95% CI: 580-711) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

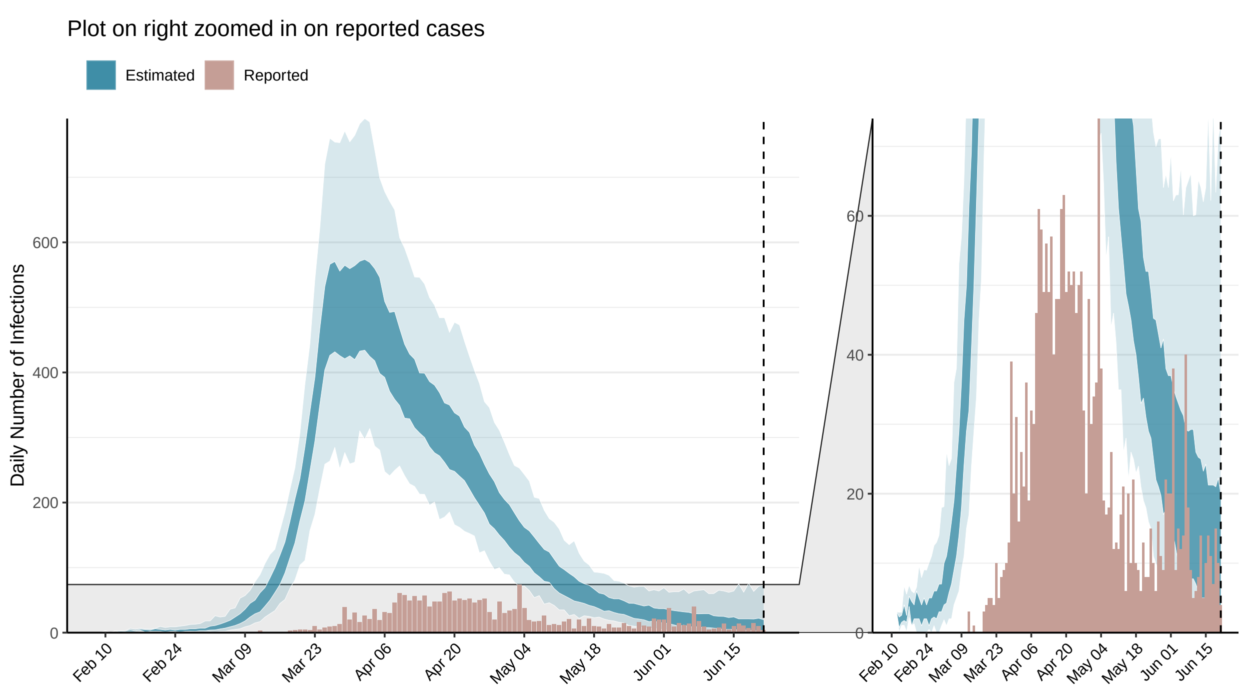


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

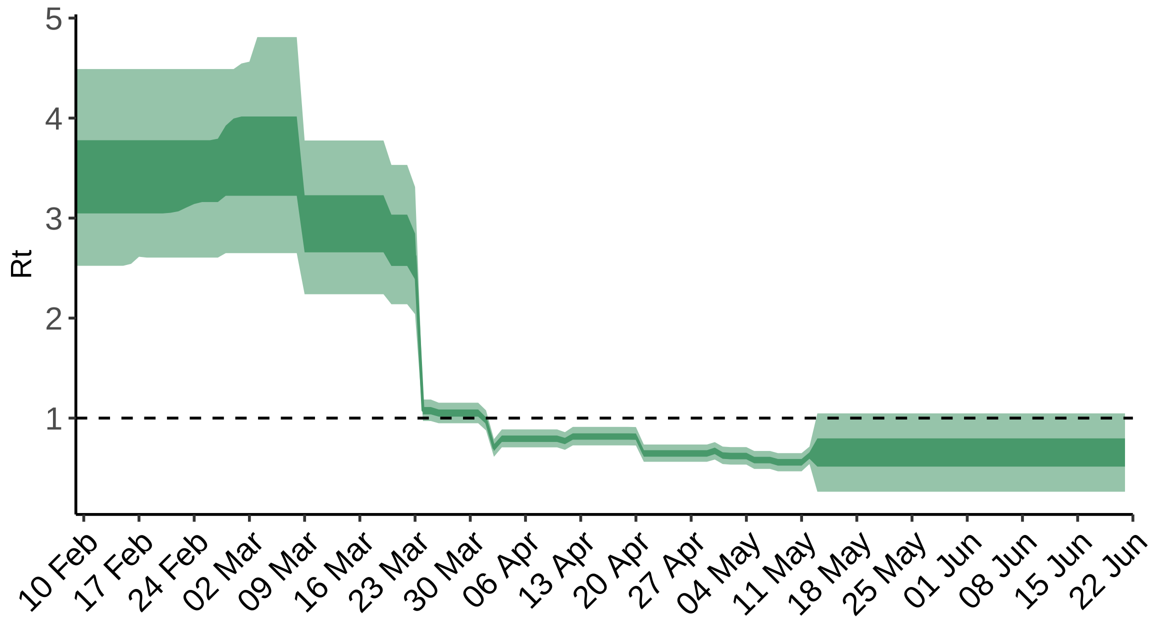


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

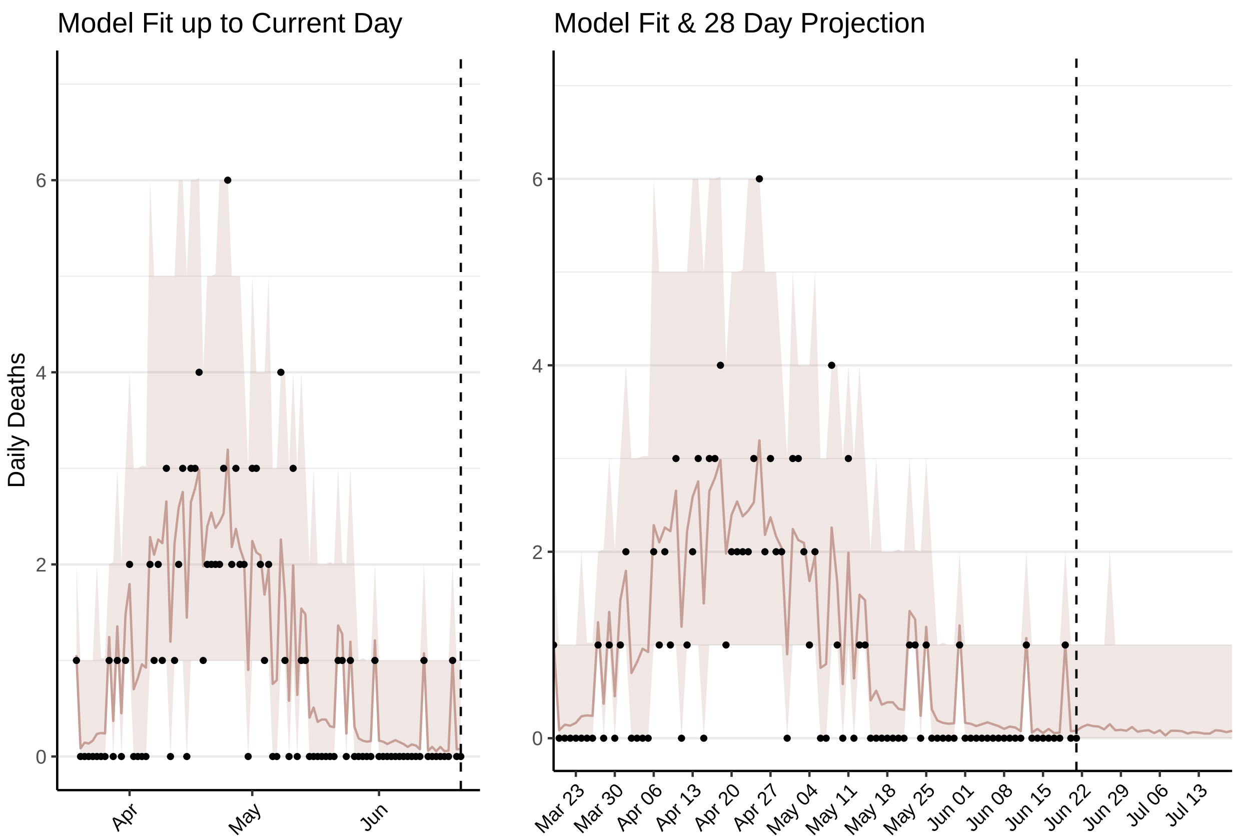


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4 (95% CI: 4-5) patients requiring treatment with high-pressure oxygen at the current date to 2 (95% CI: 2-3) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2 (95% CI: 1-2) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 1-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

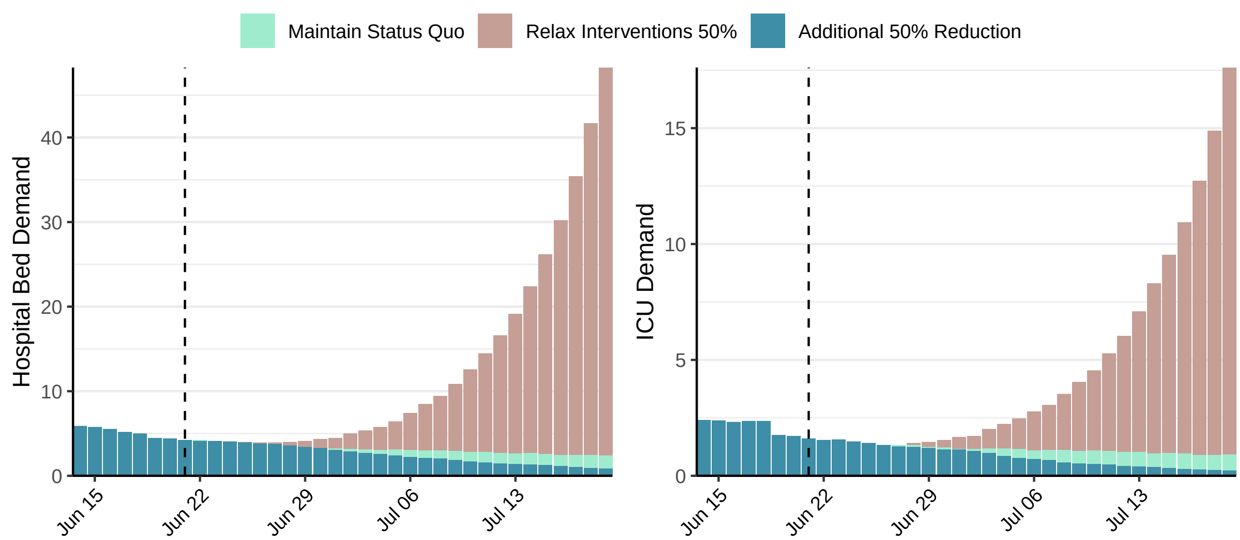


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 15 (95% CI: 12-18) at the current date to 1 (95% CI: 1-1) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 15 (95% CI: 12-18) at the current date to 913 (95% CI: 561-1,264) by 2020-07-19.

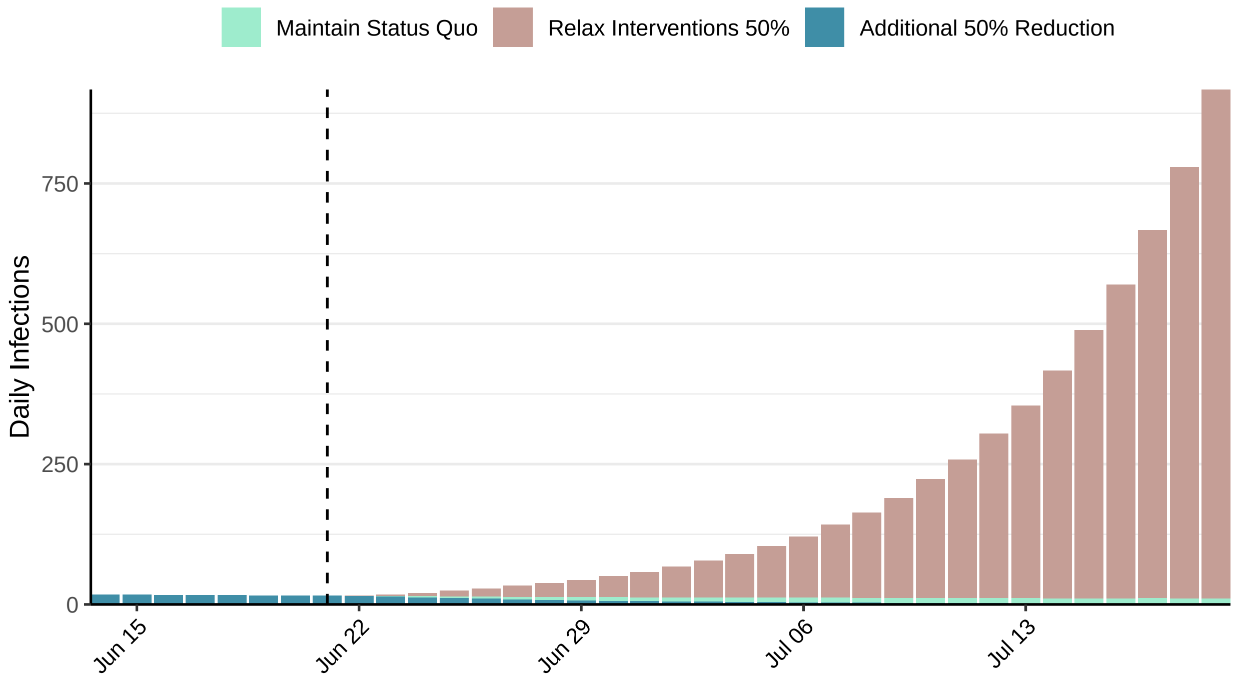


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Djibouti, 2020-06-21

**Download the report for Djibouti, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 4,565 | 0 | 45 | 0 | 0.87 (95% CI: 0.57-1.11) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

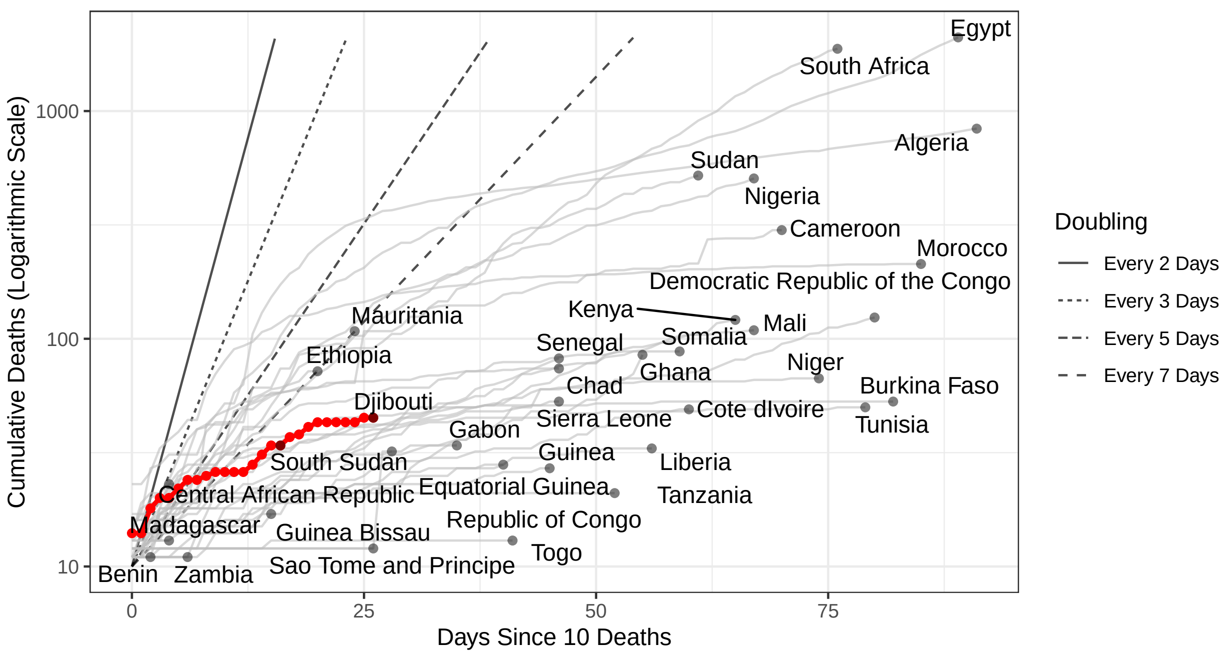


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 11,957 (95% CI: 11,265-12,649) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

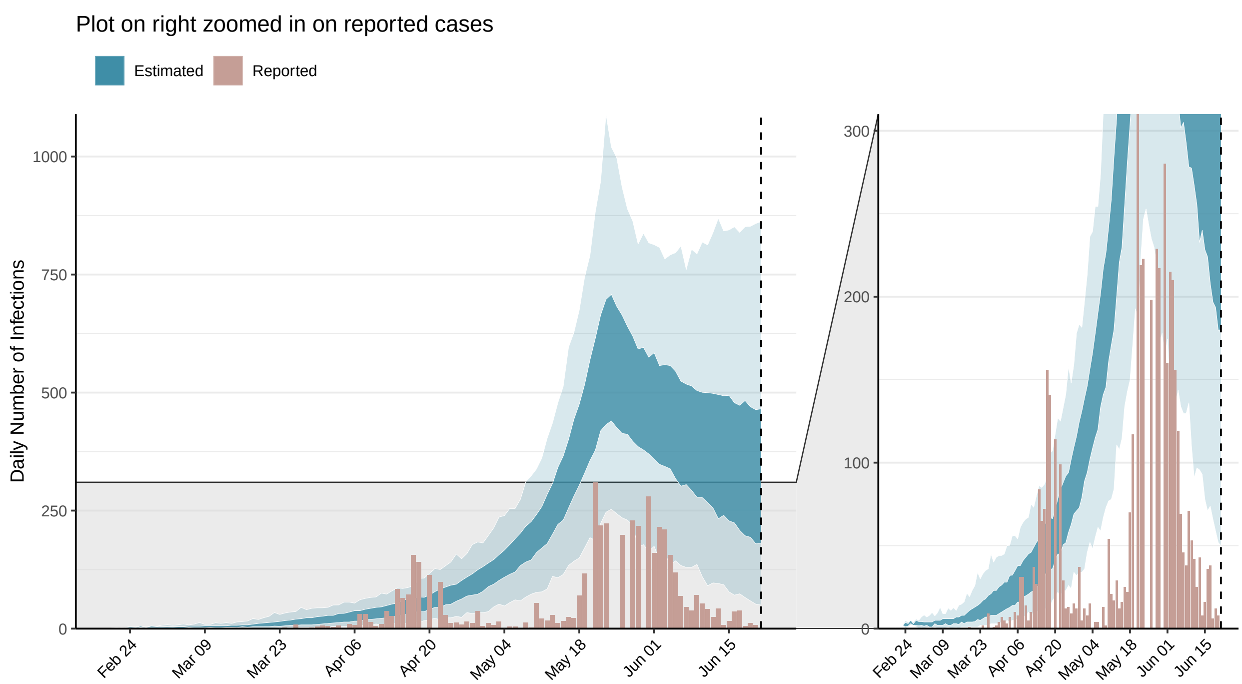


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

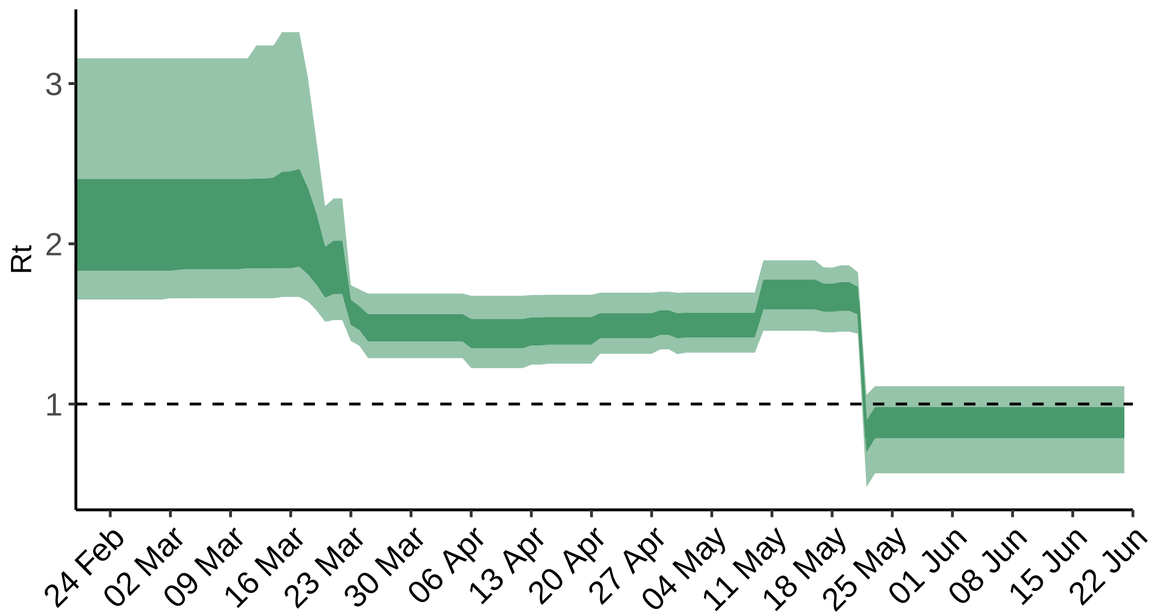


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

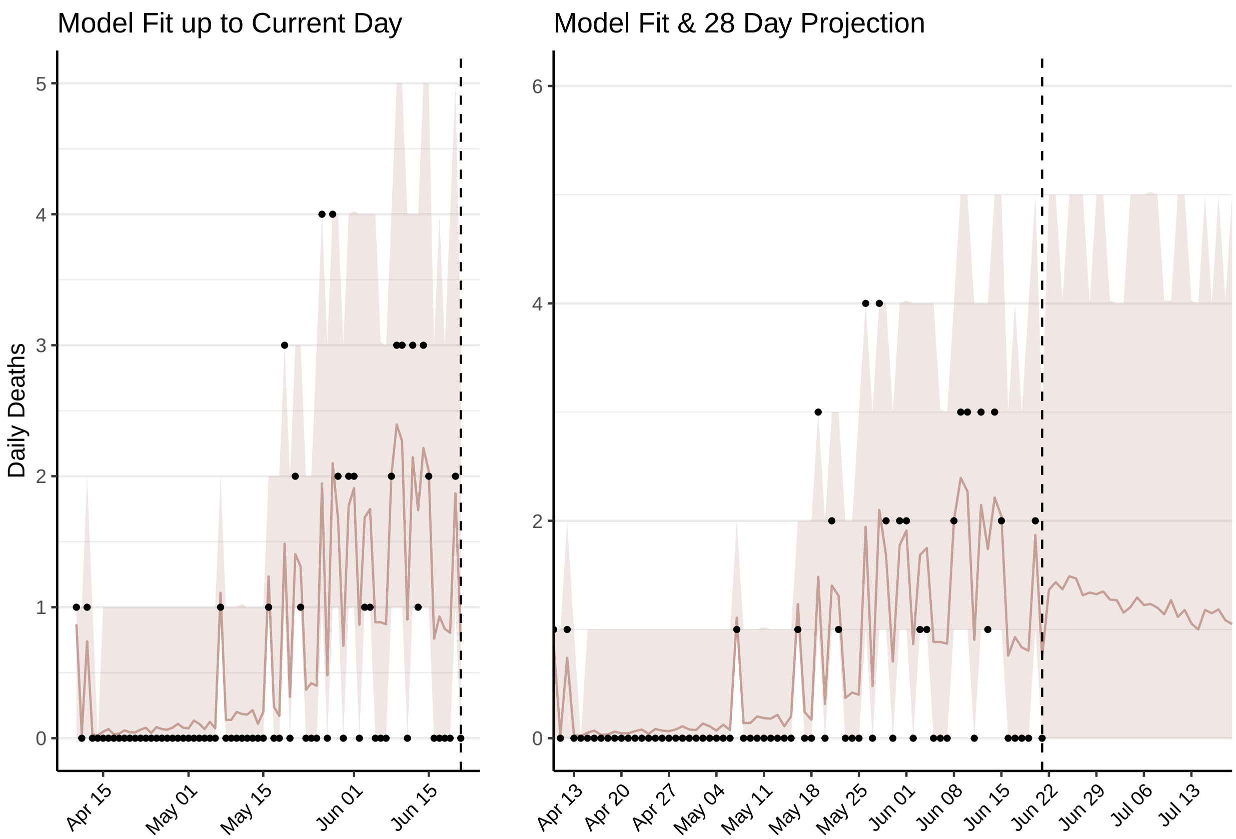


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 72 (95% CI: 67-76) patients requiring treatment with high-pressure oxygen at the current date to 53 (95% CI: 46-60) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 21 (95% CI: 19-22) patients requiring treatment with mechanical ventilation at the current date to 15 (95% CI: 13-16) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

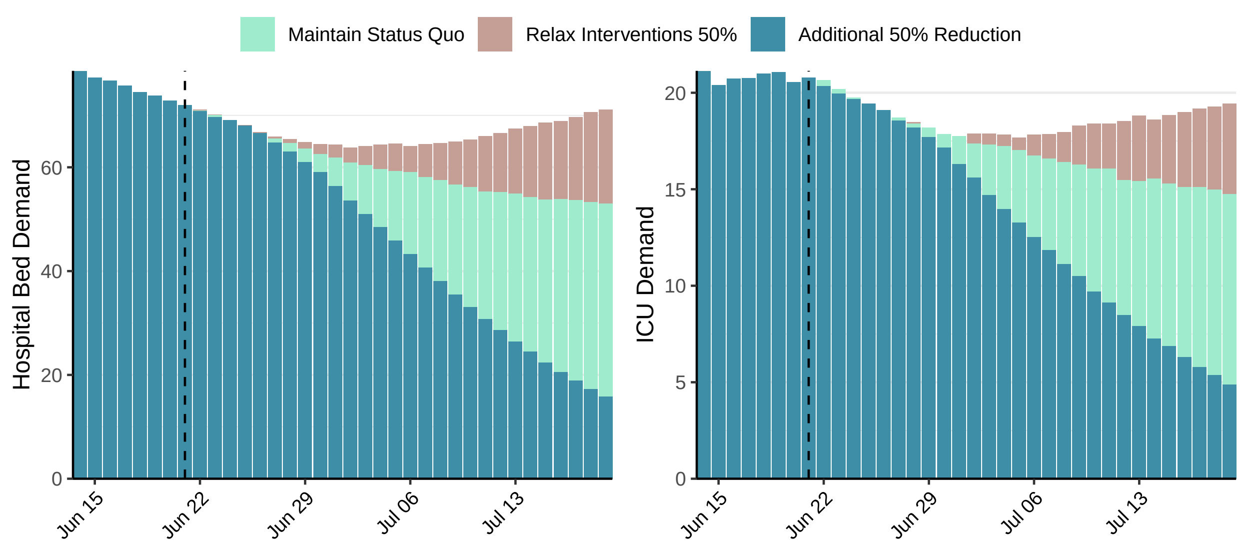


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 345 (95% CI: 314-376) at the current date to 25 (95% CI: 21-28) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 345 (95% CI: 314-376) at the current date to 445 (95% CI: 374-516) by 2020-07-19.

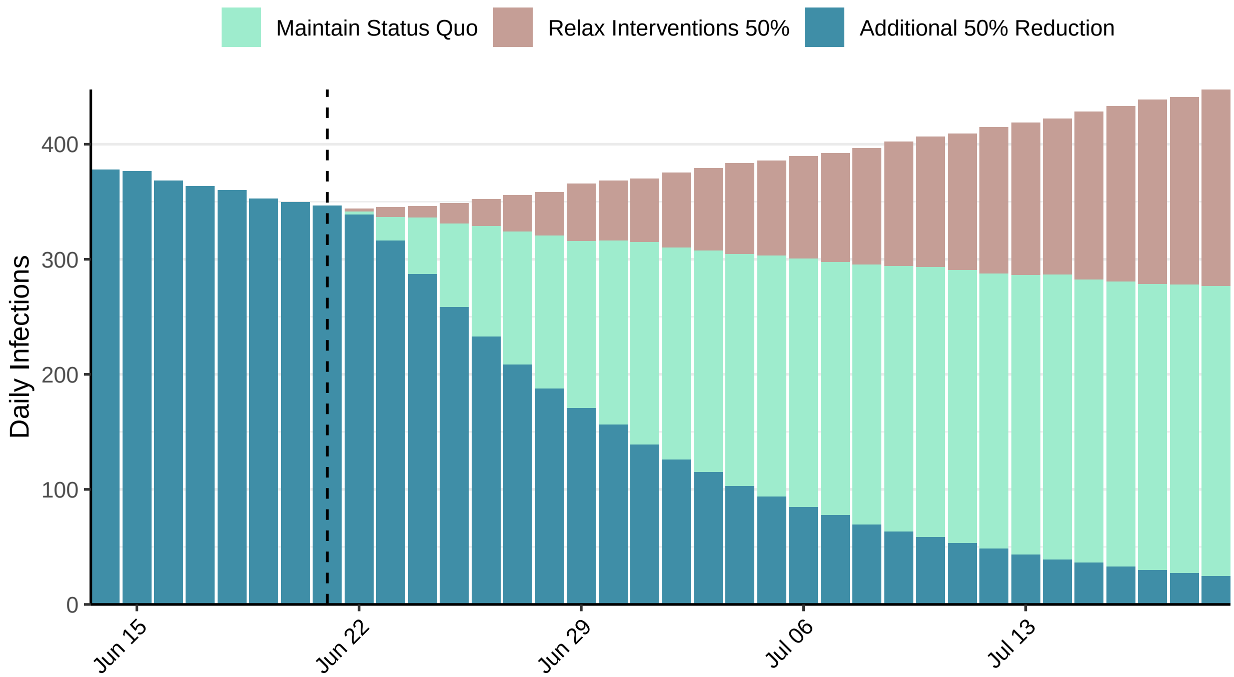


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Dominican Republic, 2020-06-21

**Download the report for Dominican Republic, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 25,778 | 710 | 655 | 8 | 1.49 (95% CI: 1.4-1.61) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

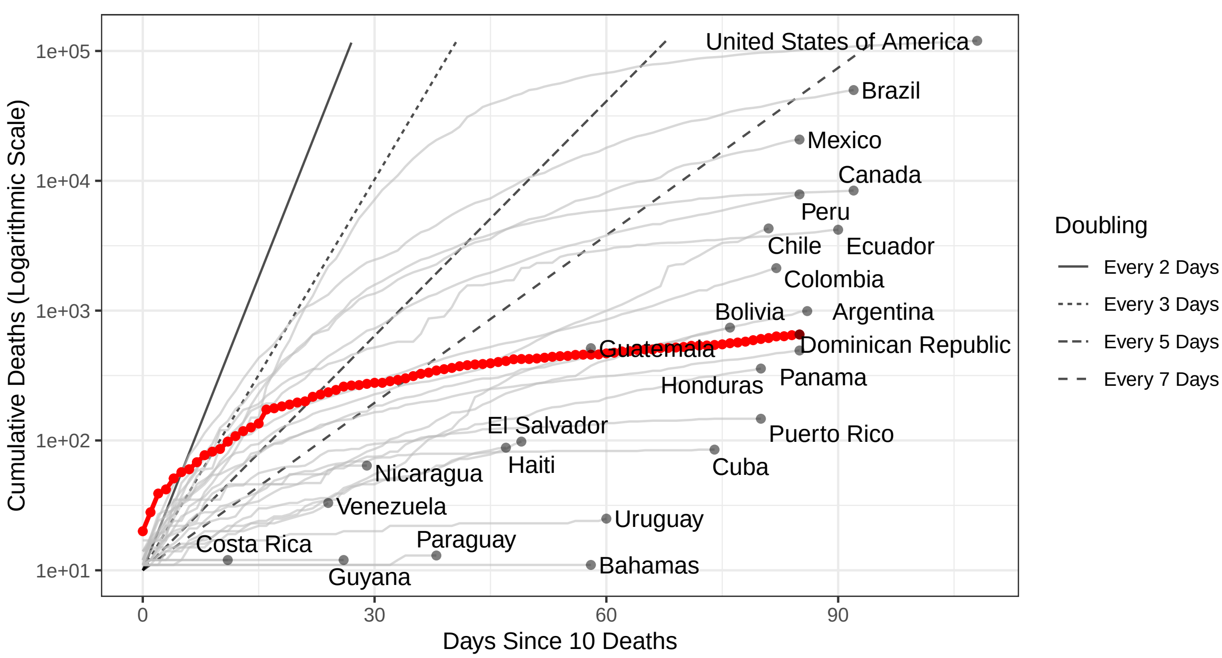


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 132,209 (95% CI: 128,384-136,035) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

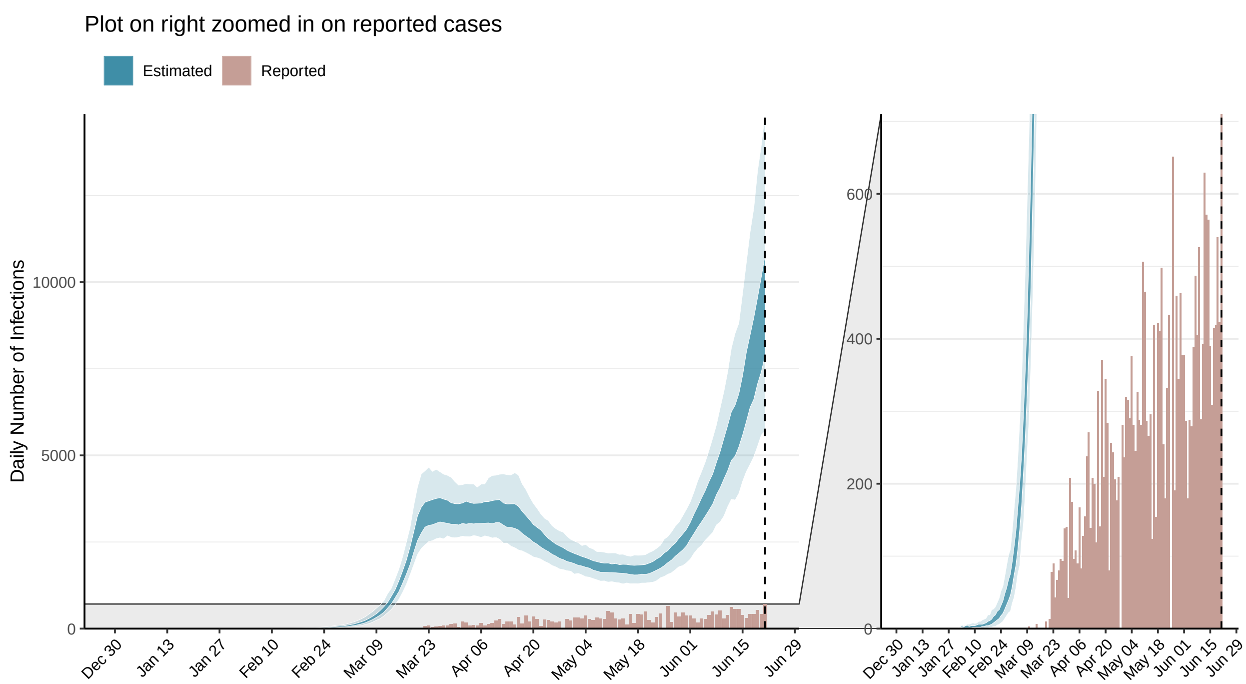


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

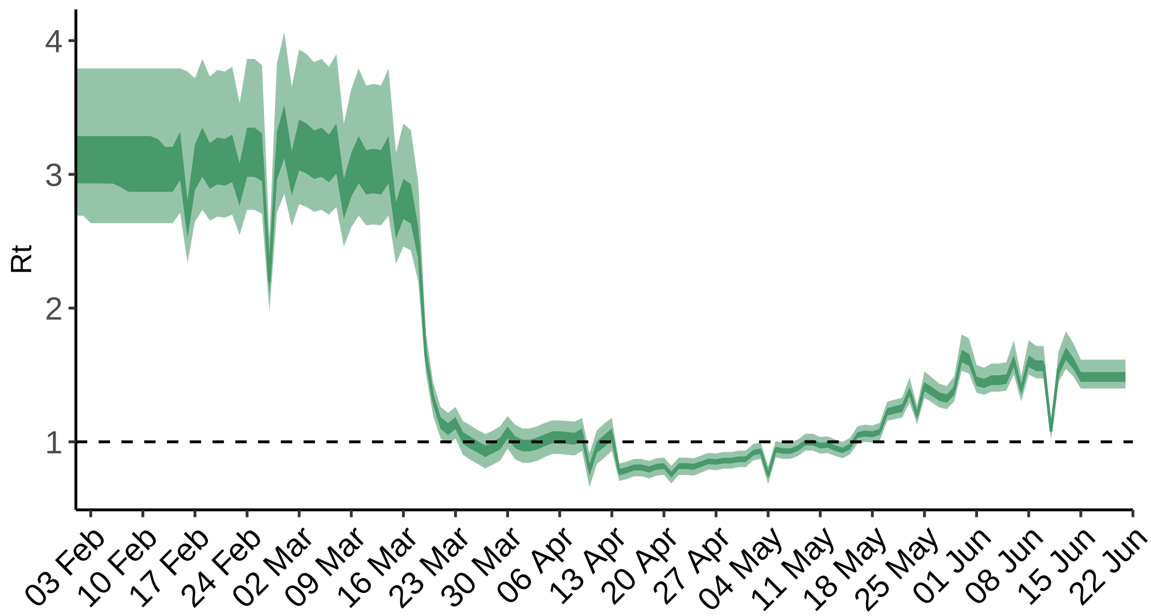


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Dominican Republic is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

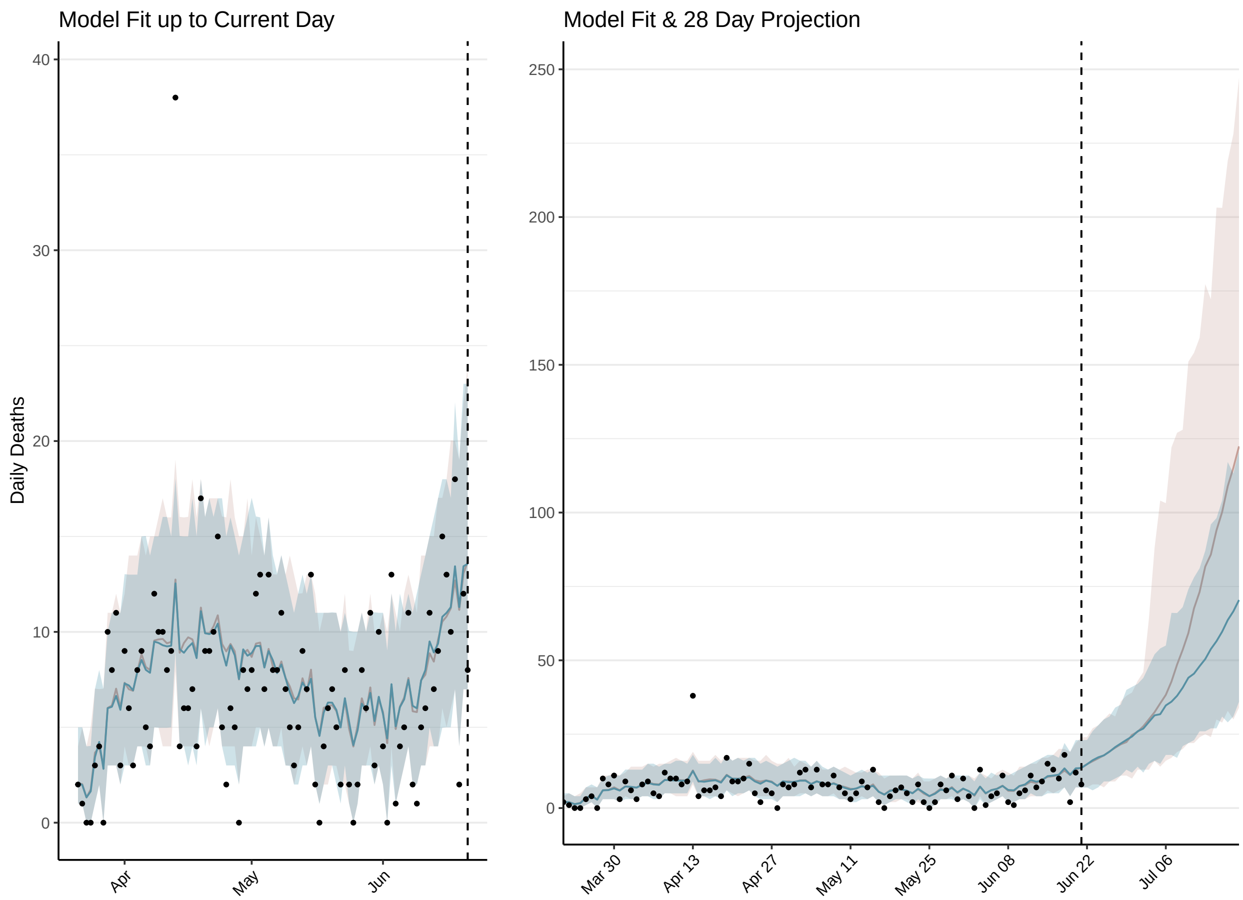


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 758 (95% CI: 735-781) patients requiring treatment with high-pressure oxygen at the current date to 3,617 (95% CI: 3,449-3,785) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 228 (95% CI: 221-235) patients requiring treatment with mechanical ventilation at the current date to 760 (95% CI: 746-773) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

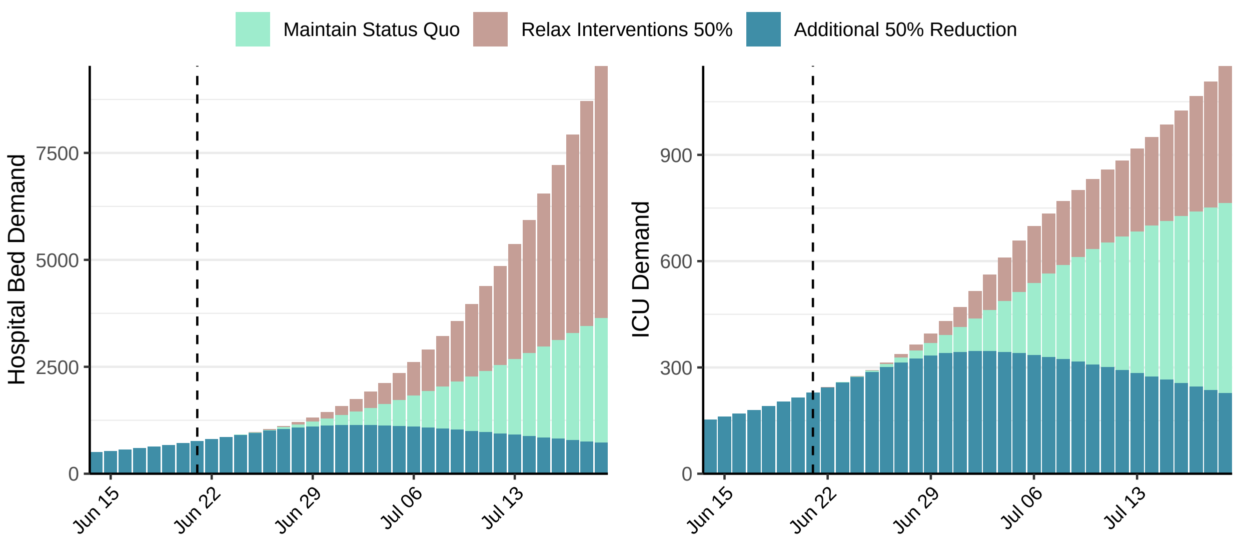


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 9,408 (95% CI: 9,073-9,742) at the current date to 2,756 (95% CI: 2,614-2,898) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 9,408 (95% CI: 9,073-9,742) at the current date to 132,705 (95% CI: 127,758-137,653) by 2020-07-19.

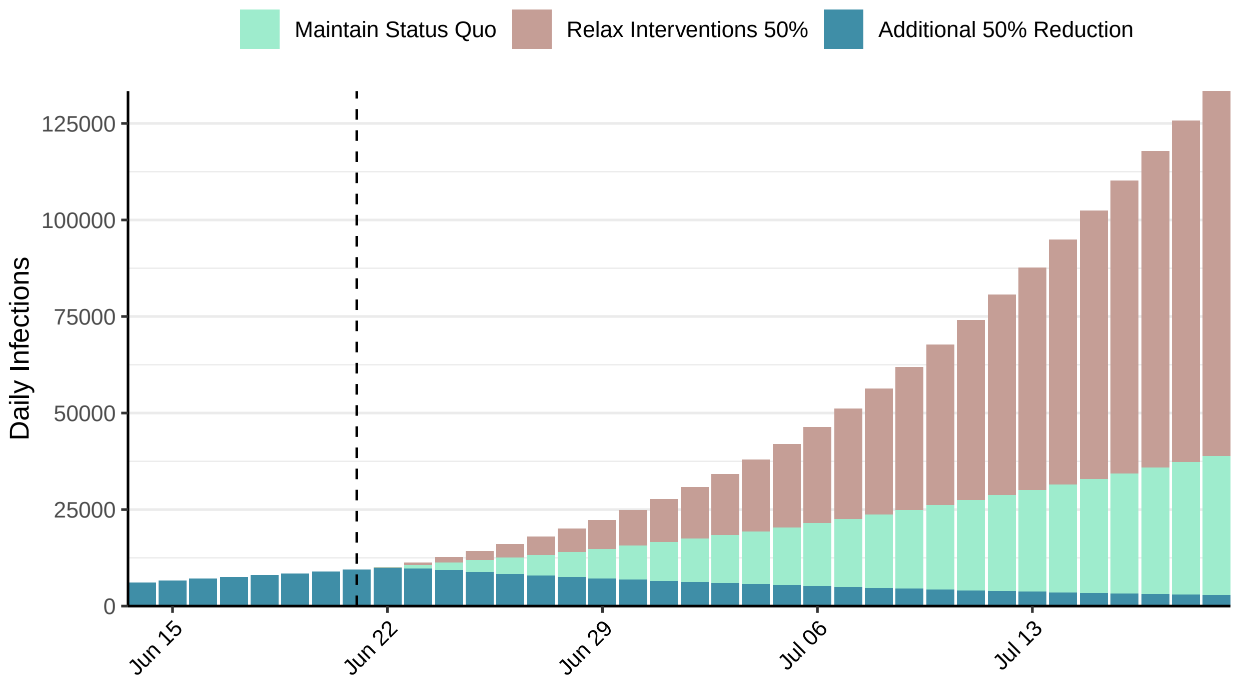


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Algeria, 2020-06-21

**Download the report for Algeria, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 11,631 | 127 | 837 | 12 | 1.4 (95% CI: 1.31-1.49) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

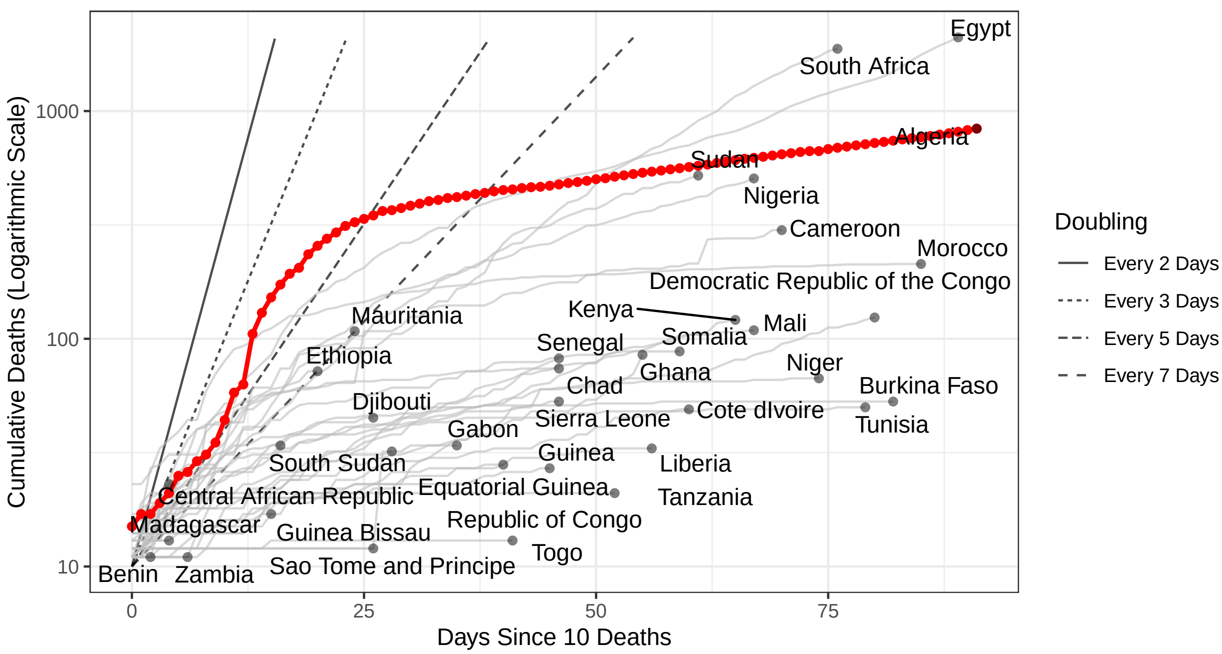


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 119,694 (95% CI: 116,155-123,233) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

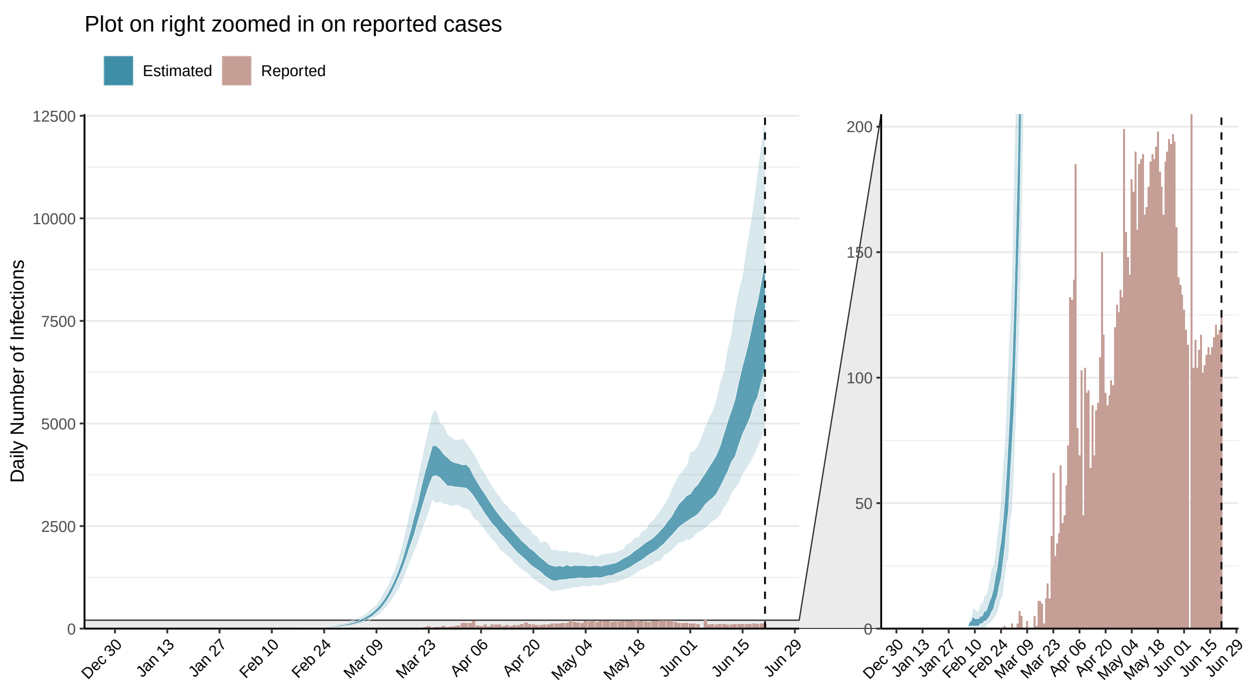


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

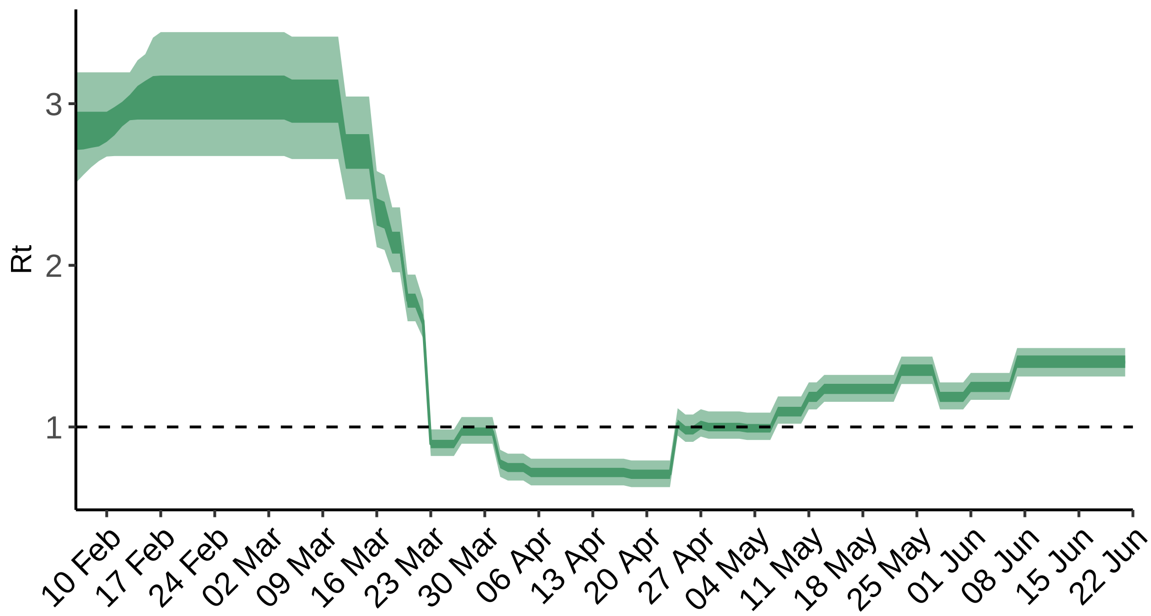


Figure 3: **Time-varying reproduction number,** $R_t$**.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

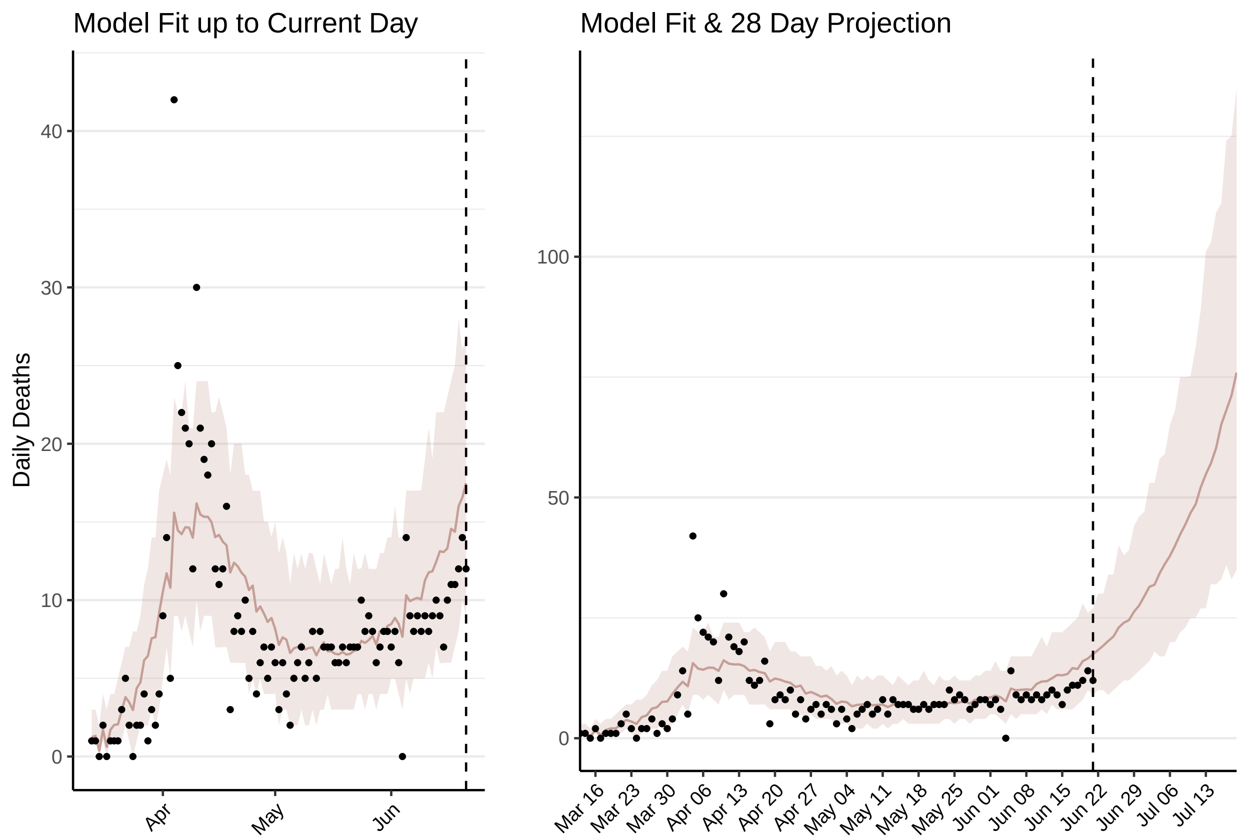


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,039 (95% CI: 1,007-1,071) patients requiring treatment with high-pressure oxygen at the current date to 4,514 (95% CI: 4,297-4,730) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 276 (95% CI: 267-285) patients requiring treatment with mechanical ventilation at the current date to 1,212 (95% CI: 1,154-1,270) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

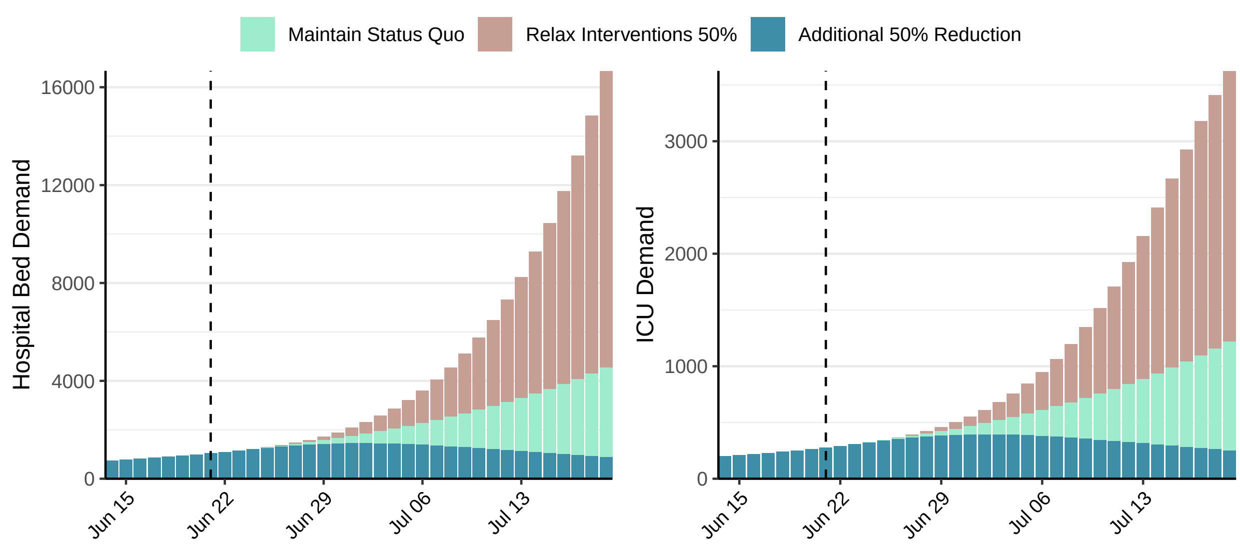


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 7,727 (95% CI: 7,450-8,005) at the current date to 2,190 (95% CI: 2,079-2,301) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 7,727 (95% CI: 7,450-8,005) at the current date to 209,743 (95% CI: 198,875-220,612) by 2020-07-19.

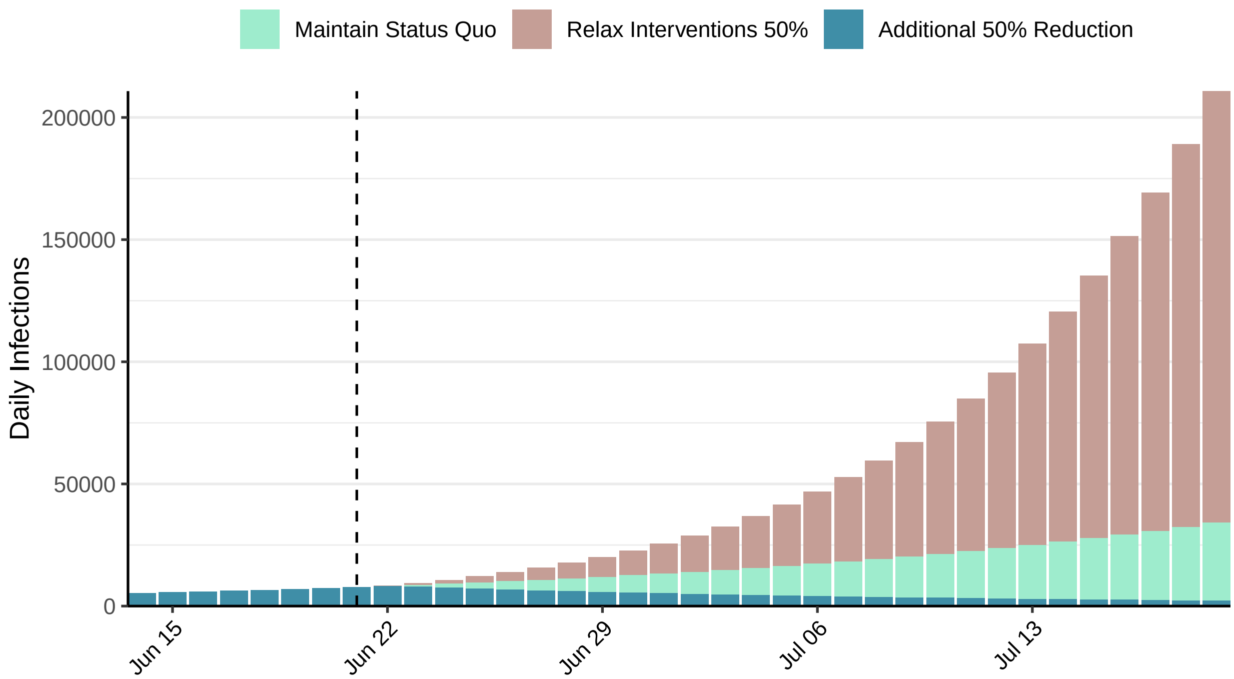


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Ecuador, 2020-06-21

**Download the report for Ecuador, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 50,183 | 452 | 4,199 | 43 | 1.42 (95% CI: 1.36-1.47) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

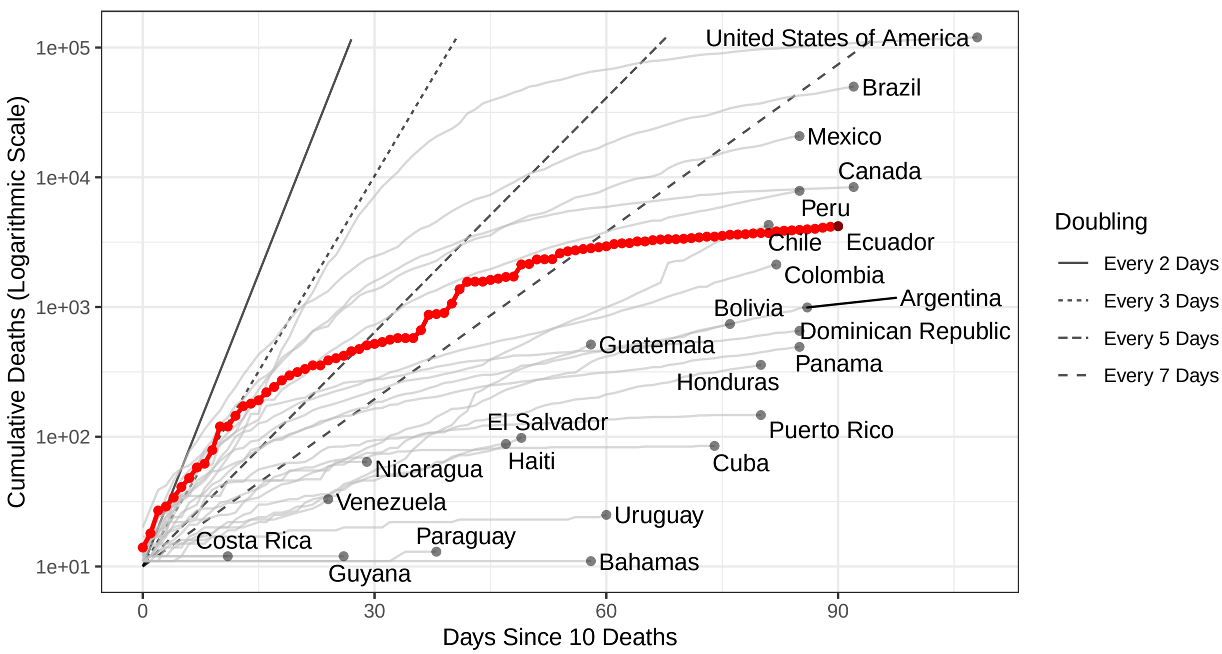


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 551,502 (95% CI: 540,212-562,791) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match). **N.B. Ecuador has revised their historic reported cases and thus have reported negative cases.**

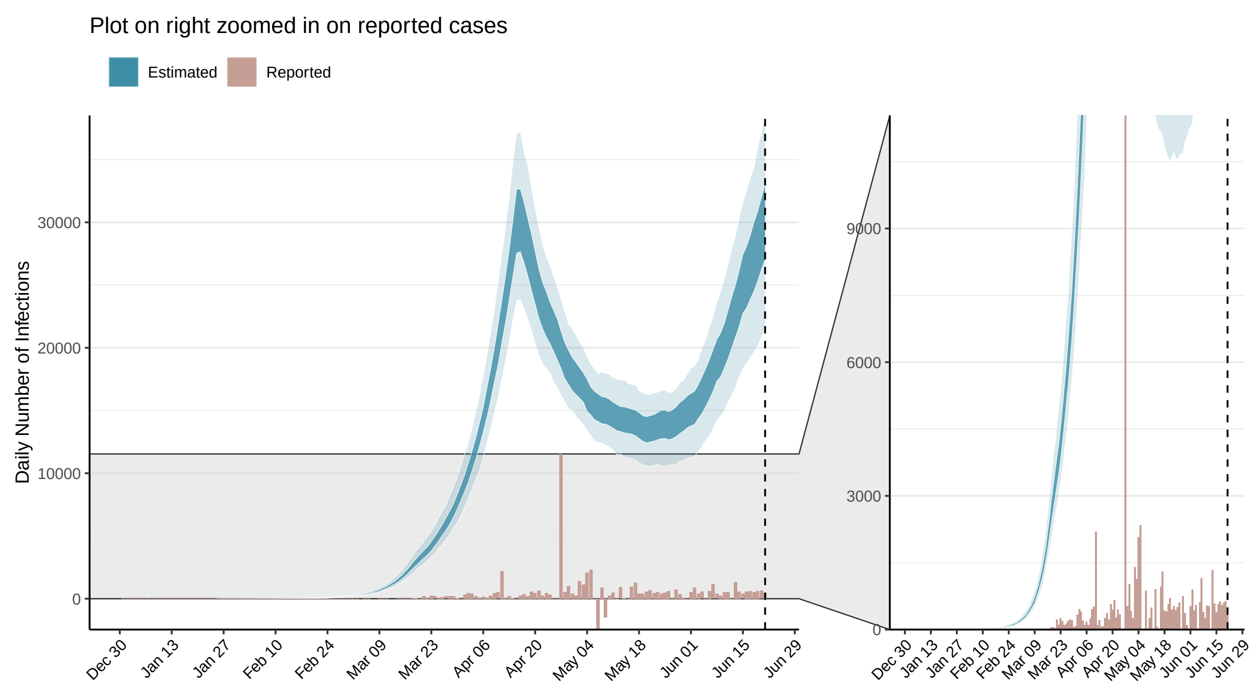


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

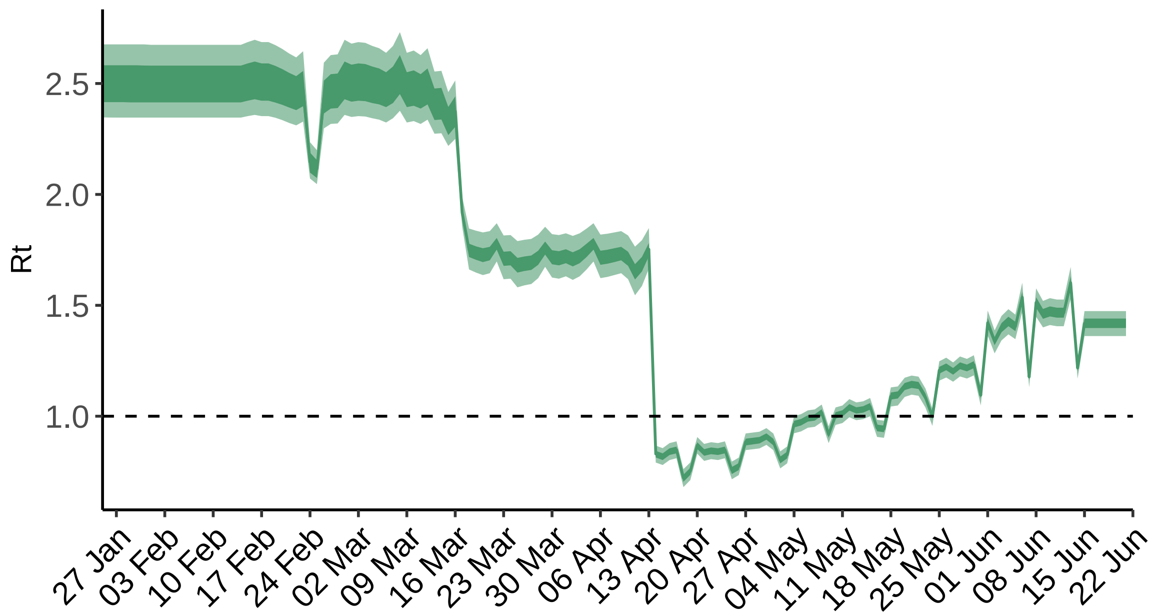


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Ecuador is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

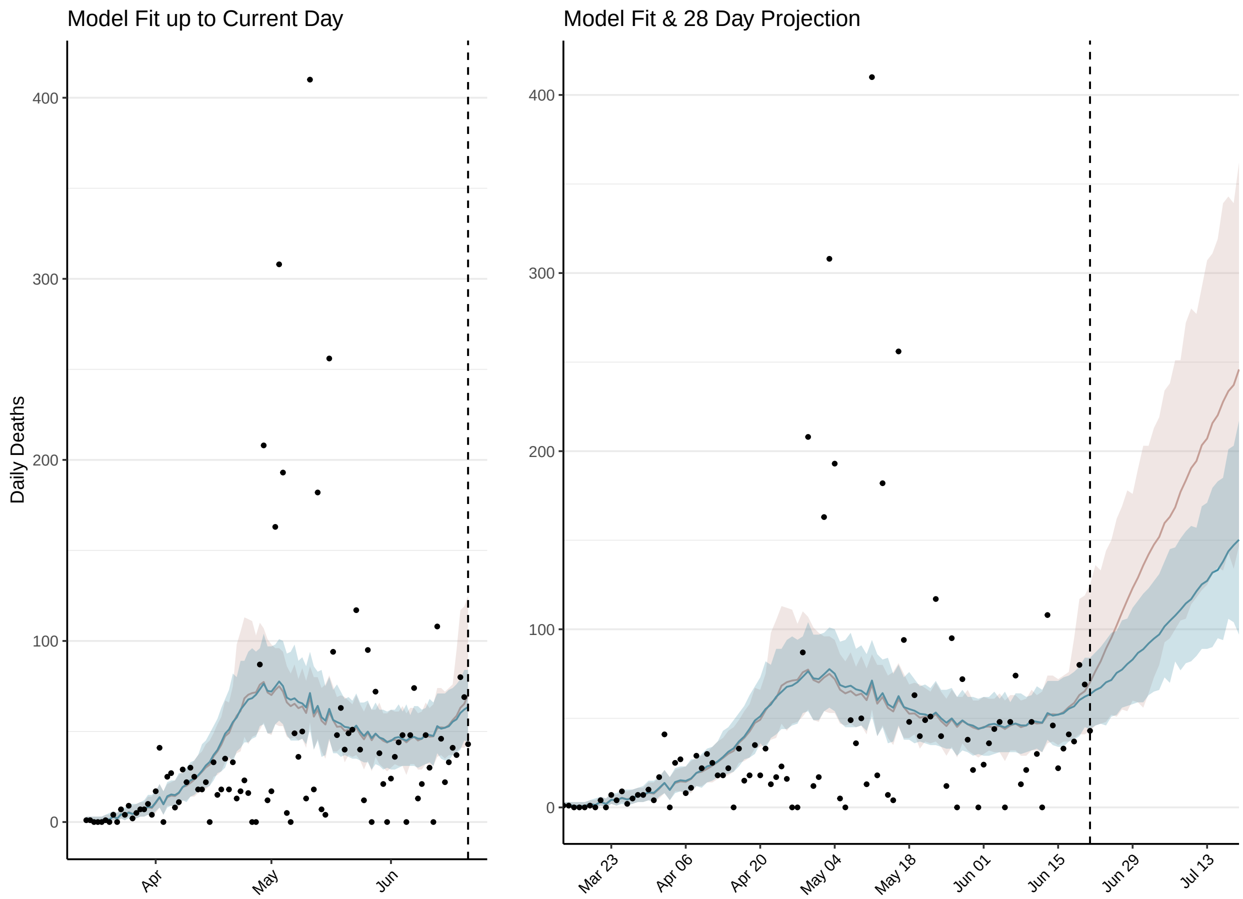


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 3,216 (95% CI: 3,148-3,284) patients requiring treatment with high-pressure oxygen at the current date to 7,347 (95% CI: 7,158-7,535) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 966 (95% CI: 948-984) patients requiring treatment with mechanical ventilation at the current date to 1,239 (95% CI: 1,224-1,253) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

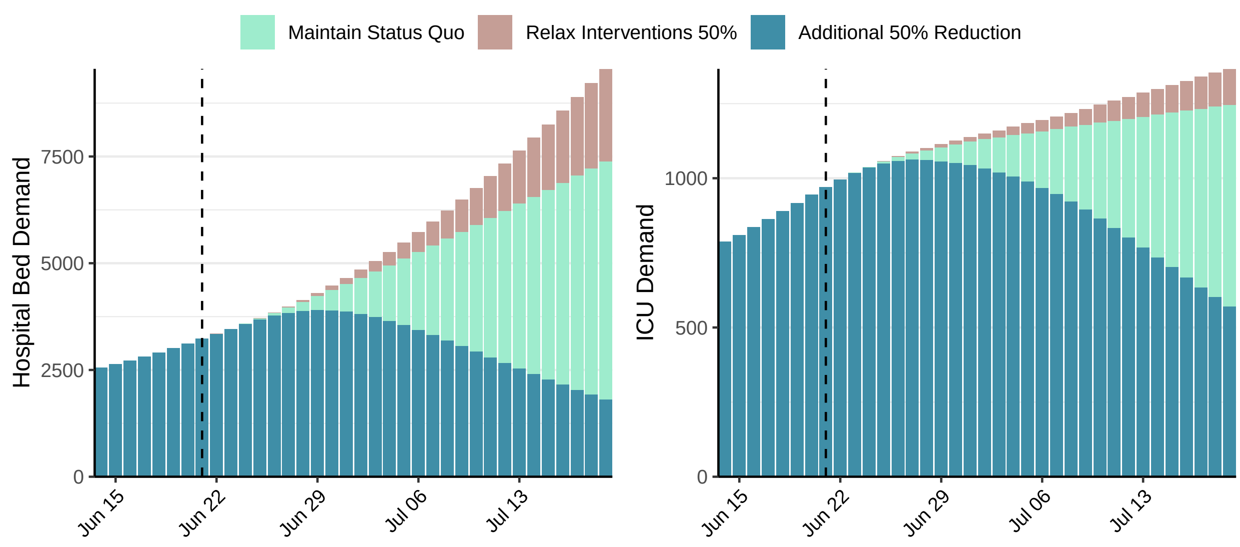


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 29,874 (95% CI: 29,194-30,554) at the current date to 4,801 (95% CI: 4,668-4,933) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 29,874 (95% CI: 29,194-30,554) at the current date to 82,088 (95% CI: 80,096-84,079) by 2020-07-19.

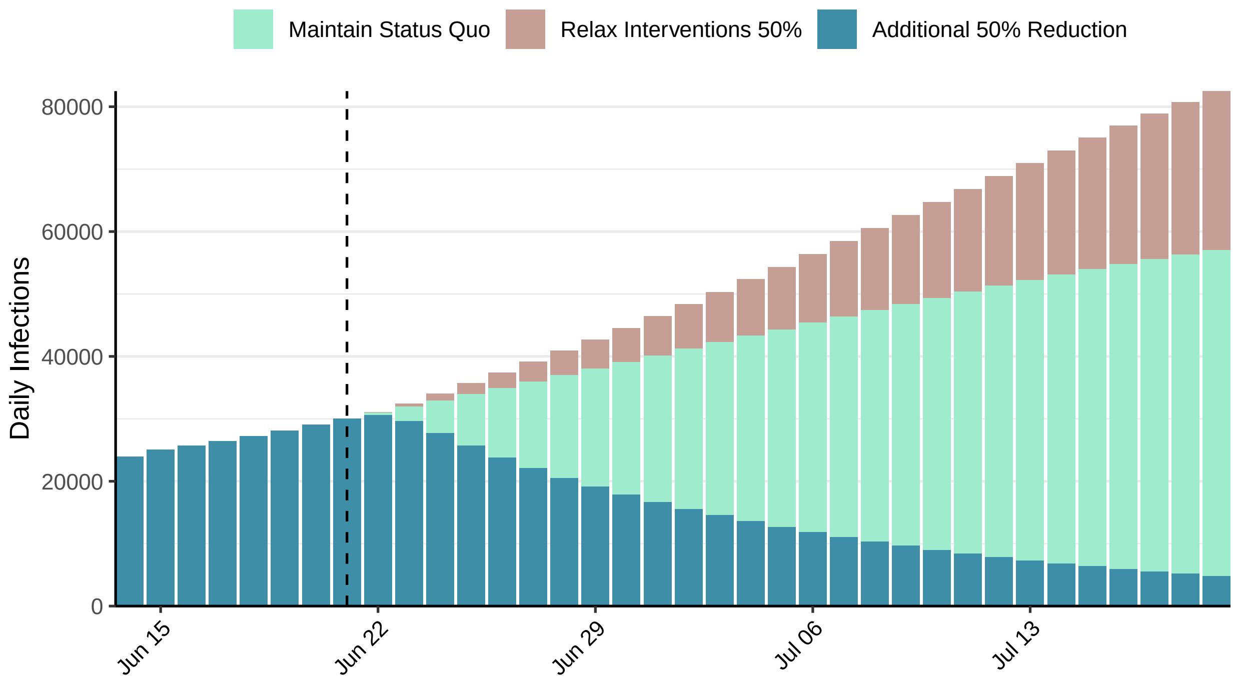


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Egypt, 2020-06-21

**Download the report for Egypt, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 53,758 | 1,547 | 2,106 | 89 | 1.46 (95% CI: 1.37-1.57) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

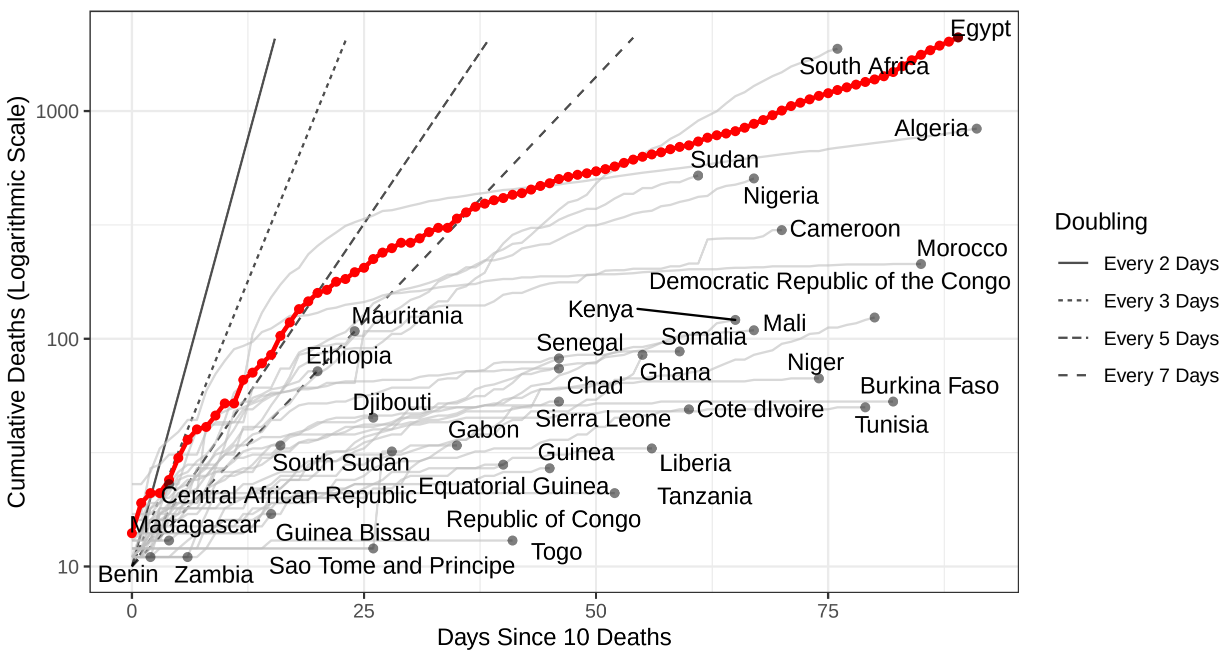


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 746,859 (95% CI: 726,028-767,690) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

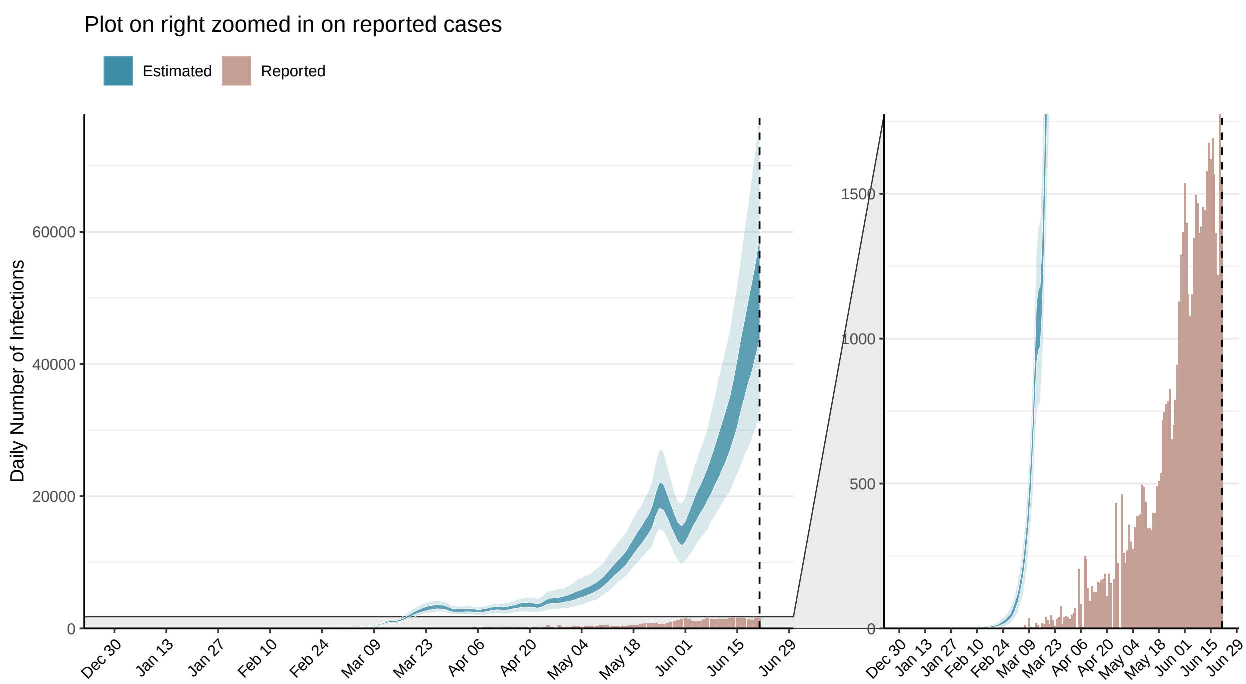


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

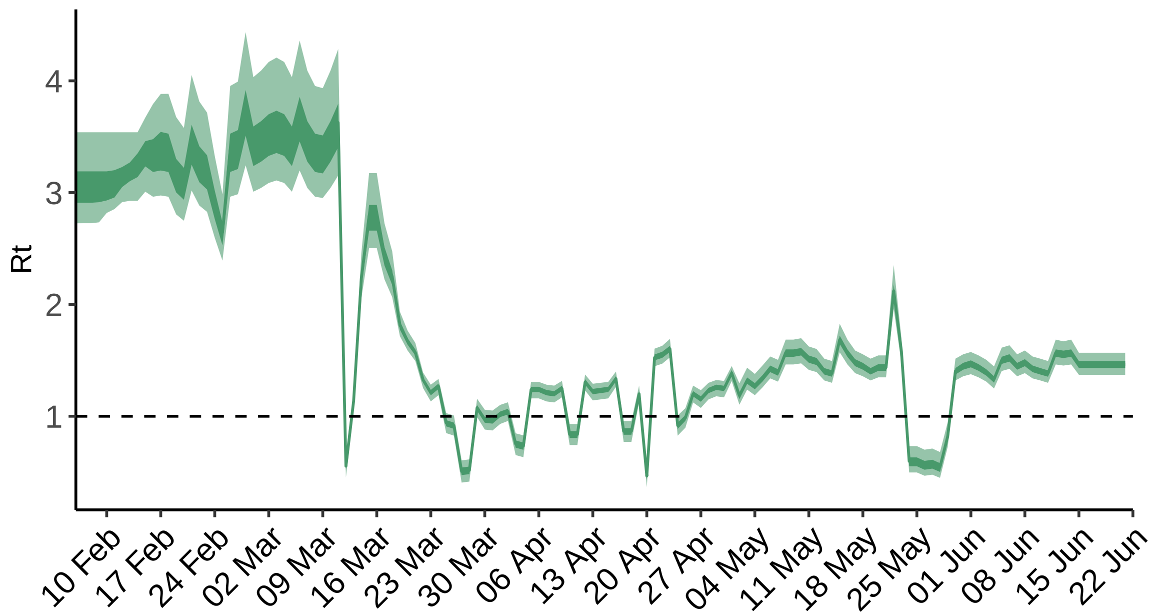


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Egypt is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

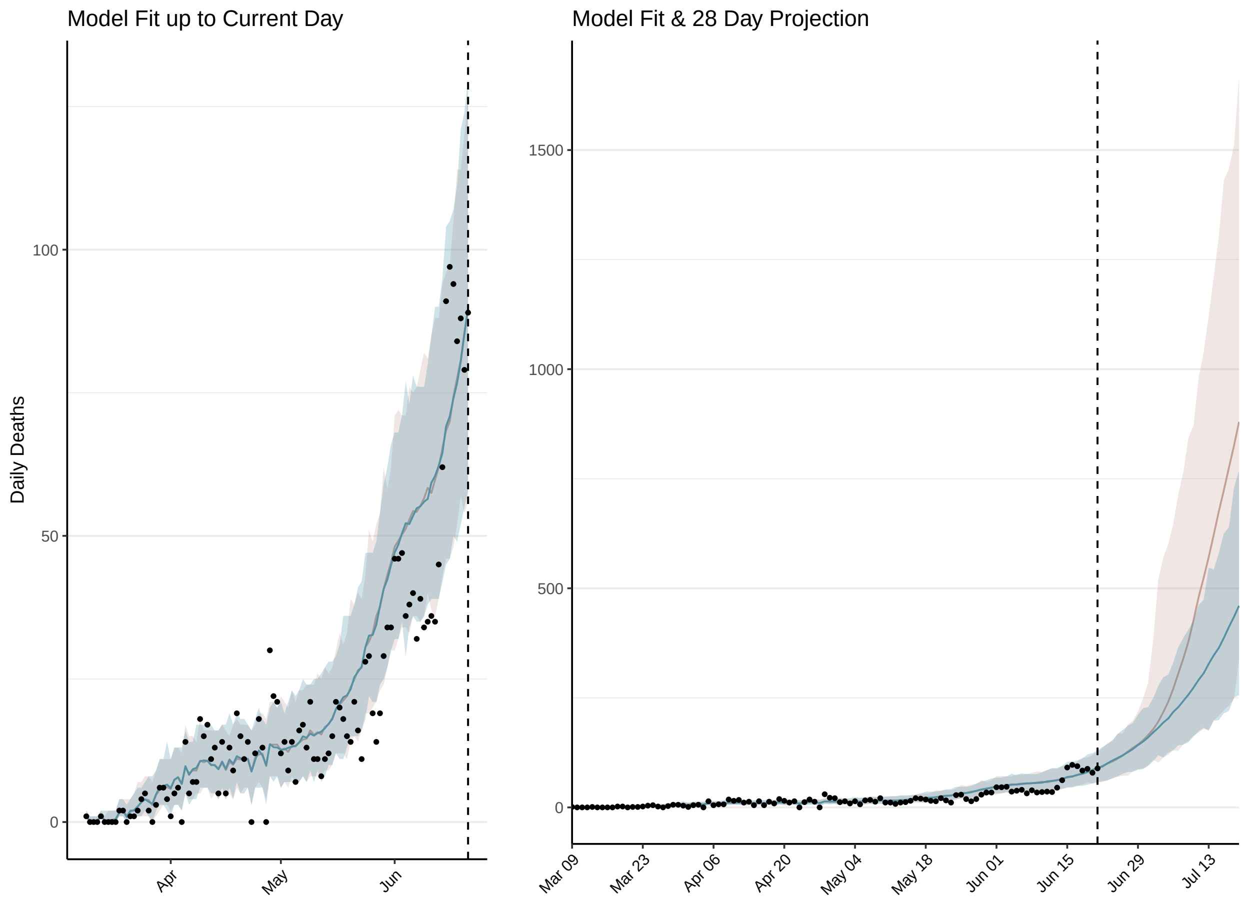


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4,948 (95% CI: 4,806-5,090) patients requiring treatment with high-pressure oxygen at the current date to 25,112 (95% CI: 24,036-26,188) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1,447 (95% CI: 1,406-1,488) patients requiring treatment with mechanical ventilation at the current date to 4,555 (95% CI: 4,480-4,630) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

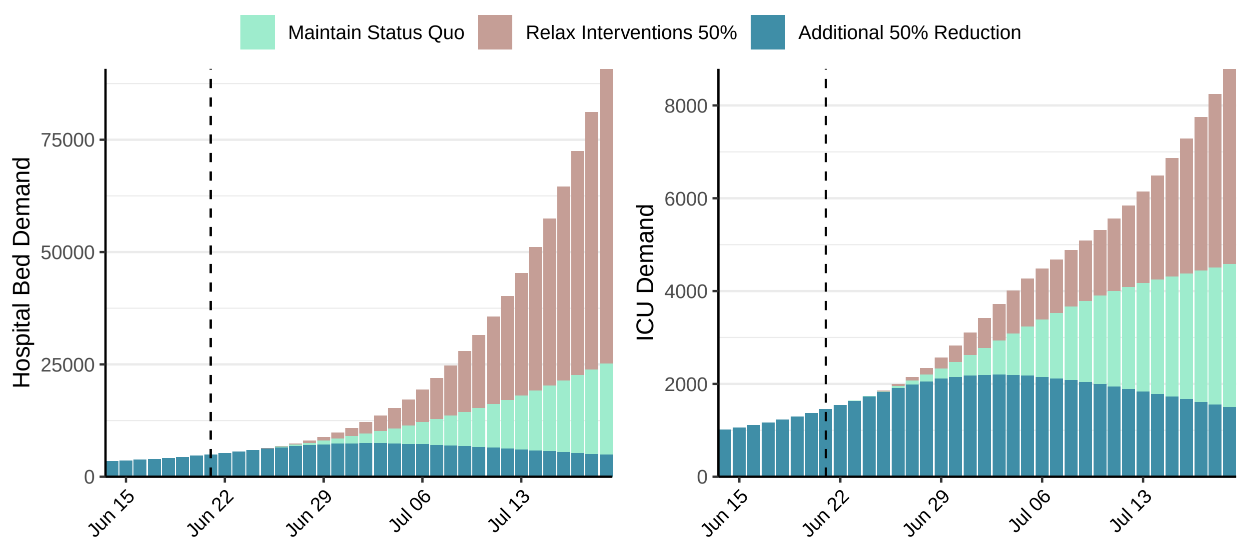


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 51,645 (95% CI: 49,936-53,354) at the current date to 16,433 (95% CI: 15,664-17,203) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 51,645 (95% CI: 49,936-53,354) at the current date to 1,382,949 (95% CI: 1,328,239-1,437,658) by 2020-07-19.

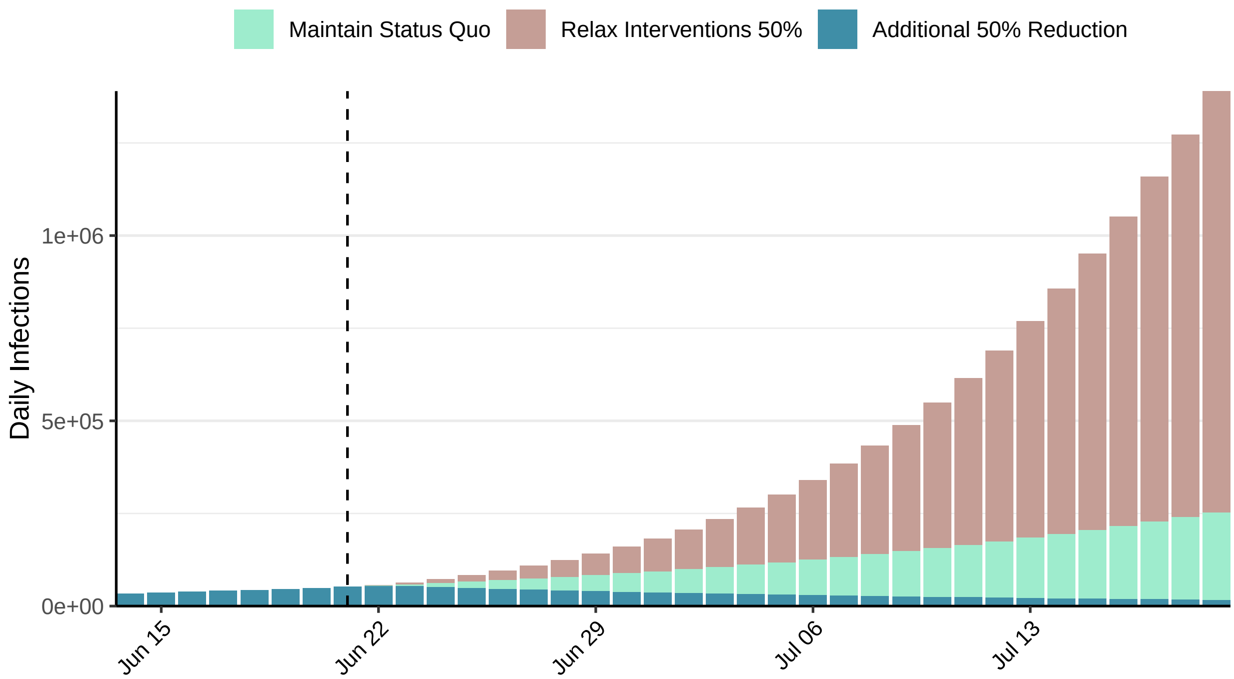


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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## Situation Report for COVID-19: Ethiopia, 2020-06-21

**Download the report for Ethiopia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 4,469 | 399 | 72 | 0 | 1.6 (95% CI: 1.48-1.72) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

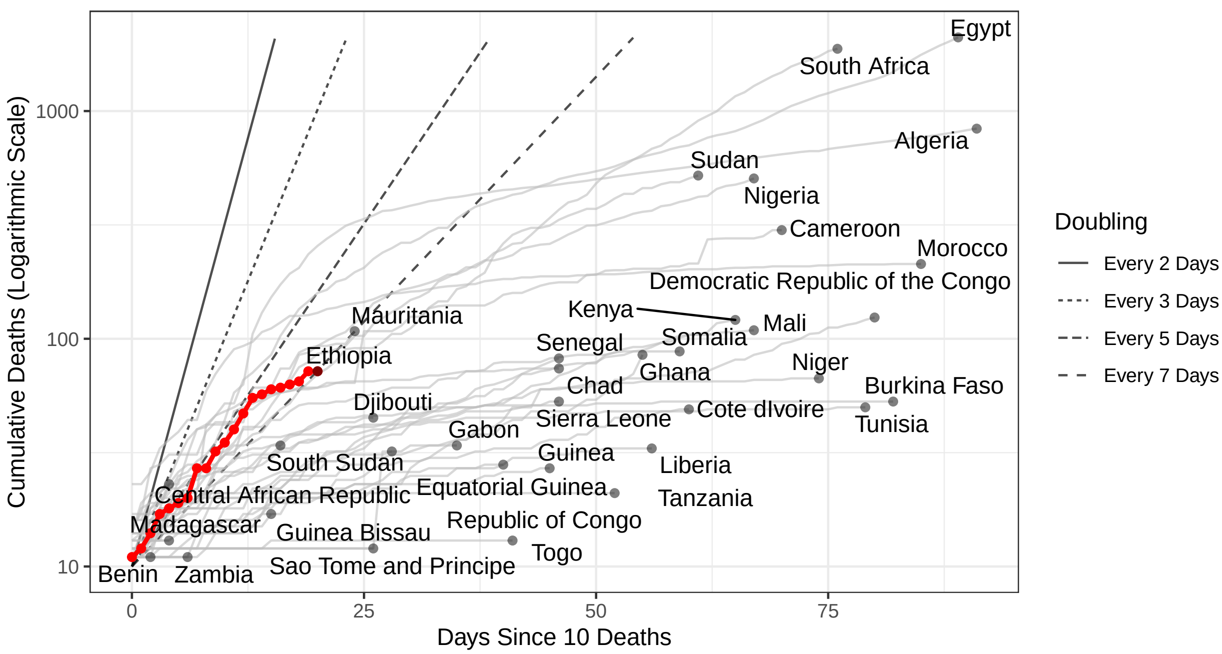


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 59,684 (95% CI: 56,964-62,404) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

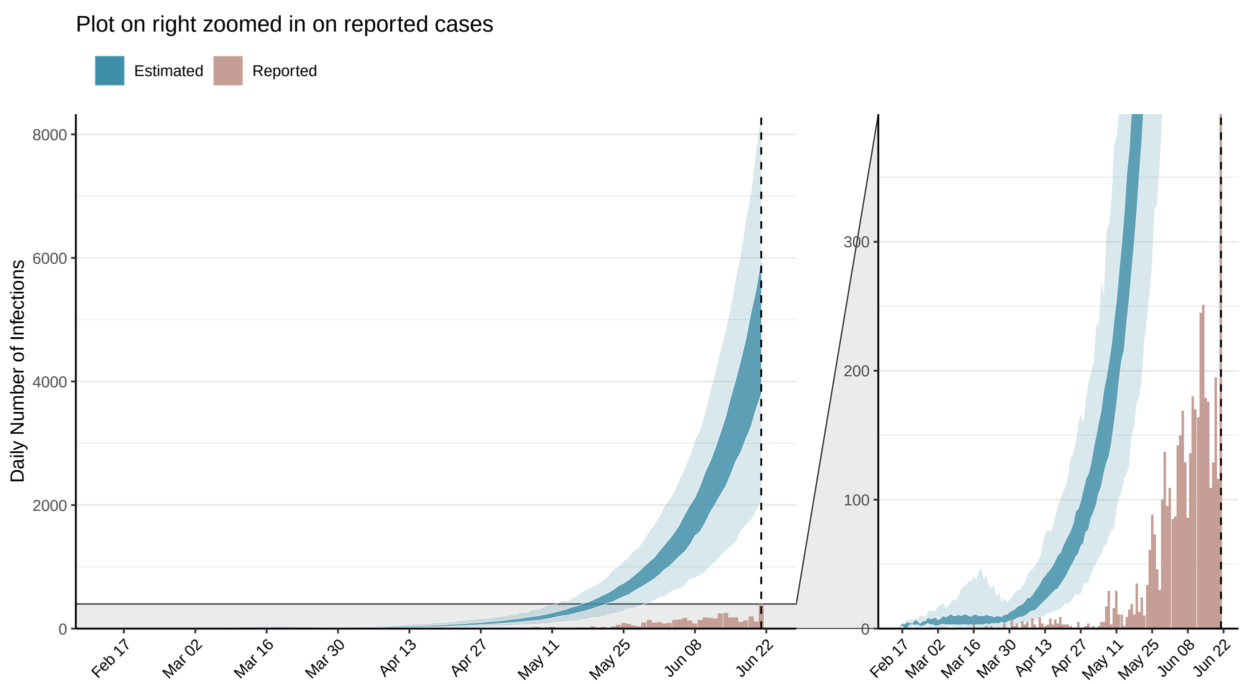


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

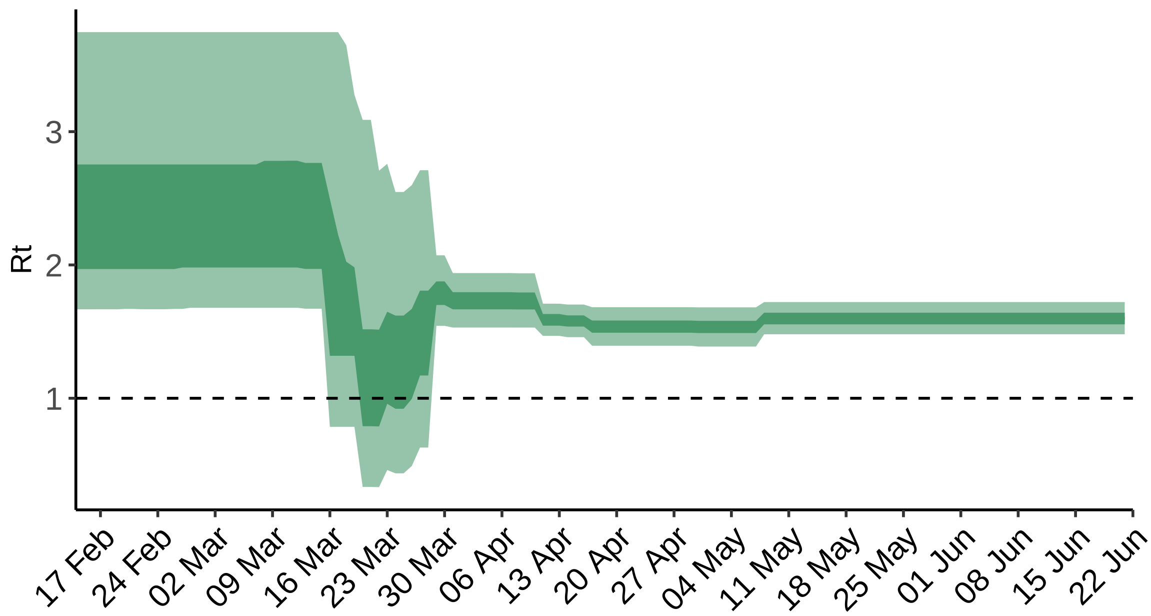


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

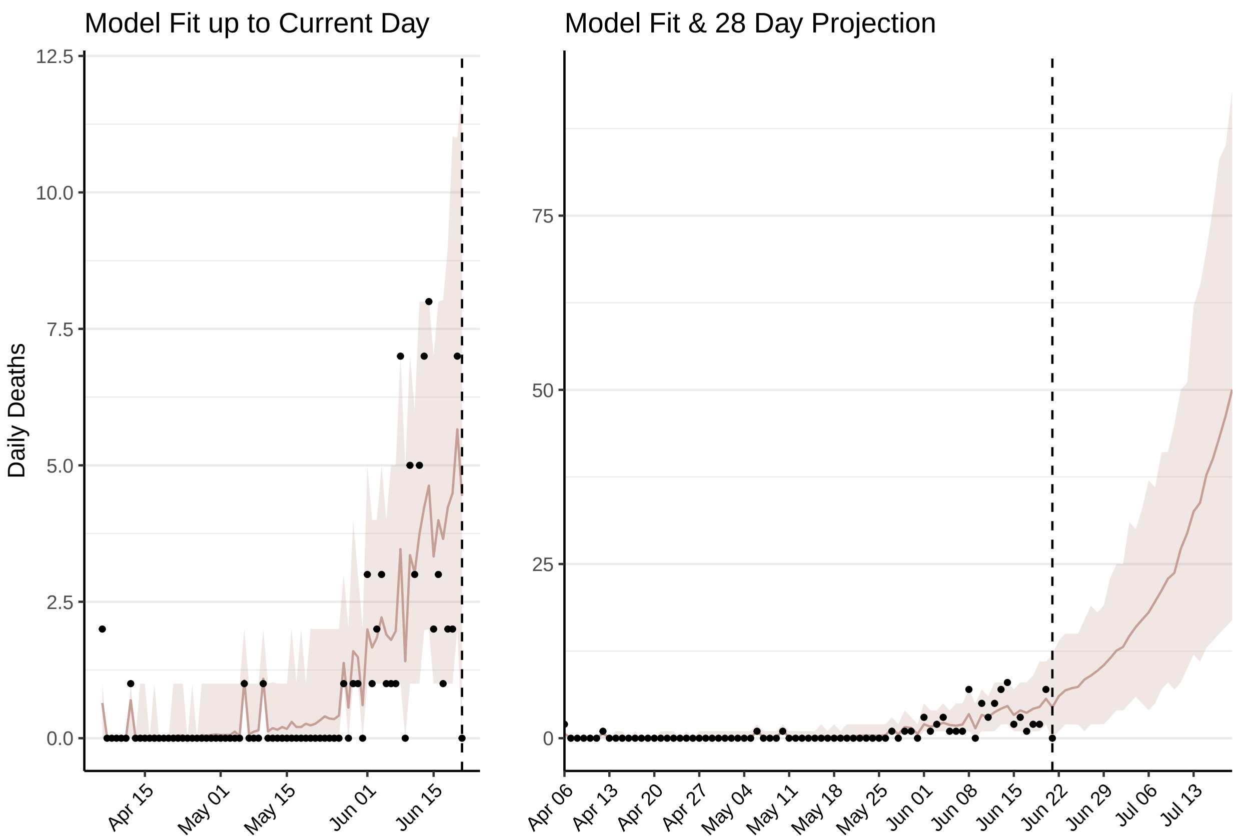


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 351 (95% CI: 335-367) patients requiring treatment with high-pressure oxygen at the current date to 3,034 (95% CI: 2,853-3,215) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 96 (95% CI: 92-101) patients requiring treatment with mechanical ventilation at the current date to 843 (95% CI: 792-893) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

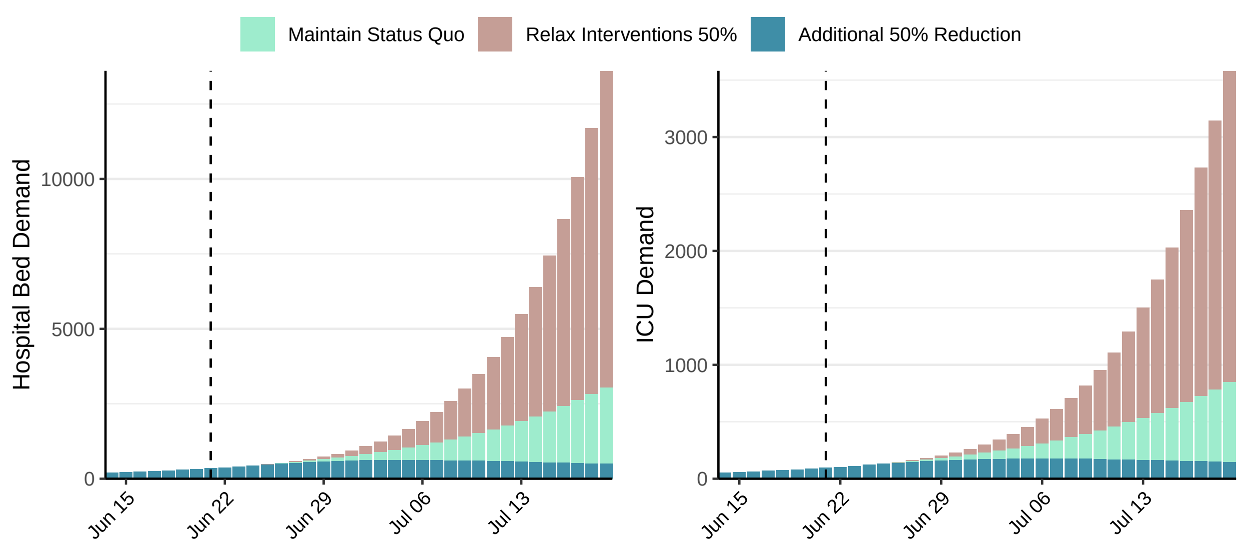


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 4,992 (95% CI: 4,748-5,235) at the current date to 2,400 (95% CI: 2,252-2,548) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 4,992 (95% CI: 4,748-5,235) at the current date to 334,773 (95% CI: 312,943-356,603) by 2020-07-19.

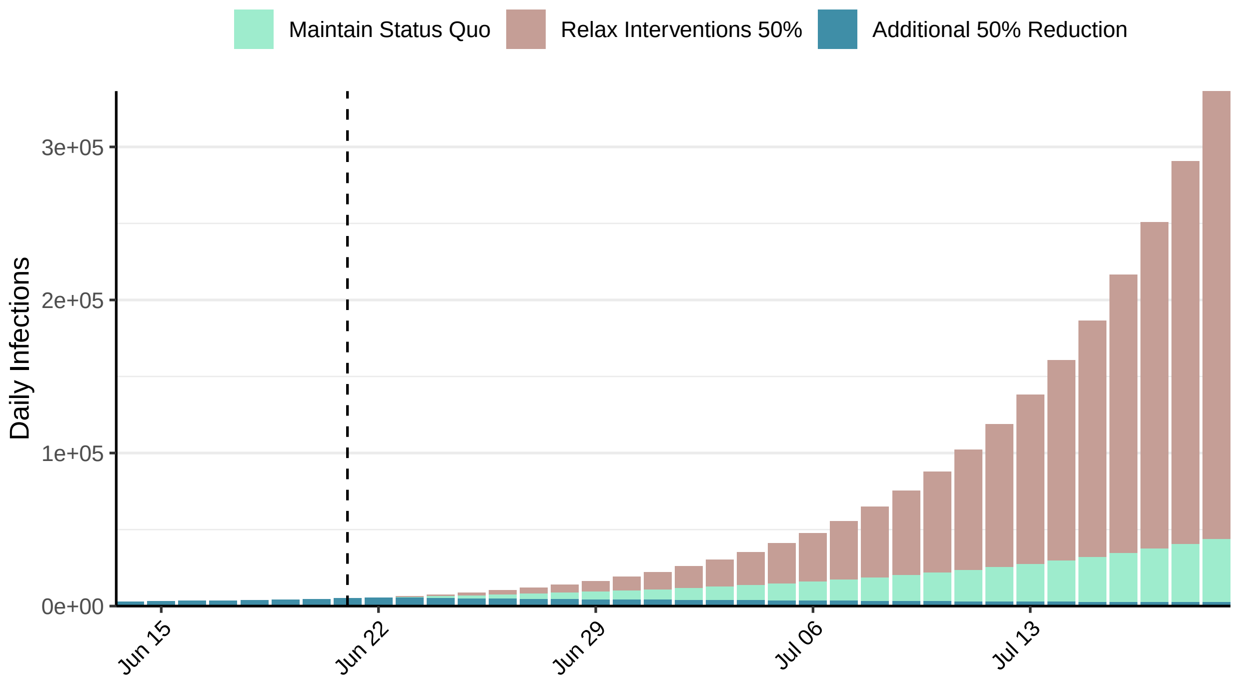


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Gabon, 2020-06-21

**Download the report for Gabon, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 4,428 | 0 | 34 | 0 | 1.32 (95% CI: 1.14-1.53) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

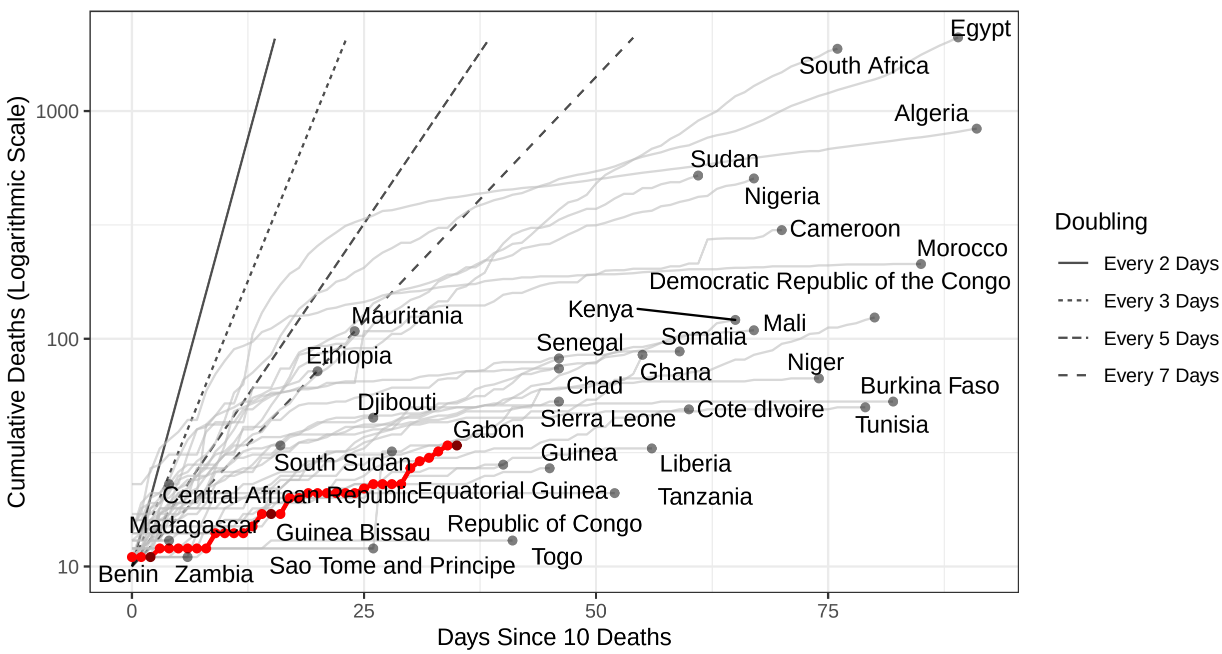


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 14,941 (95% CI: 13,963-15,919) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

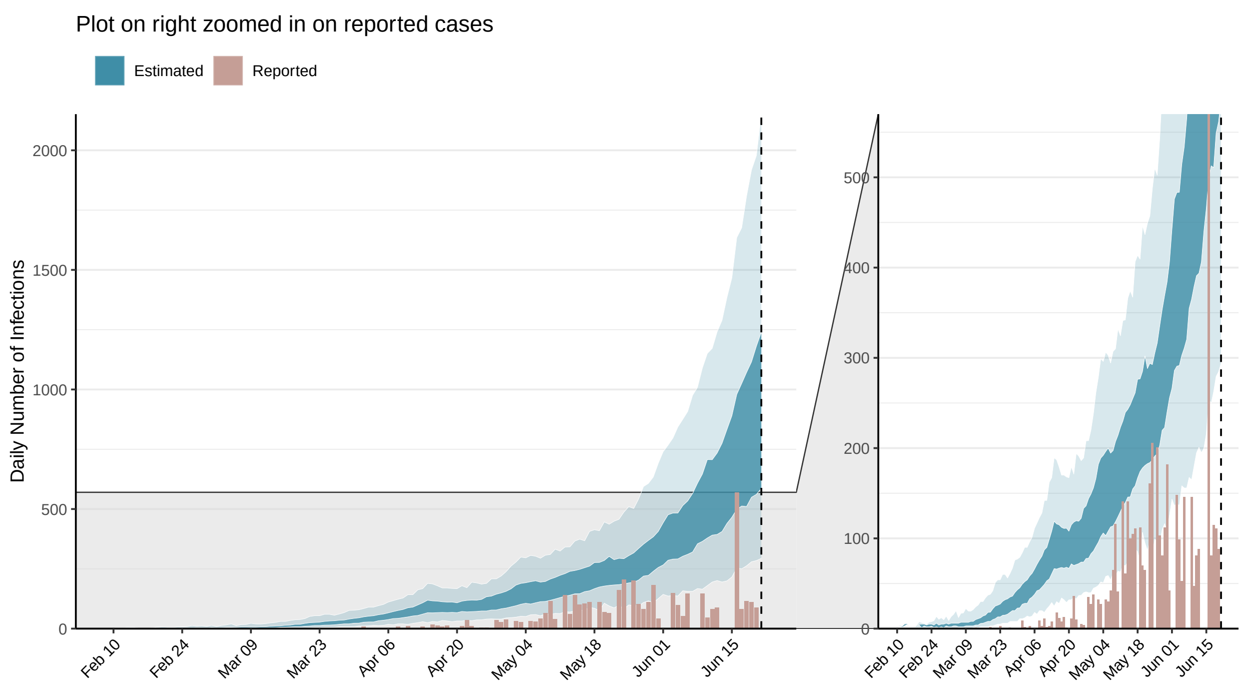


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

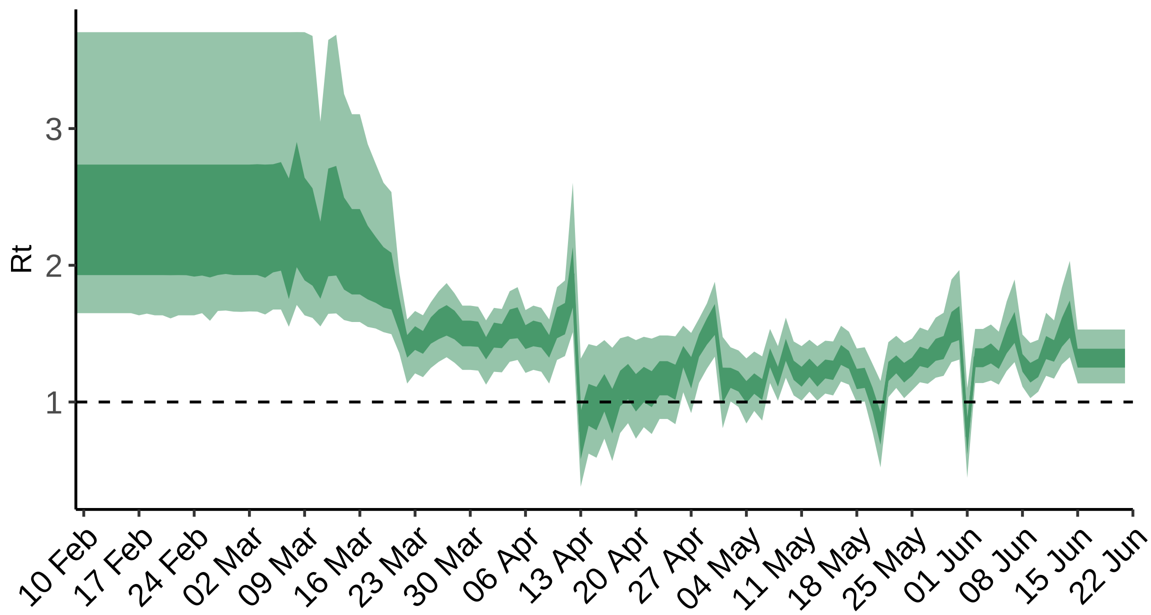


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

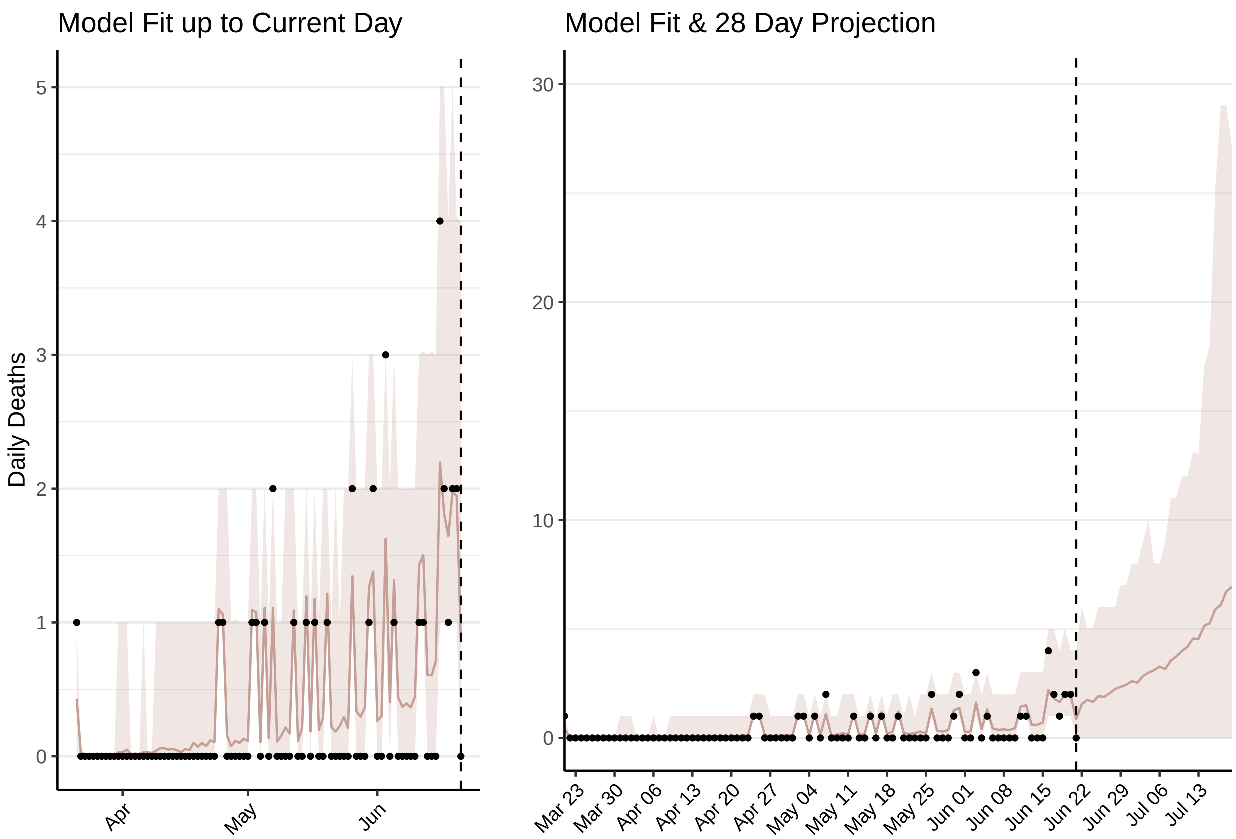


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 93 (95% CI: 86-99) patients requiring treatment with high-pressure oxygen at the current date to 344 (95% CI: 311-377) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 24 (95% CI: 22-26) patients requiring treatment with mechanical ventilation at the current date to 88 (95% CI: 81-95) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

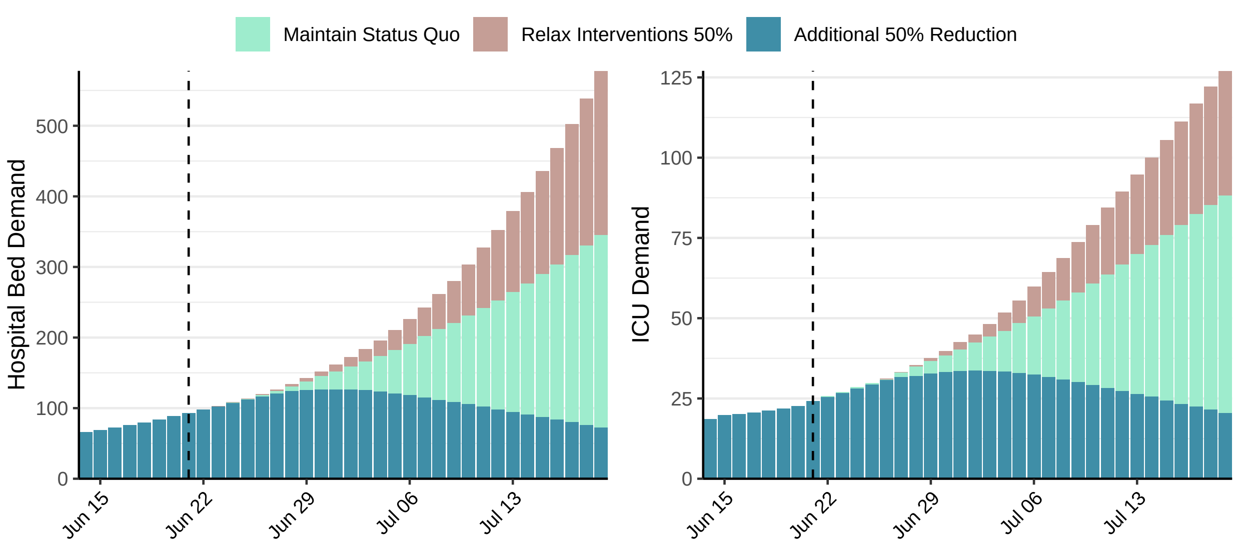


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 972 (95% CI: 898-1,046) at the current date to 235 (95% CI: 210-260) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 972 (95% CI: 898-1,046) at the current date to 7,157 (95% CI: 6,414-7,900) by 2020-07-19.

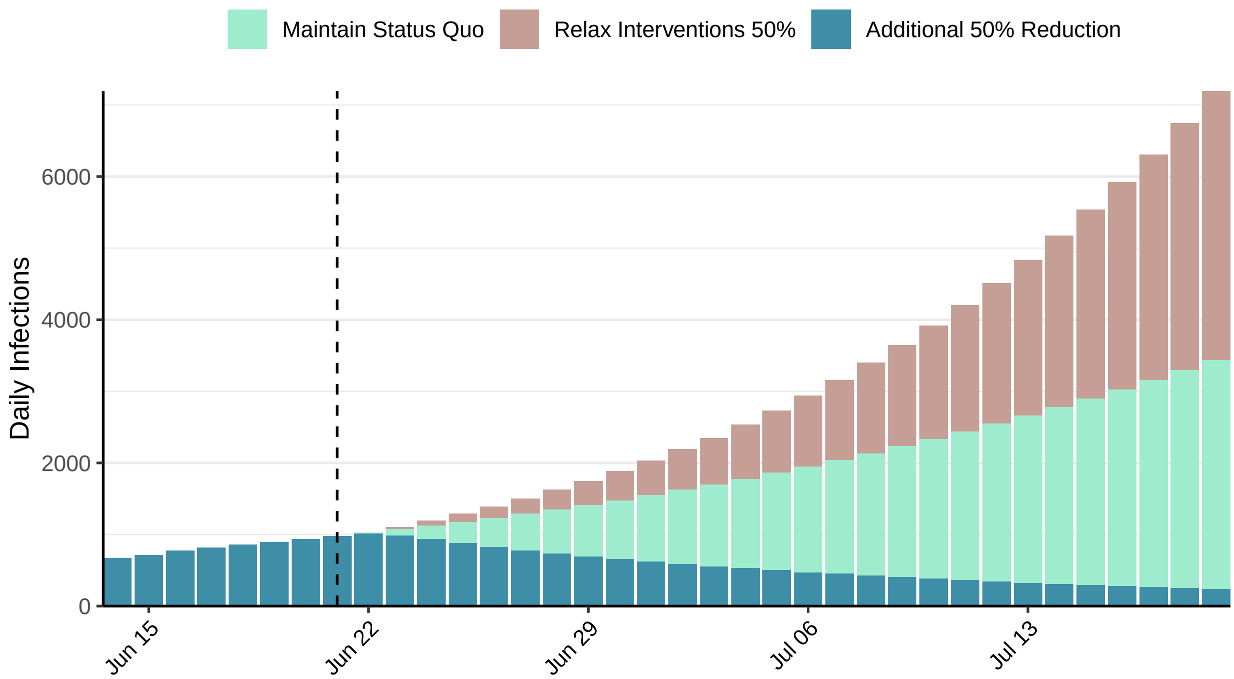


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Georgia, 2020-06-21

**Download the report for Georgia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 898 | 2 | 14 | 0 | 0.69 (95% CI: 0.3-1.08) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

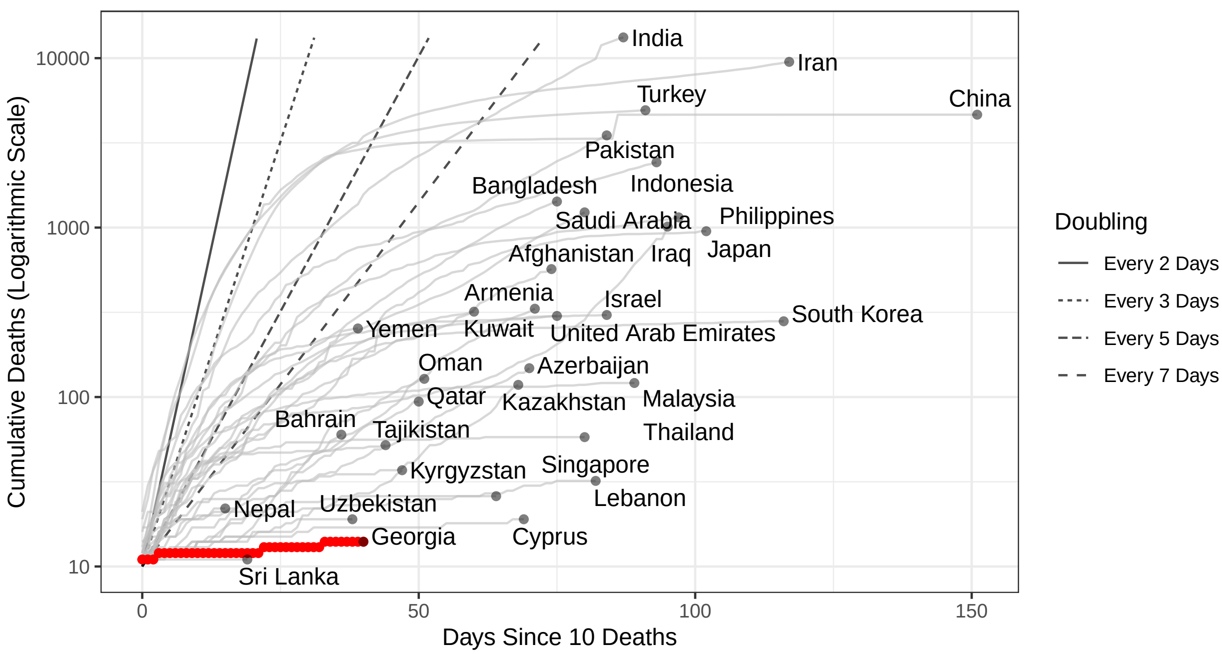


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 514 (95% CI: 450-578) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

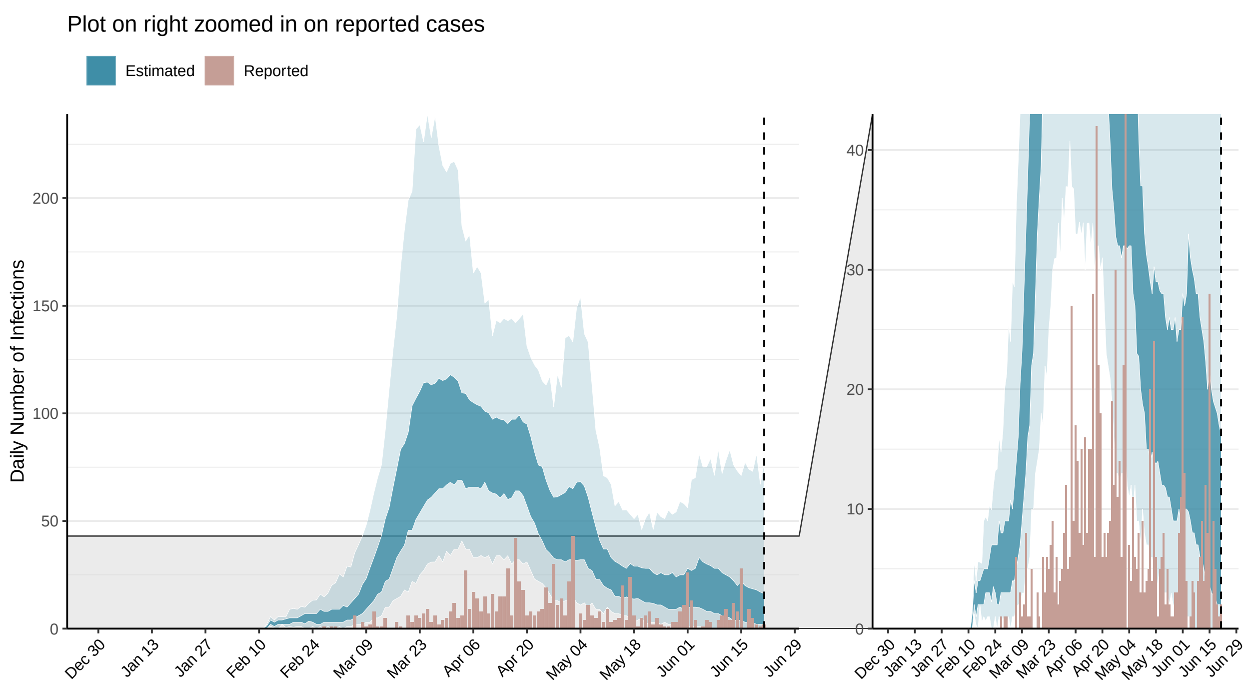


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

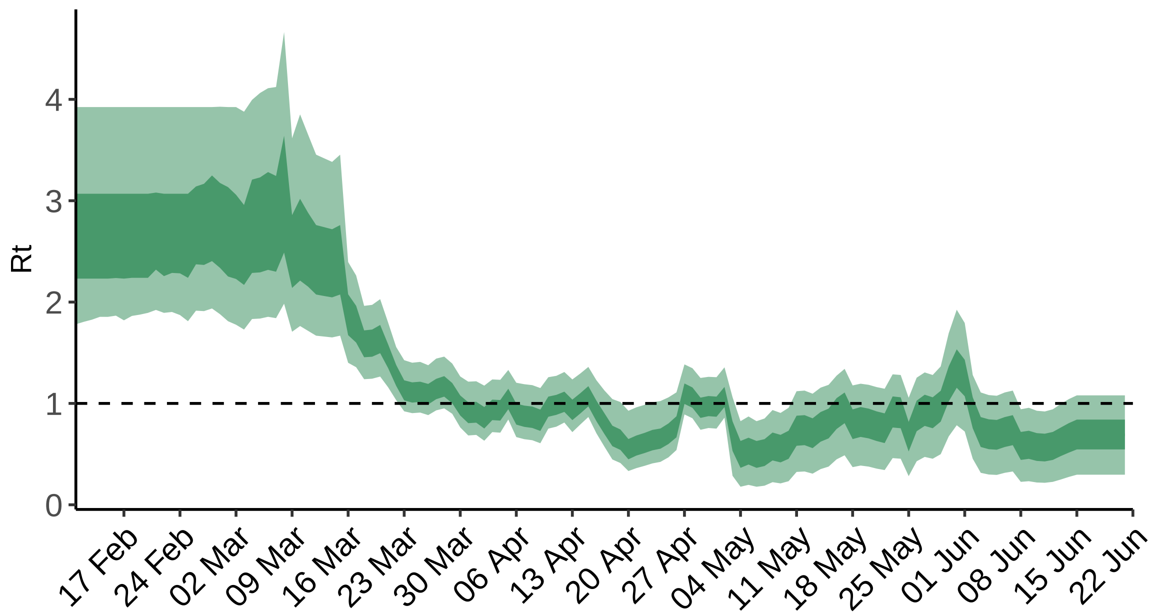


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

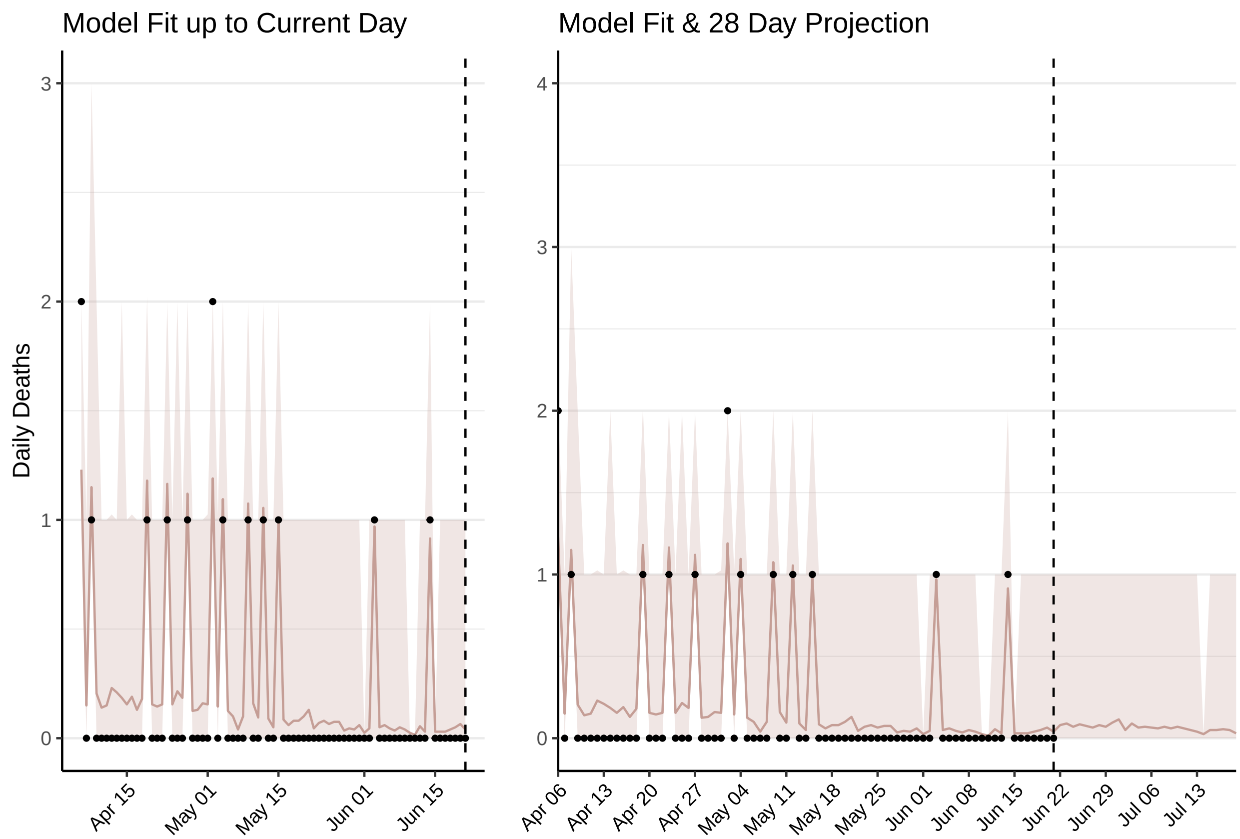


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4 (95% CI: 3-4) patients requiring treatment with high-pressure oxygen at the current date to 2 (95% CI: 2-3) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1 (95% CI: 1-1) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 0-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

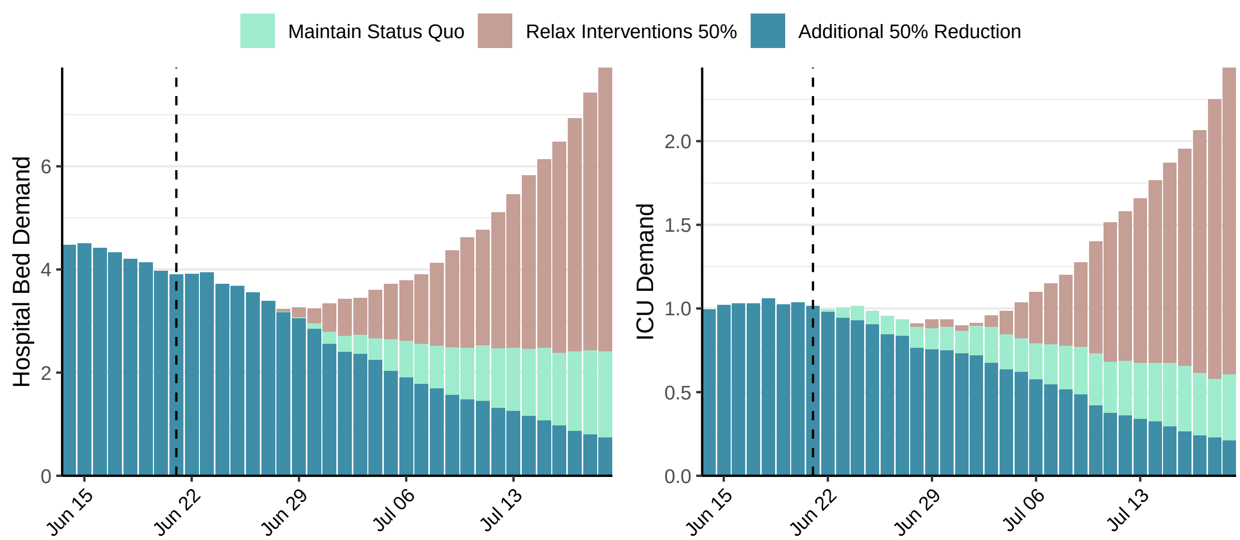


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 14 (95% CI: 11-17) at the current date to 1 (95% CI: 1-1) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 14 (95% CI: 11-17) at the current date to 77 (95% CI: 48-106) by 2020-07-19.

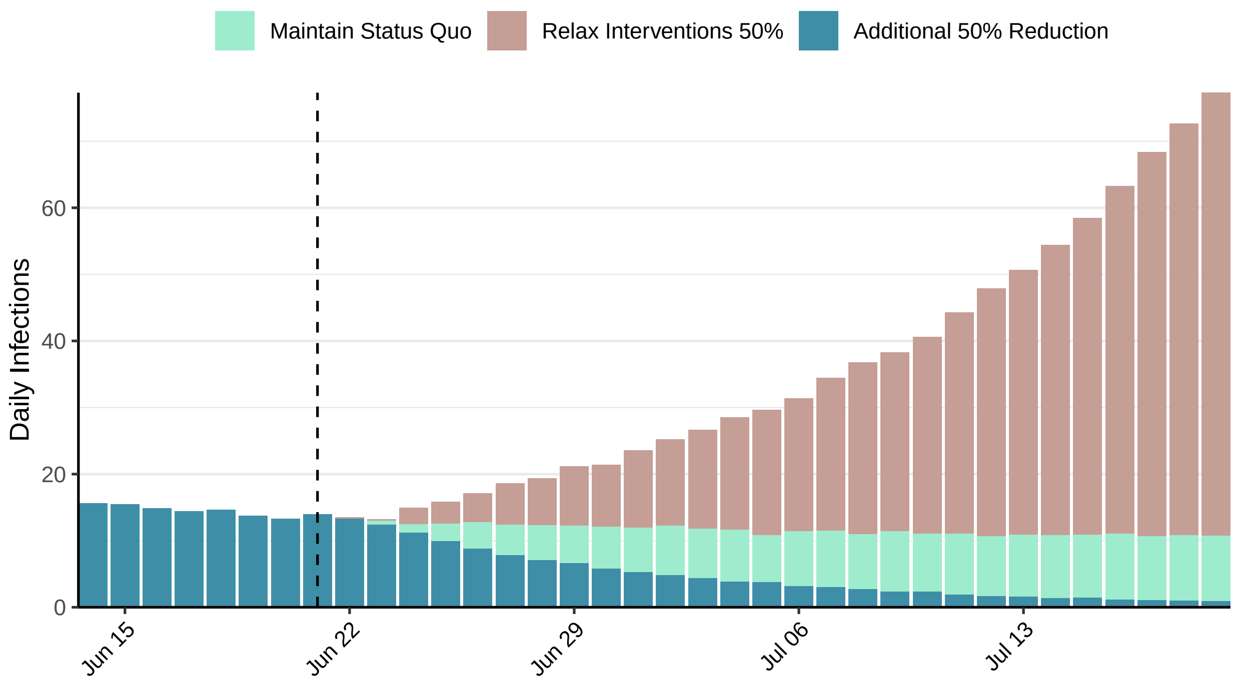


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Ghana, 2020-06-21

**Download the report for Ghana, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 13,711 | 508 | 85 | 15 | 1.65 (95% CI: 1.5-1.81) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

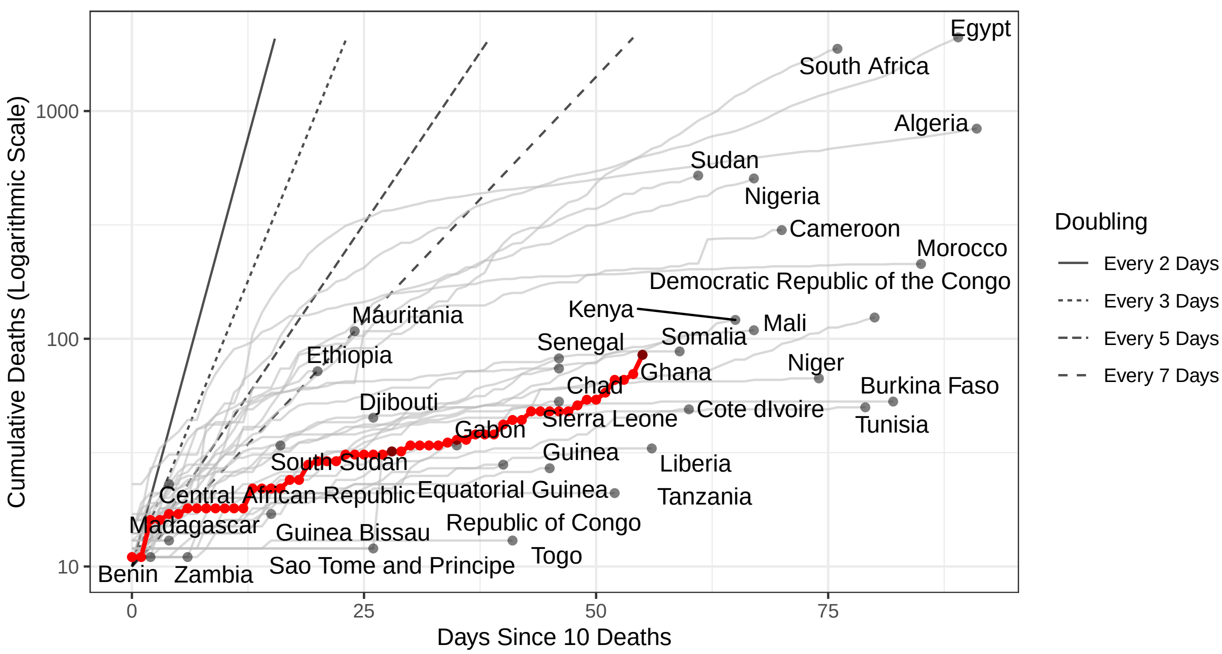


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 55,365 (95% CI: 52,548-58,183) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

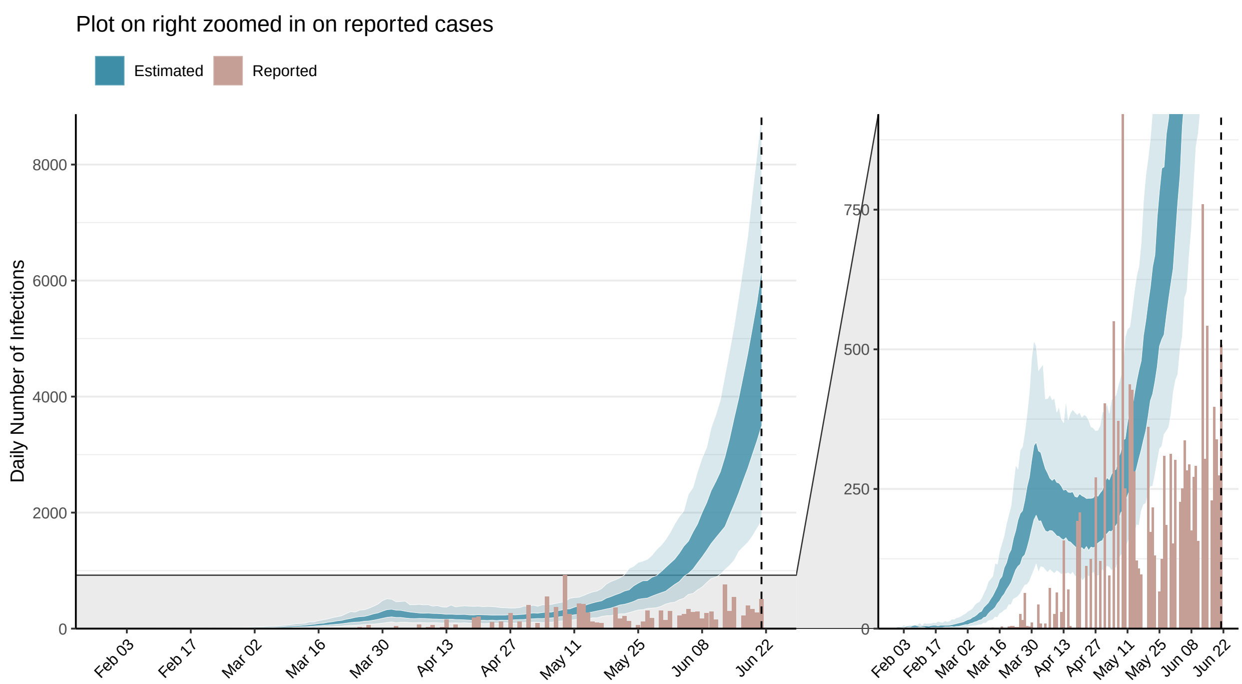


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

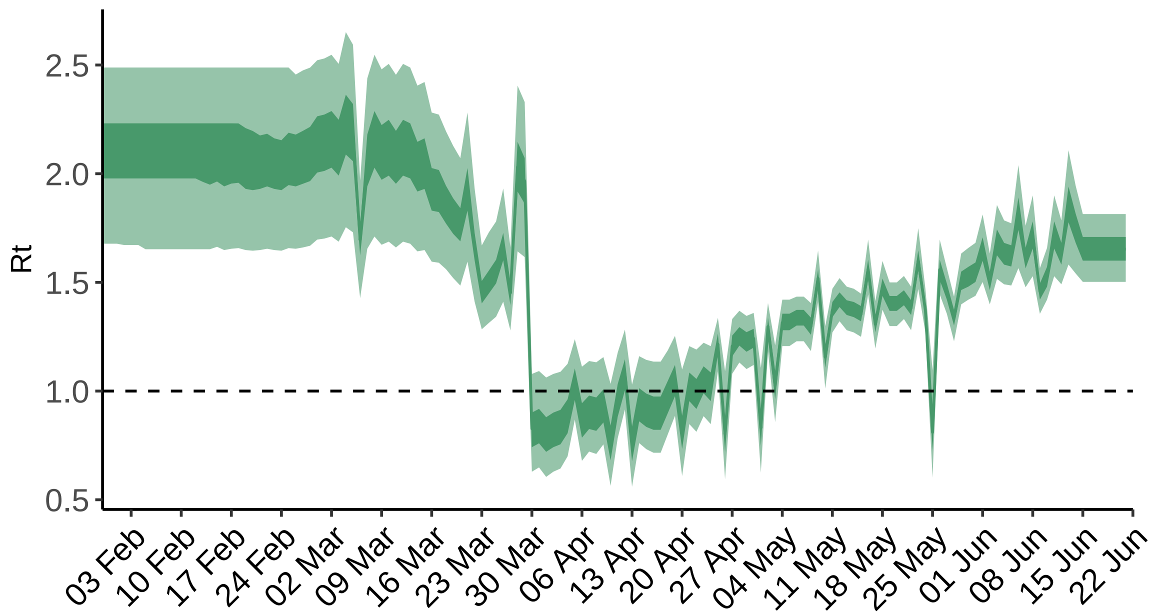


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

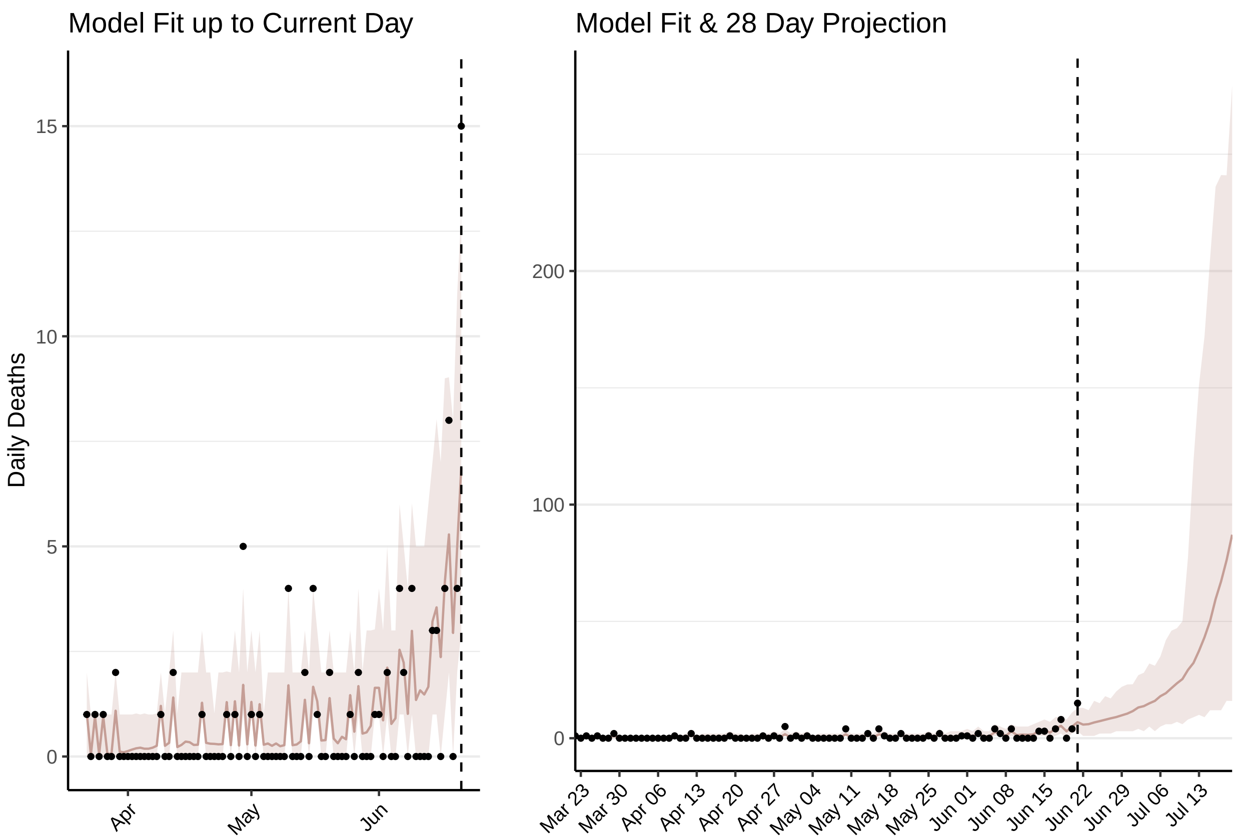


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 341 (95% CI: 324-359) patients requiring treatment with high-pressure oxygen at the current date to 3,477 (95% CI: 3,224-3,730) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 88 (95% CI: 84-93) patients requiring treatment with mechanical ventilation at the current date to 765 (95% CI: 728-801) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

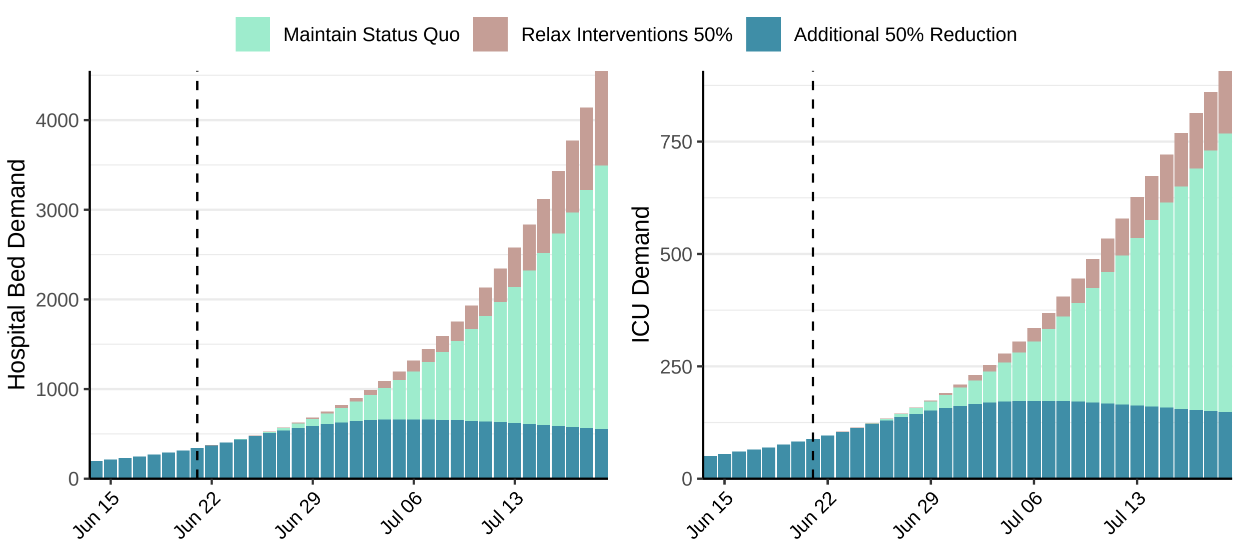


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 4,871 (95% CI: 4,598-5,145) at the current date to 2,686 (95% CI: 2,479-2,893) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 4,871 (95% CI: 4,598-5,145) at the current date to 70,422 (95% CI: 64,808-76,035) by 2020-07-19.

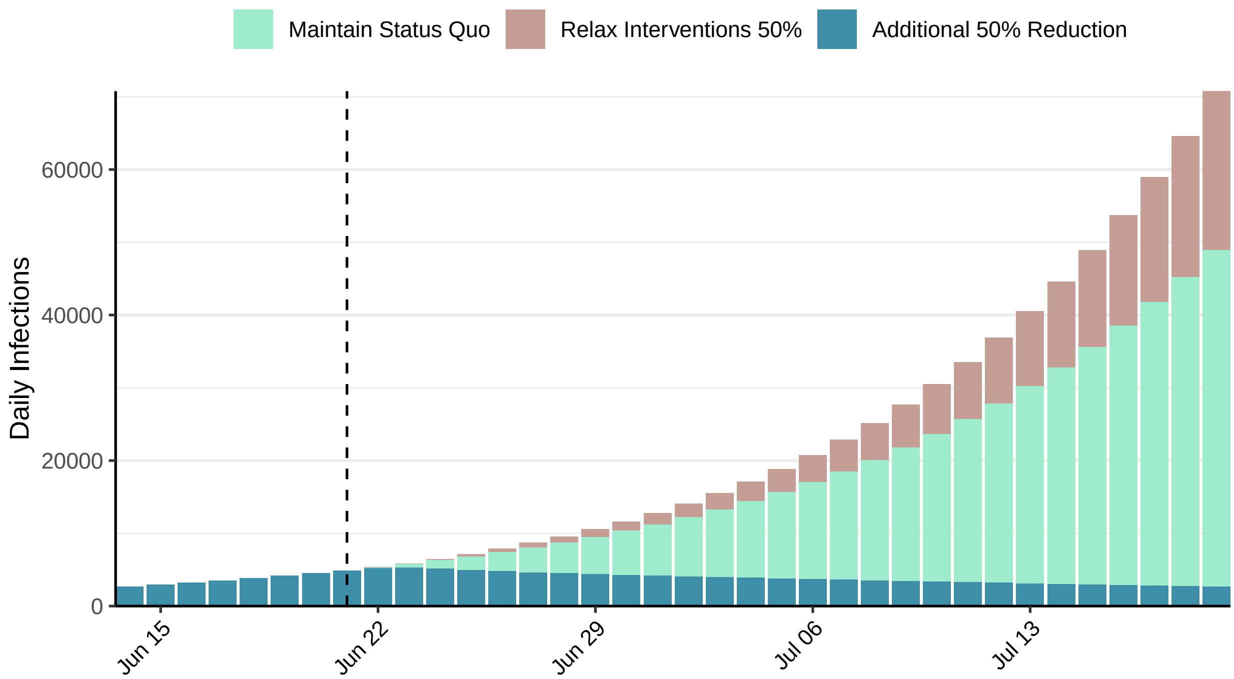


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Guinea, 2020-06-21

**Download the report for Guinea, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 4,960 | 56 | 27 | 0 | 1.76 (95% CI: 1.56-2.11) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

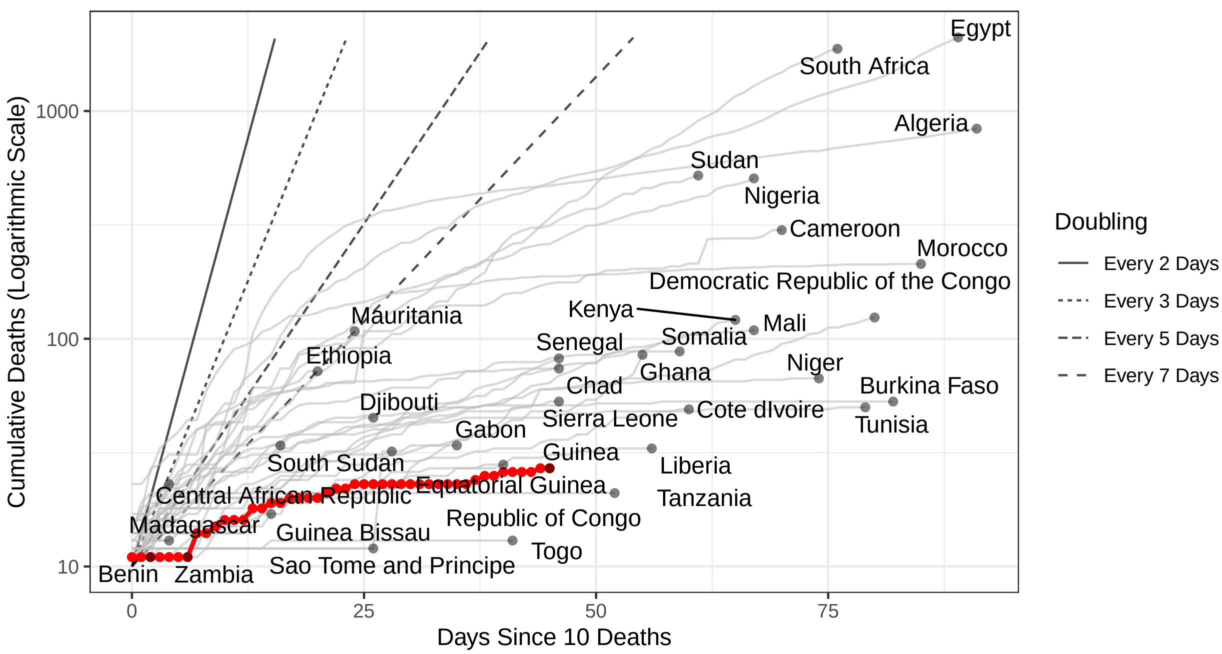


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 5,691 (95% CI: 5,376-6,006) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

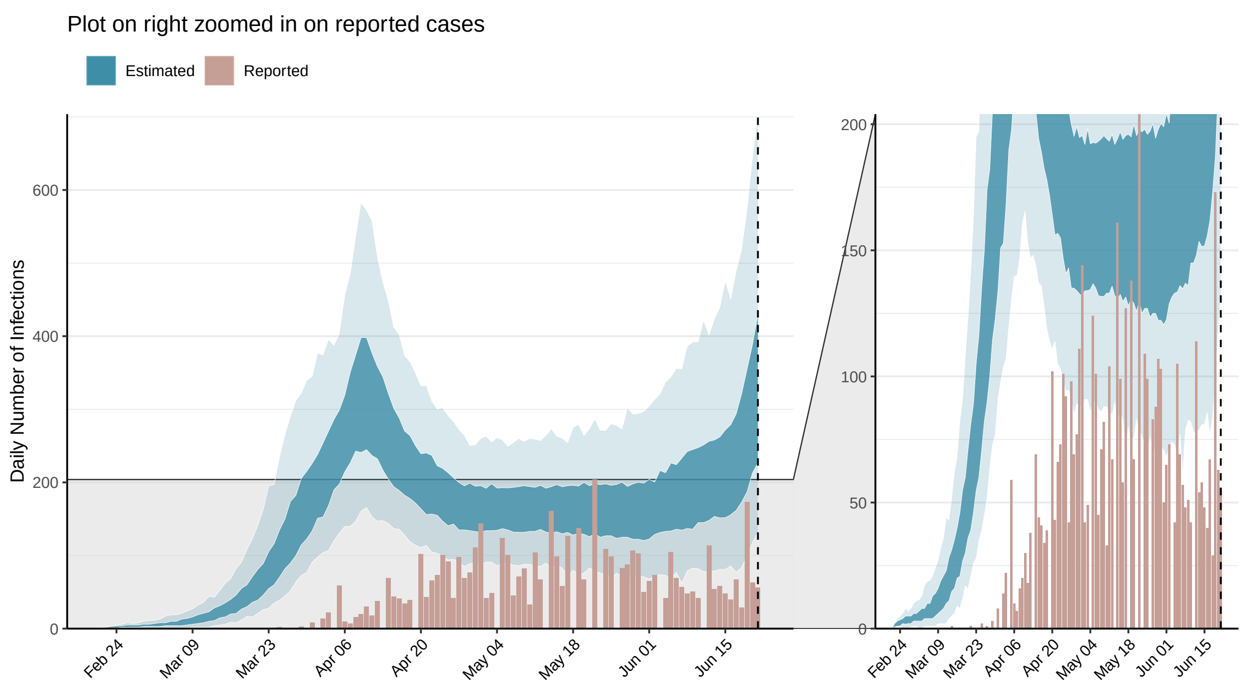


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

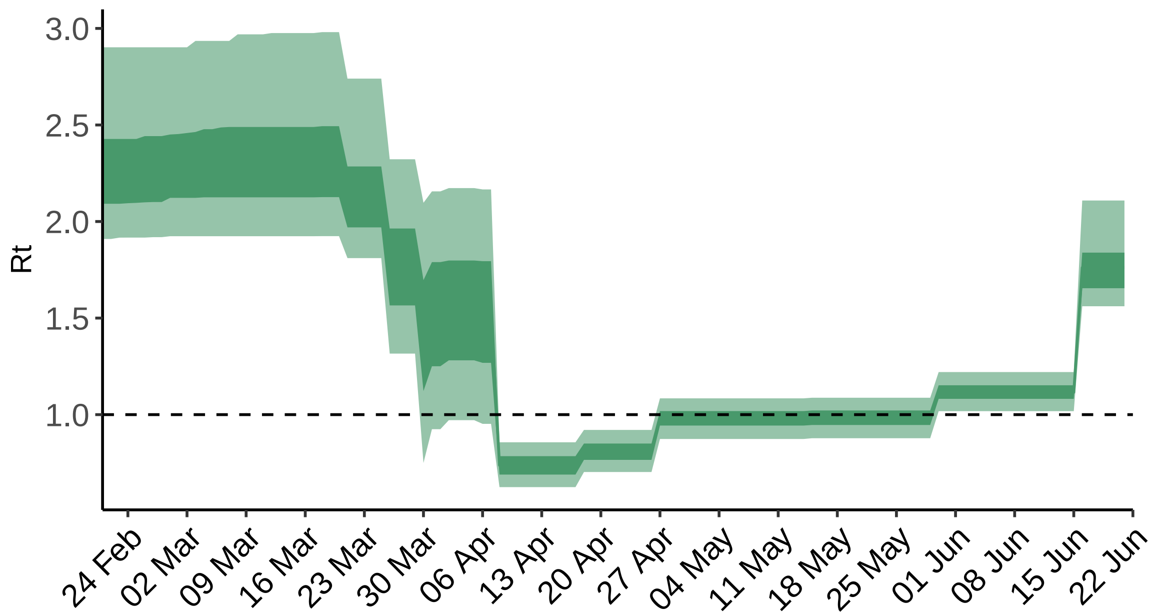


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Guinea is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

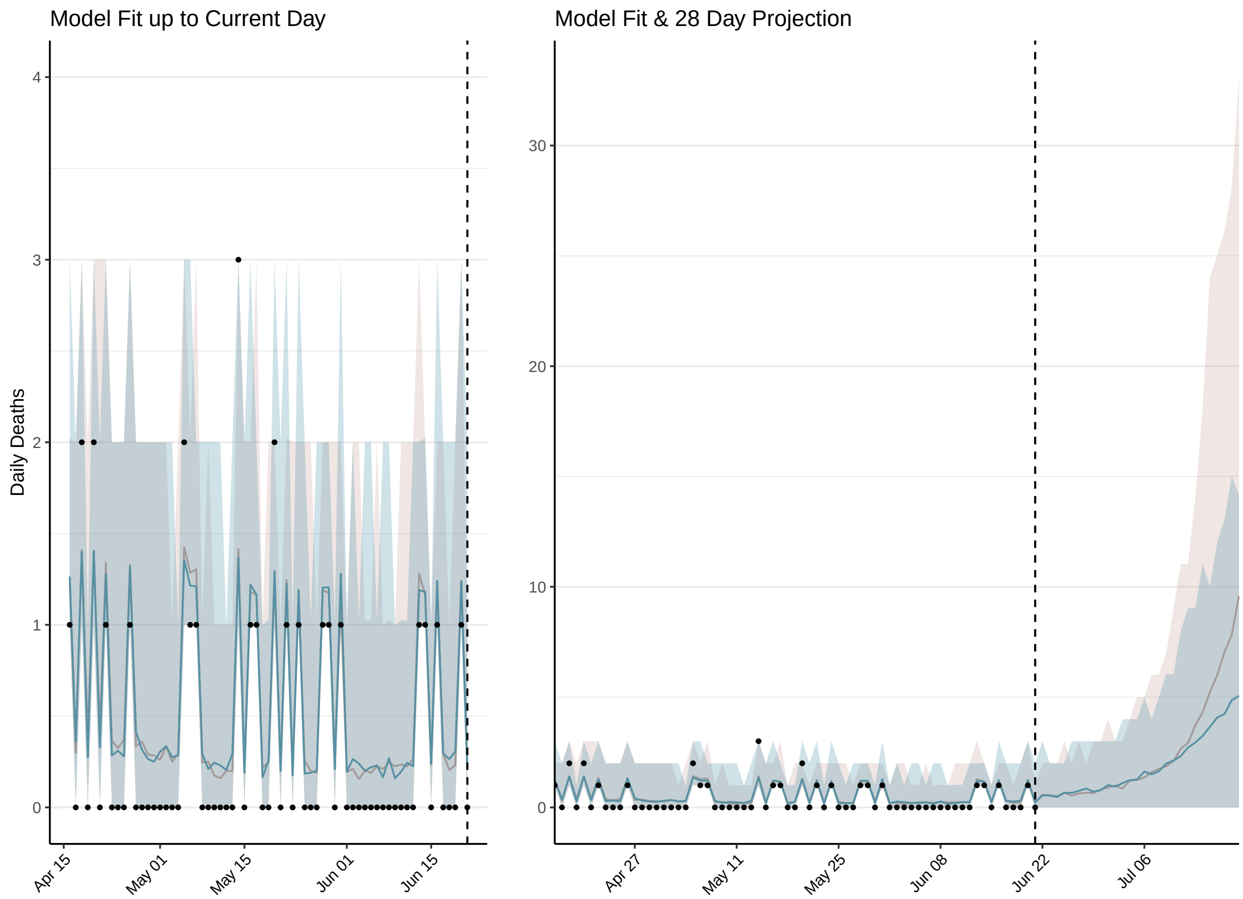


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 29 (95% CI: 28-31) patients requiring treatment with high-pressure oxygen at the current date to 296 (95% CI: 264-328) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 8 (95% CI: 8-9) patients requiring treatment with mechanical ventilation at the current date to 58 (95% CI: 55-61) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

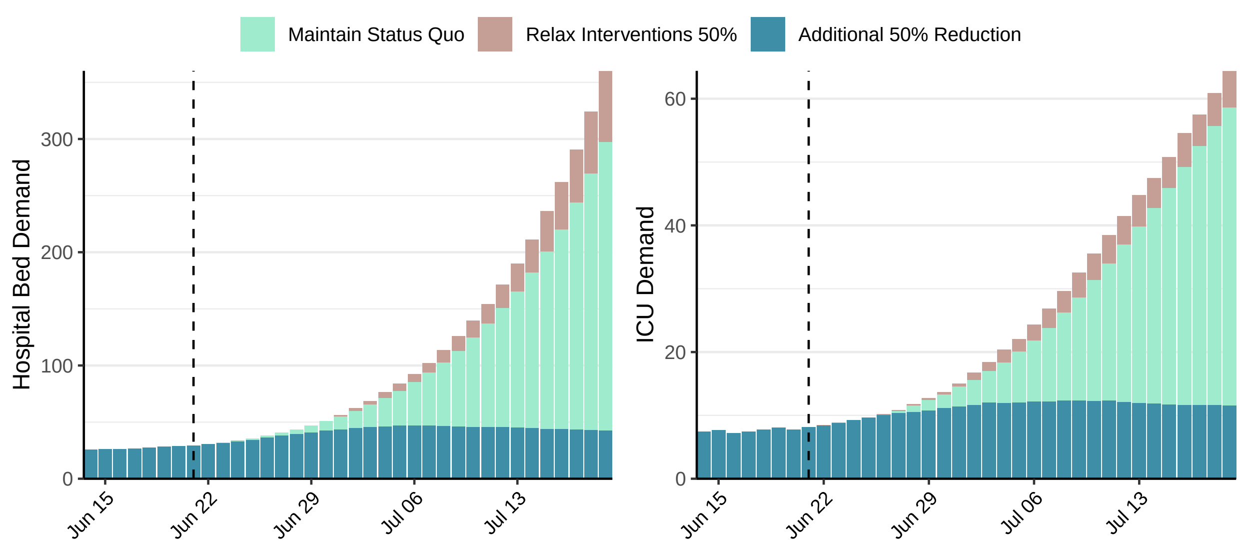


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 345 (95% CI: 323-367) at the current date to 262 (95% CI: 232-293) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 345 (95% CI: 323-367) at the current date to 6,939 (95% CI: 5,985-7,892) by 2020-07-19.

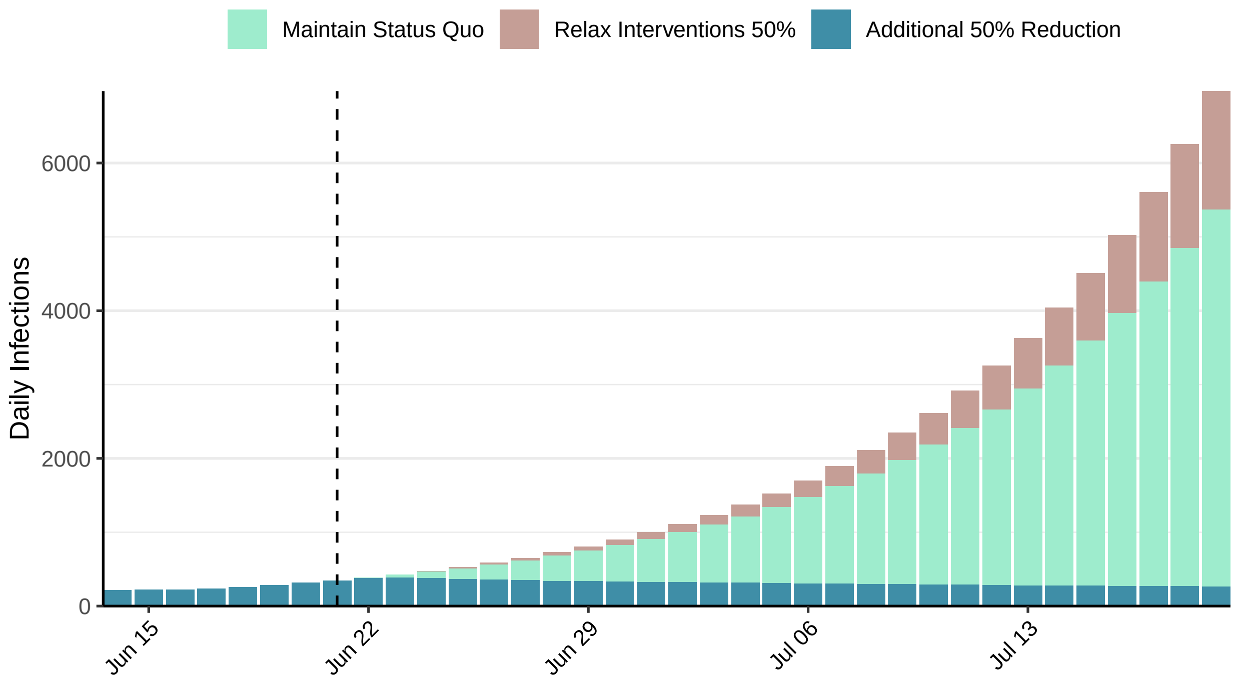


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Gambia, 2020-06-21

**Download the report for Gambia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 37 | 1 | 2 | 1 | 1.62 (95% CI: 0.94-2.33) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Gambia is not shown in the following plot as only 2 deaths have been reported to date**

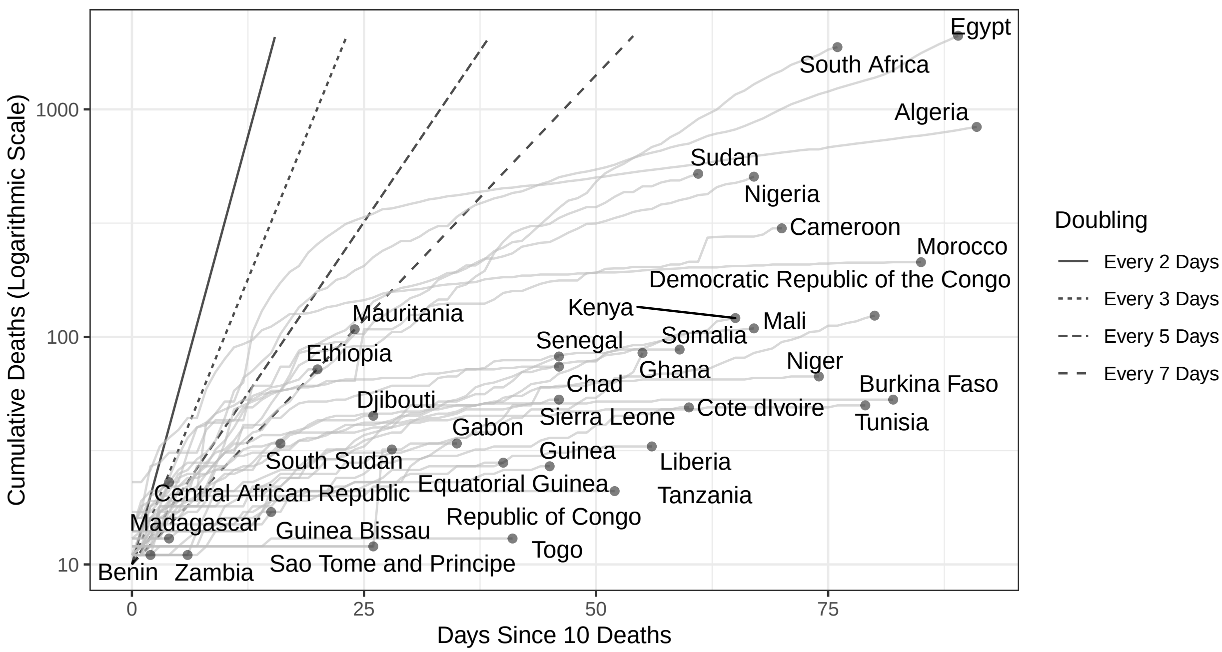


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,021 (95% CI: 866-1,177) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

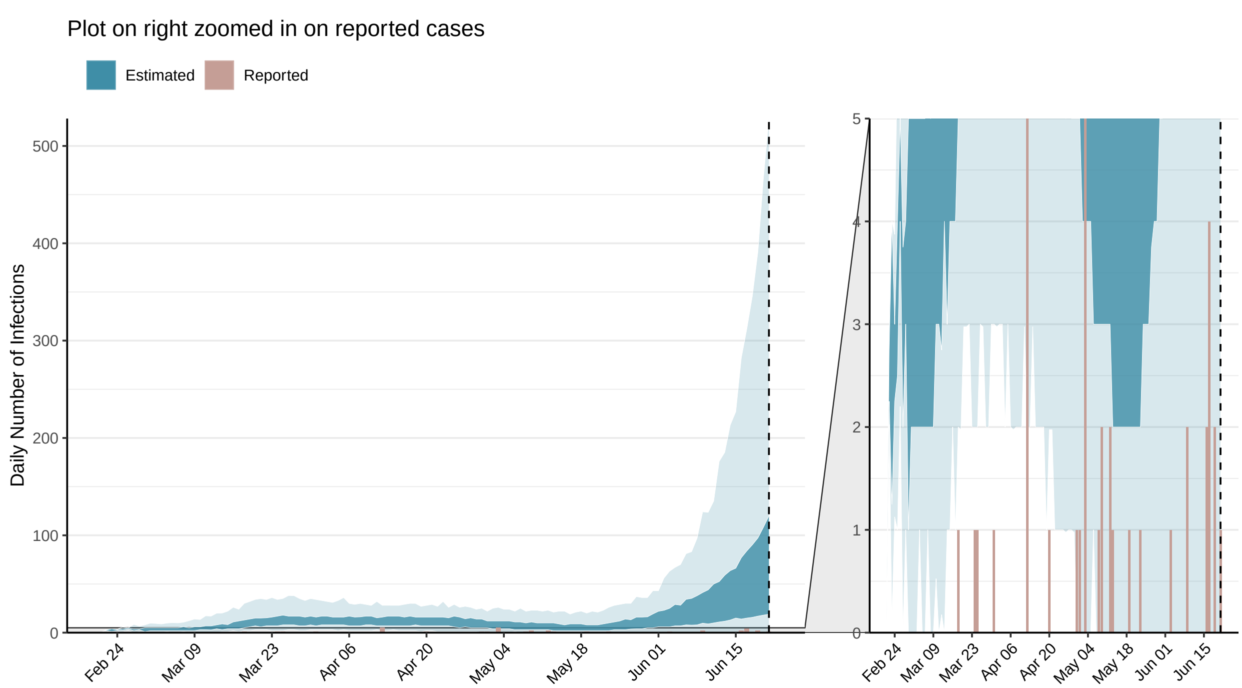


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

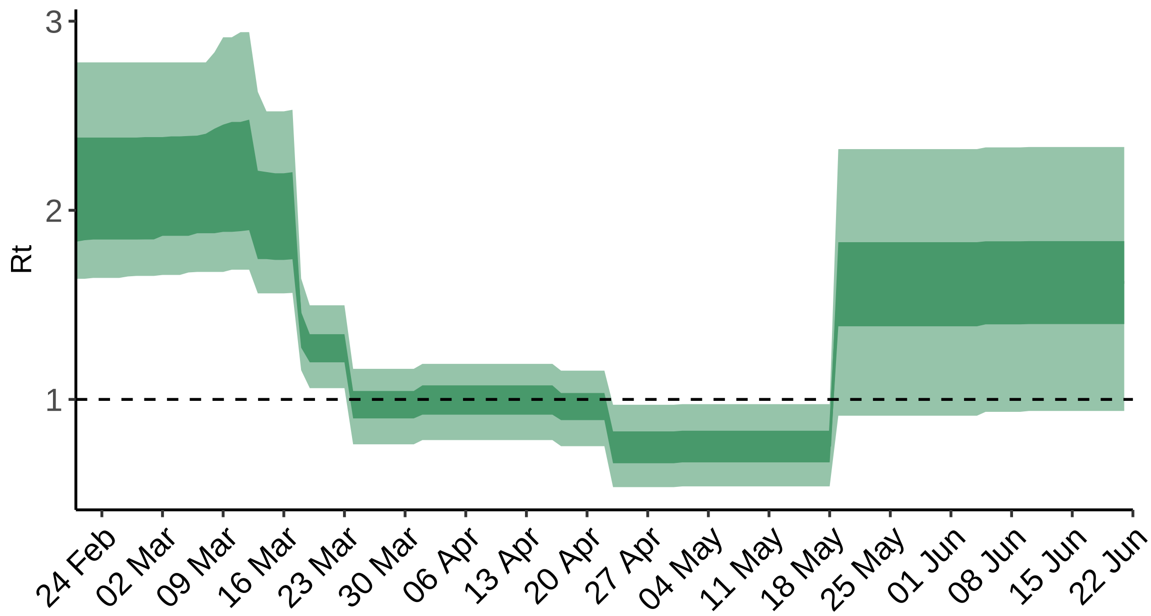


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

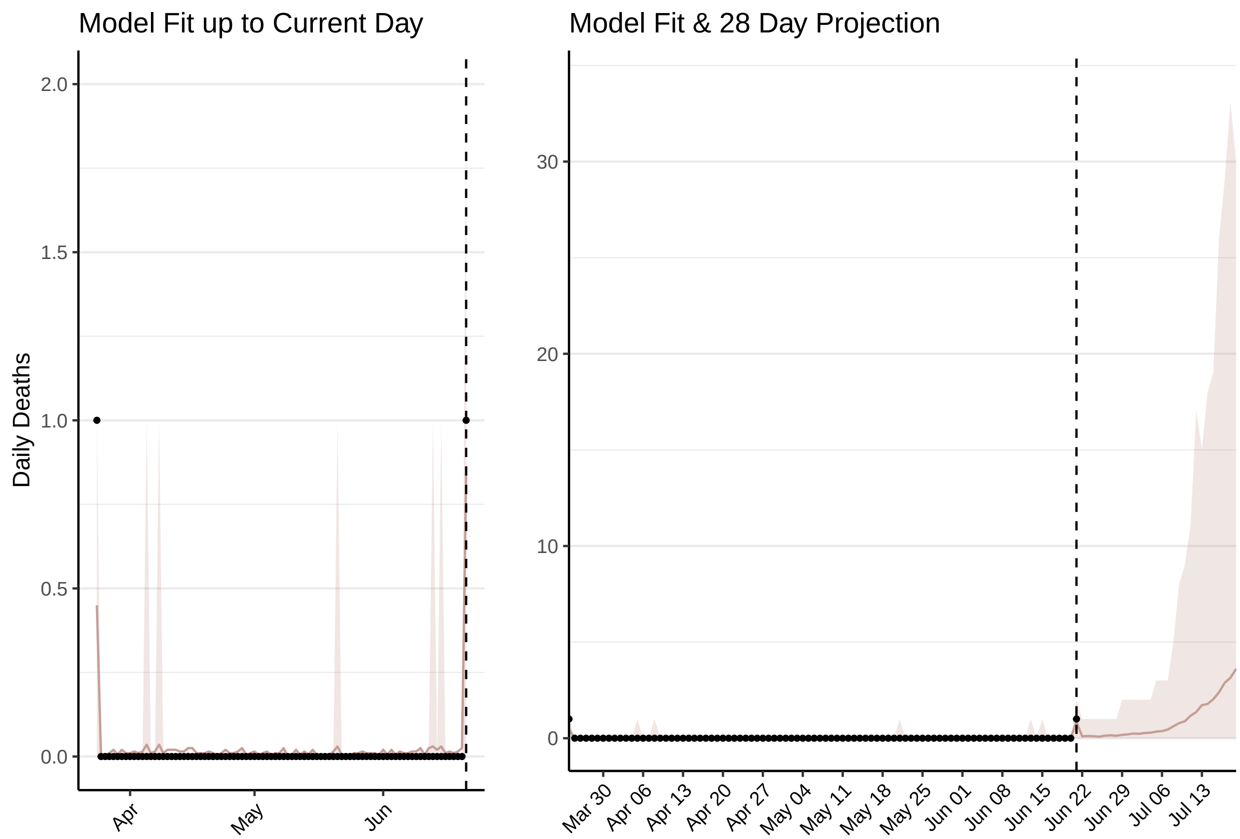


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 6 (95% CI: 5-7) patients requiring treatment with high-pressure oxygen at the current date to 113 (95% CI: 83-144) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1 (95% CI: 1-2) patients requiring treatment with mechanical ventilation at the current date to 18 (95% CI: 15-22) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

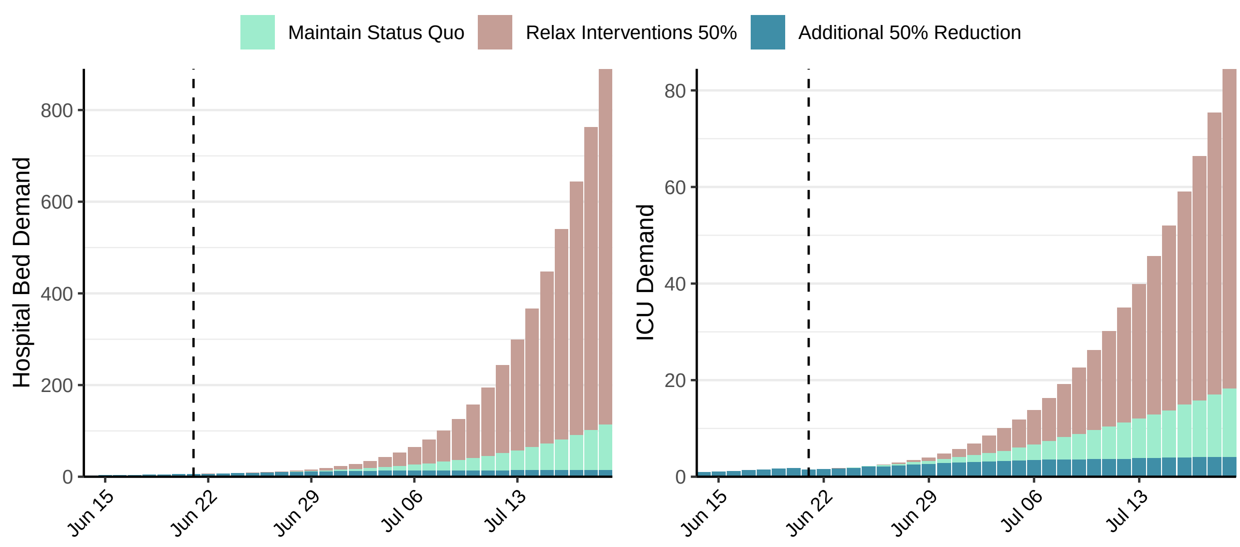


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 103 (95% CI: 84-122) at the current date to 108 (95% CI: 77-139) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 103 (95% CI: 84-122) at the current date to 25,629 (95% CI: 20,347-30,910) by 2020-07-19.

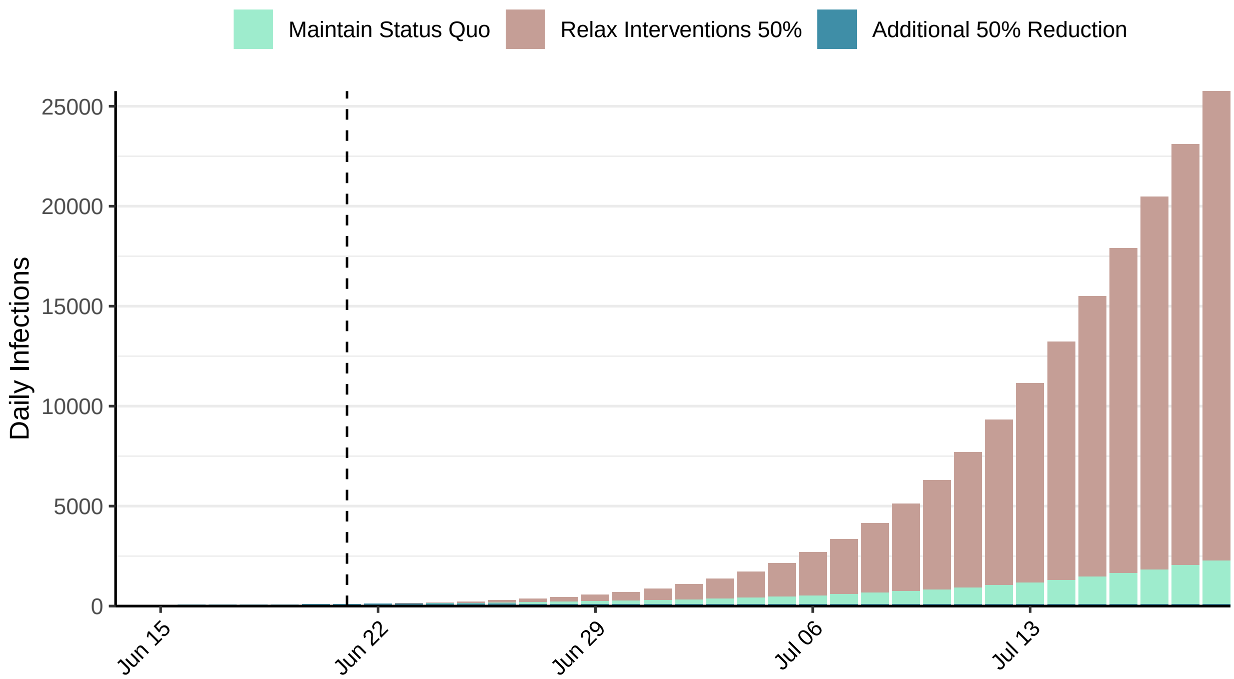


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Guinea-Bissau, 2020-06-21

**Download the report for Guinea-Bissau, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,541 | 29 | 17 | 2 | 1.19 (95% CI: 0.74-1.72) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

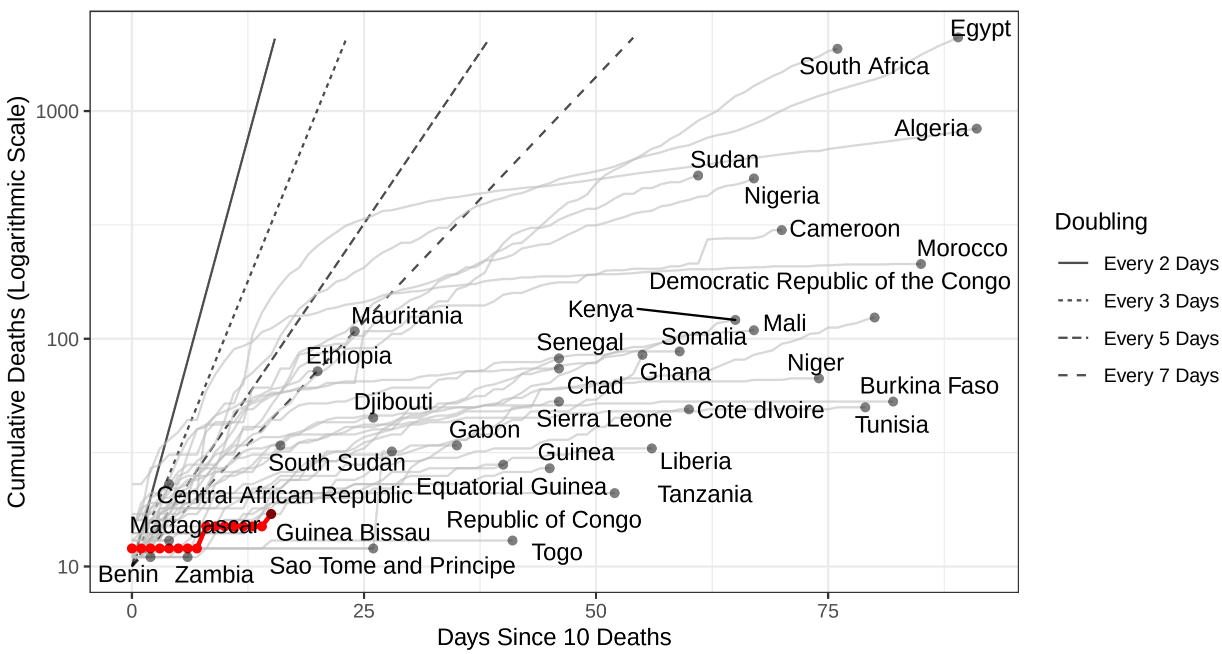


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 7,821 (95% CI: 7,140-8,503) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

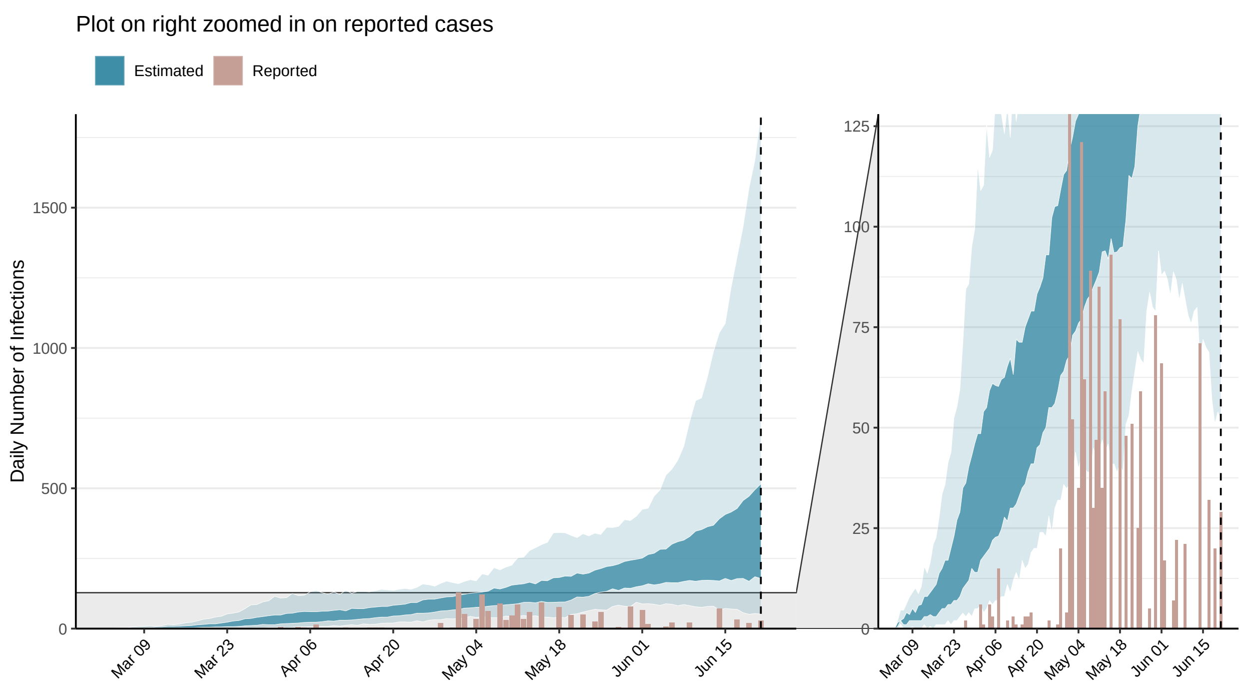


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

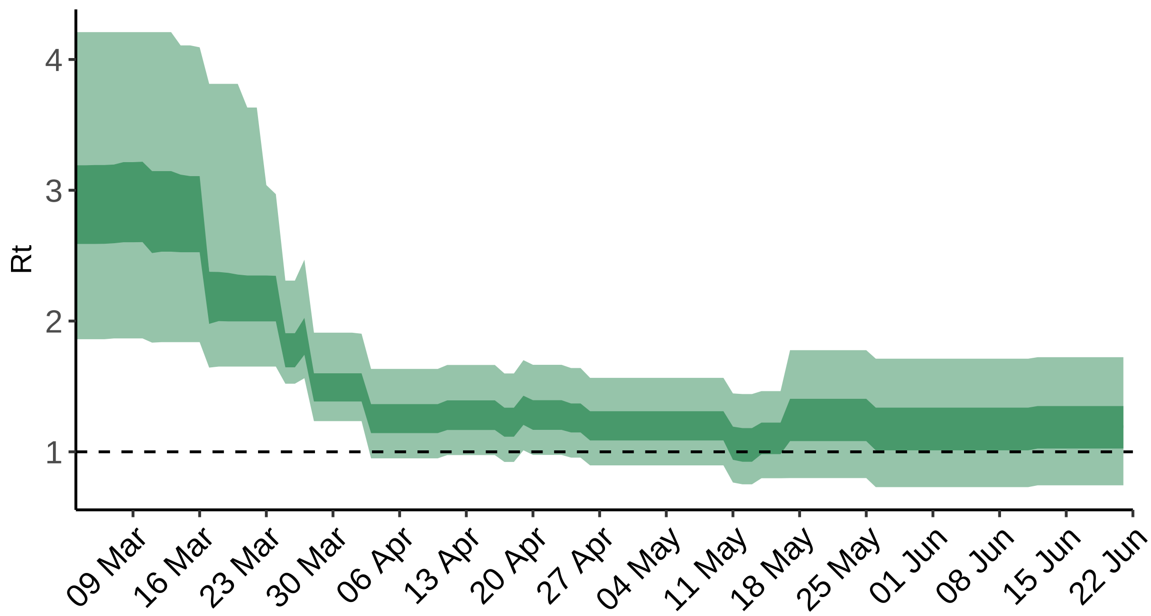


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

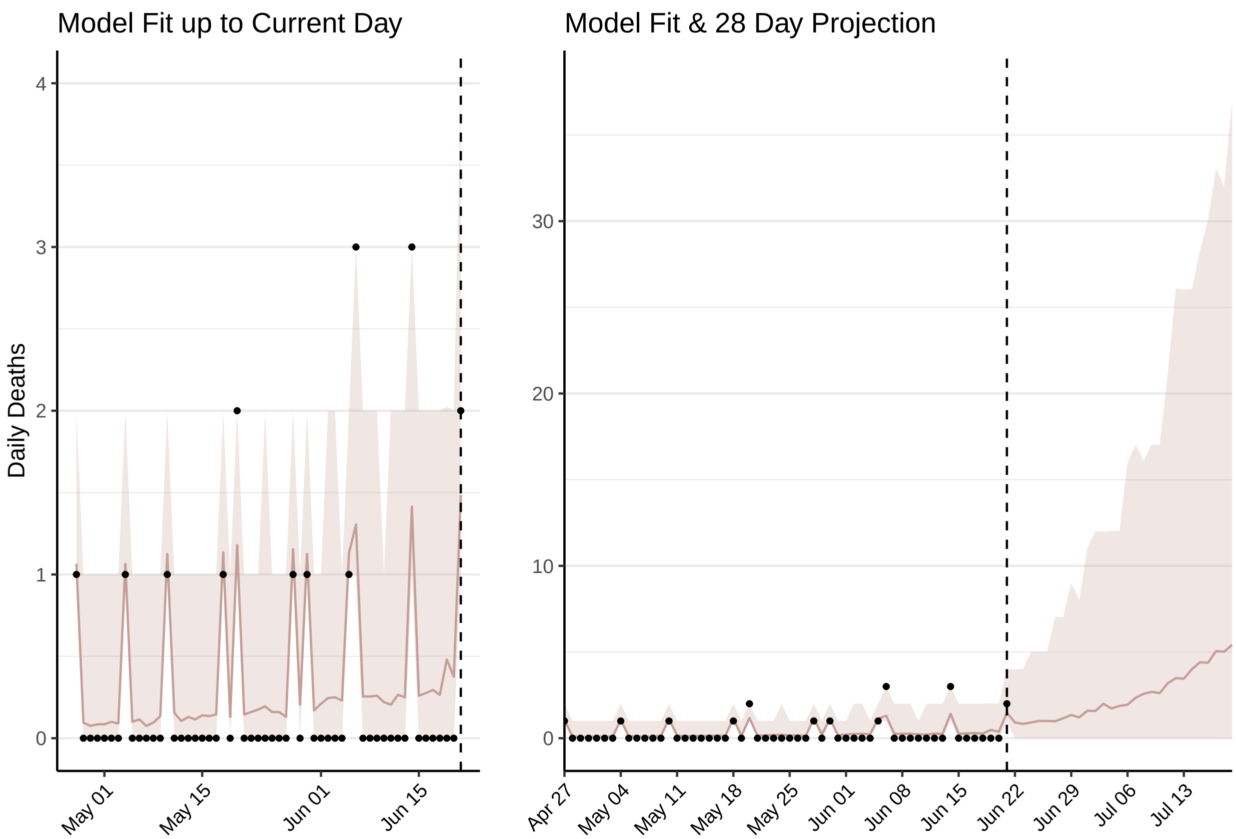


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 43 (95% CI: 39-47) patients requiring treatment with high-pressure oxygen at the current date to 172 (95% CI: 128-216) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 11 (95% CI: 10-12) patients requiring treatment with mechanical ventilation at the current date to 24 (95% CI: 21-28) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

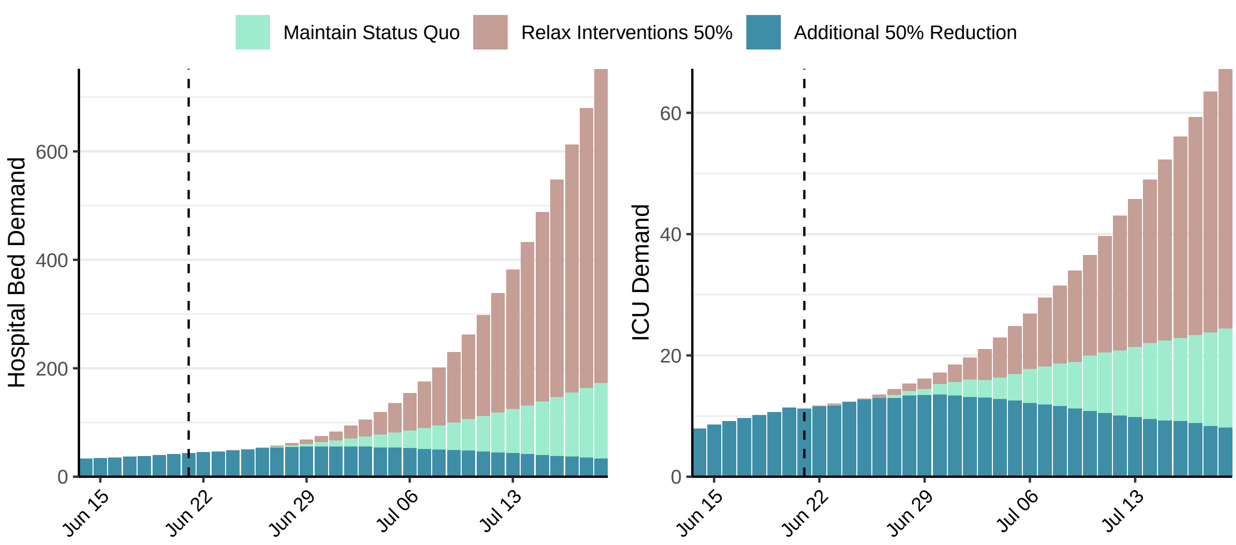


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 457 (95% CI: 391-523) at the current date to 142 (95% CI: 99-185) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 457 (95% CI: 391-523) at the current date to 14,117 (95% CI: 11,386-16,847) by 2020-07-19.

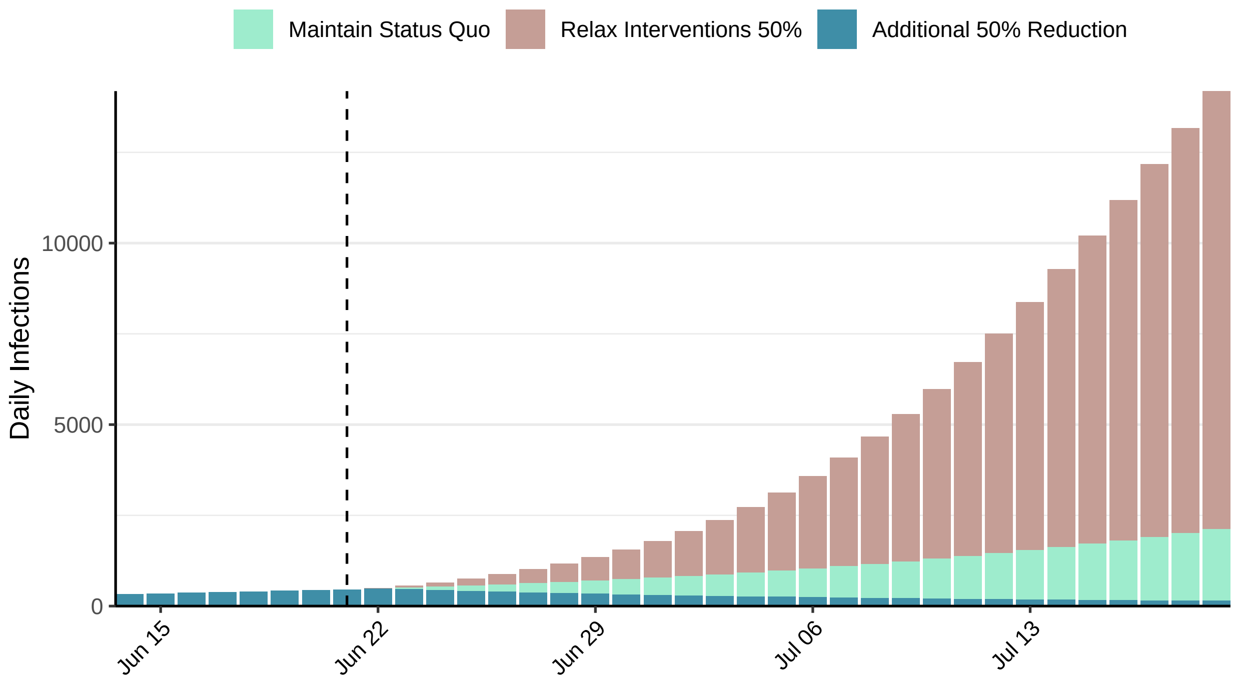


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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# Situation Report for COVID-19: Equatorial Guinea, 2020-06-21

**Download the report for Equatorial Guinea, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,664 | 0 | 32 | 0 | 1.83 (95% CI: 1.5-2.15) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

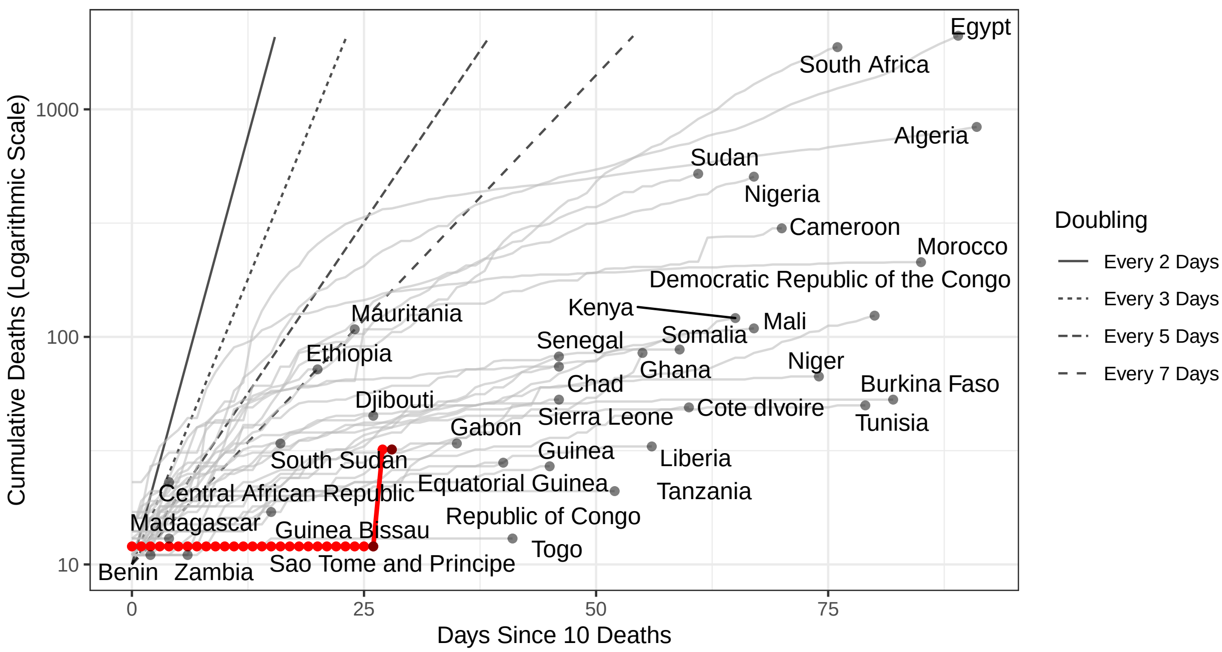


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 24,989 (95% CI: 23,556-26,422) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

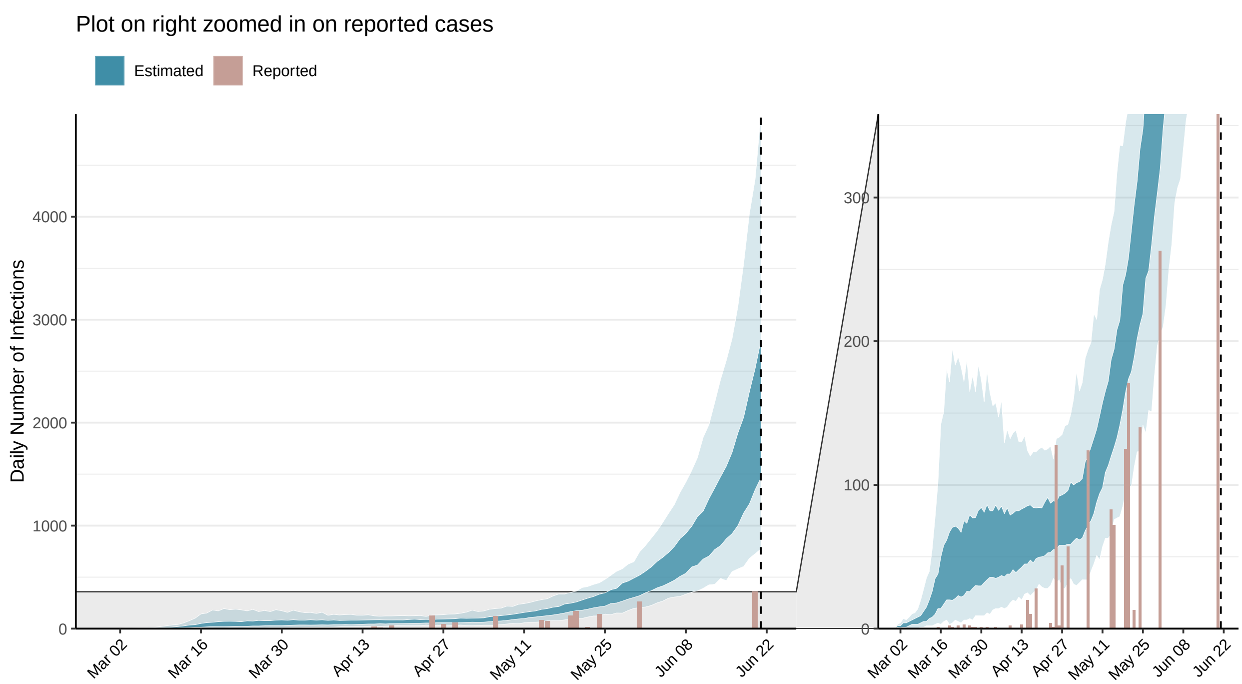


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

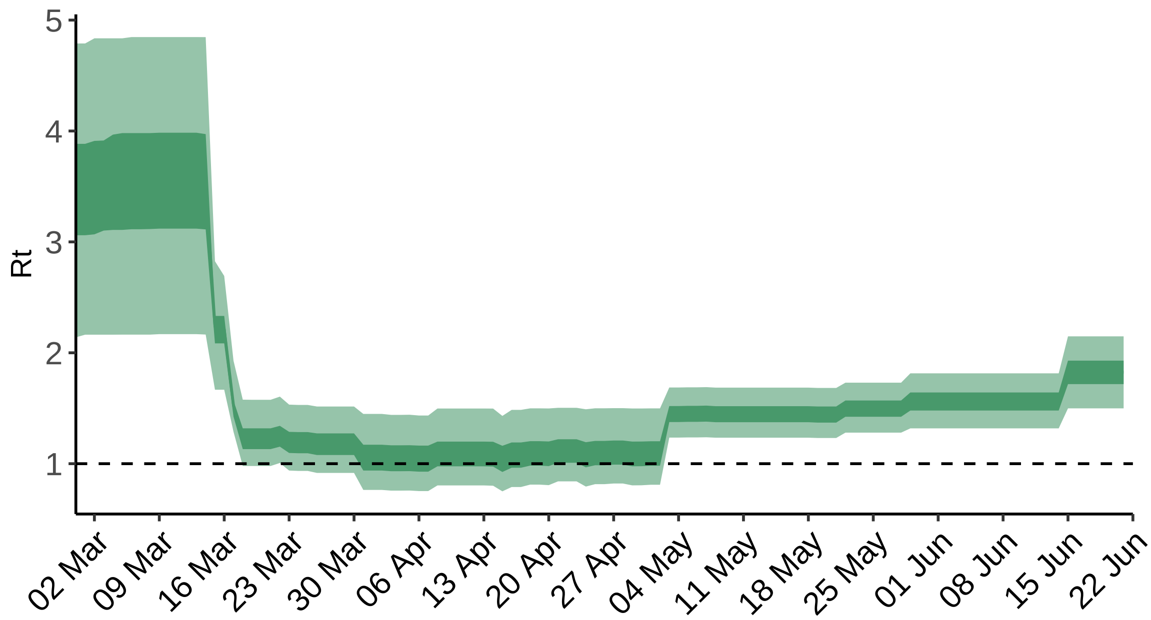


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Equatorial Guinea is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

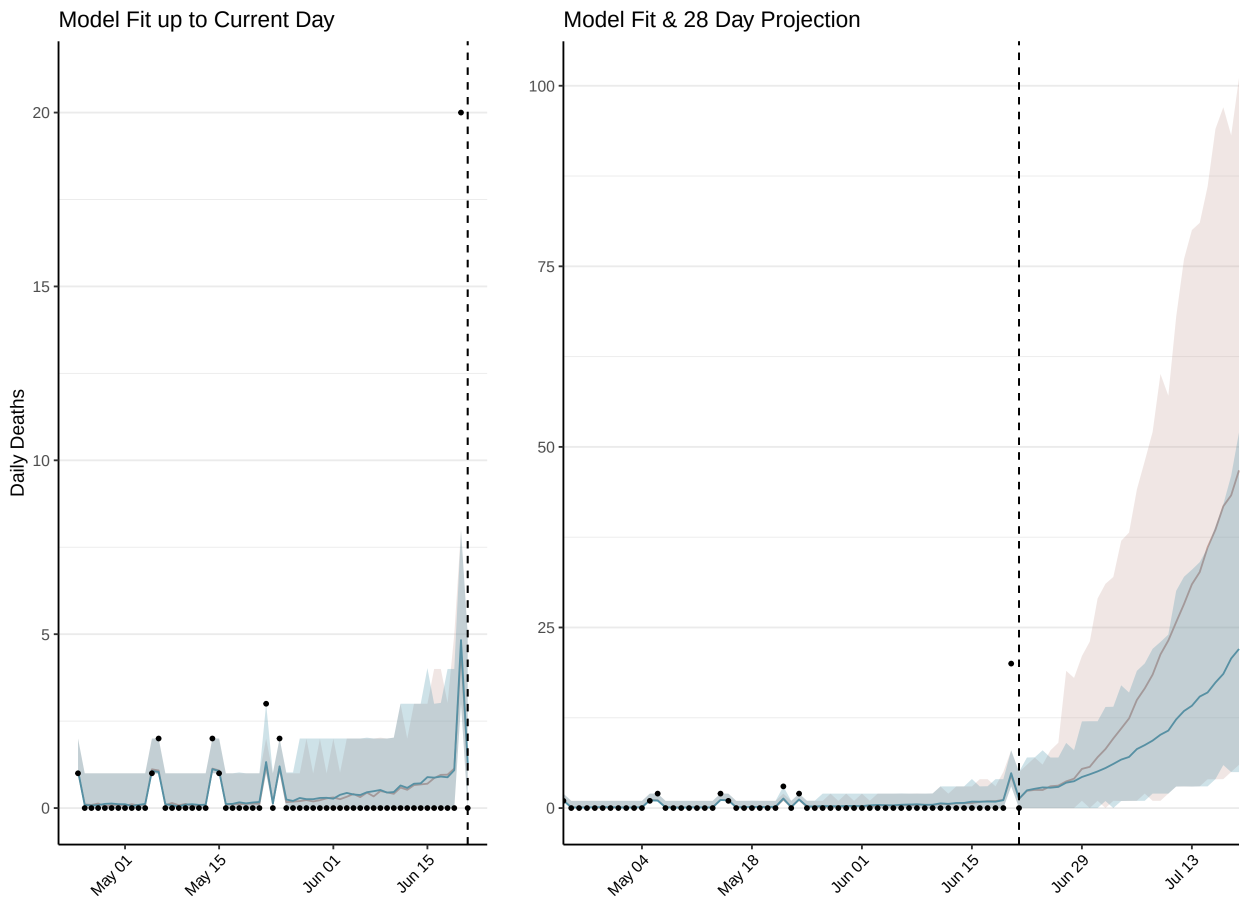


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 141 (95% CI: 133-149) patients requiring treatment with high-pressure oxygen at the current date to 1,458 (95% CI: 1,353-1,563) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 35 (95% CI: 33-37) patients requiring treatment with mechanical ventilation at the current date to 149 (95% CI: 145-154) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

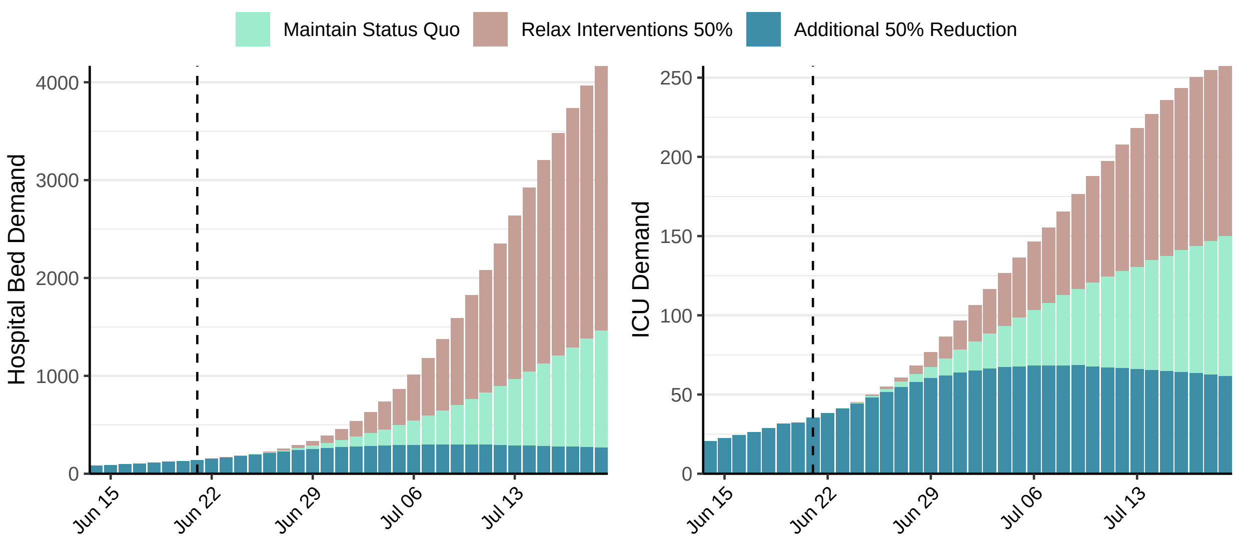


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,218 (95% CI: 2,066-2,370) at the current date to 1,517 (95% CI: 1,377-1,657) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,218 (95% CI: 2,066-2,370) at the current date to 47,529 (95% CI: 46,307-48,751) by 2020-07-19.

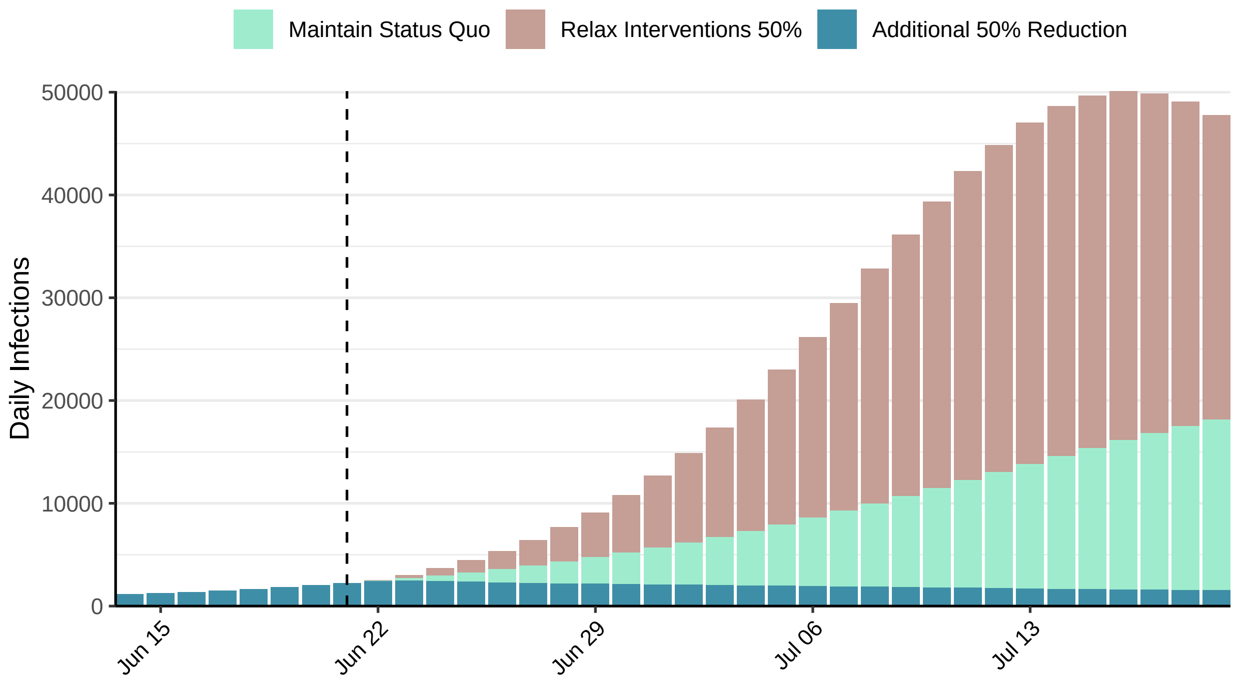


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Guatemala, 2020-06-21

**Download the report for Guatemala, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 12,755 | 246 | 514 | 31 | 1.71 (95% CI: 1.59-1.81) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

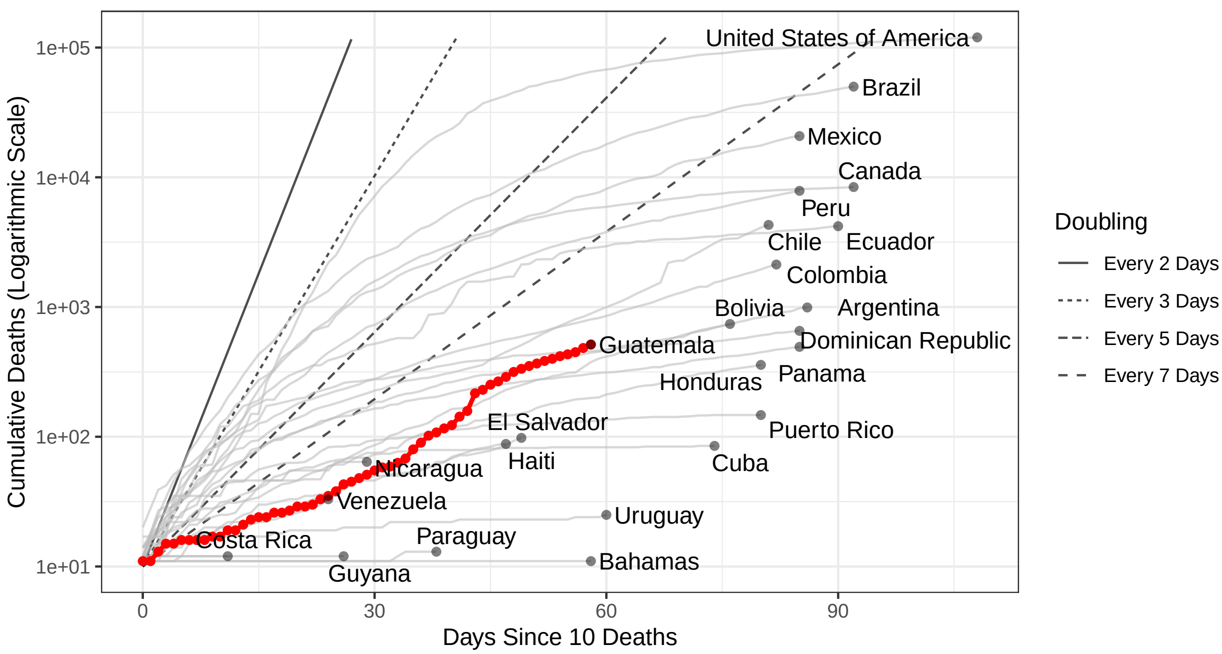


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 529,950 (95% CI: 509,687-550,213) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

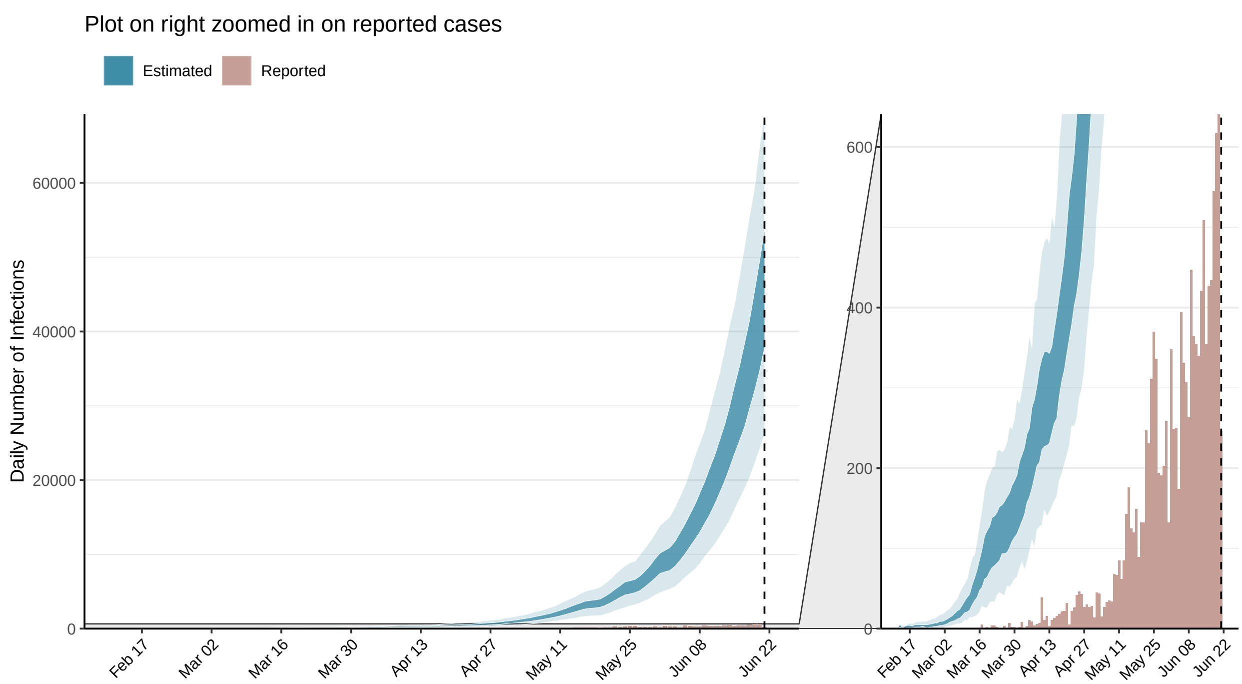


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

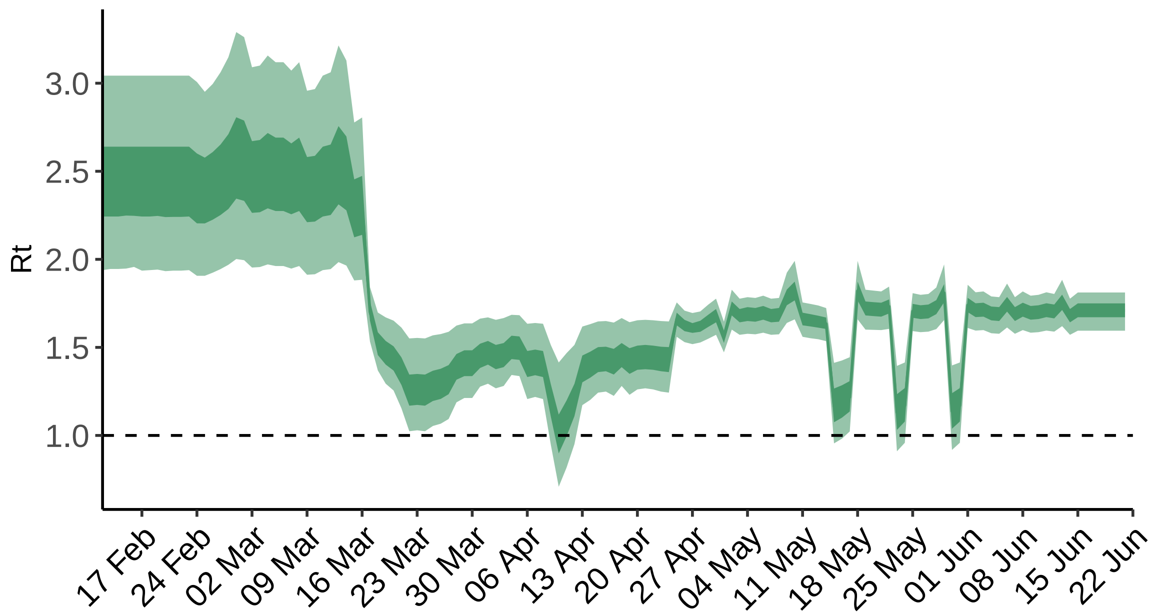


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Guatemala is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

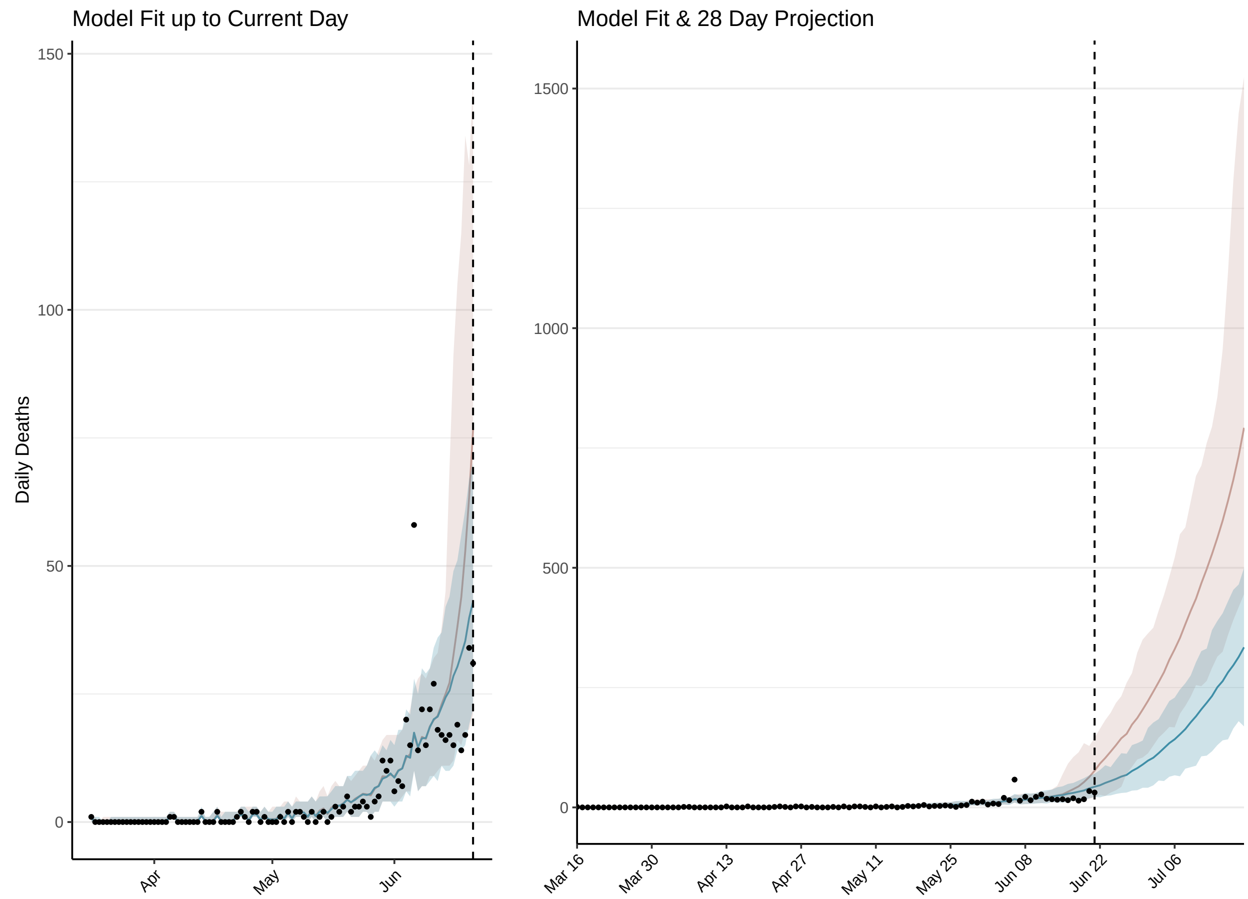


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 2,599 (95% CI: 2,499-2,700) patients requiring treatment with high-pressure oxygen at the current date to 18,098 (95% CI: 17,549-18,648) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 612 (95% CI: 599-625) patients requiring treatment with mechanical ventilation at the current date to 1,354 (95% CI: 1,326-1,382) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

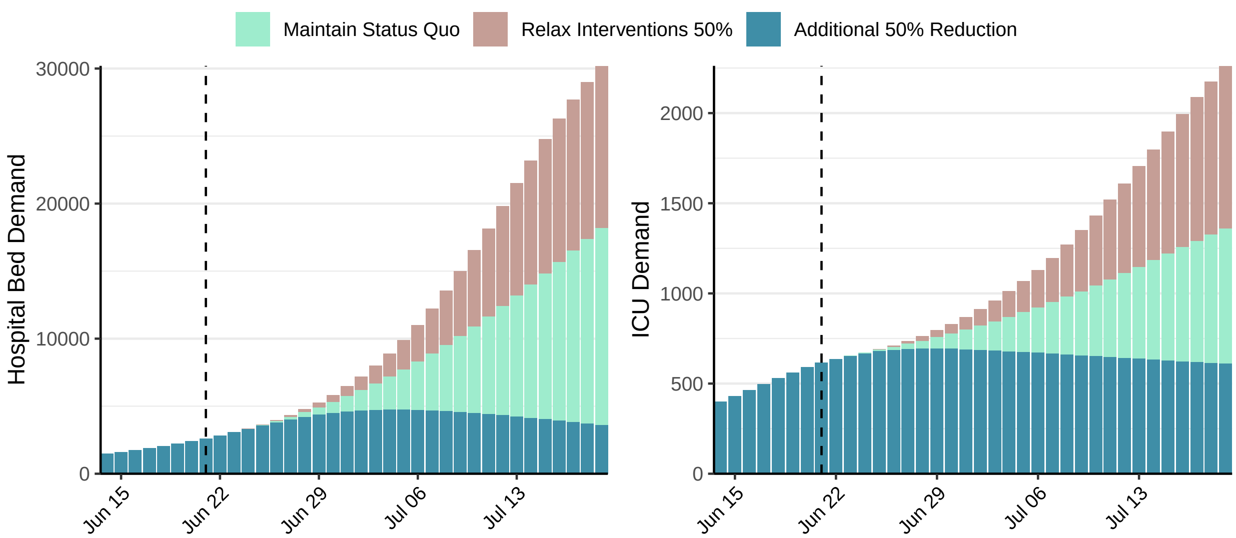


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 45,713 (95% CI: 43,993-47,434) at the current date to 18,989 (95% CI: 18,325-19,653) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 45,713 (95% CI: 43,993-47,434) at the current date to 391,267 (95% CI: 385,291-397,243) by 2020-07-19.

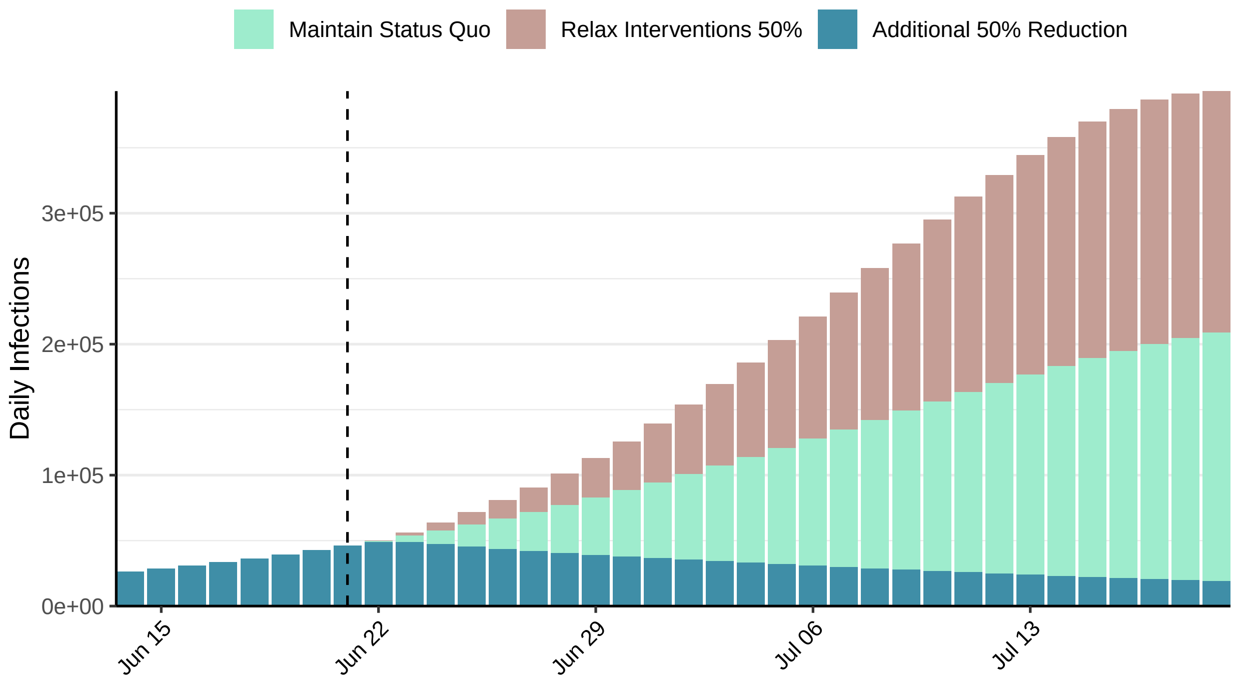


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Guyana, 2020-06-21

**Download the report for Guyana, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 183 | 0 | 12 | 0 | 0.53 (95% CI: 0.05-1.41) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

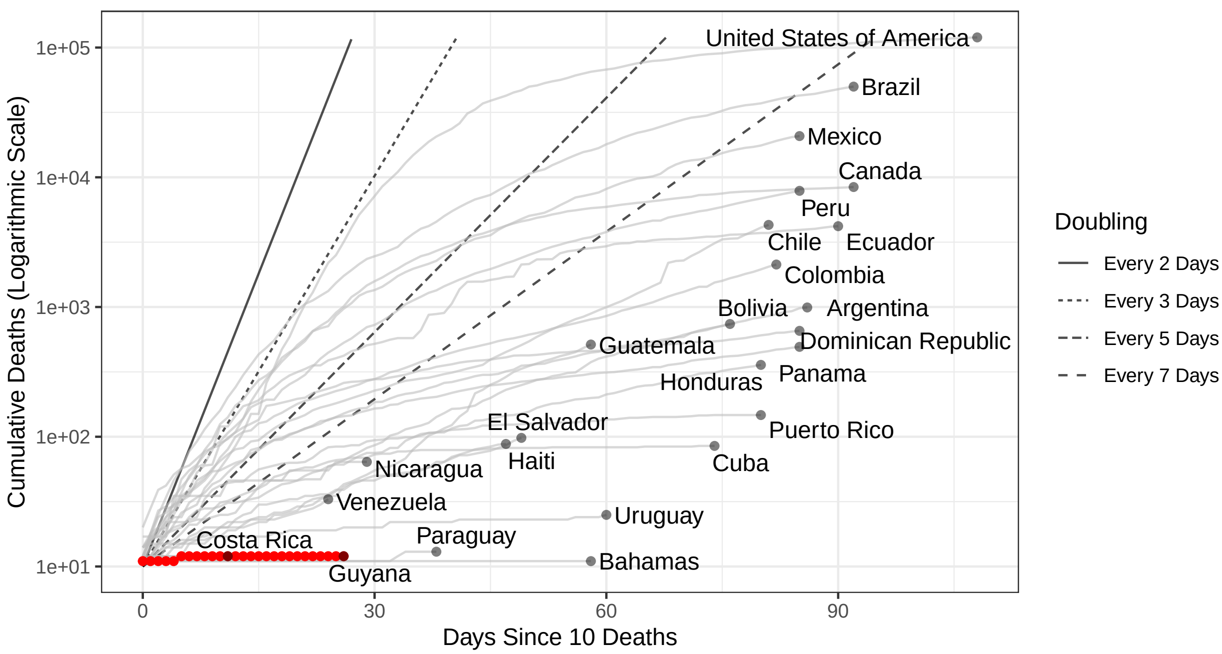


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 114 (95% CI: 79-150) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

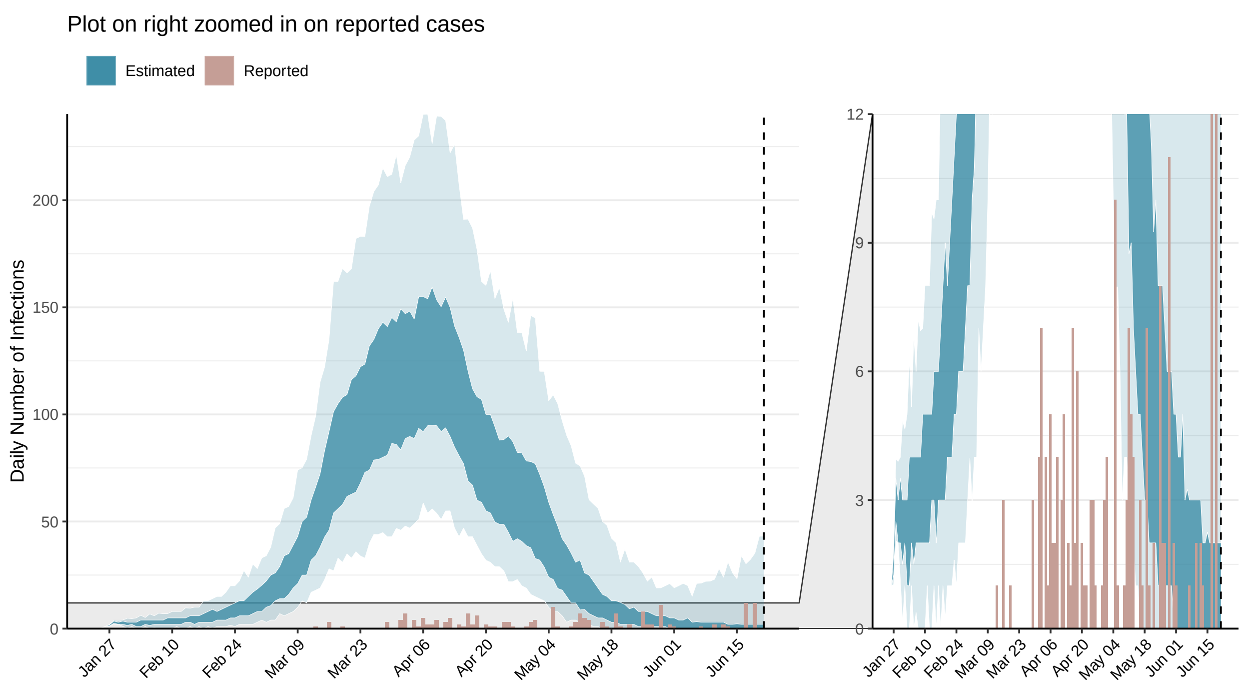


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

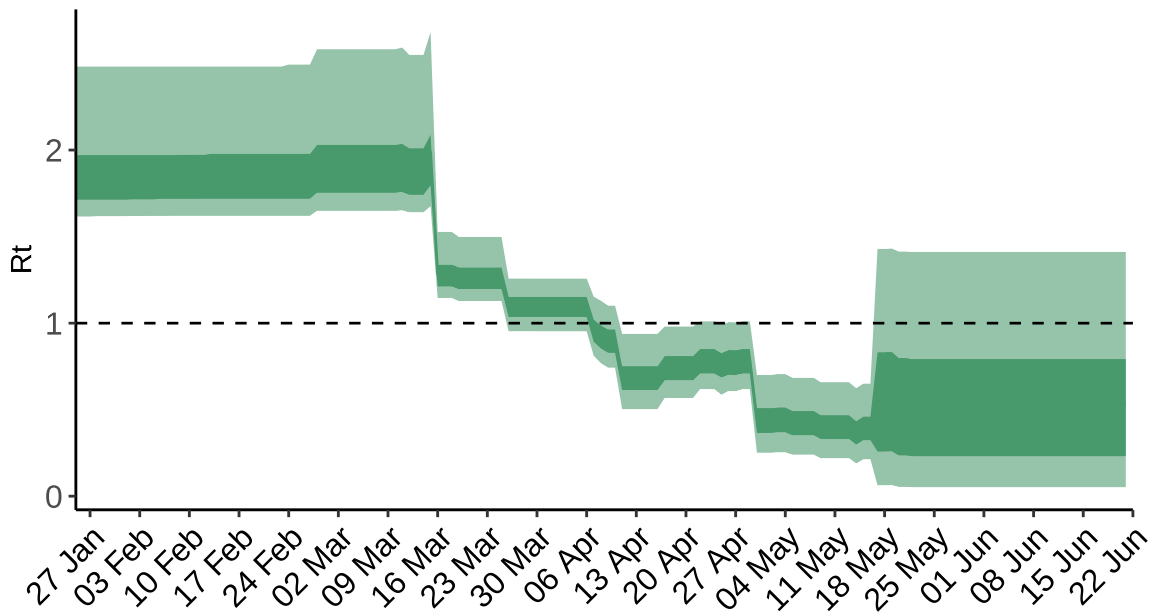


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

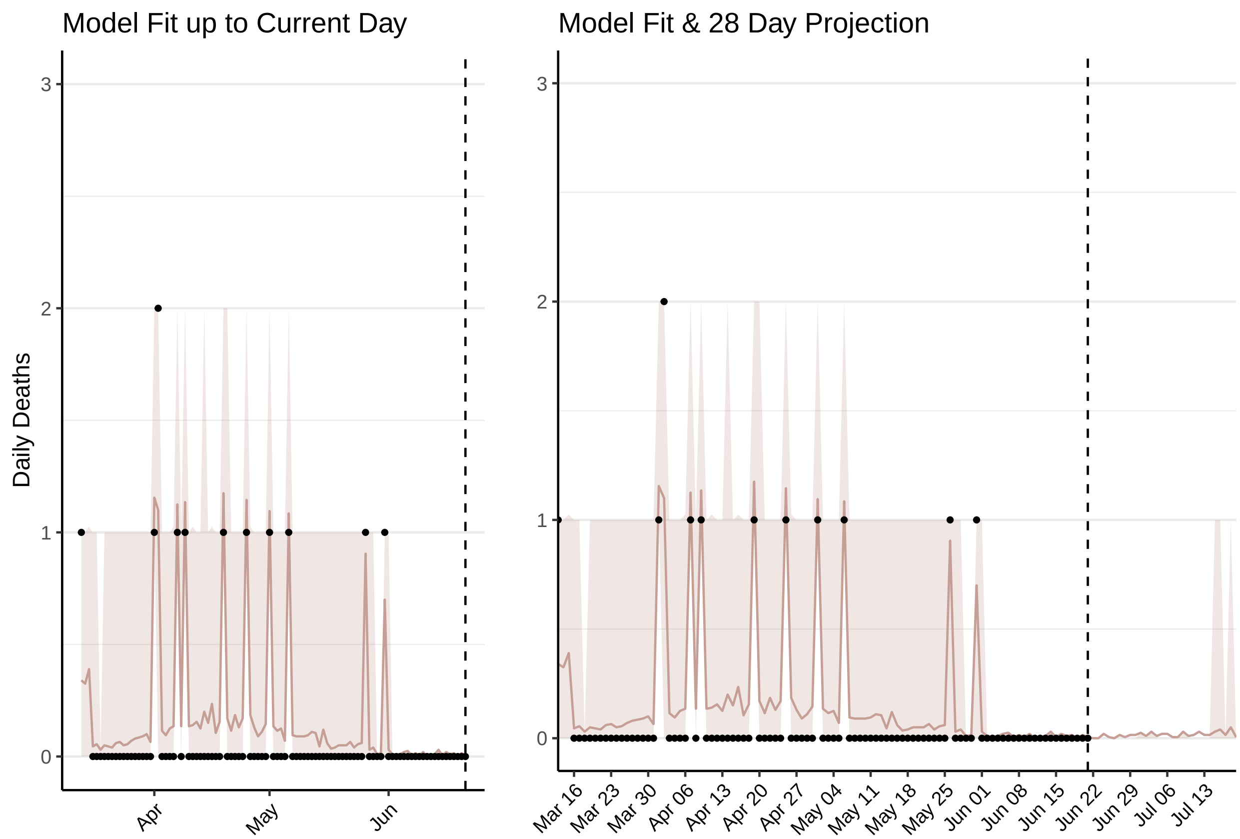


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1 (95% CI: 0-1) patients requiring treatment with high-pressure oxygen at the current date to 1 (95% CI: 1-2) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 0 (95% CI: 0-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

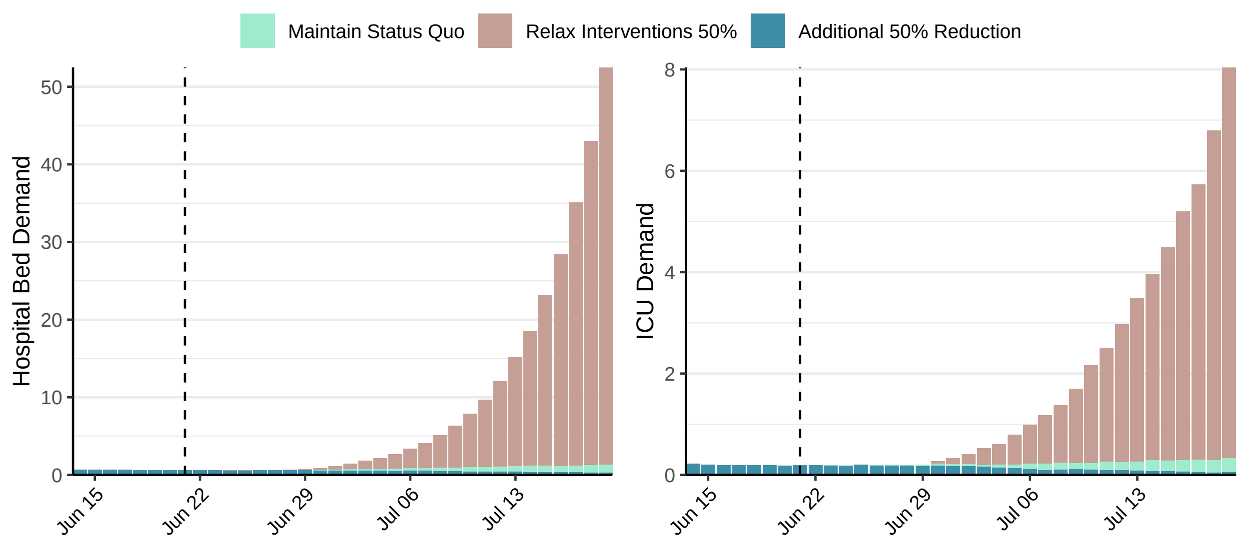


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 5 (95% CI: 2-7) at the current date to 1 (95% CI: 0-2) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 5 (95% CI: 2-7) at the current date to 1,434 (95% CI: 605-2,263) by 2020-07-19.

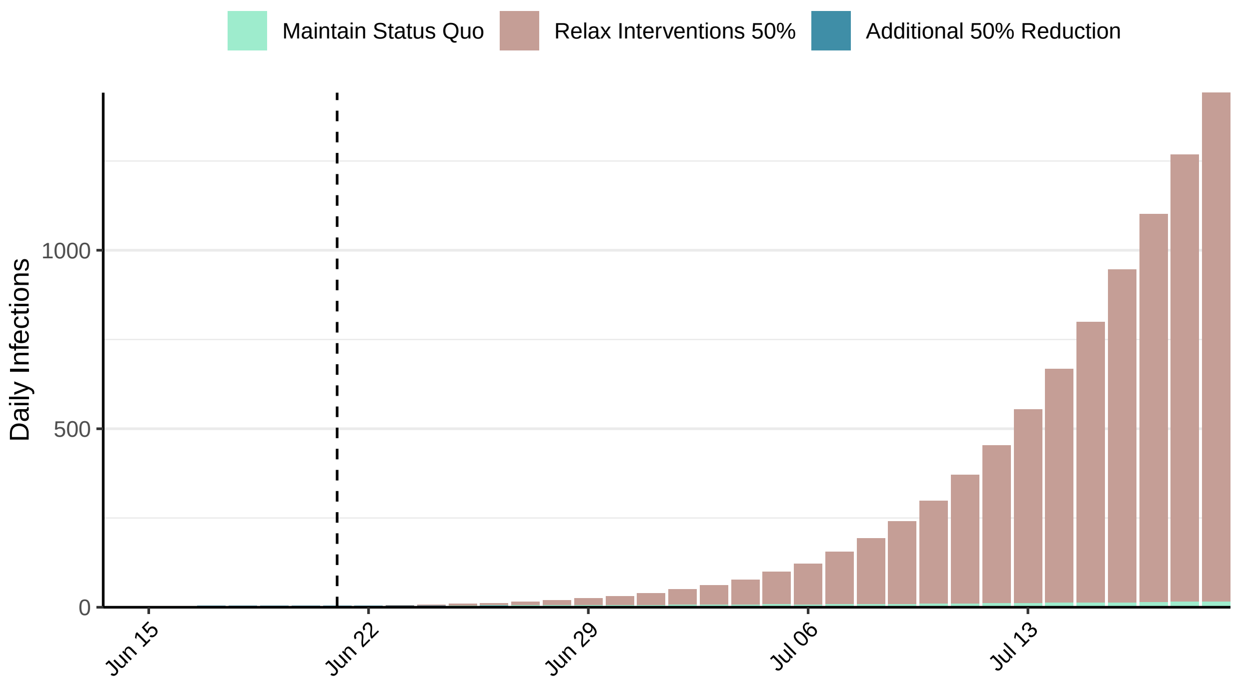


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our [COVID-19 Scenario Analysis Tool - https://covidsim.org/](https://covidsim.org/), which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Honduras, 2020-06-21

**Download the report for Honduras, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 12,250 | 992 | 358 | 9 | 1.3 (95% CI: 1.24-1.4) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

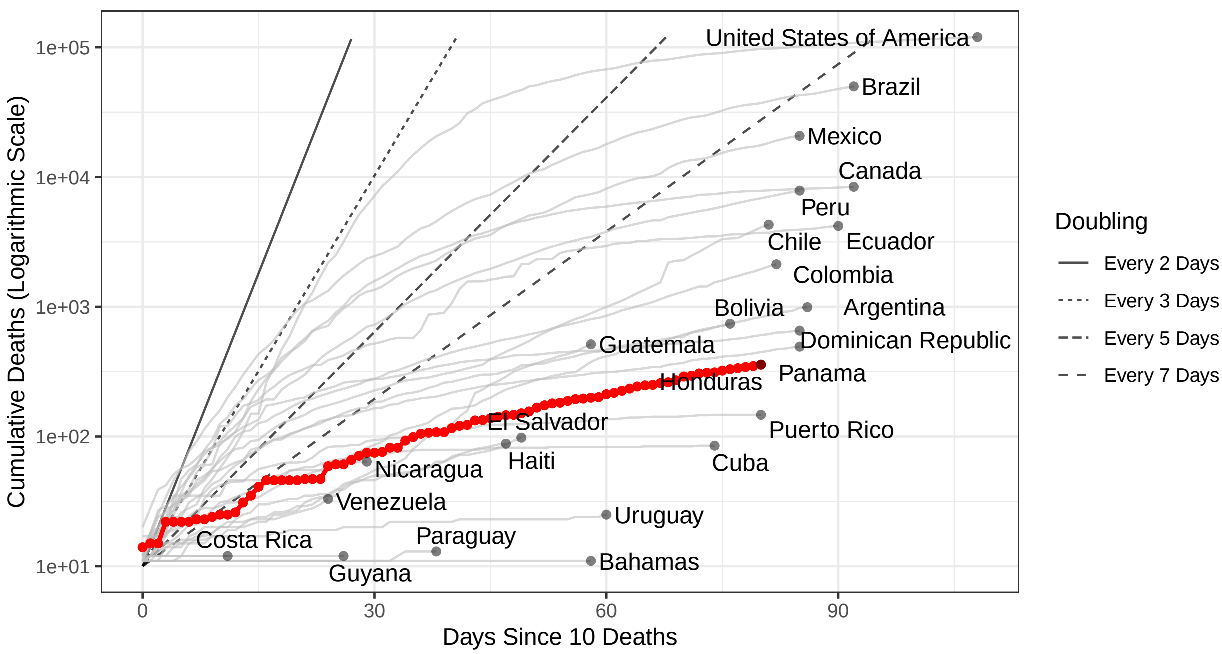


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

### COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 134,747 (95% CI: 130,435-139,059) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

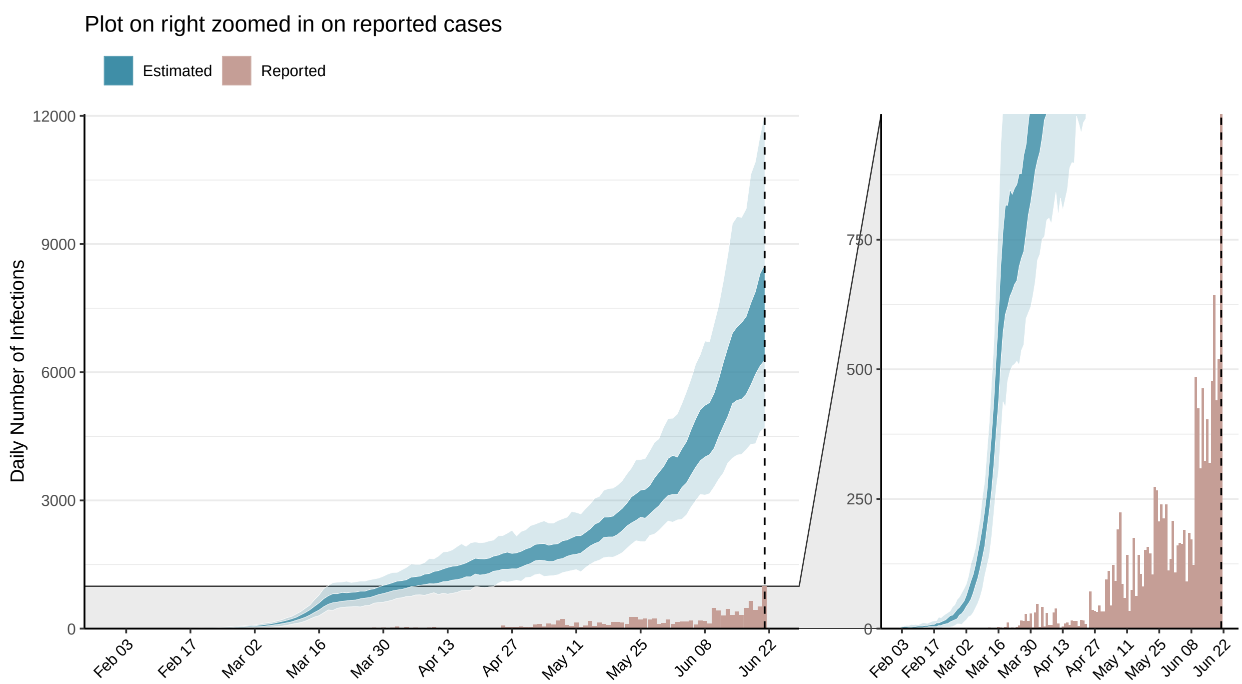


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

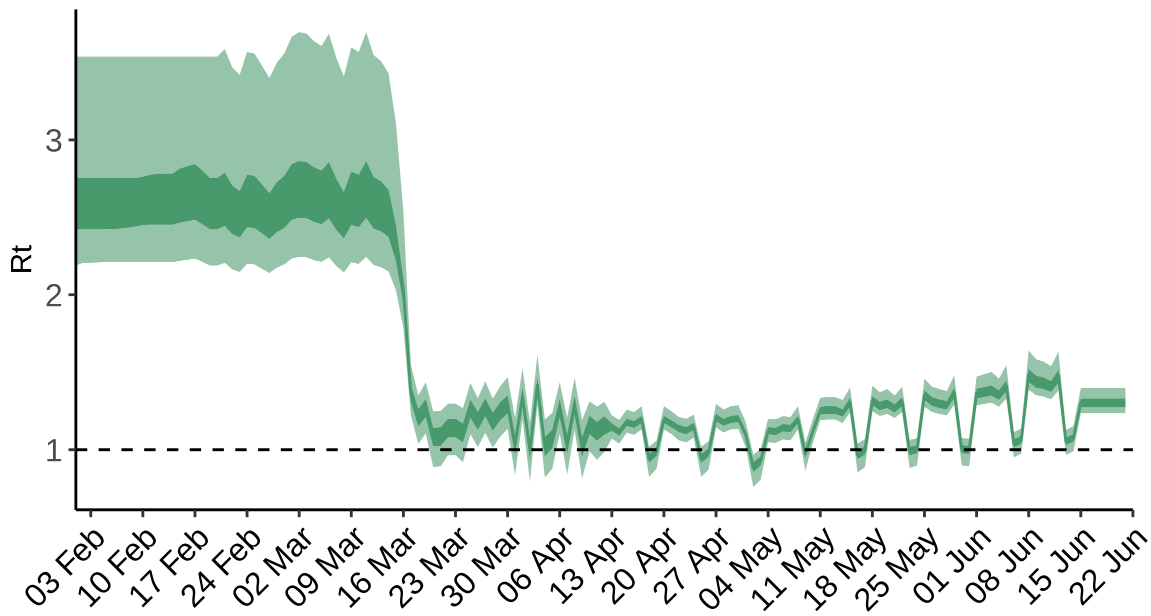


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

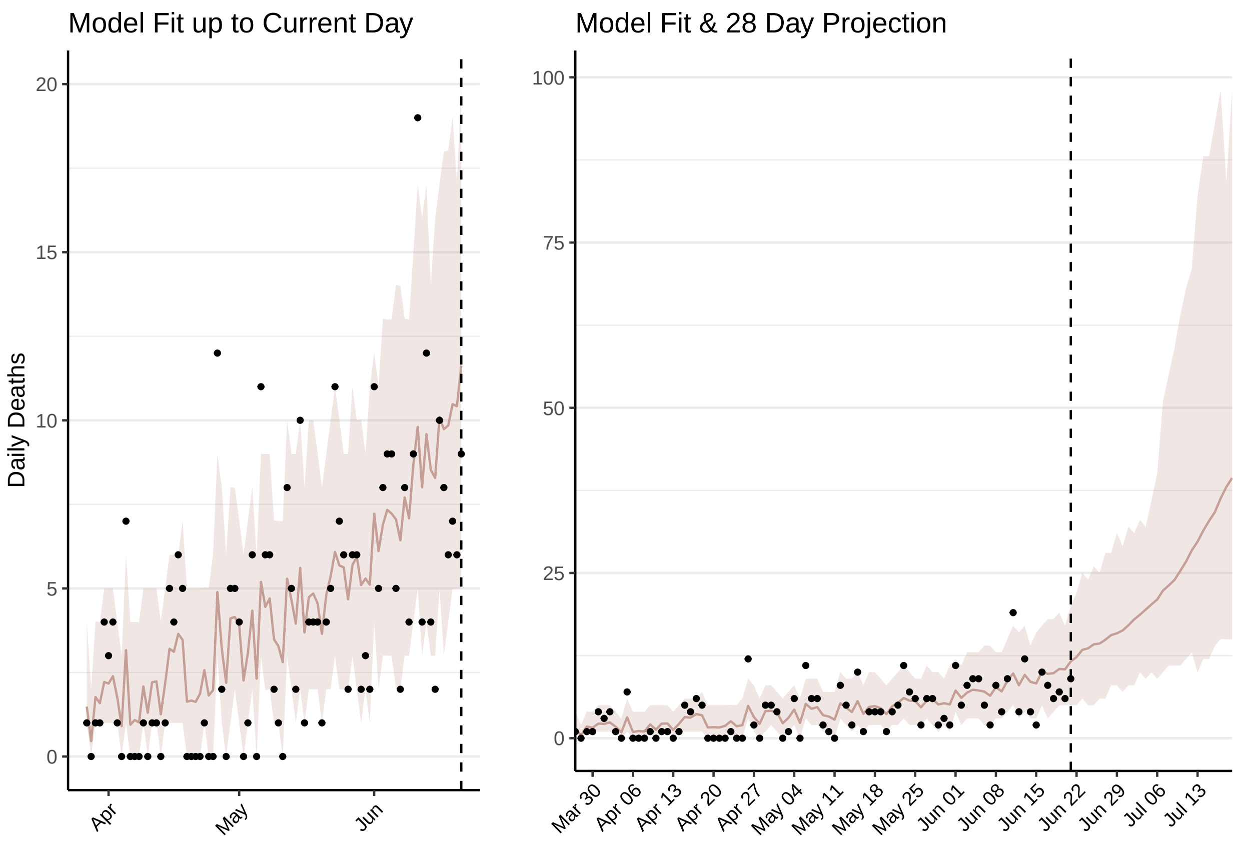


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 670 (95% CI: 647-692) patients requiring treatment with high-pressure oxygen at the current date to 1,817 (95% CI: 1,738-1,895) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 186 (95% CI: 179-193) patients requiring treatment with mechanical ventilation at the current date to 469 (95% CI: 455-482) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

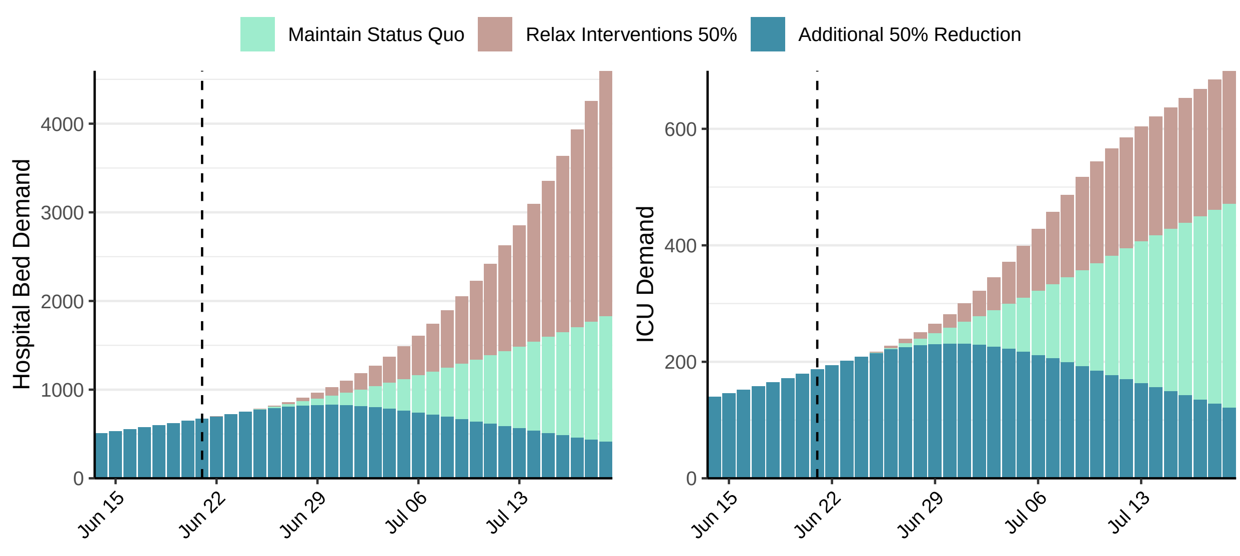


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 7,569 (95% CI: 7,292-7,845) at the current date to 1,428 (95% CI: 1,362-1,494) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 7,569 (95% CI: 7,292-7,845) at the current date to 69,854 (95% CI: 67,111-72,597) by 2020-07-19.

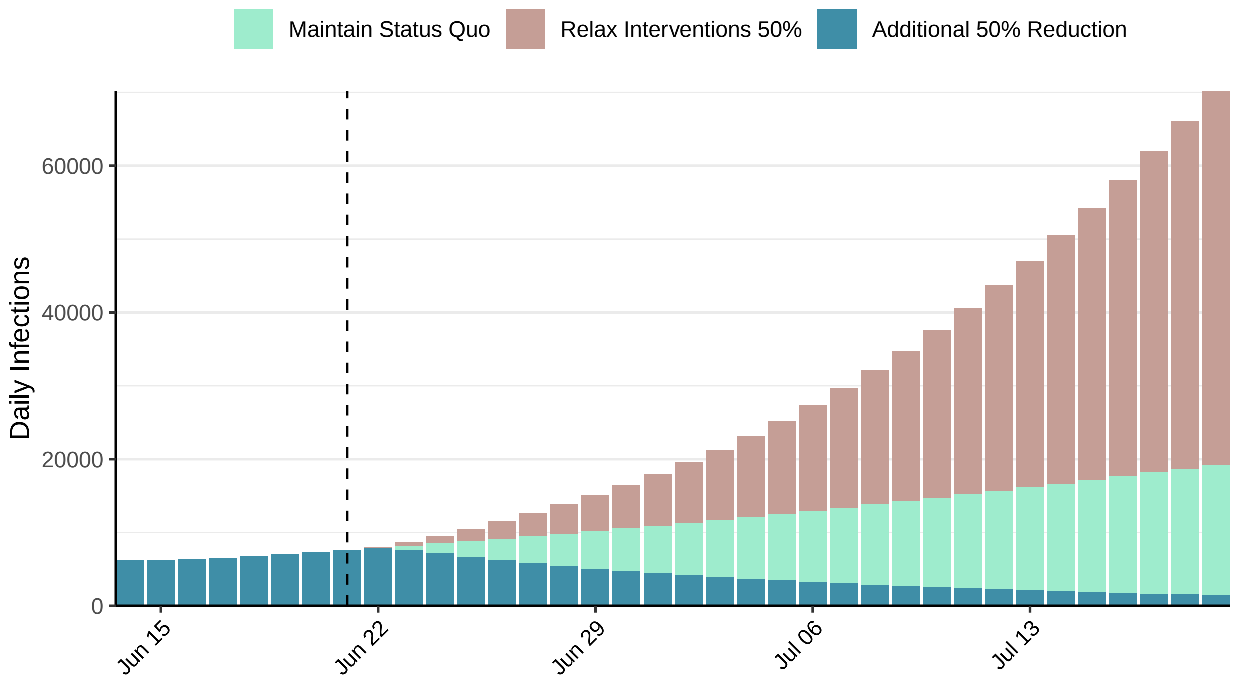


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Haiti, 2020-06-21

**Download the report for Haiti, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 5,077 | 97 | 88 | 1 | 0.97 (95% CI: 0.51-1.56) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

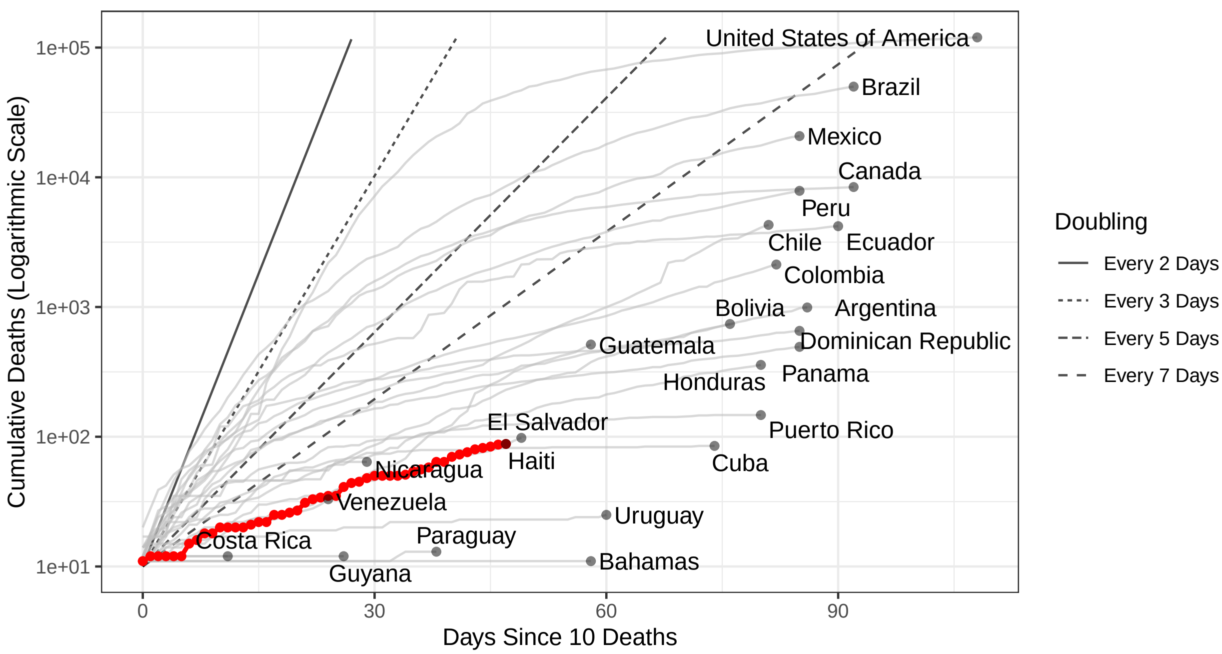


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 43,706 (95% CI: 41,314-46,099) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

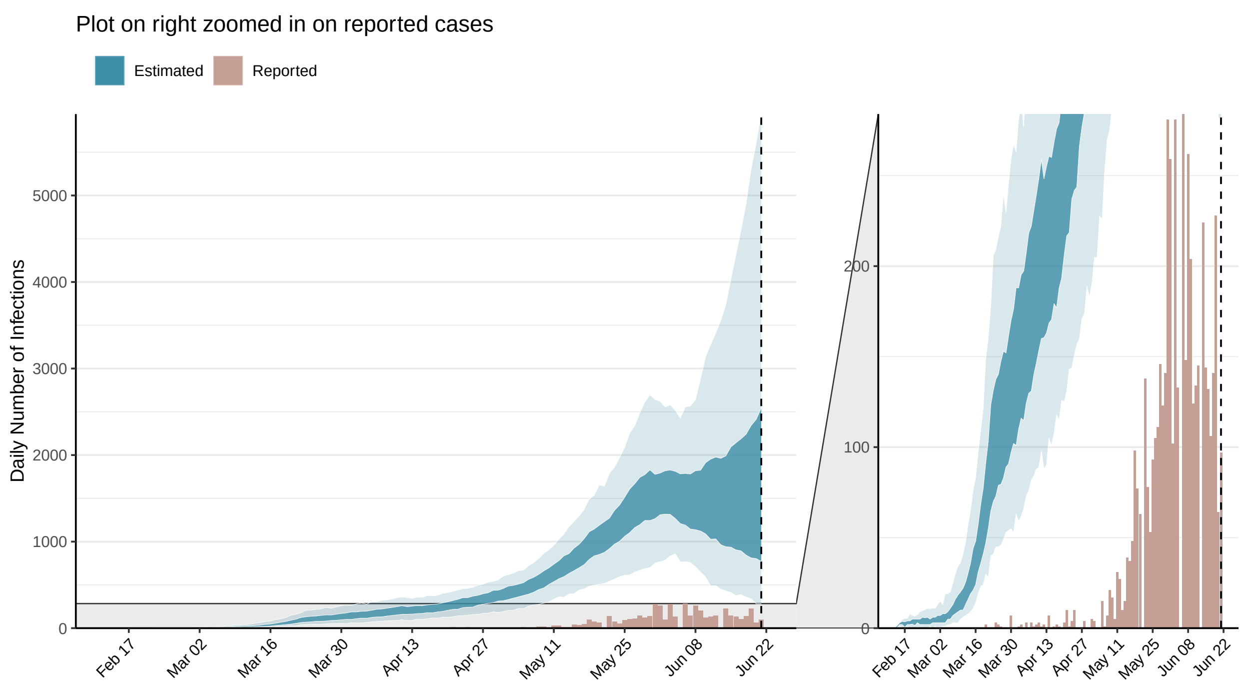


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

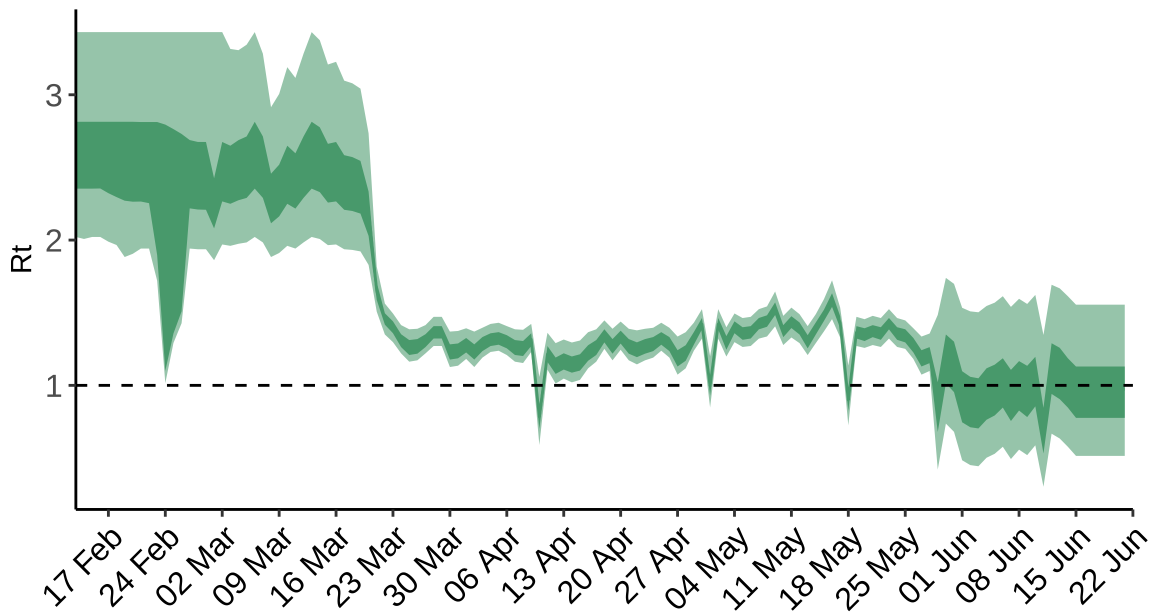


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

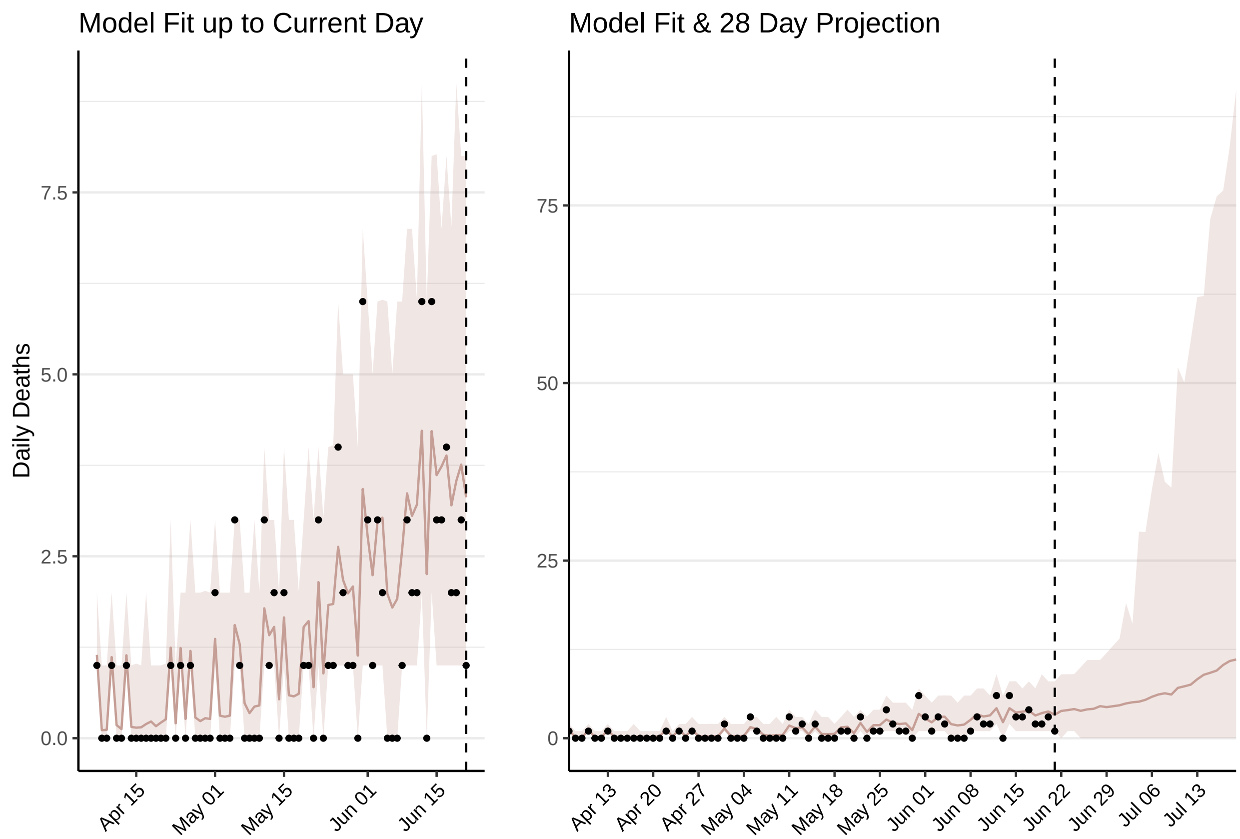


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 200 (95% CI: 187-213) patients requiring treatment with high-pressure oxygen at the current date to 403 (95% CI: 306-499) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 56 (95% CI: 52-59) patients requiring treatment with mechanical ventilation at the current date to 81 (95% CI: 69-94) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

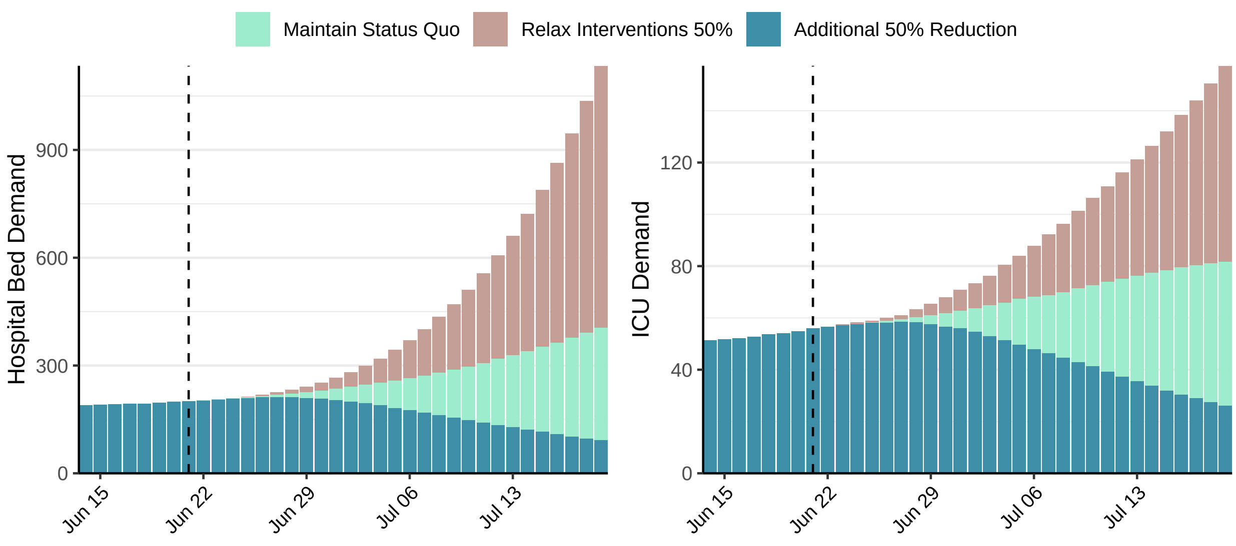


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 1,818 (95% CI: 1,597-2,039) at the current date to 327 (95% CI: 236-419) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 1,818 (95% CI: 1,597-2,039) at the current date to 19,839 (95% CI: 14,229-25,449) by 2020-07-19.

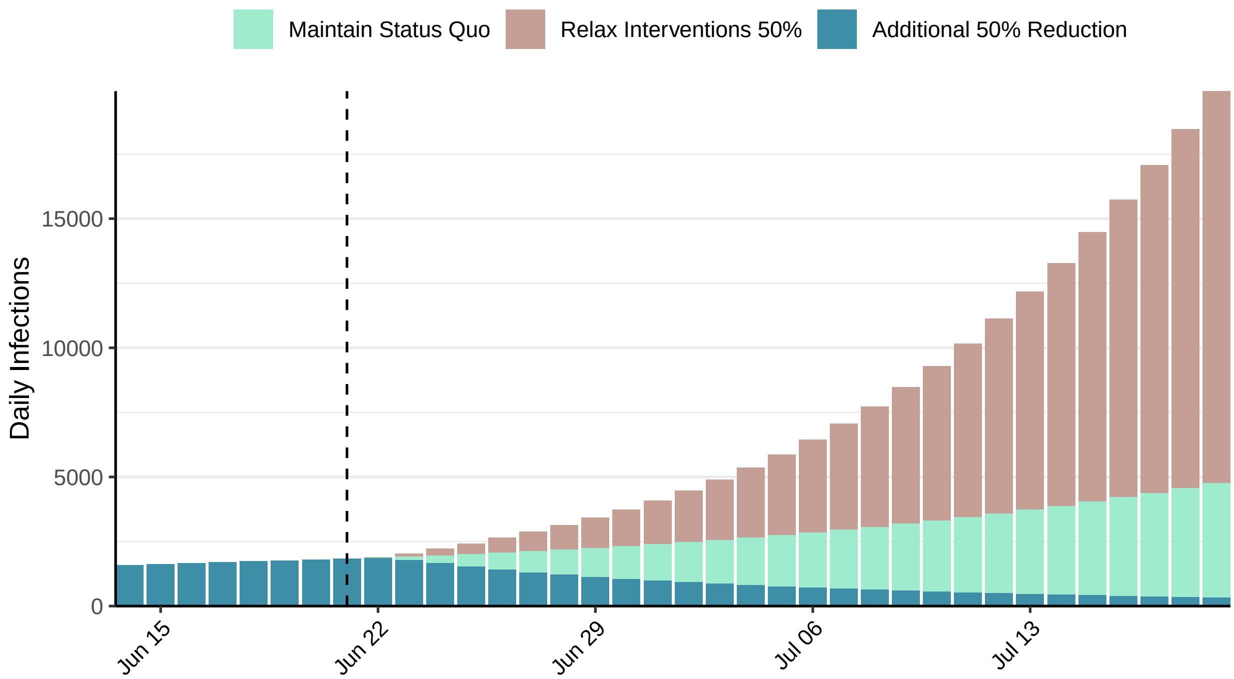


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Indonesia, 2020-06-21

**Download the report for Indonesia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 45,029 | 1,226 | 2,429 | 56 | 1.45 (95% CI: 1.36-1.54) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

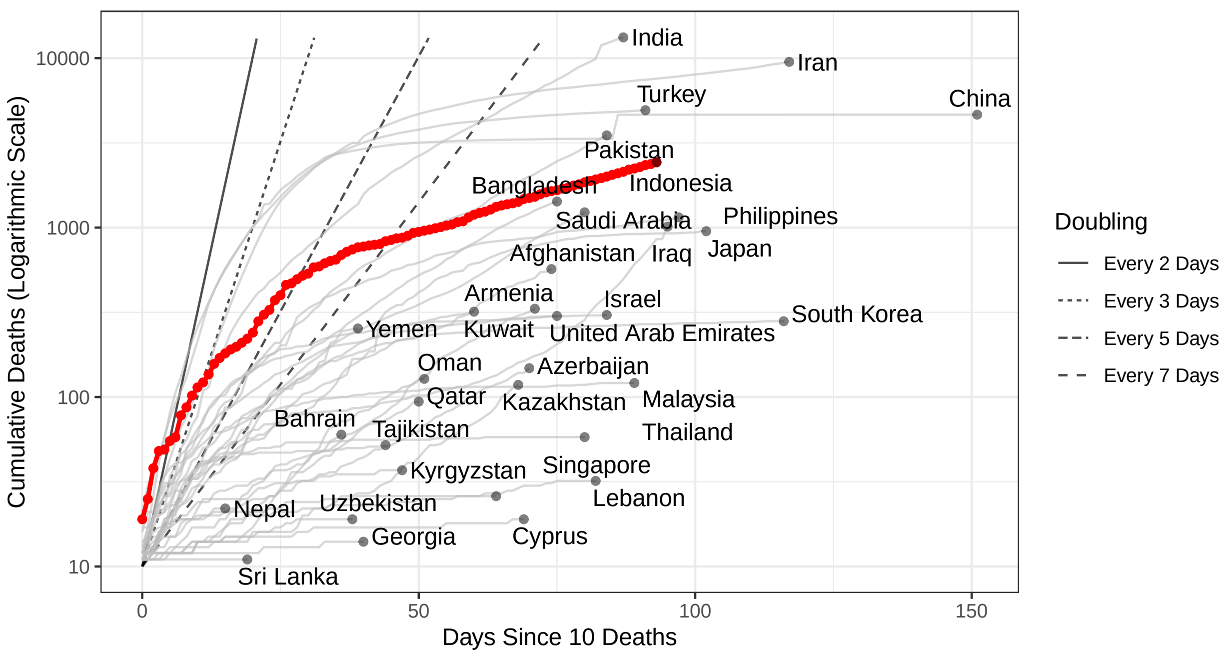


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

### COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 521,867 (95% CI: 508,099-535,634) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

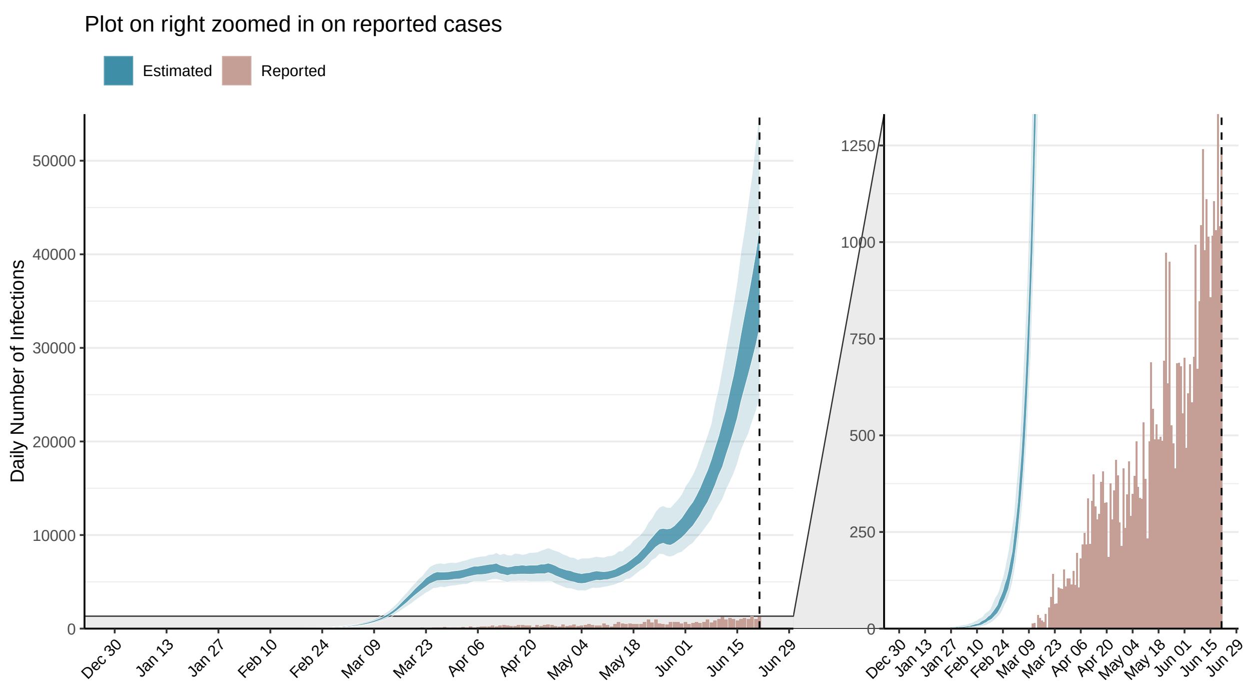


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

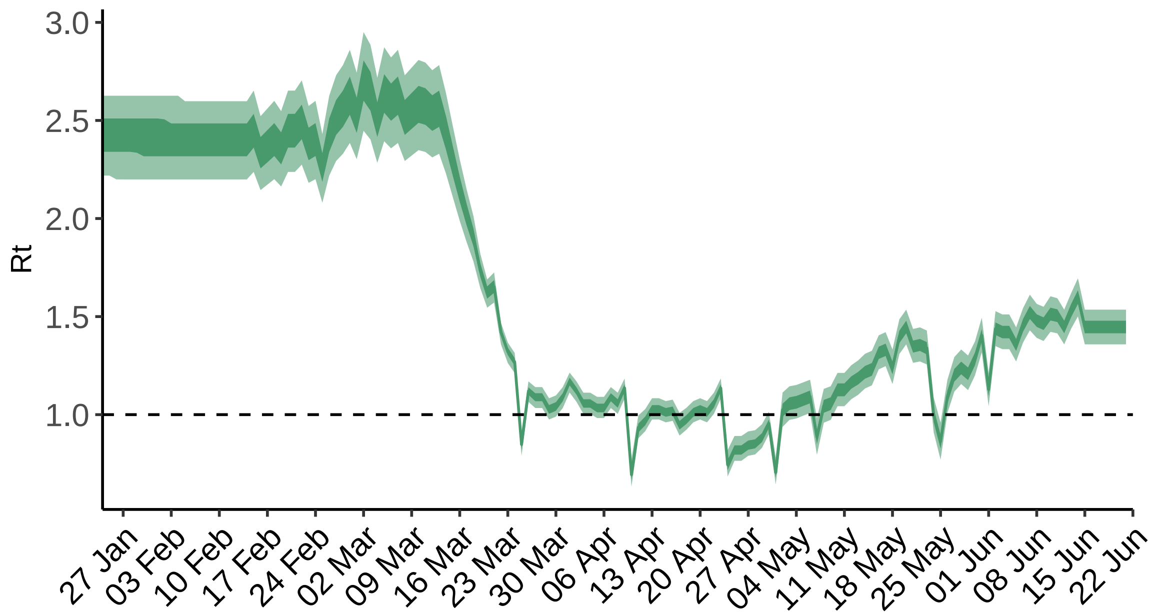


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

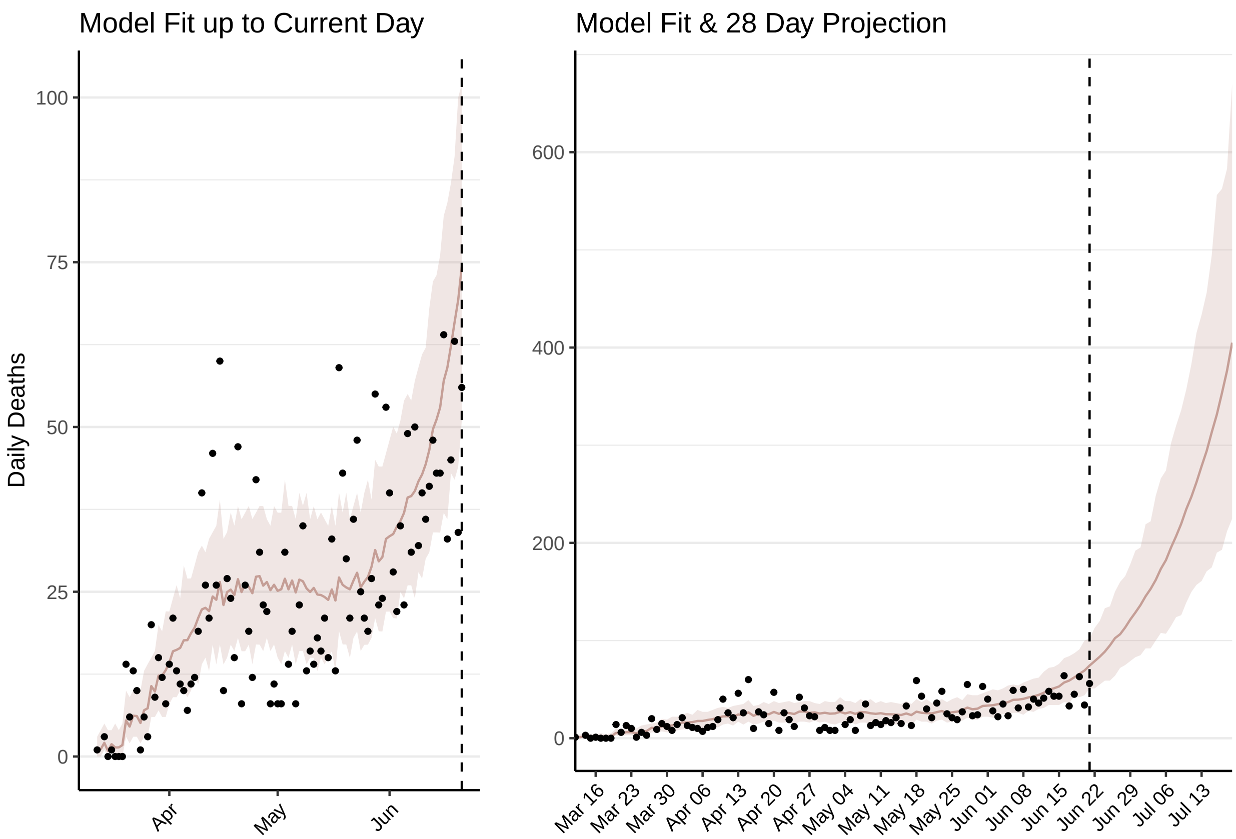


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4,661 (95% CI: 4,536-4,786) patients requiring treatment with high-pressure oxygen at the current date to 24,708 (95% CI: 23,665-25,751) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1,211 (95% CI: 1,178-1,243) patients requiring treatment with mechanical ventilation at the current date to 6,401 (95% CI: 6,136-6,666) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

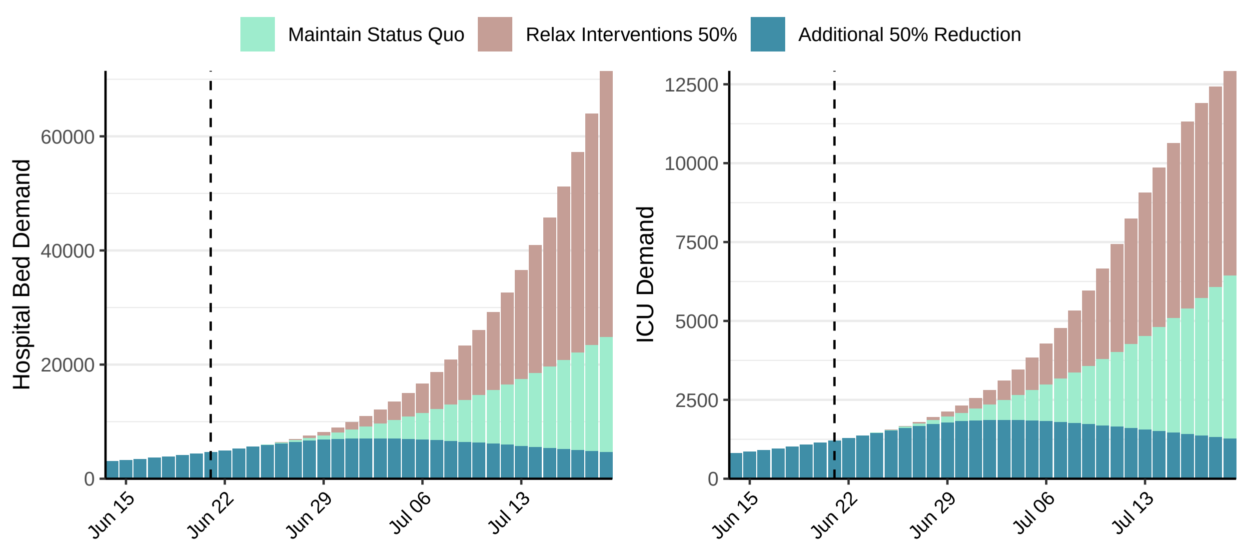


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 37,211 (95% CI: 36,046-38,377) at the current date to 11,993 (95% CI: 11,457-12,530) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 37,211 (95% CI: 36,046-38,377) at the current date to 855,603 (95% CI: 815,039-896,167) by 2020-07-19.

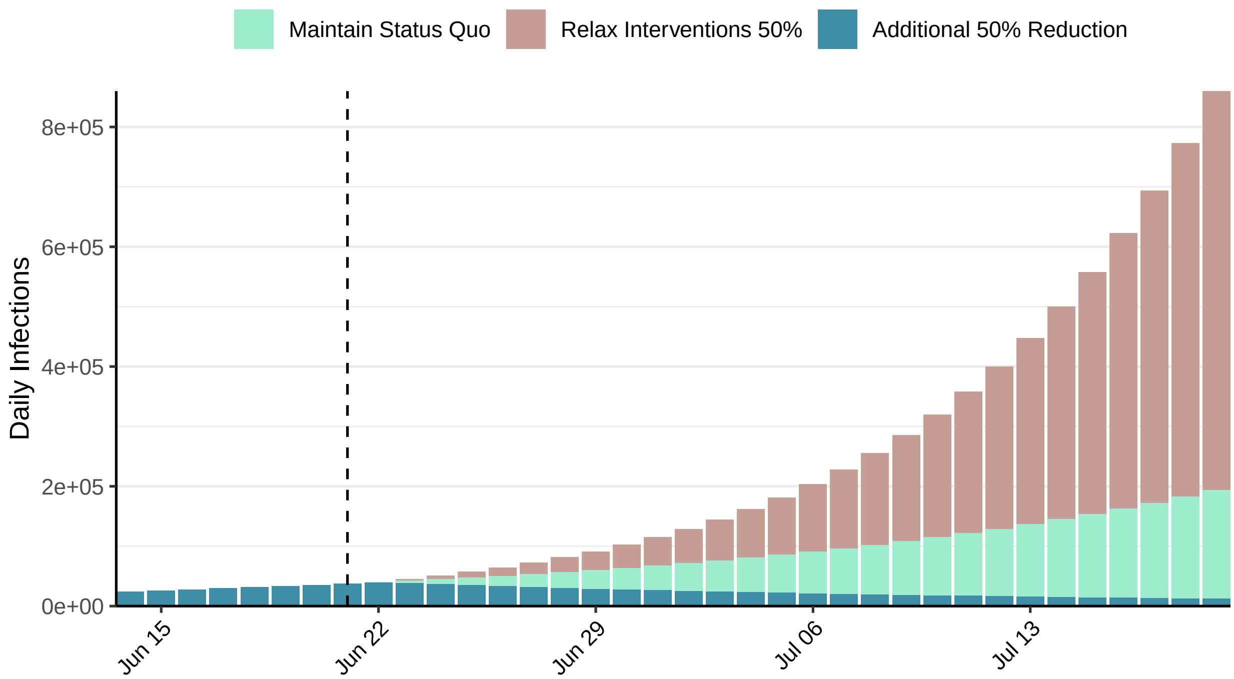


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: India, 2020-06-21

**Download the report for India, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 410,461 | 15,413 | 13,254 | 306 | 1.82 (95% CI: 1.72-1.93) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

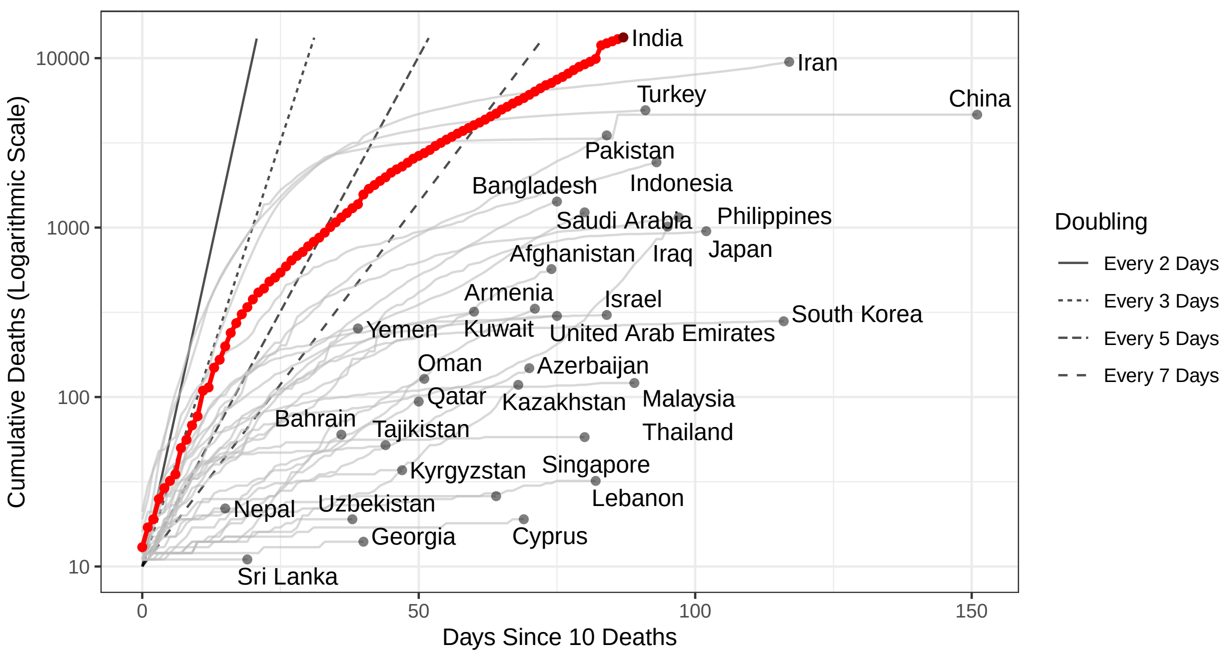


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 7,547,373 (95% CI: 7,341,494-7,753,251) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

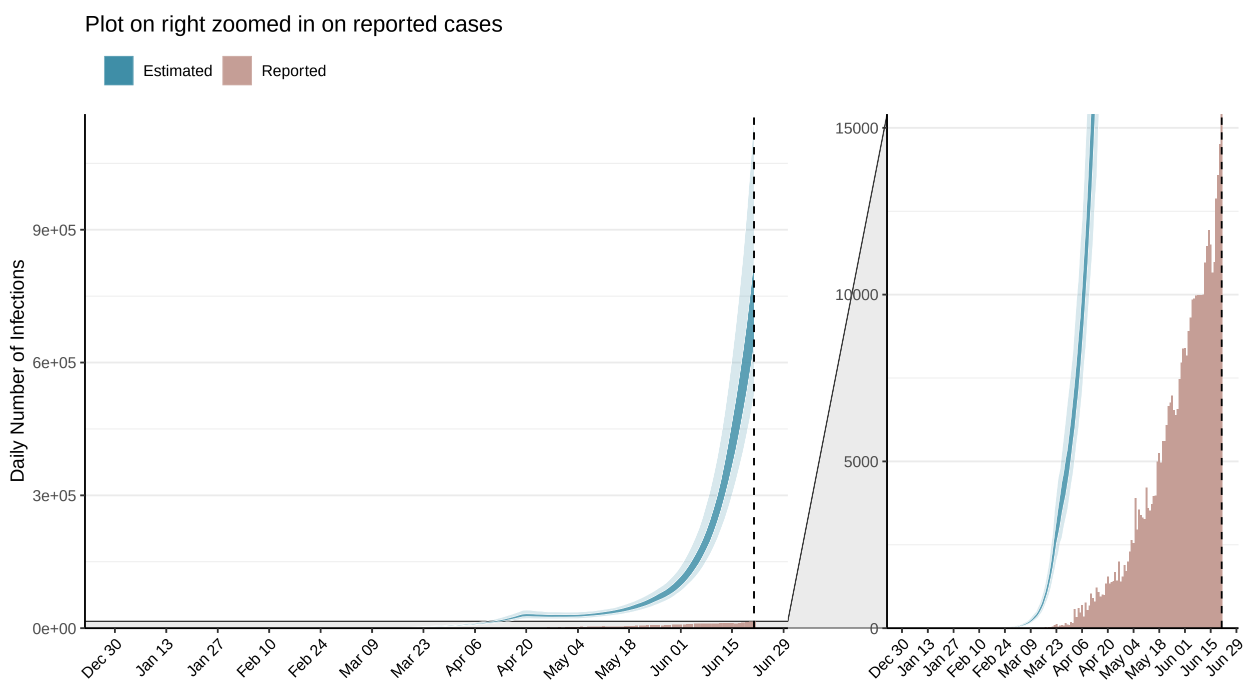


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

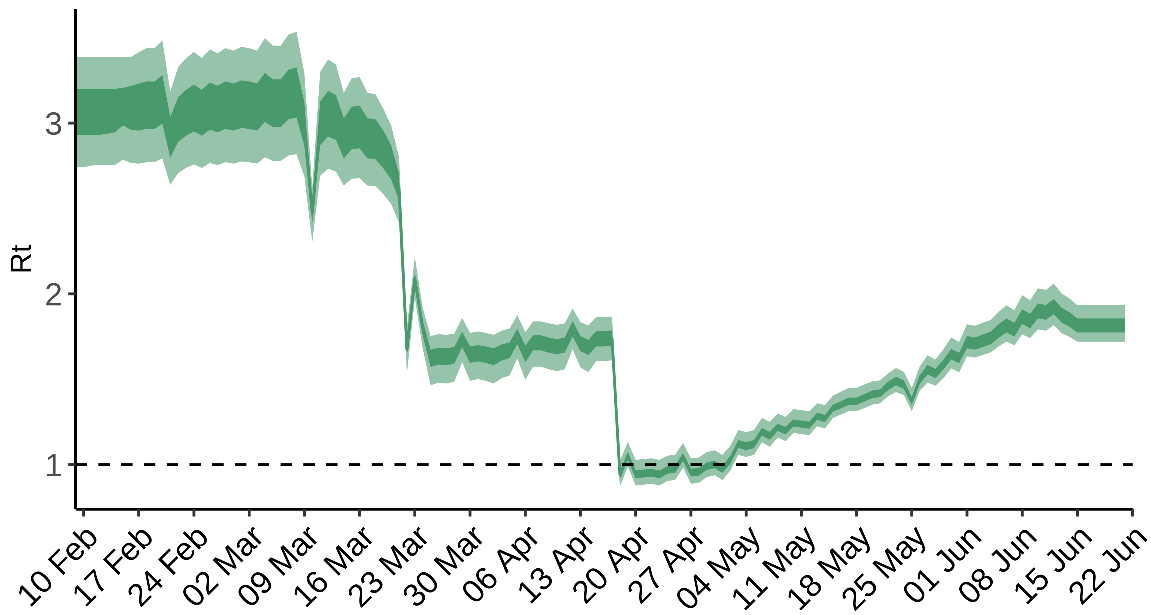


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. India is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

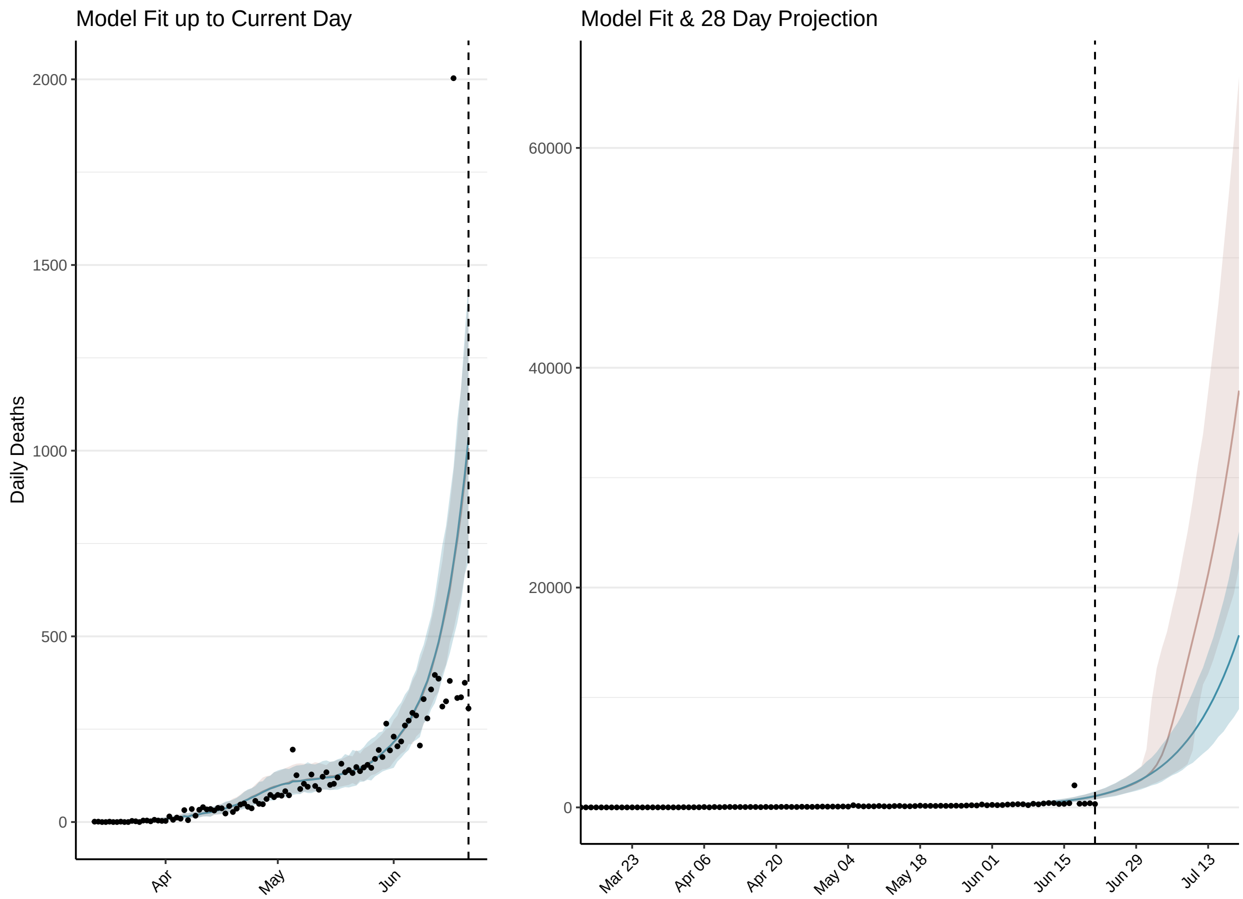


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 59,057 (95% CI: 57,451-60,663) patients requiring treatment with high-pressure oxygen at the current date to 842,003 (95% CI: 808,175-875,831) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 17,825 (95% CI: 17,342-18,308) patients requiring treatment with mechanical ventilation at the current date to 108,297 (95% CI: 106,084-110,511) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

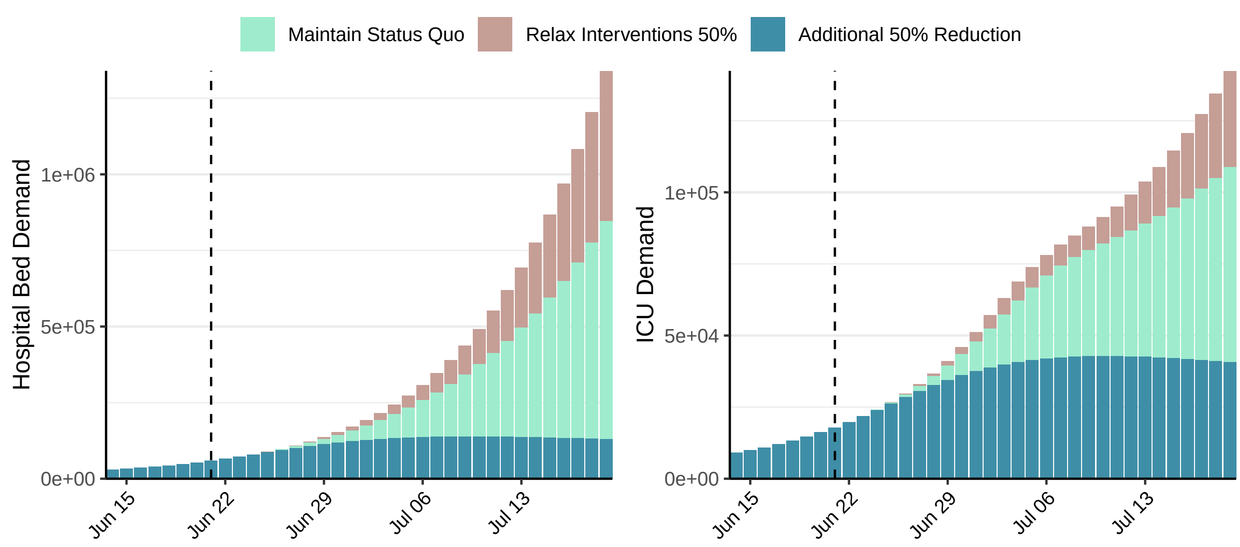


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 755,740 (95% CI: 732,011-779,468) at the current date to 559,099 (95% CI: 534,343-583,855) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 755,740 (95% CI: 732,011-779,468) at the current date to 17,334,254 (95% CI: 16,691,869-17,976,639) by 2020-07-19.

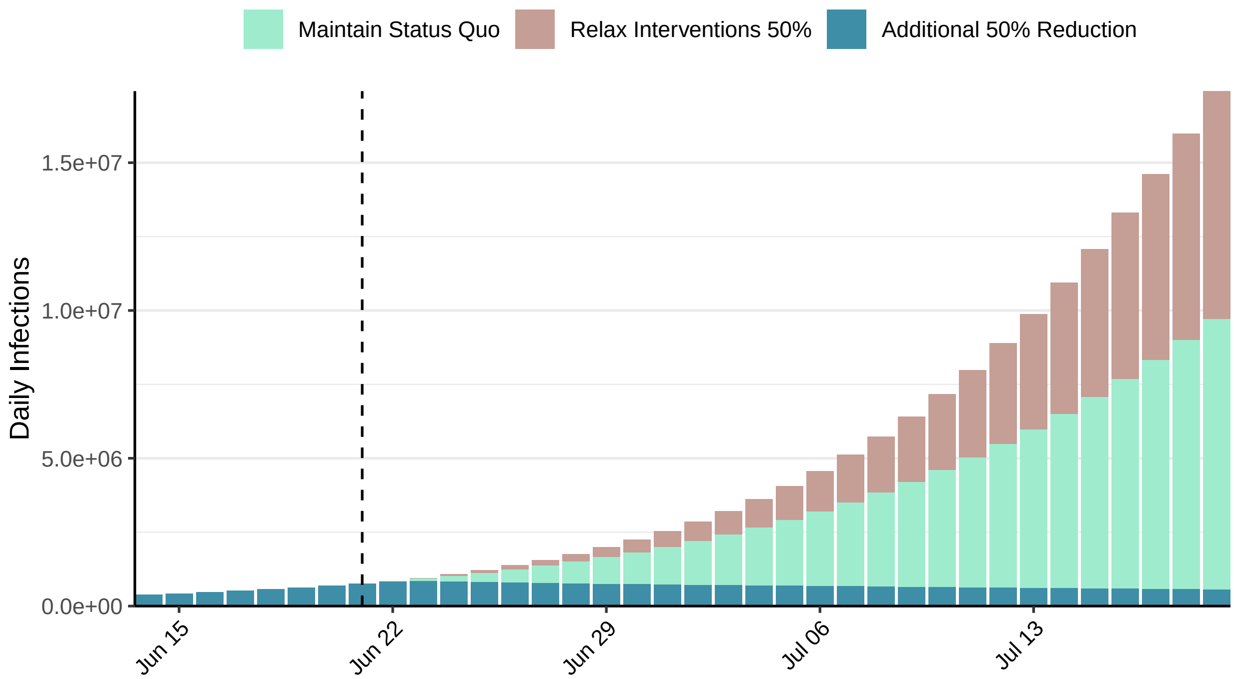


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Iraq, 2020-06-21

**Download the report for Iraq, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 29,222 | 3,505 | 1,013 | 157 | 1.74 (95% CI: 1.66-1.82) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

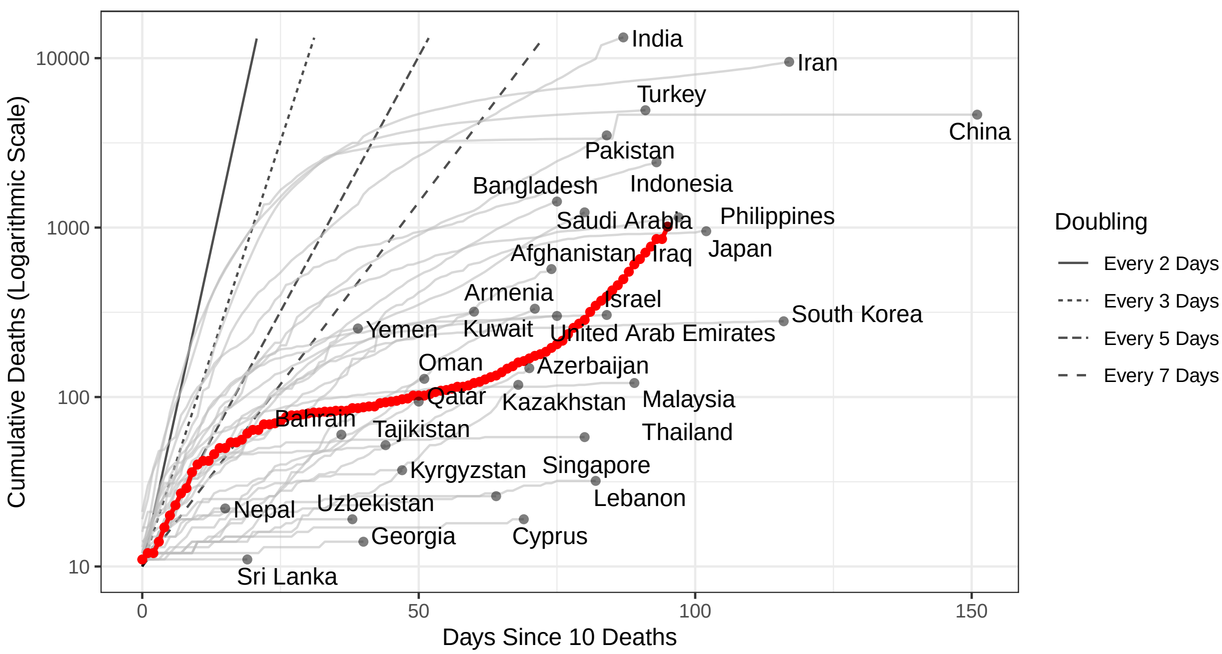


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 788,613 (95% CI: 768,570-808,655) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

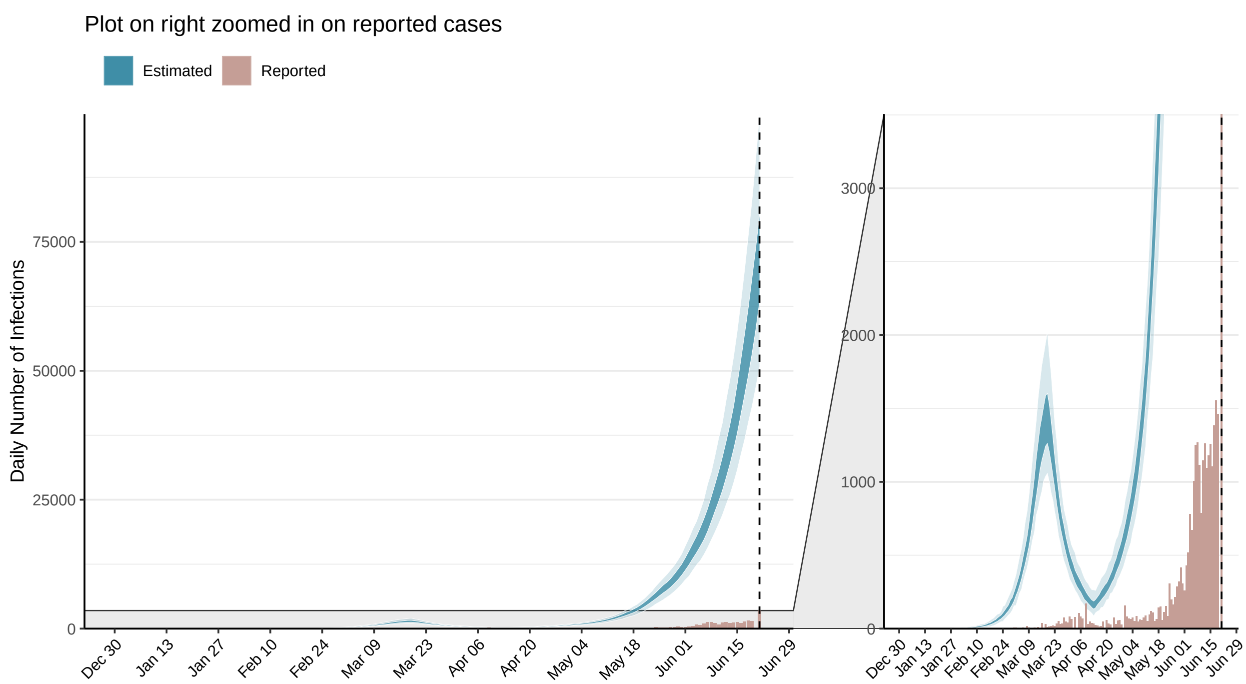


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

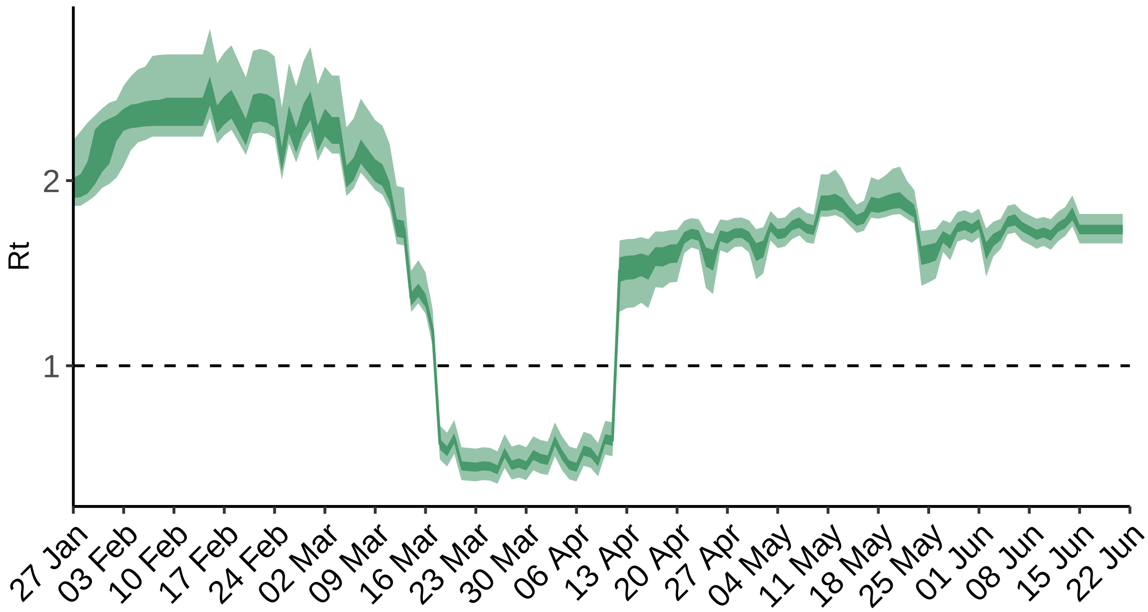


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Iraq is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

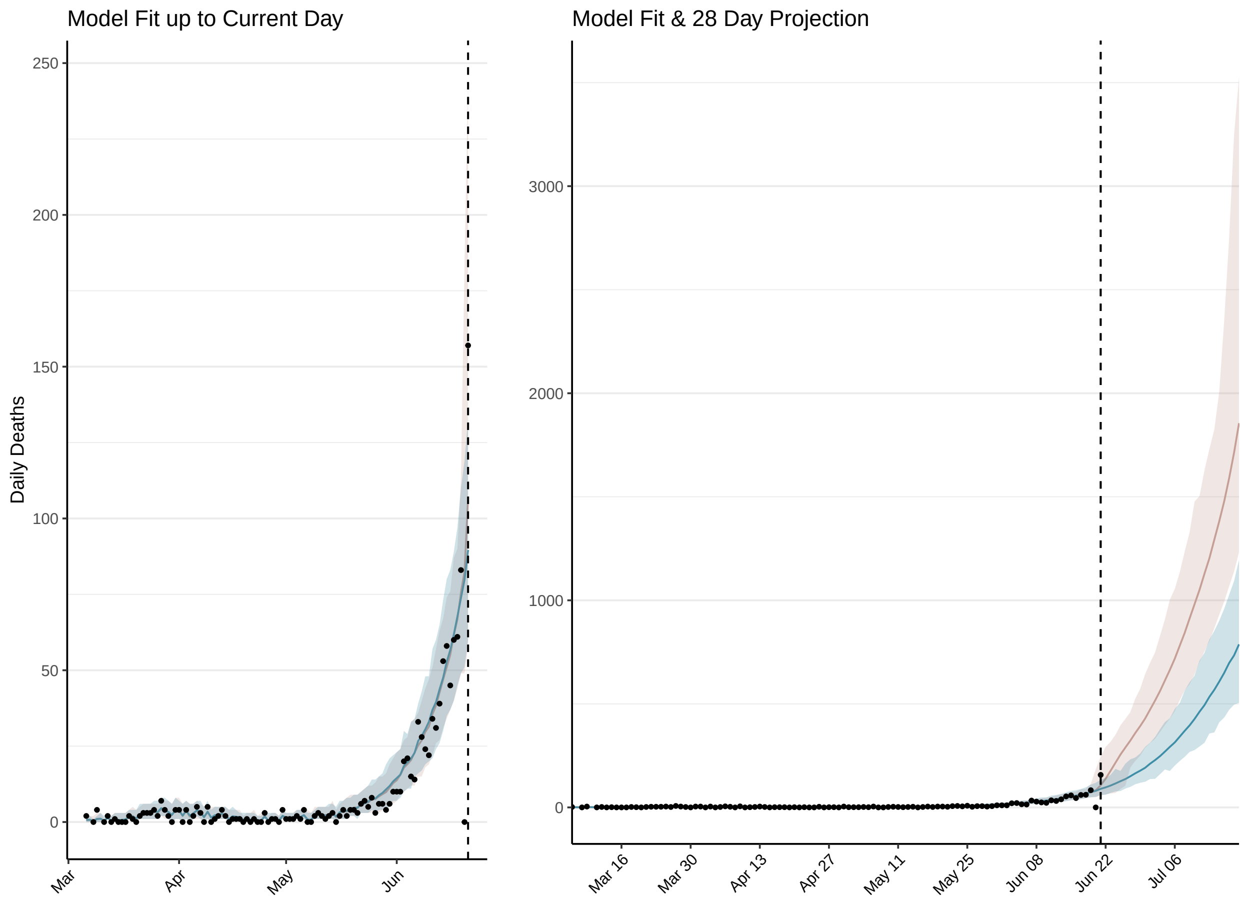


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 6,081 (95% CI: 5,926-6,236) patients requiring treatment with high-pressure oxygen at the current date to 49,346 (95% CI: 48,151-50,540) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1,430 (95% CI: 1,400-1,460) patients requiring treatment with mechanical ventilation at the current date to 3,337 (95% CI: 3,280-3,394) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

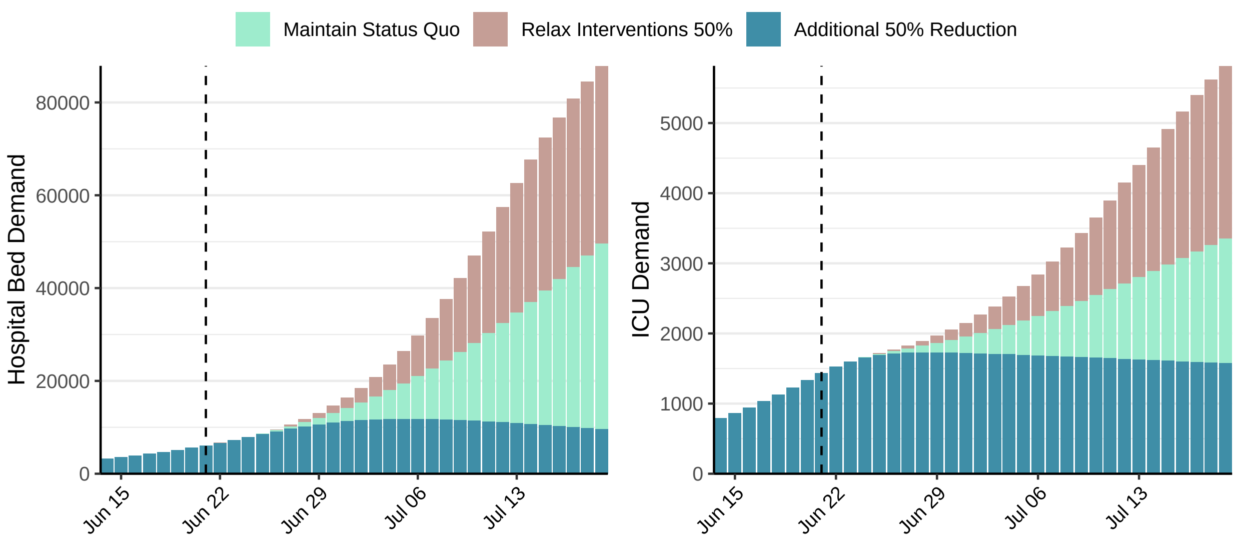


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 72,044 (95% CI: 70,041-74,047) at the current date to 36,545 (95% CI: 35,389-37,702) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 72,044 (95% CI: 70,041-74,047) at the current date to 1,015,327 (95% CI: 1,002,582-1,028,072) by 2020-07-19.

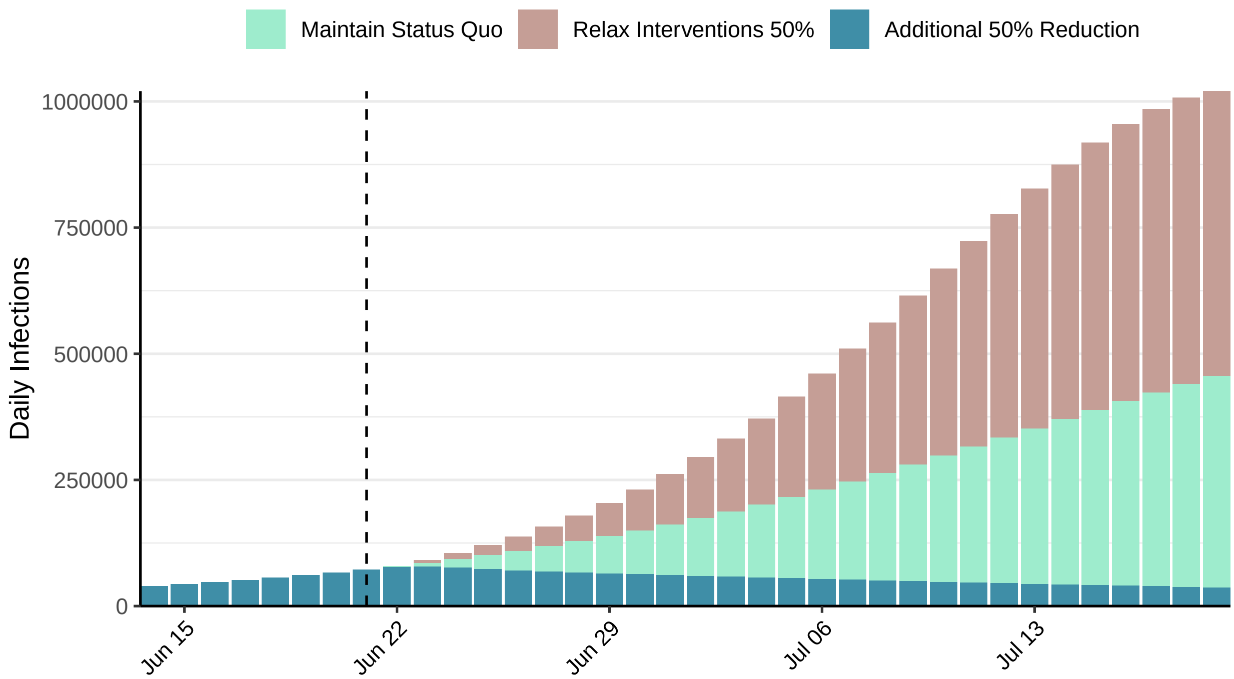


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Jamaica, 2020-06-21

**Download the report for Jamaica, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 657 | 5 | 10 | 0 | 1.2 (95% CI: 0.62-1.93) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

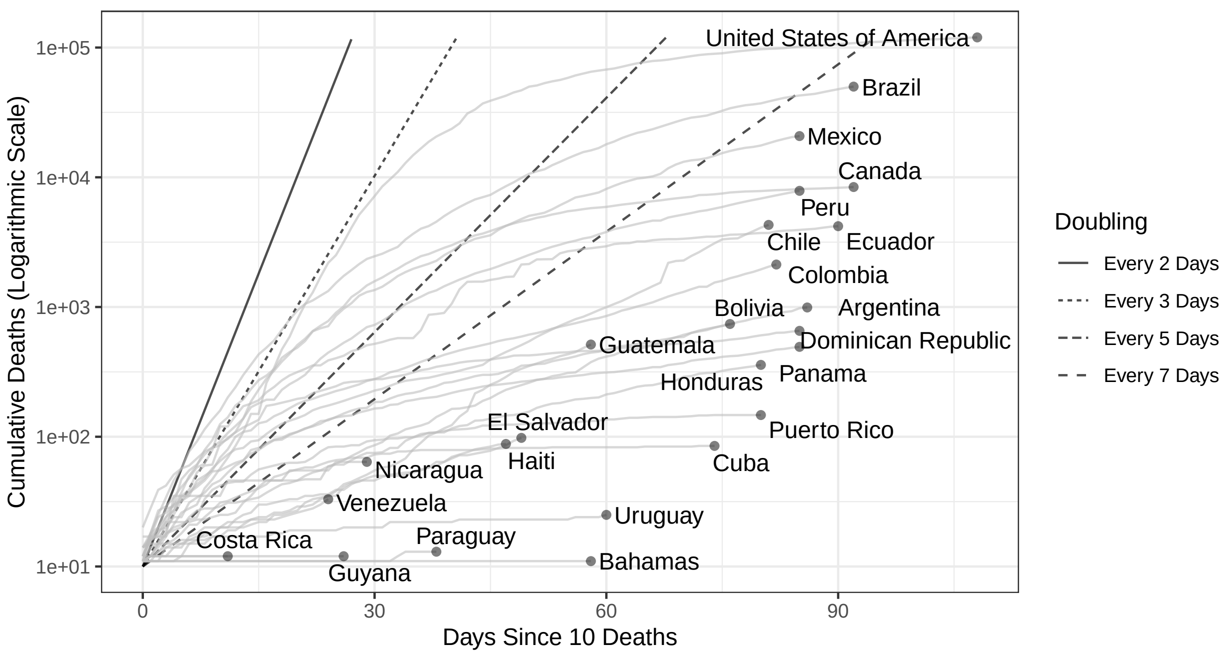


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 622 (95% CI: 450-793) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

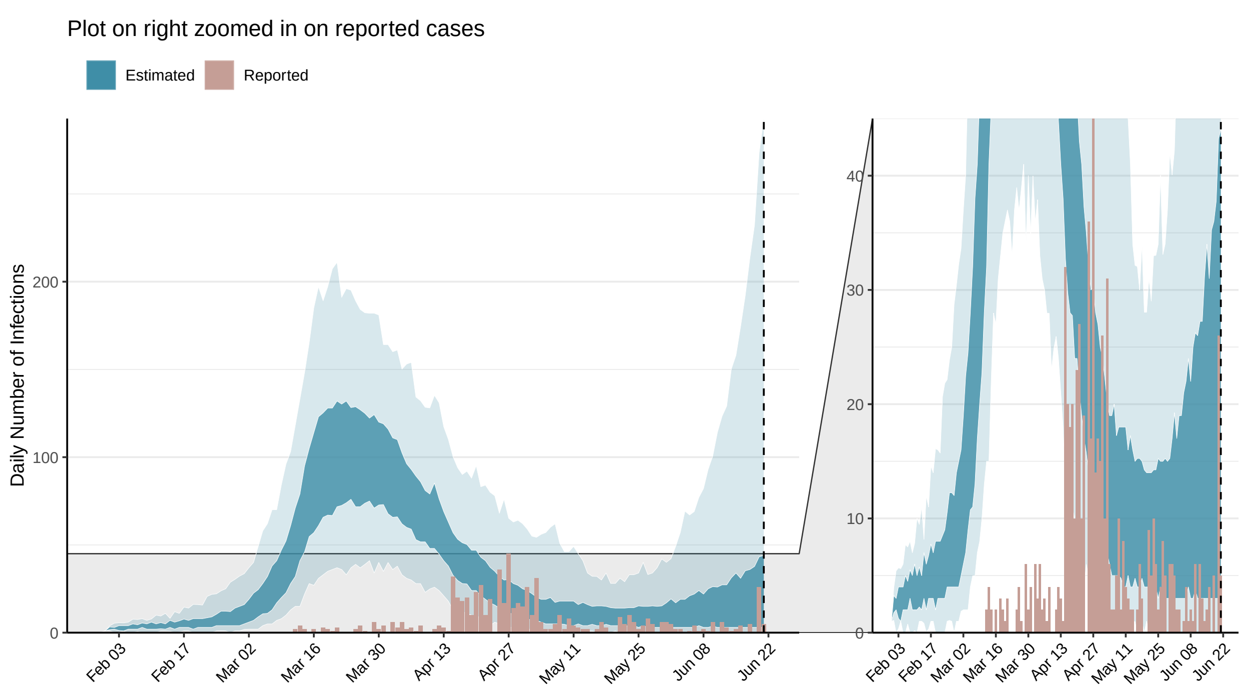


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

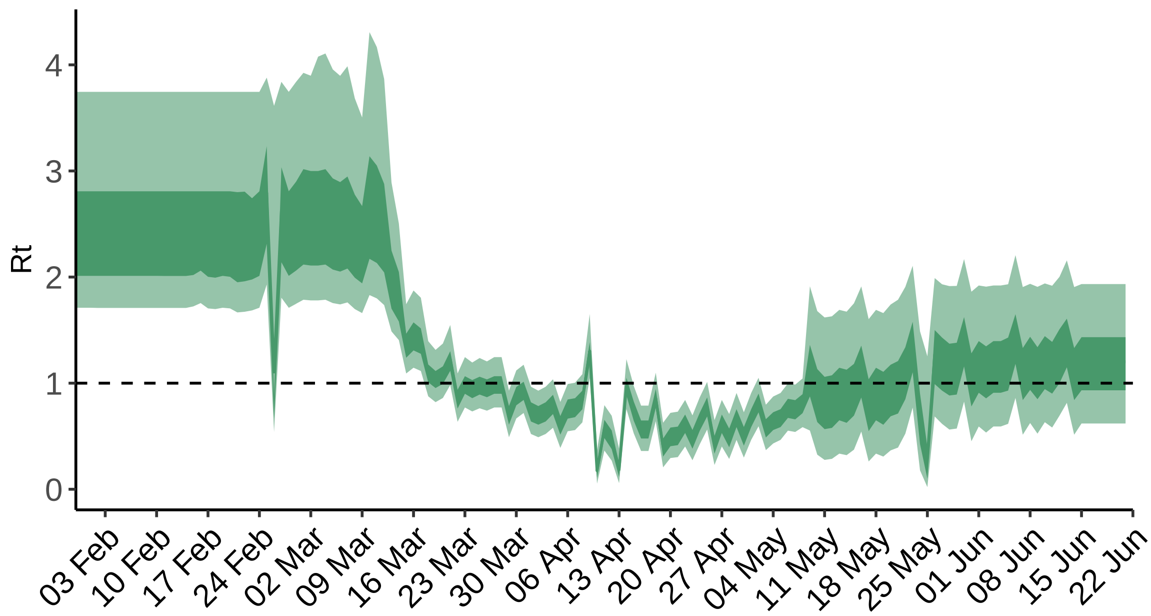


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

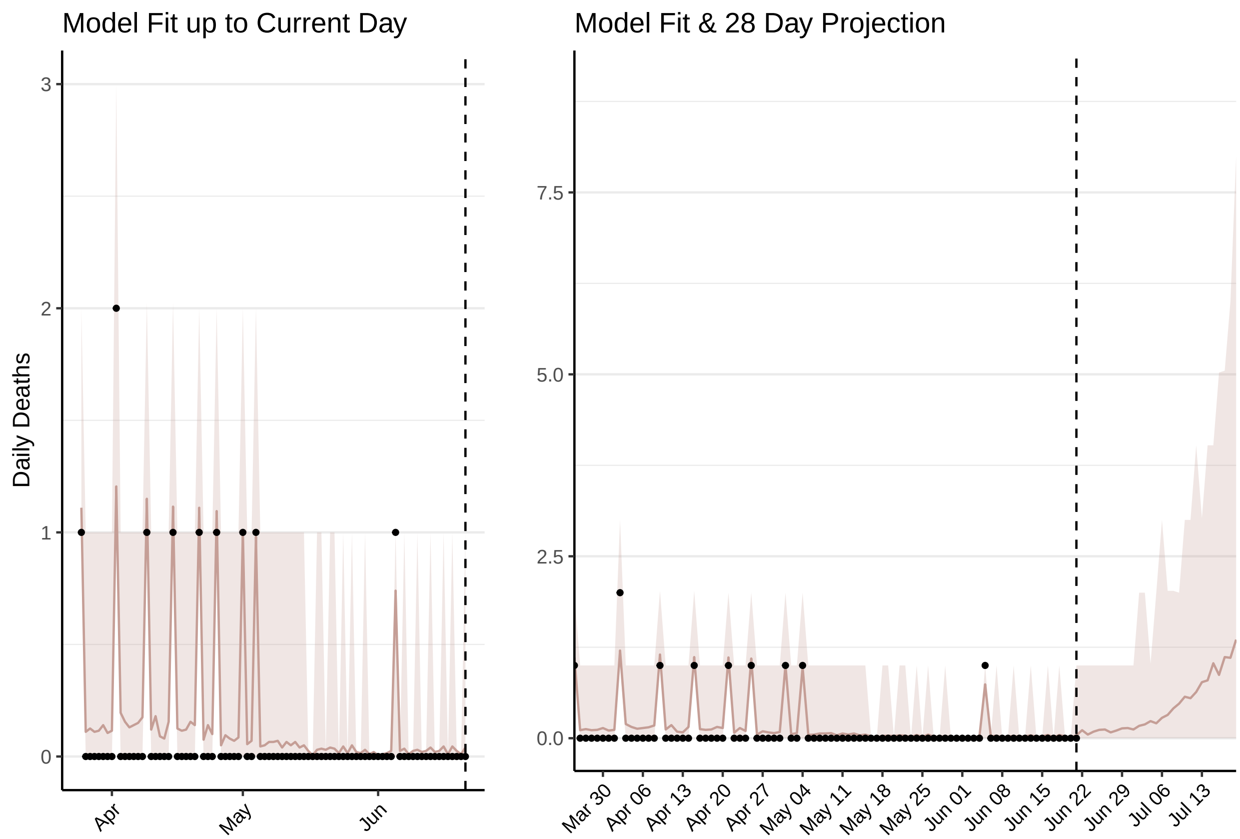


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4 (95% CI: 3-5) patients requiring treatment with high-pressure oxygen at the current date to 48 (95% CI: 15-80) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1 (95% CI: 1-2) patients requiring treatment with mechanical ventilation at the current date to 12 (95% CI: 7-18) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

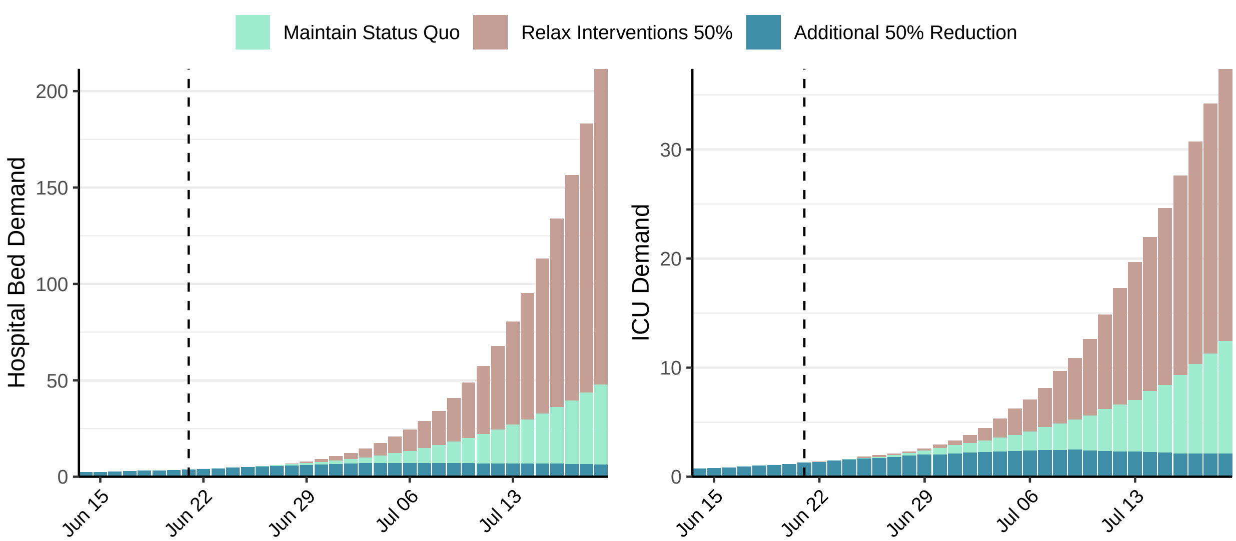


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 50 (95% CI: 30-70) at the current date to 40 (95% CI: 11-70) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 50 (95% CI: 30-70) at the current date to 4,266 (95% CI: 2,264-6,269) by 2020-07-19.

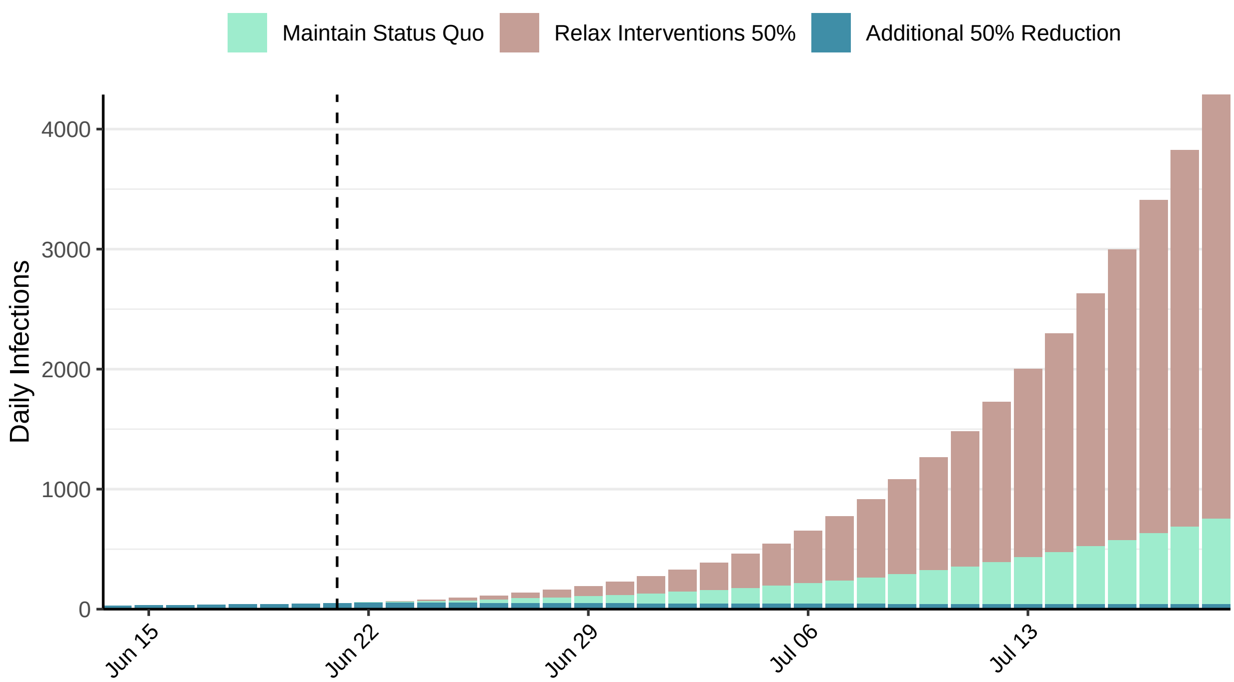


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Jordan, 2020-06-21

**Download the report for Jordan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,015 | 7 | 9 | 0 | 1.12 (95% CI: 0.53-1.79) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Jordan is not shown in the following plot as only 9 deaths have been reported to date**

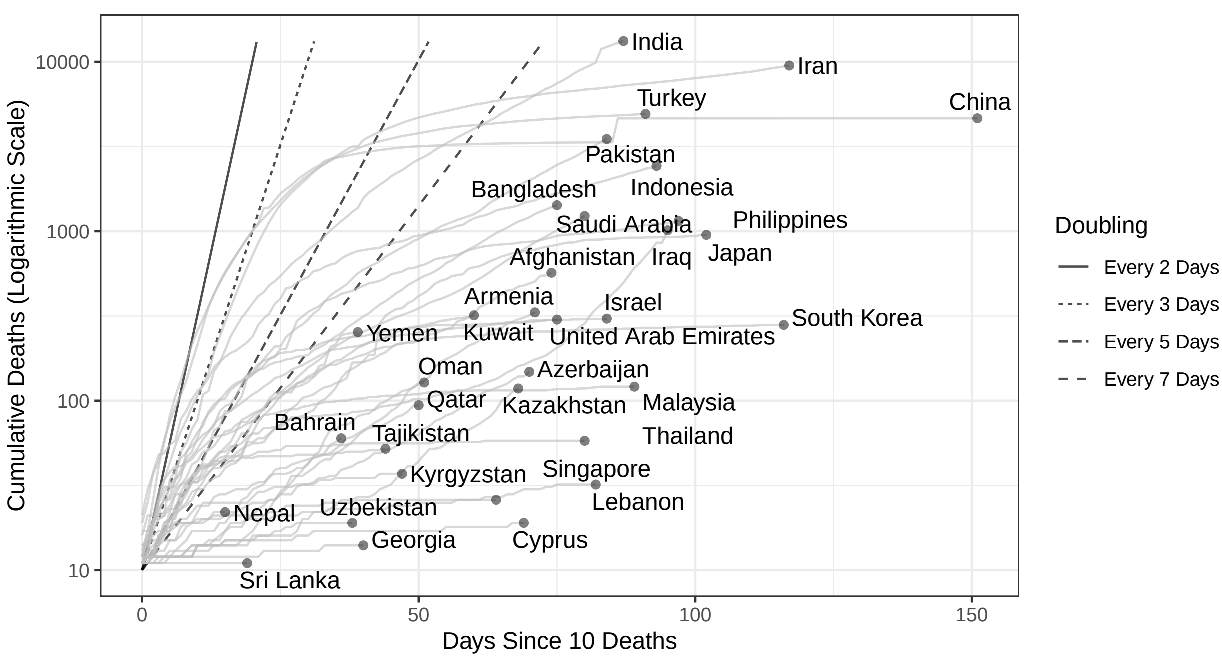


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 29 (95% CI: 15-43) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

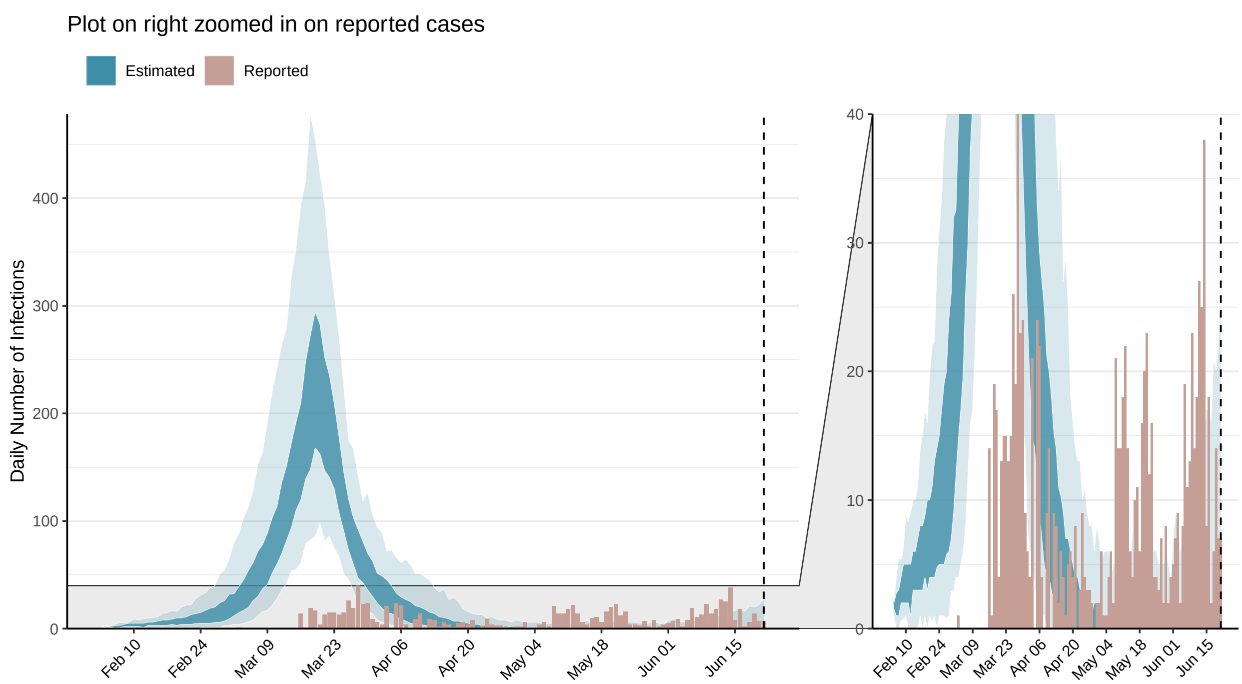


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

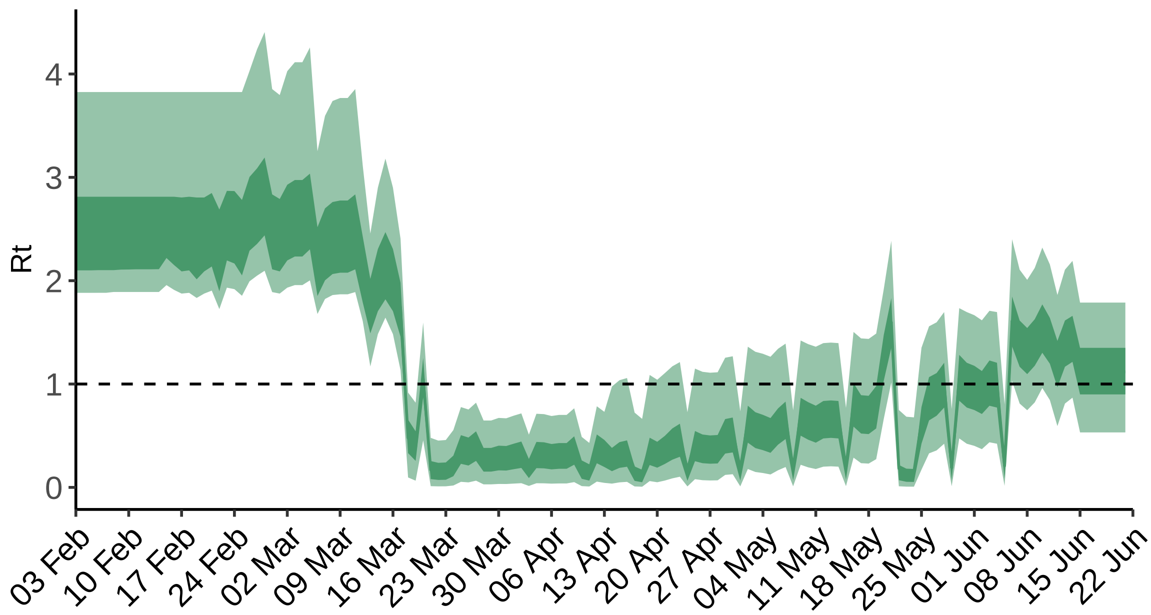


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

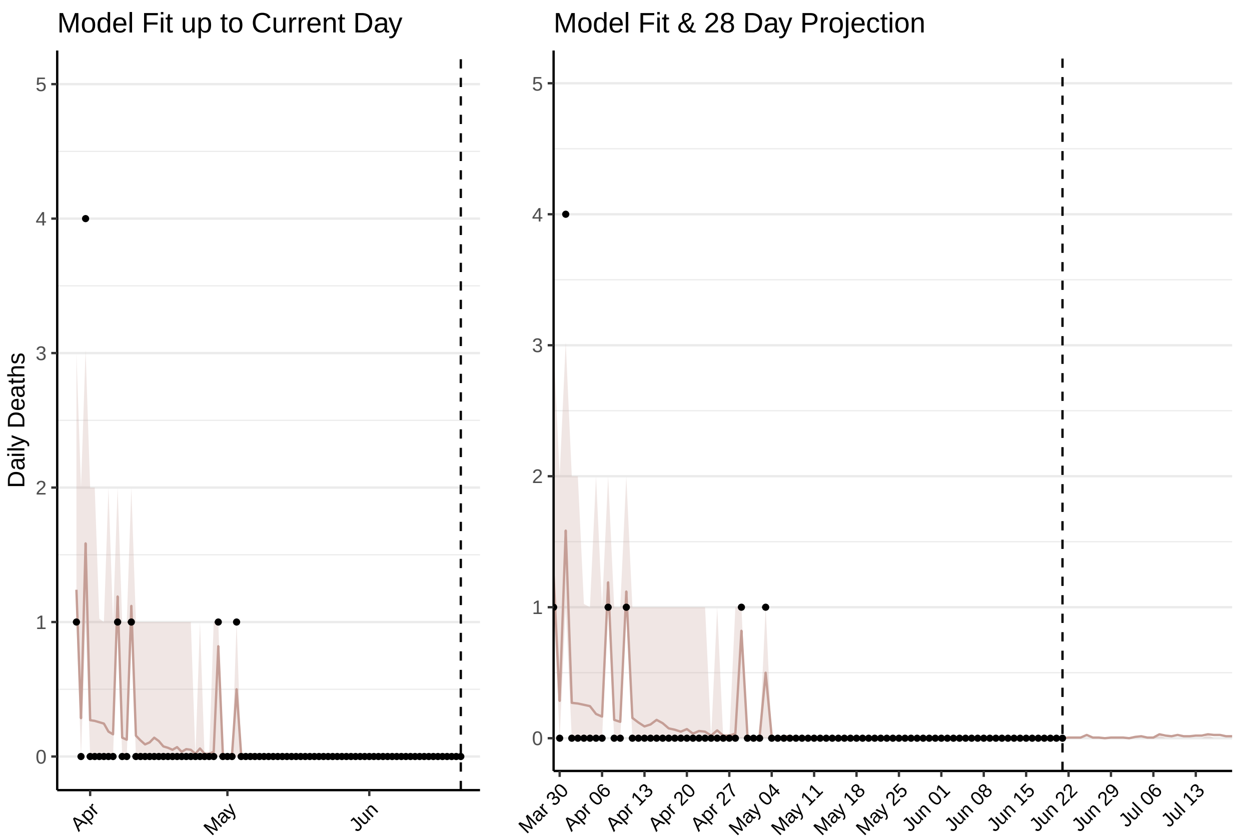


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 0 (95% CI: 0-0) patients requiring treatment with high-pressure oxygen at the current date to 2 (95% CI: 0-3) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 0-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

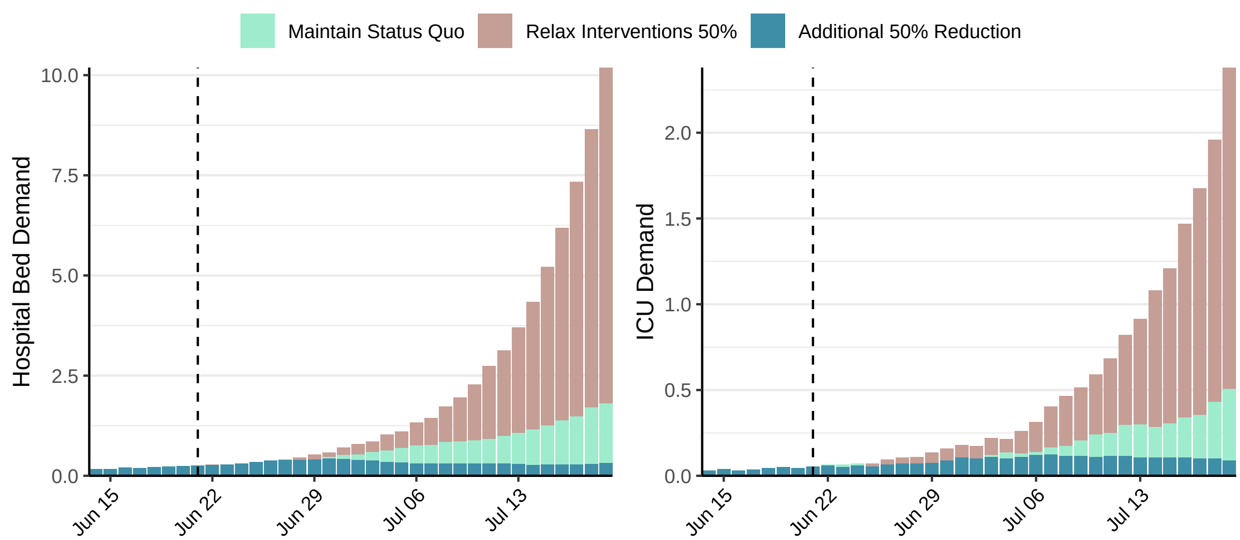


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2 (95% CI: 1-4) at the current date to 1 (95% CI: 0-2) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2 (95% CI: 1-4) at the current date to 208 (95% CI: 29-387) by 2020-07-19.

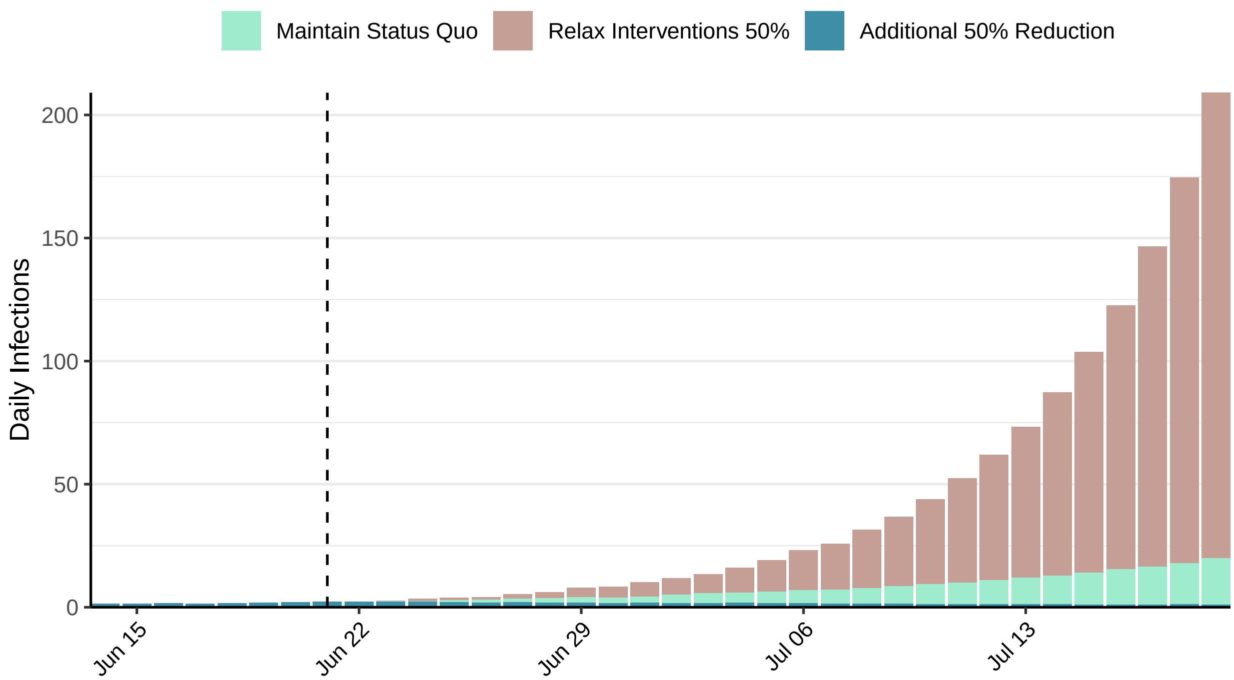


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Kazakhstan, 2020-06-21

**Download the report for Kazakhstan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 17,225 | 446 | 118 | 5 | 2.27 (95% CI: 1.91-2.74) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

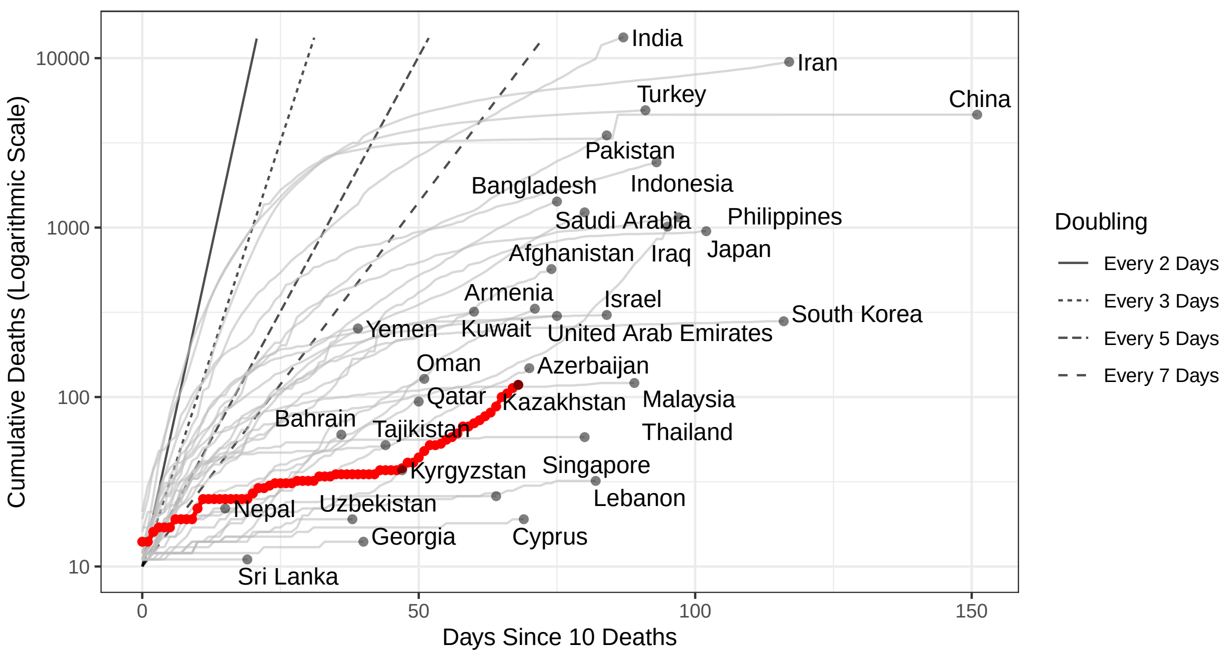


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 173,630 (95% CI: 165,844-181,416) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

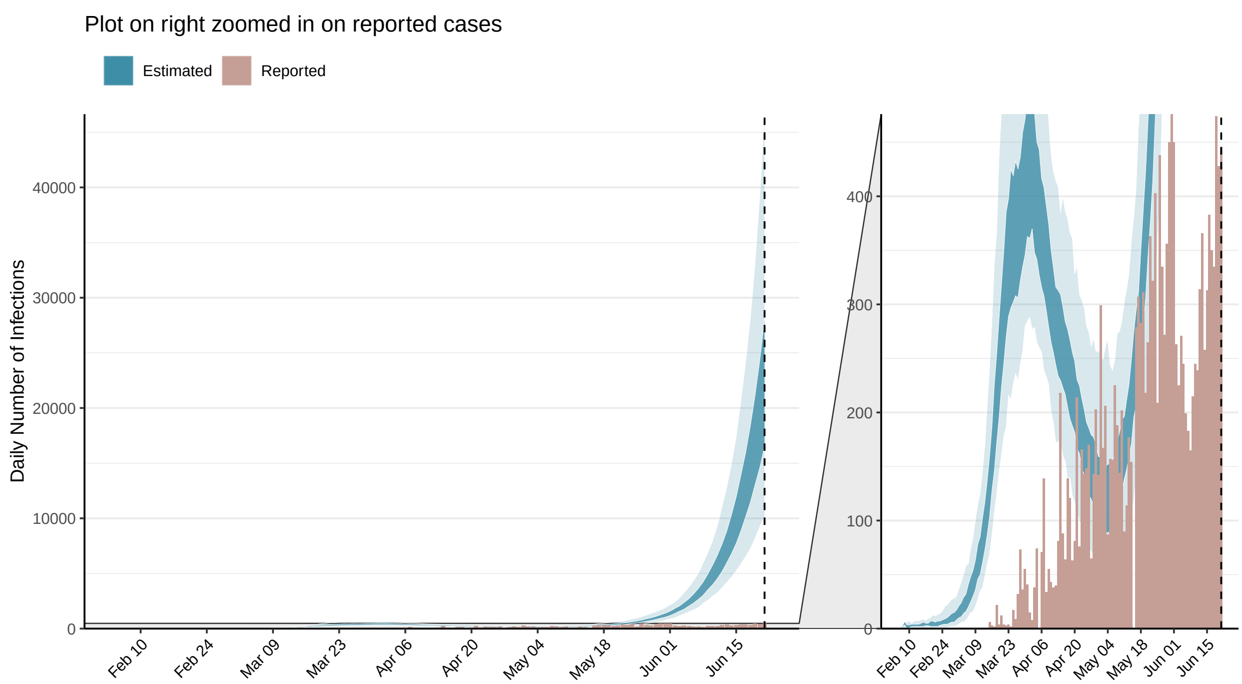


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

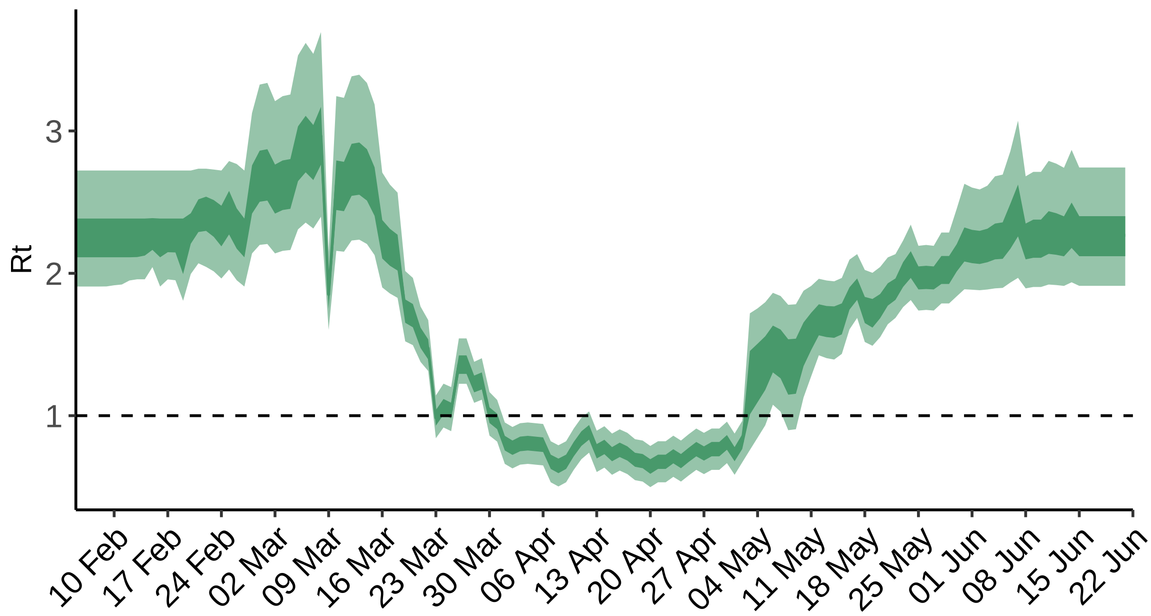


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Kazakhstan is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

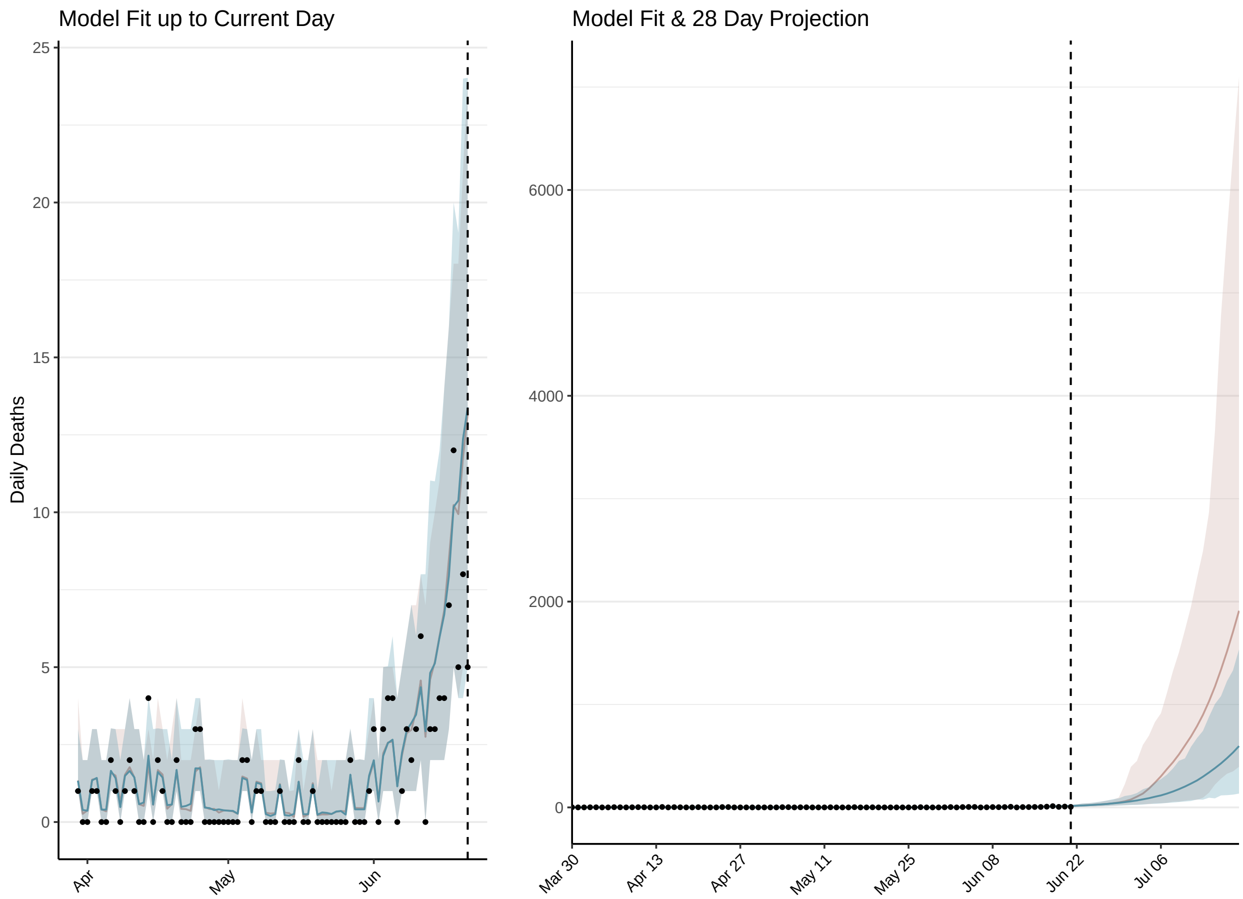


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,164 (95% CI: 1,114-1,214) patients requiring treatment with high-pressure oxygen at the current date to 40,496 (95% CI: 37,808-43,184) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 275 (95% CI: 263-286) patients requiring treatment with mechanical ventilation at the current date to 3,474 (95% CI: 3,325-3,622) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

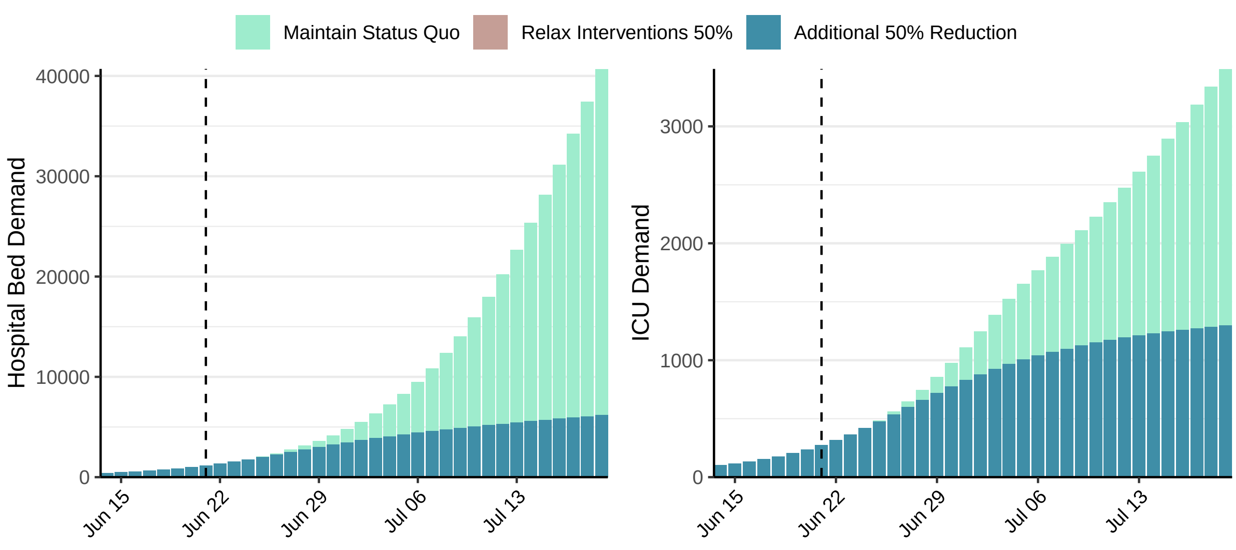


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 23,321 (95% CI: 21,994-24,649) at the current date to 40,894 (95% CI: 37,041-44,747) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 23,321 (95% CI: 21,994-24,649) at the current date to 415,426 (95% CI: 396,267-434,585) by 2020-07-19.

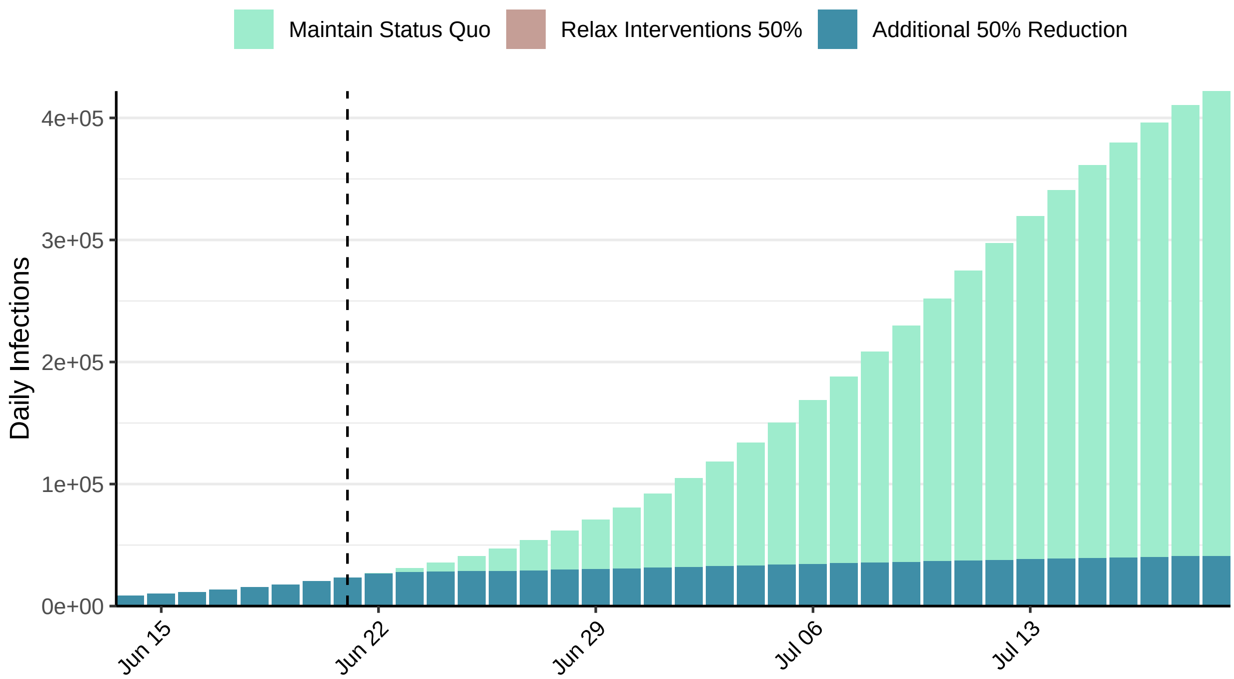


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Kenya, 2020-06-21

**Download the report for Kenya, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 4,478 | 104 | 121 | 2 | 1.1 (95% CI: 0.79-1.51) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

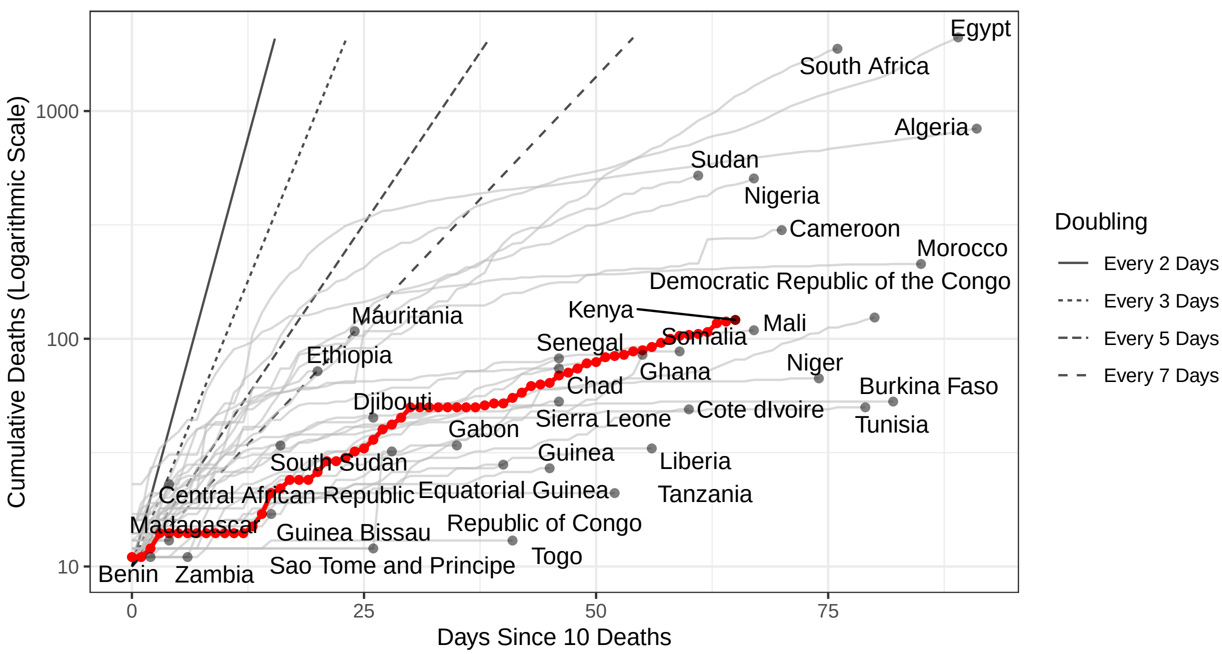


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 51,962 (95% CI: 49,546-54,378) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

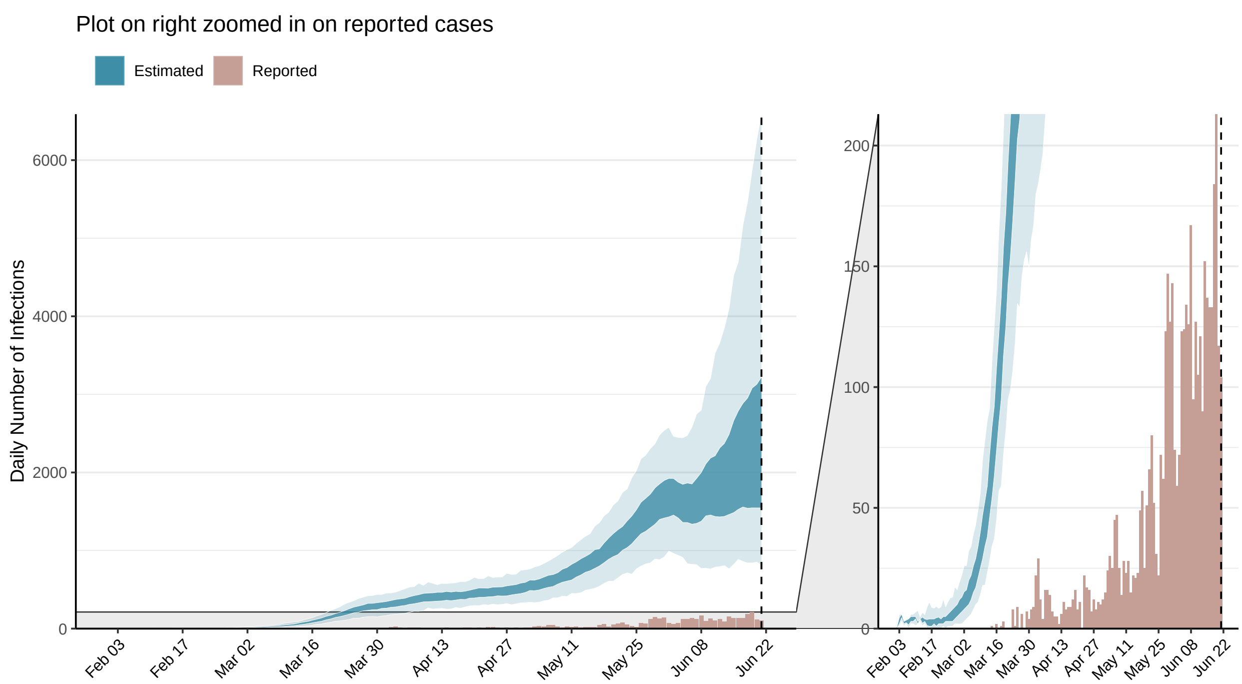


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

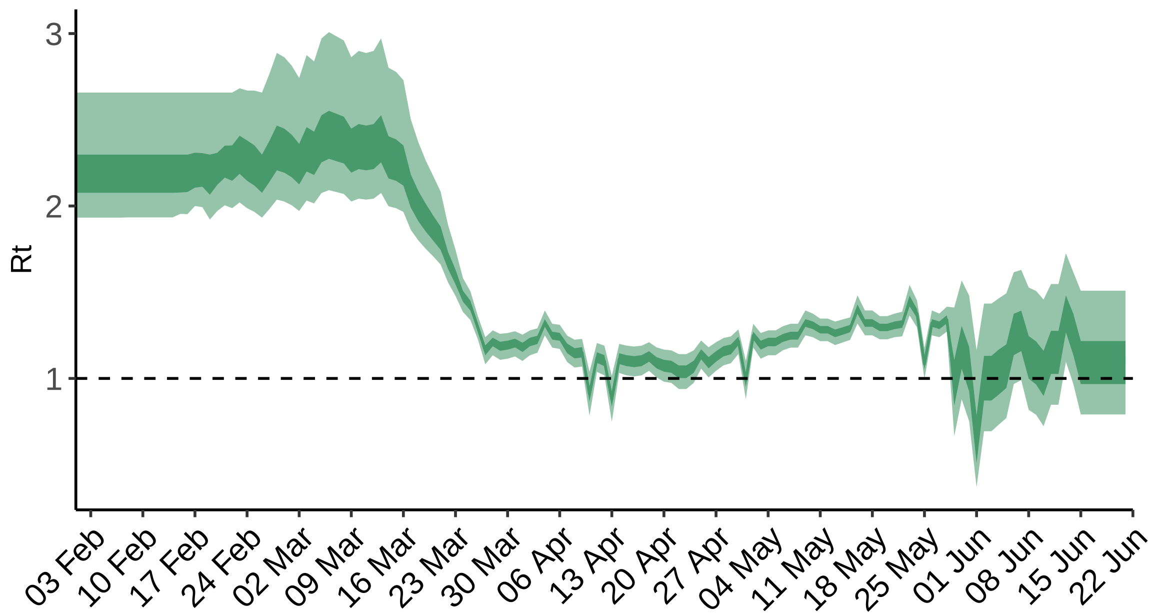


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

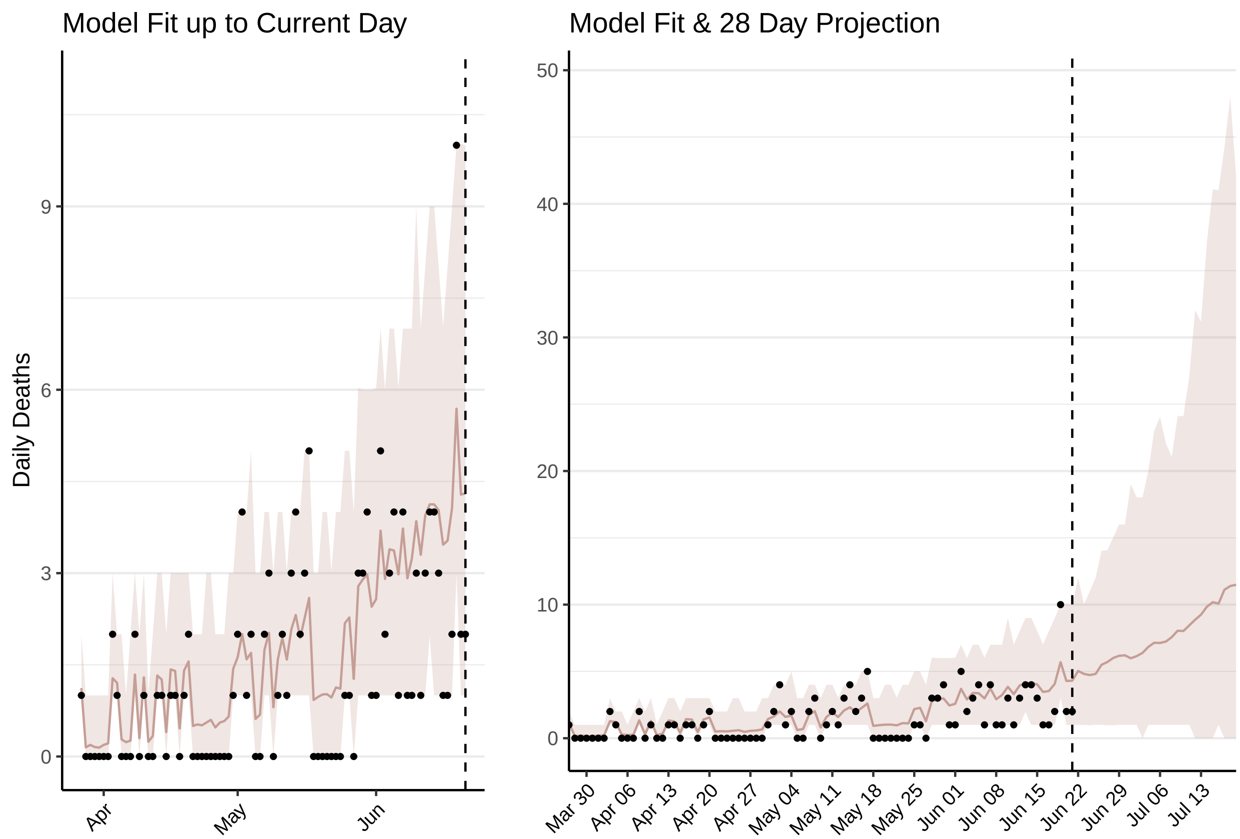


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 279 (95% CI: 265-294) patients requiring treatment with high-pressure oxygen at the current date to 718 (95% CI: 558-878) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 71 (95% CI: 68-75) patients requiring treatment with mechanical ventilation at the current date to 181 (95% CI: 141-221) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

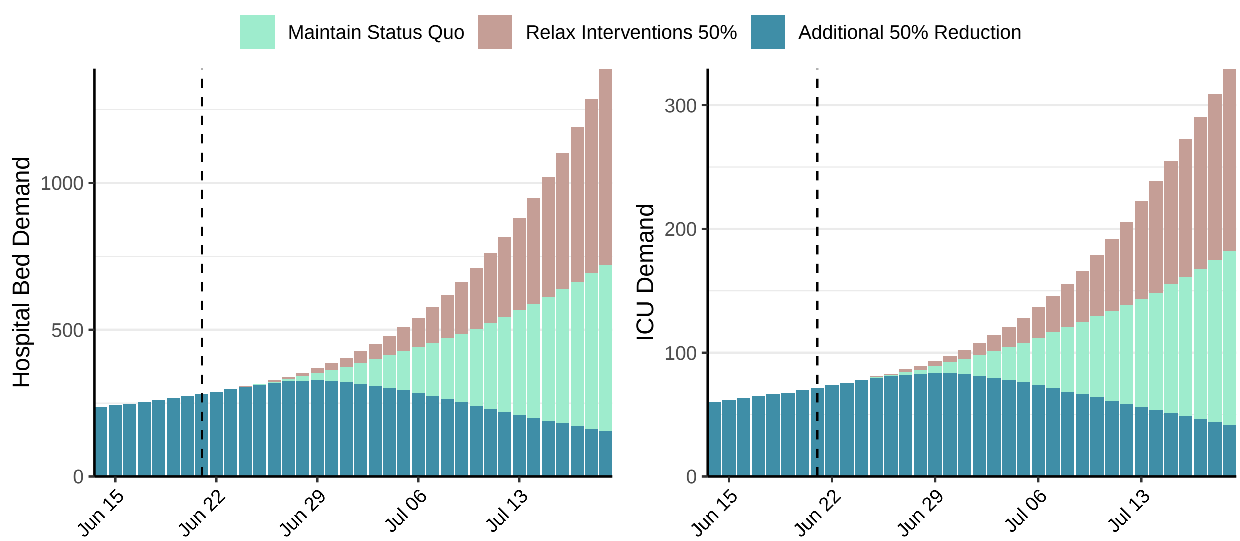


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,589 (95% CI: 2,356-2,822) at the current date to 511 (95% CI: 377-645) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,589 (95% CI: 2,356-2,822) at the current date to 20,638 (95% CI: 13,877-27,399) by 2020-07-19.

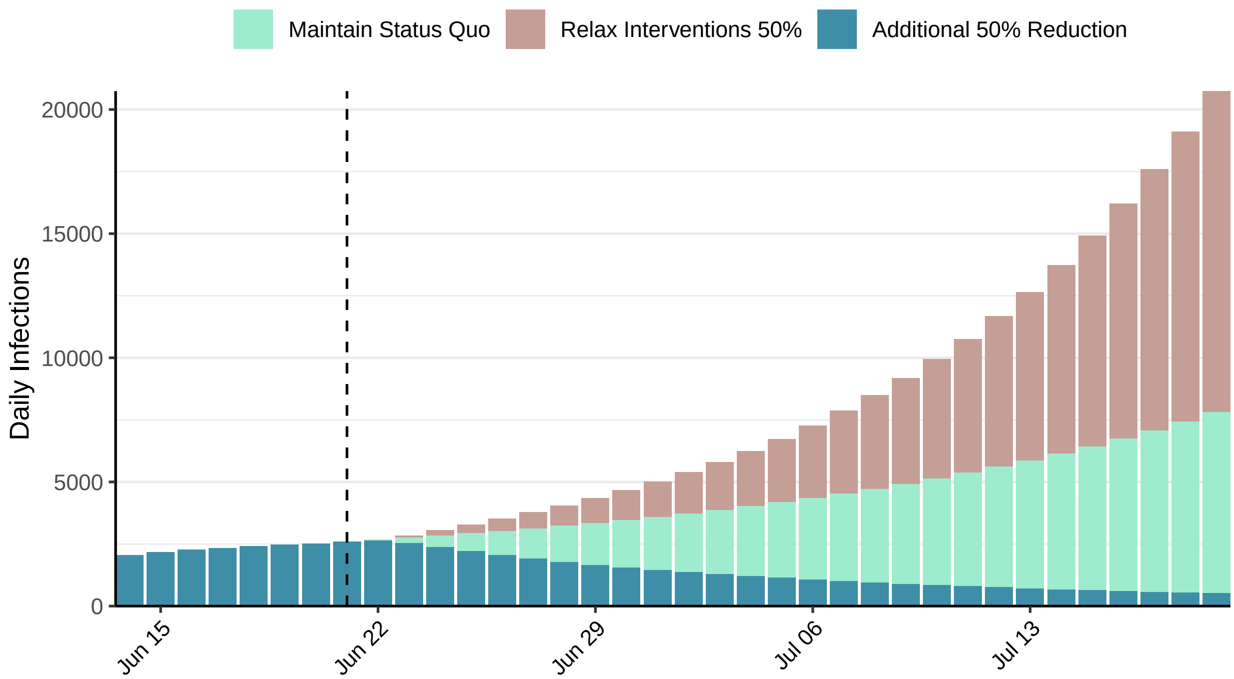


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Kyrgyz Republic, 2020-06-21

**Download the report for Kyrgyz Republic, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 3,151 | 170 | 37 | 2 | 1.96 (95% CI: 1.6-2.48) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

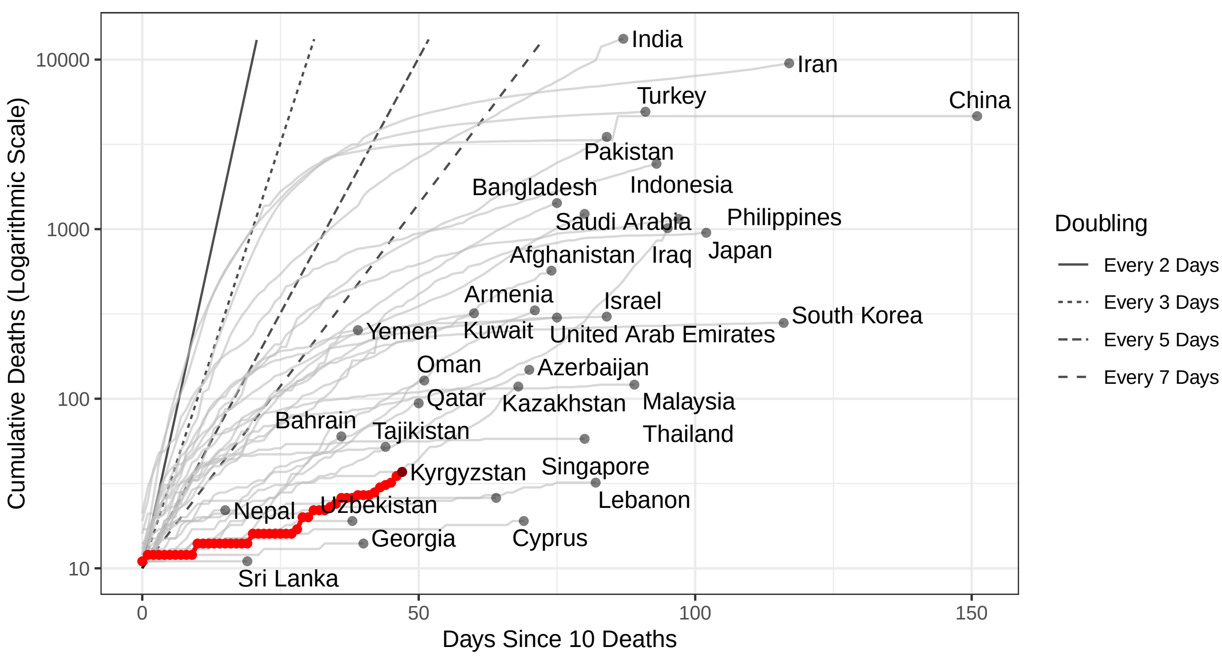


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 36,853 (95% CI: 34,565-39,141) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

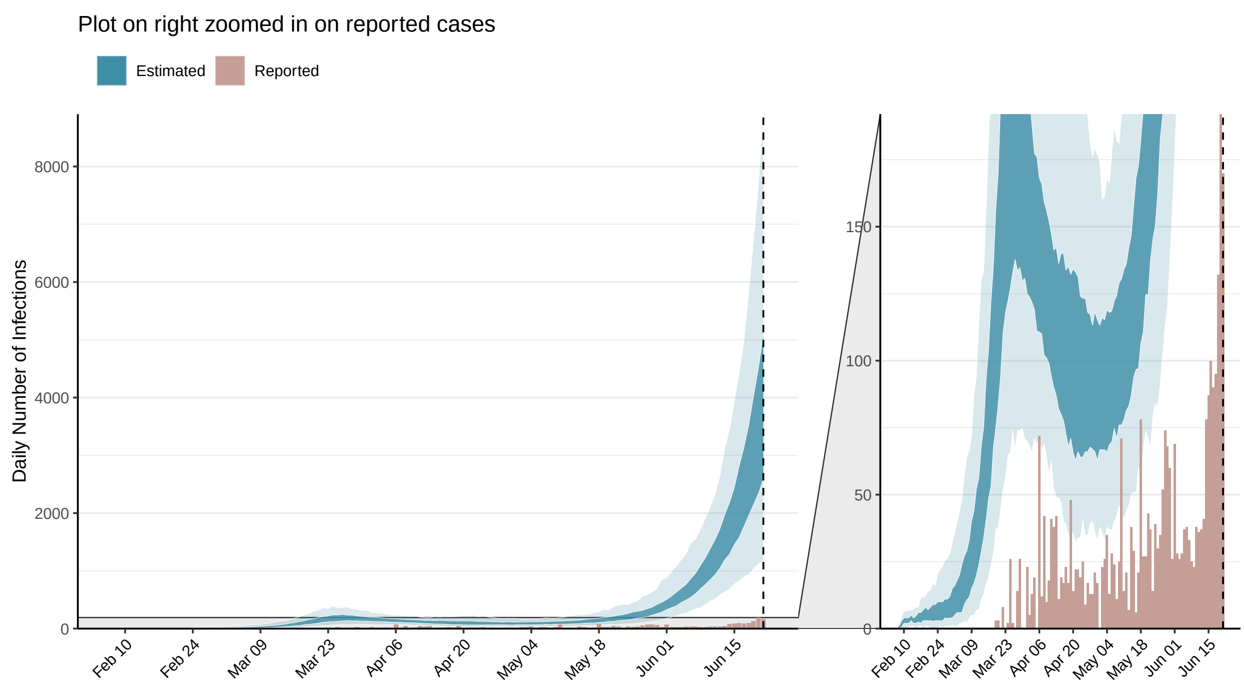


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

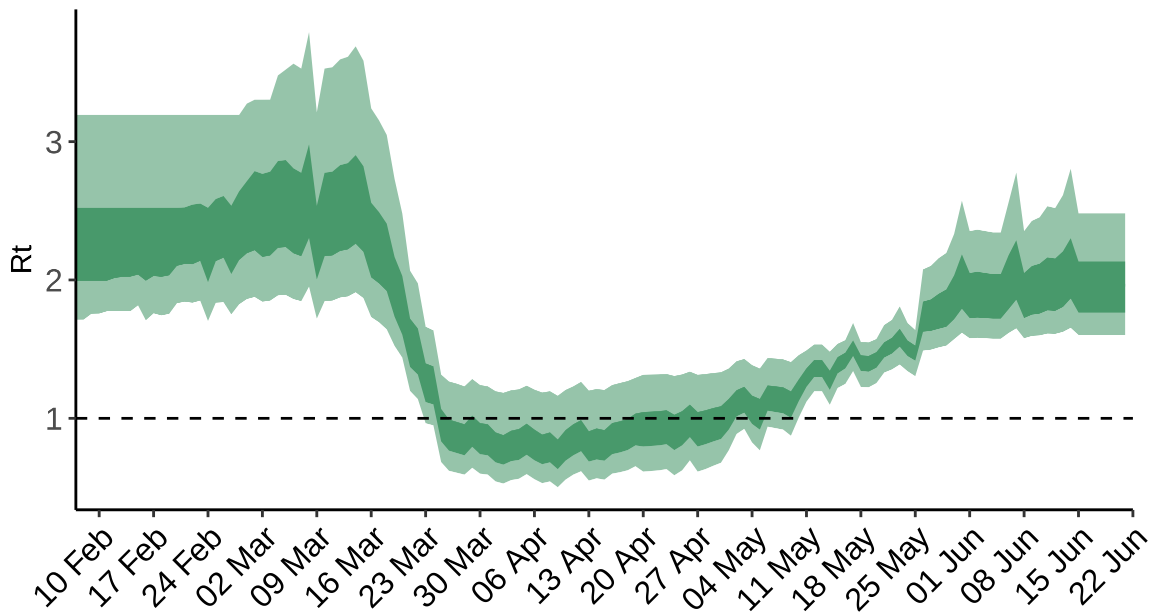


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Kyrgyz Republic is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

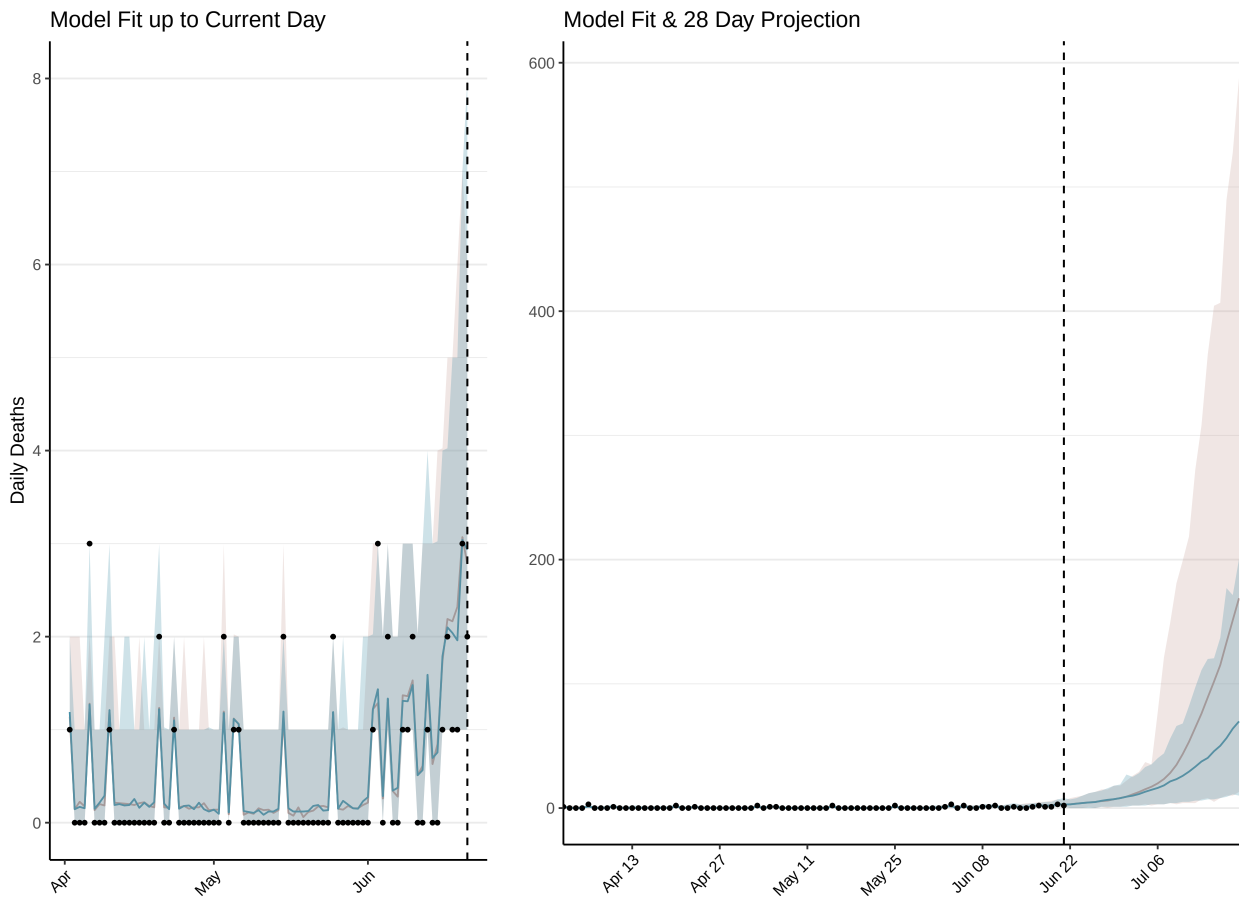


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 230 (95% CI: 215-244) patients requiring treatment with high-pressure oxygen at the current date to 5,407 (95% CI: 4,792-6,022) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 52 (95% CI: 48-55) patients requiring treatment with mechanical ventilation at the current date to 730 (95% CI: 688-772) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

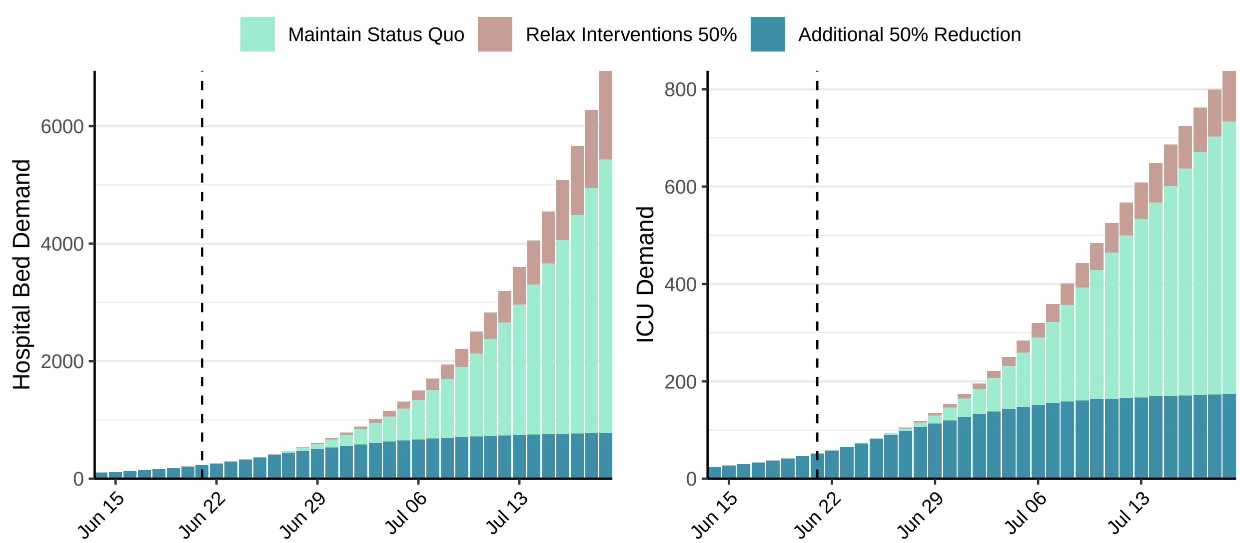


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 4,205 (95% CI: 3,872-4,537) at the current date to 5,083 (95% CI: 4,332-5,834) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 4,205 (95% CI: 3,872-4,537) at the current date to 95,397 (95% CI: 87,119-103,675) by 2020-07-19.

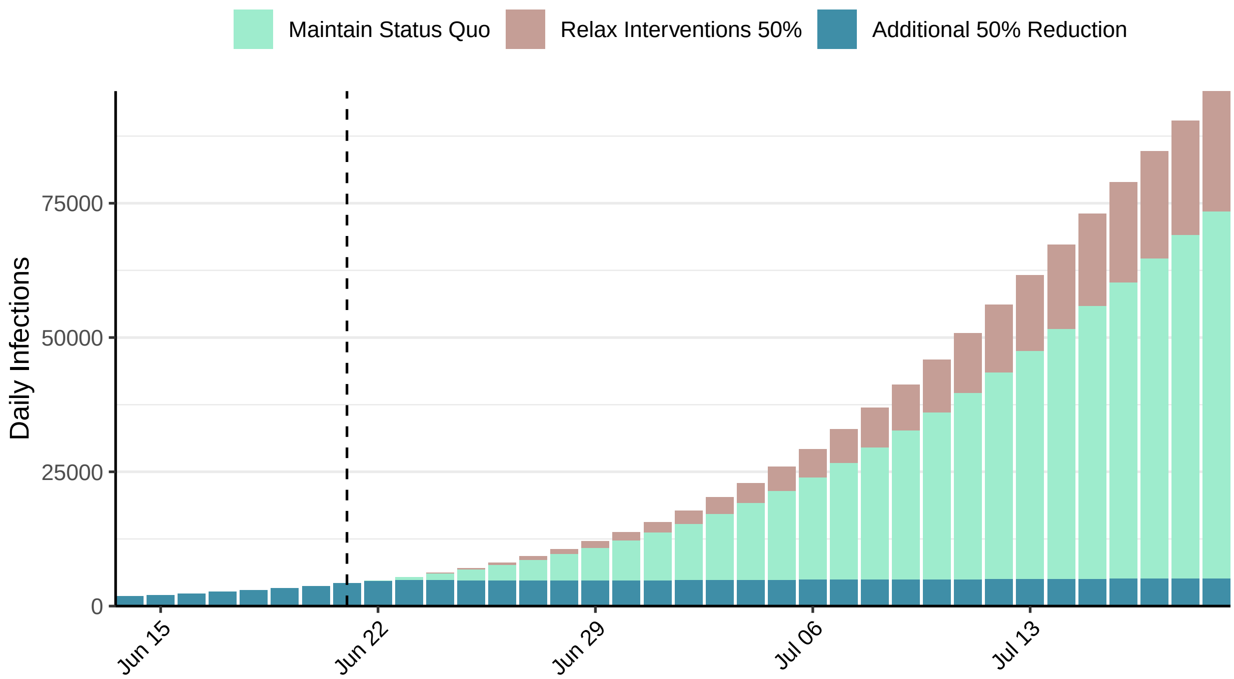


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Lebanon, 2020-06-21

**Download the report for Lebanon, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,536 | 26 | 32 | 0 | 1.53 (95% CI: 1.24-1.83) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

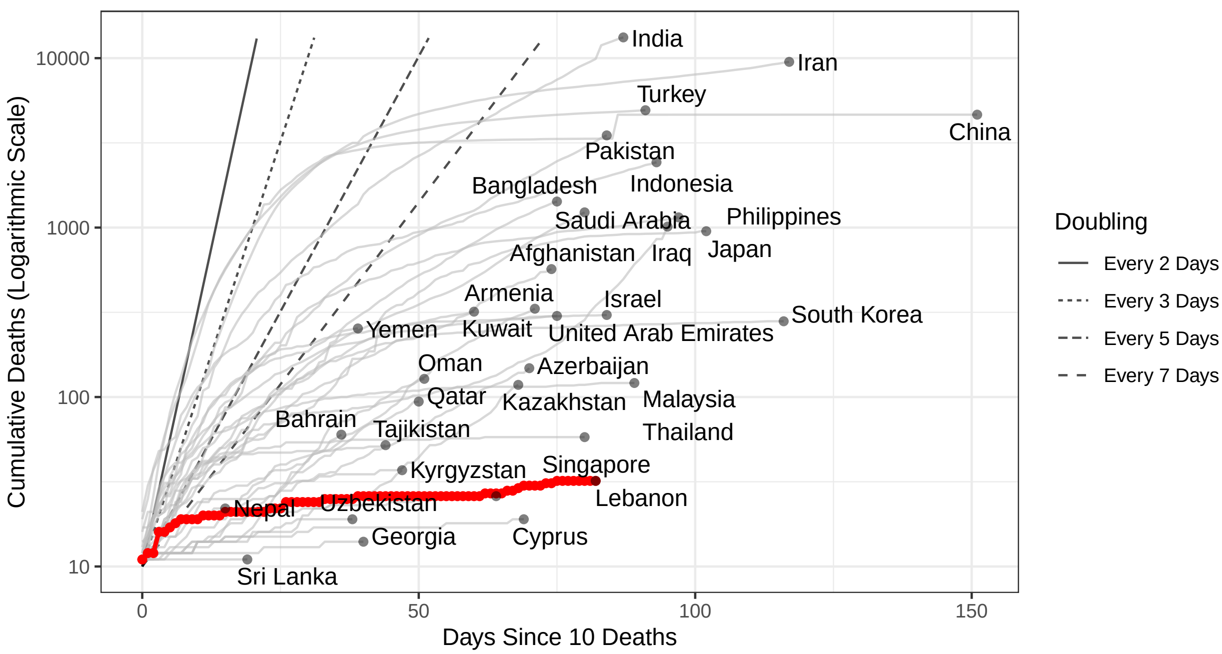


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,615 (95% CI: 3,351-3,878) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

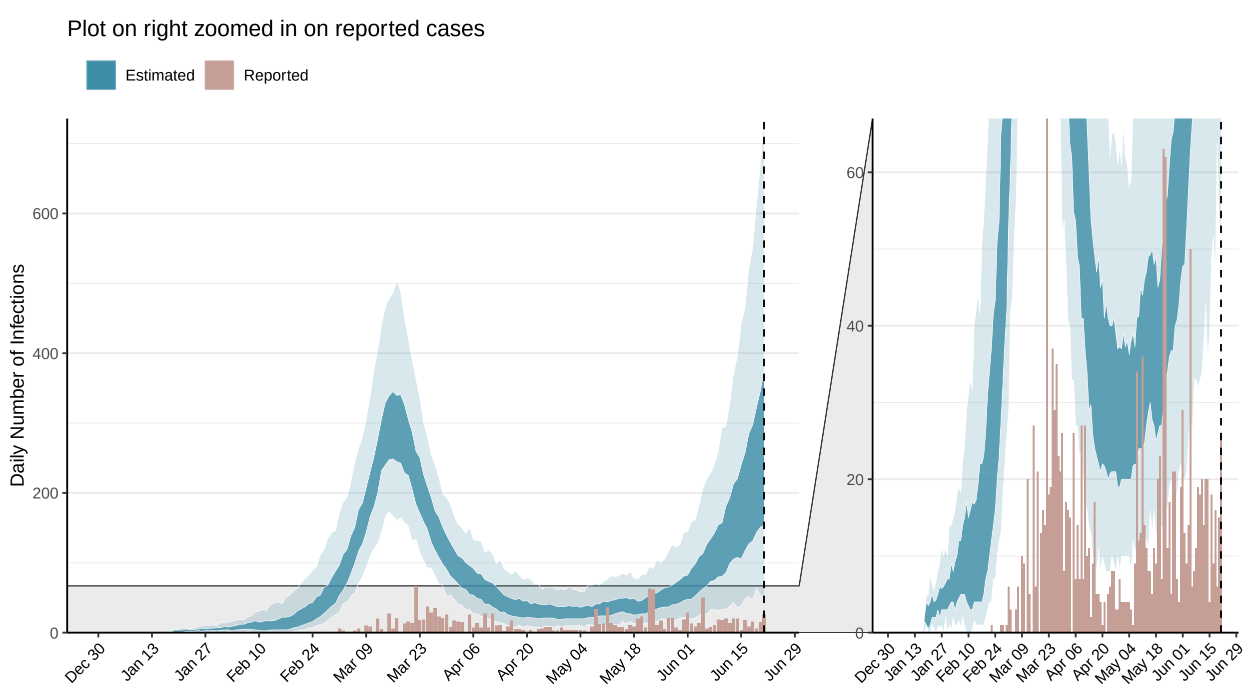


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

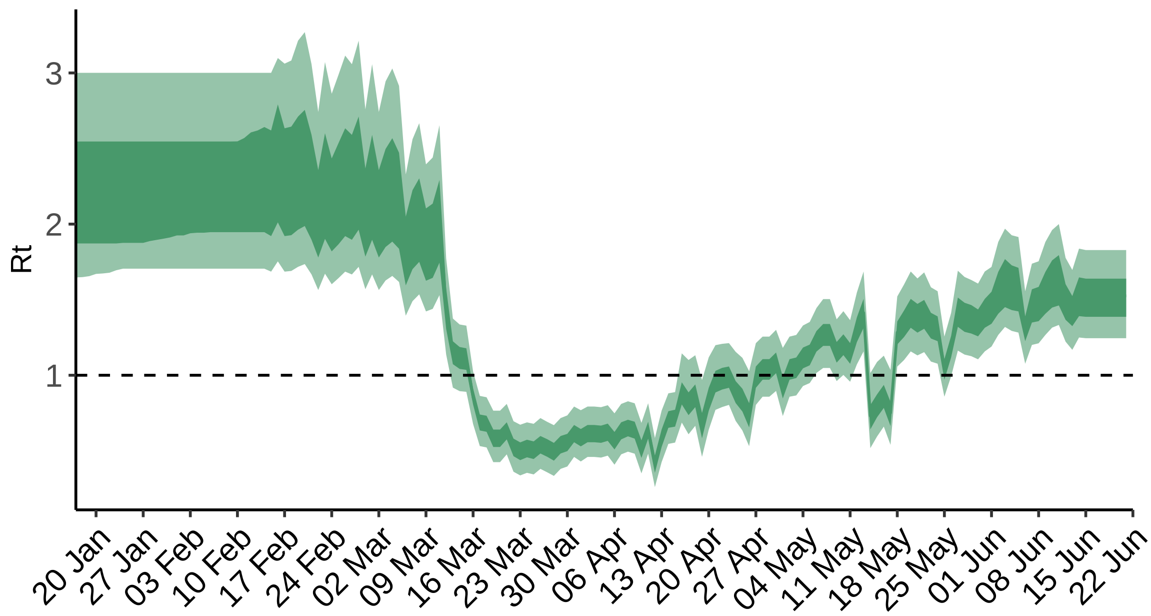


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

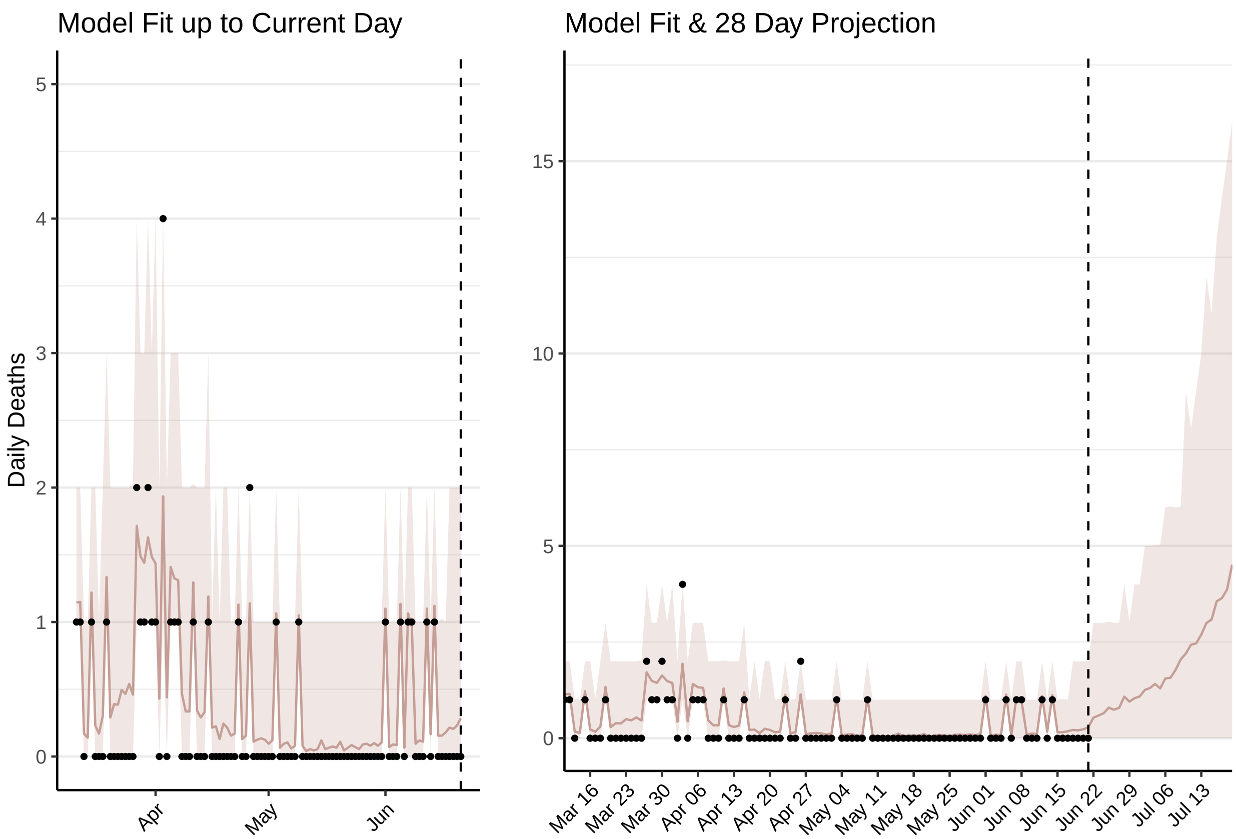


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 33 (95% CI: 30-35) patients requiring treatment with high-pressure oxygen at the current date to 270 (95% CI: 236-305) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 9 (95% CI: 8-10) patients requiring treatment with mechanical ventilation at the current date to 73 (95% CI: 64-83) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

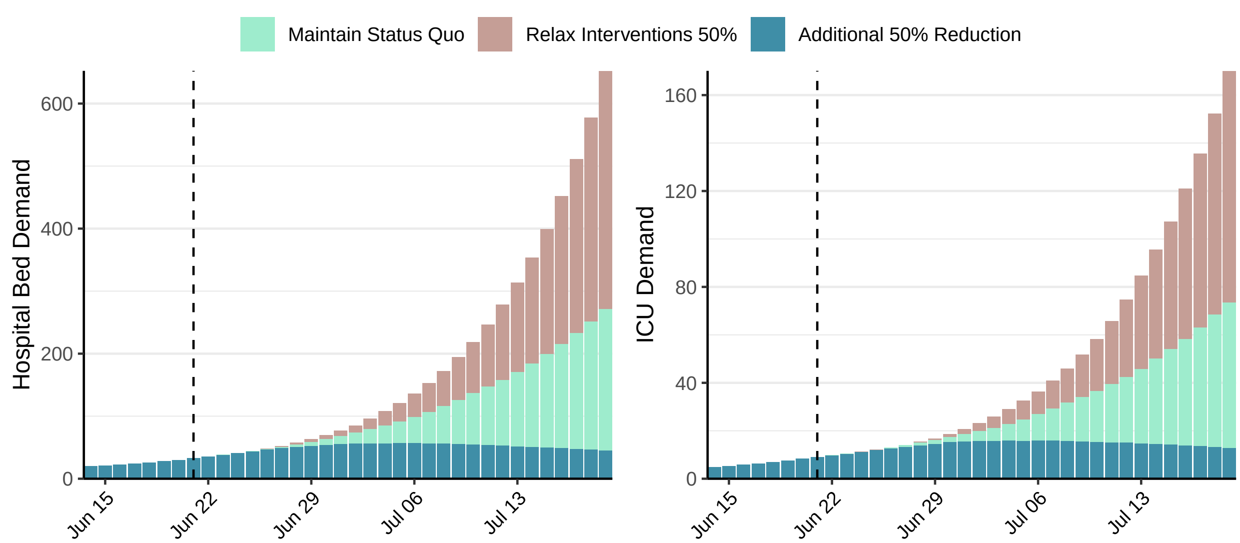


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 289 (95% CI: 263-314) at the current date to 139 (95% CI: 120-158) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 289 (95% CI: 263-314) at the current date to 8,556 (95% CI: 7,286-9,826) by 2020-07-19.

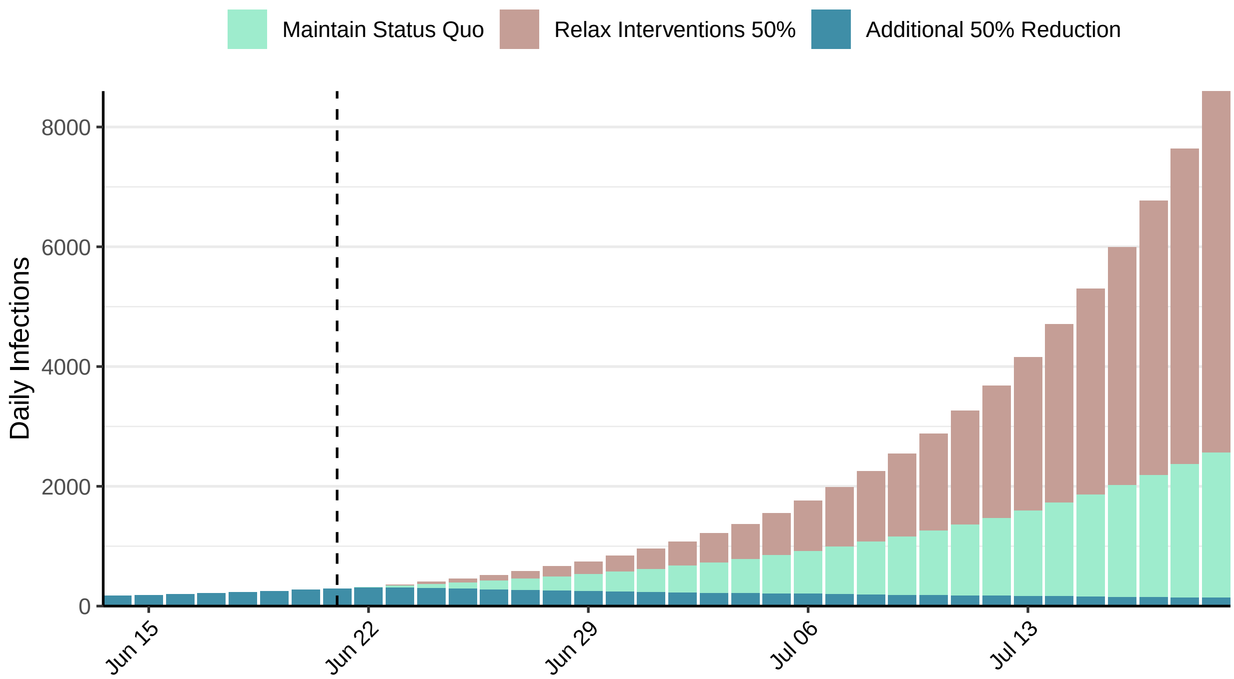


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Liberia, 2020-06-21

**Download the report for Liberia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 601 | 20 | 33 | 0 | 1.22 (95% CI: 1.11-1.37) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

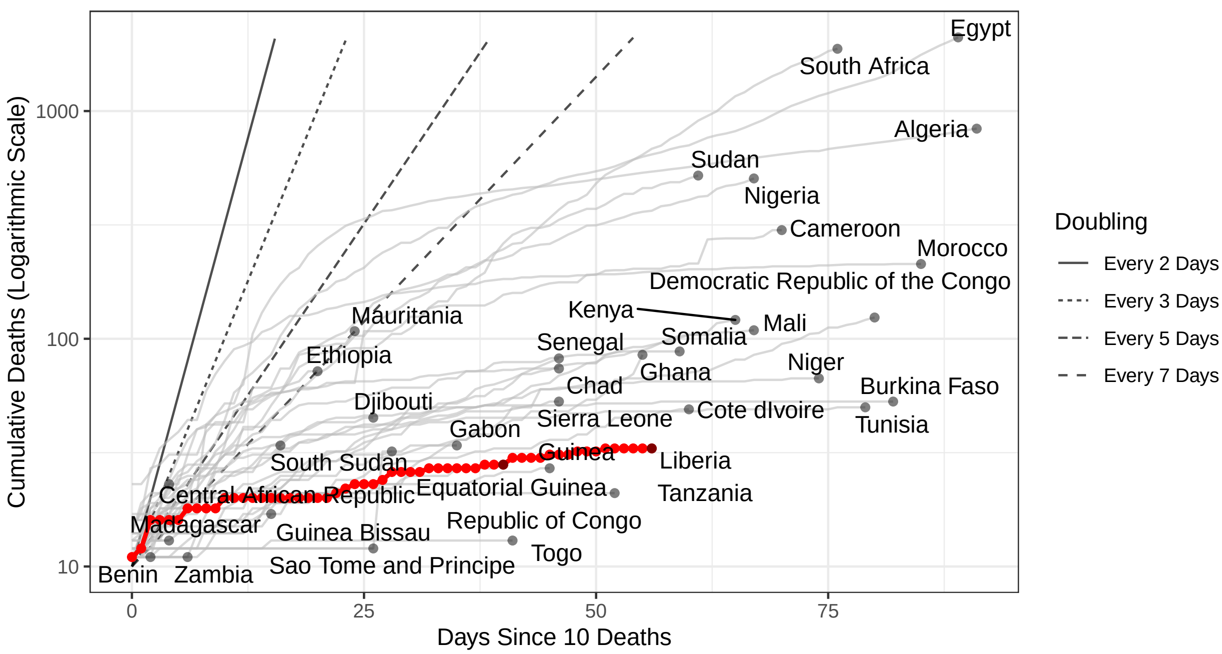


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 2,822 (95% CI: 2,630-3,013) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

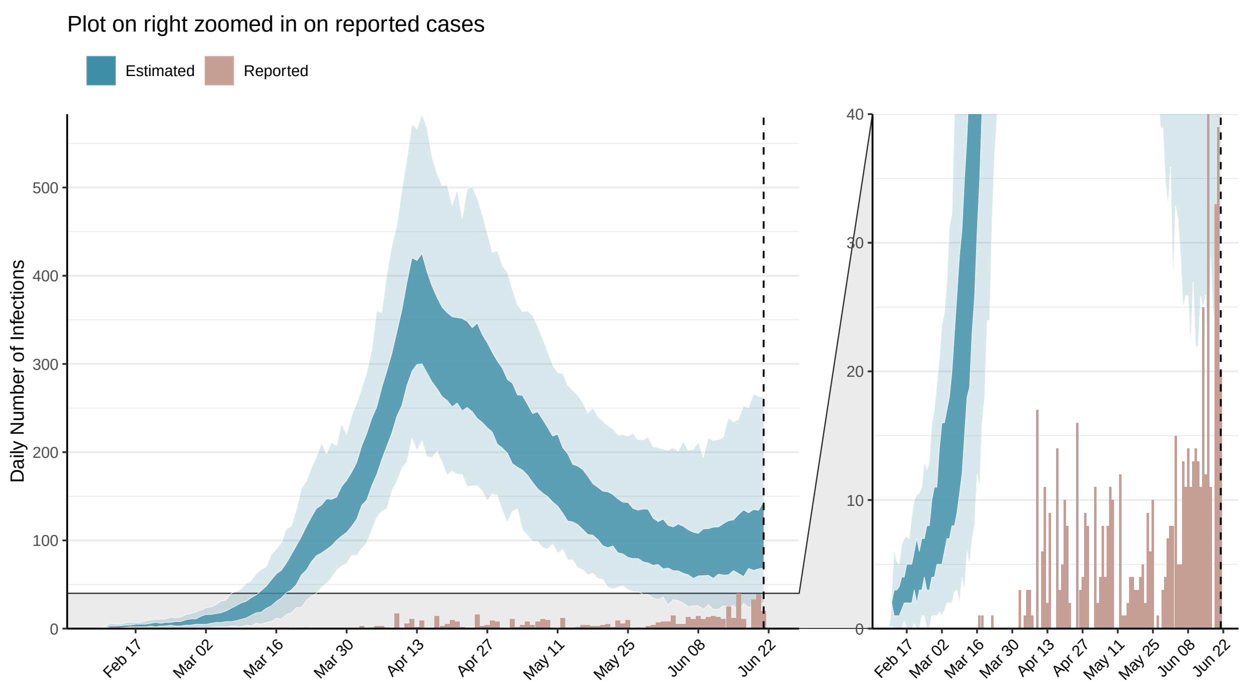


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

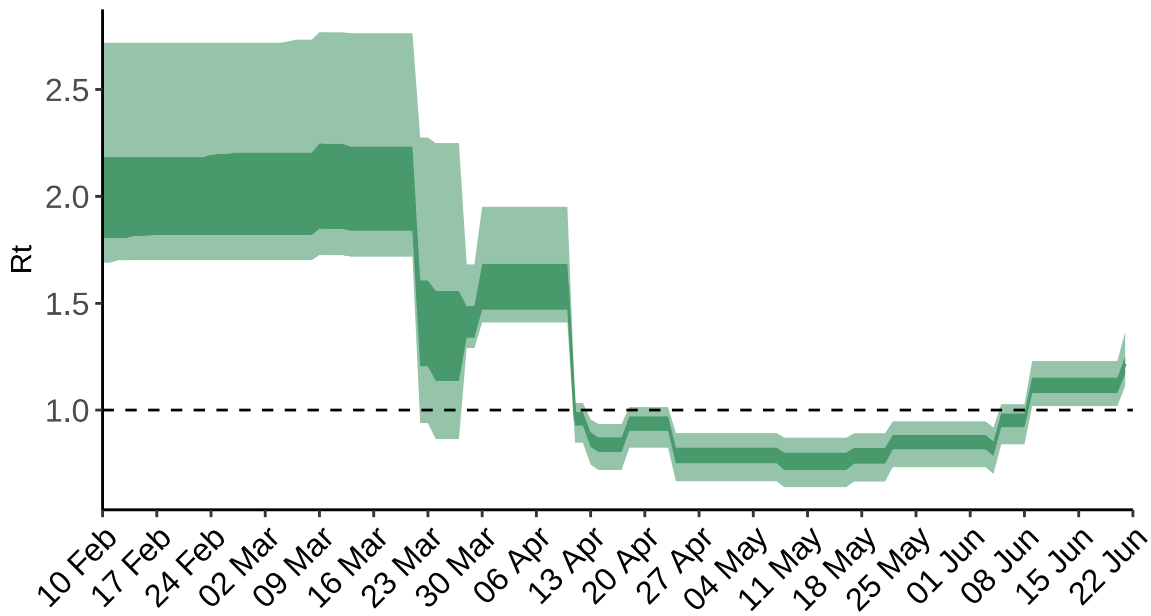


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

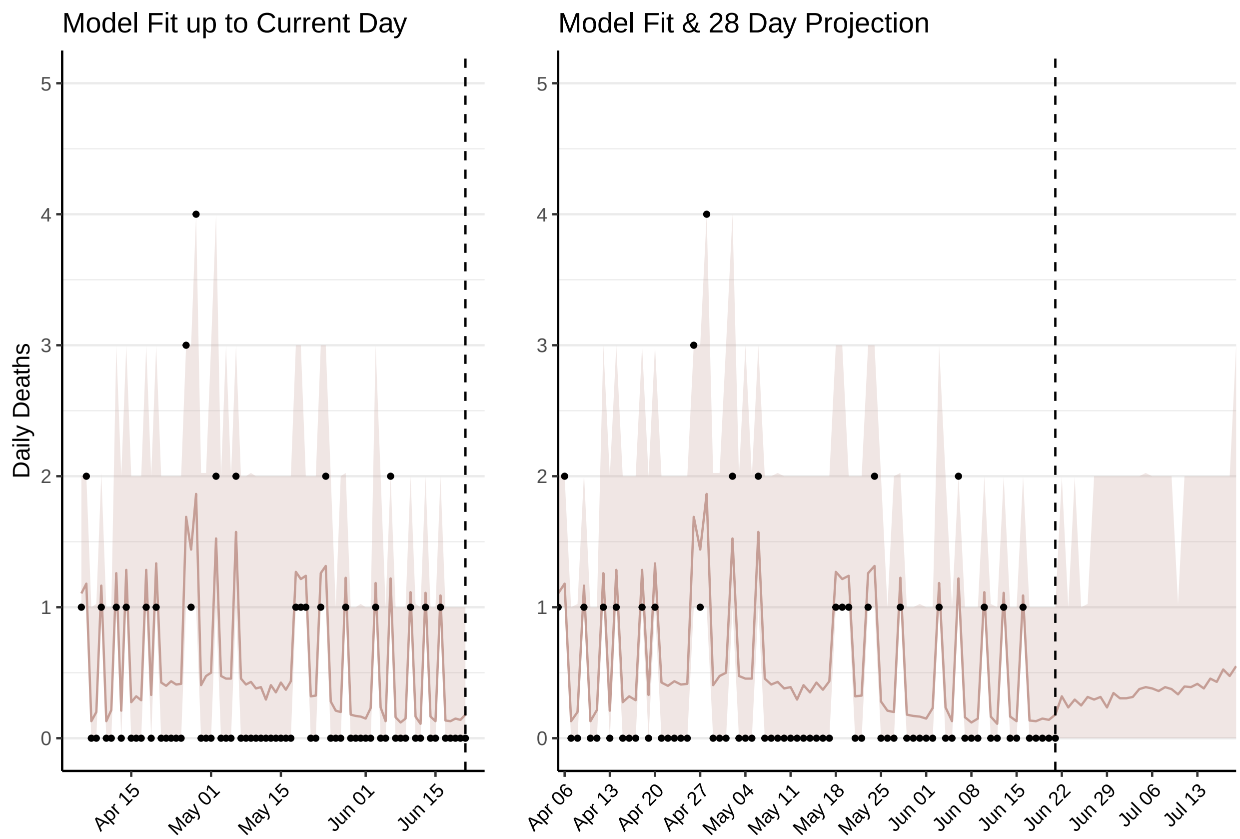


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 15 (95% CI: 14-16) patients requiring treatment with high-pressure oxygen at the current date to 30 (95% CI: 27-33) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4 (95% CI: 4-5) patients requiring treatment with mechanical ventilation at the current date to 8 (95% CI: 7-9) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

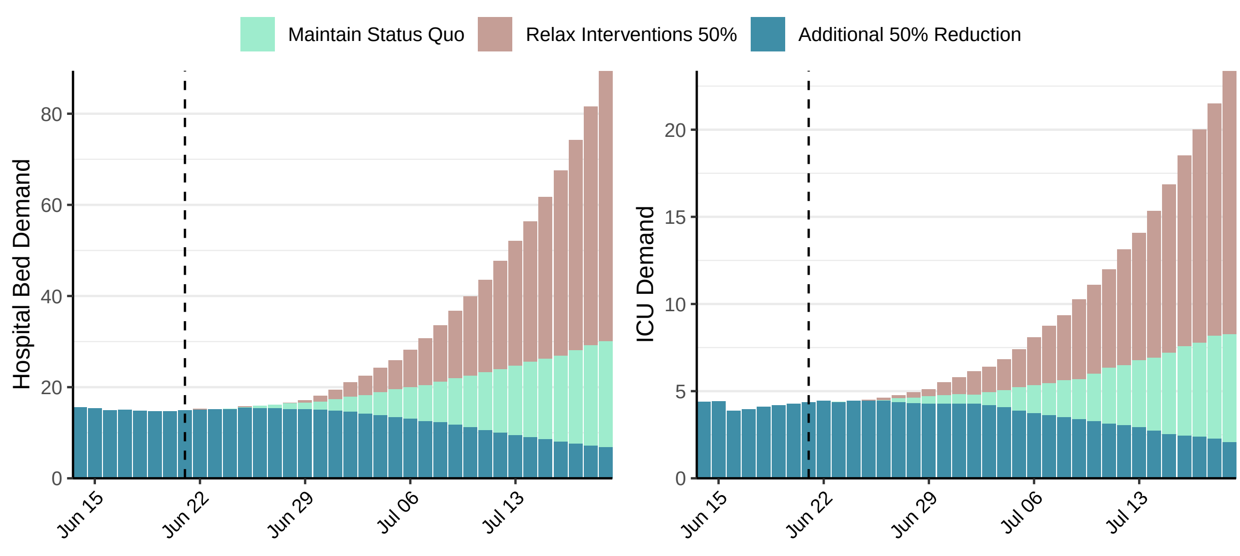


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 113 (95% CI: 104-122) at the current date to 19 (95% CI: 17-21) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 113 (95% CI: 104-122) at the current date to 1,399 (95% CI: 1,268-1,530) by 2020-07-19.

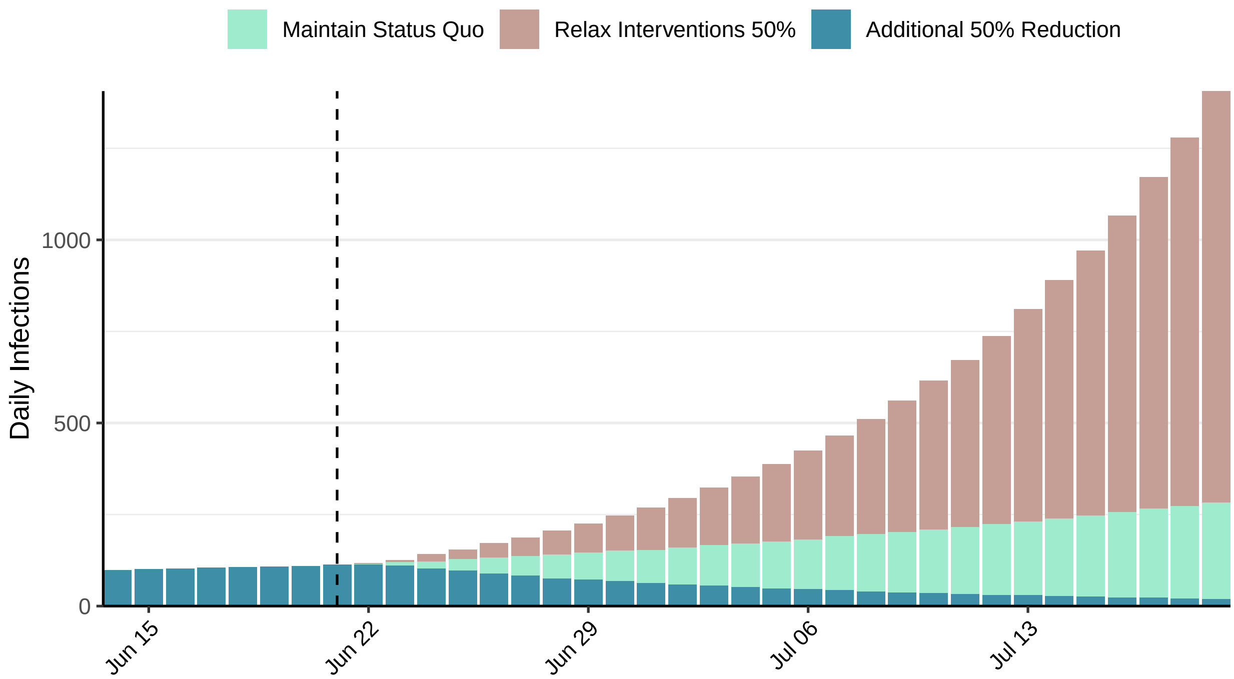


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Libya, 2020-06-21

**Download the report for Libya, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 520 | 10 | 10 | 0 | 1.67 (95% CI: 1.42-2.03) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

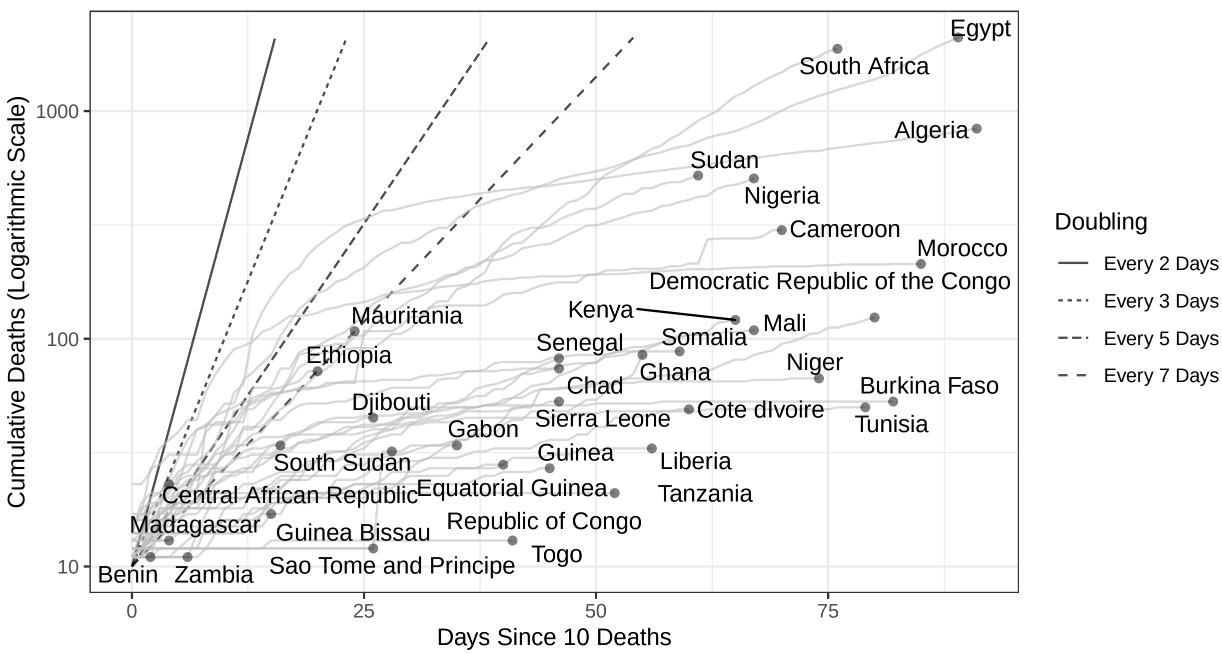


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 5,647 (95% CI: 5,123-6,171) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

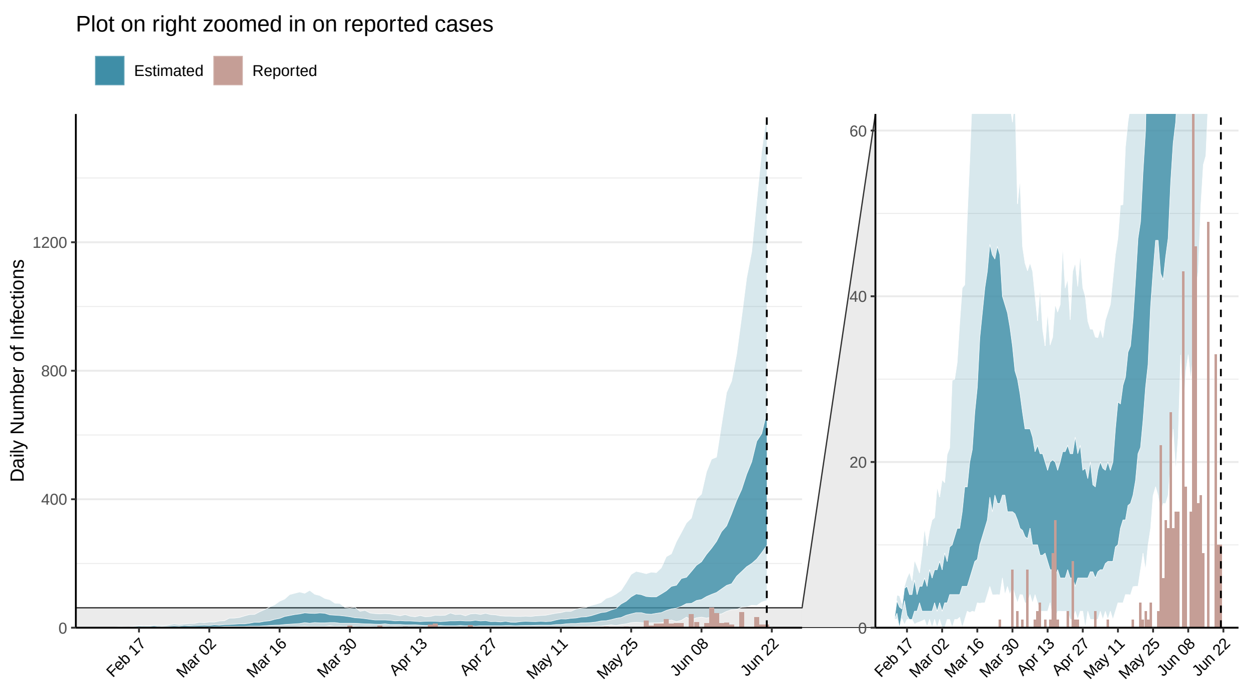


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

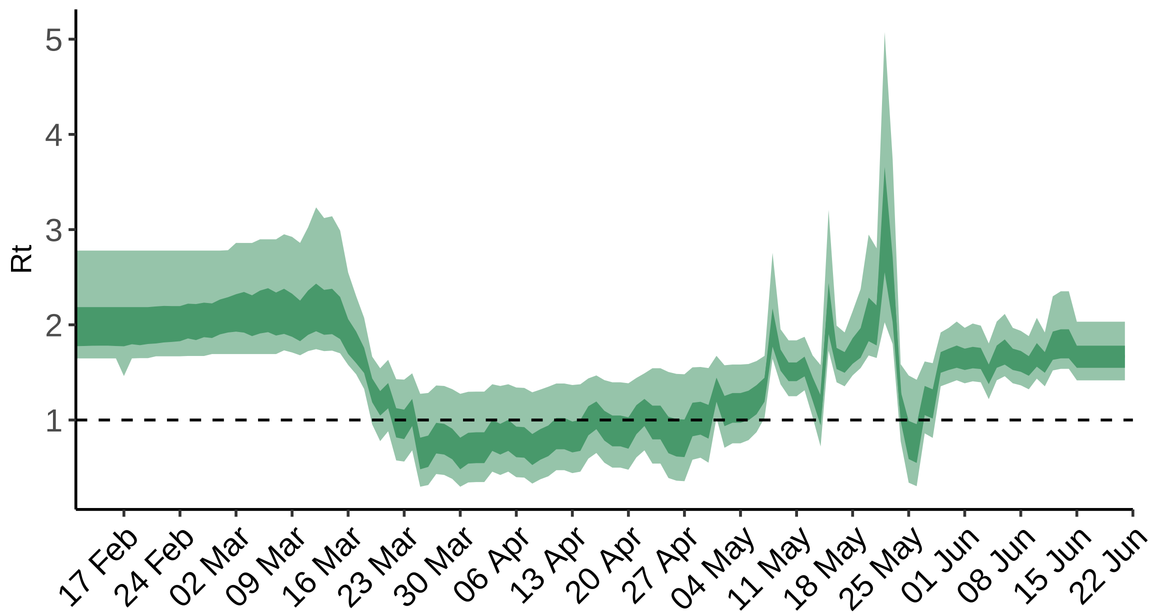


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

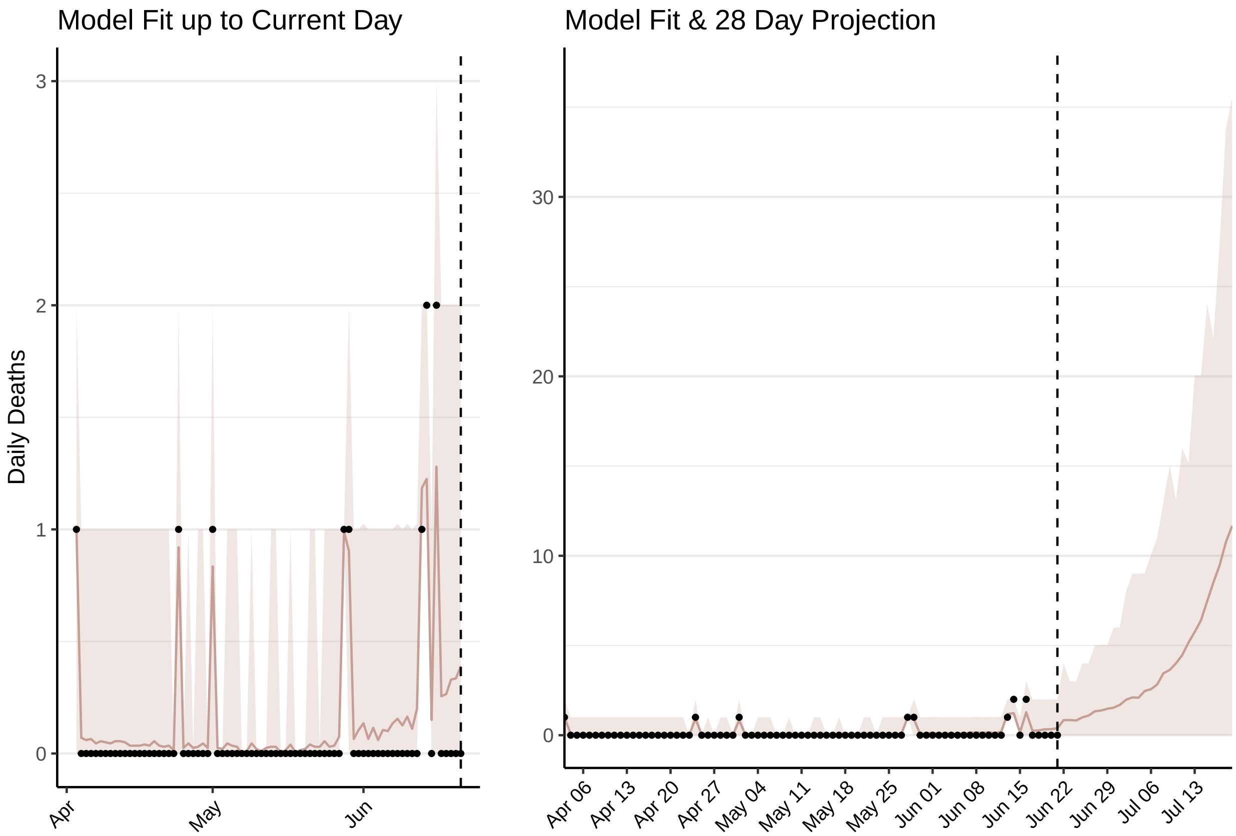


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 49 (95% CI: 44-53) patients requiring treatment with high-pressure oxygen at the current date to 643 (95% CI: 528-758) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 13 (95% CI: 11-14) patients requiring treatment with mechanical ventilation at the current date to 147 (95% CI: 127-168) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

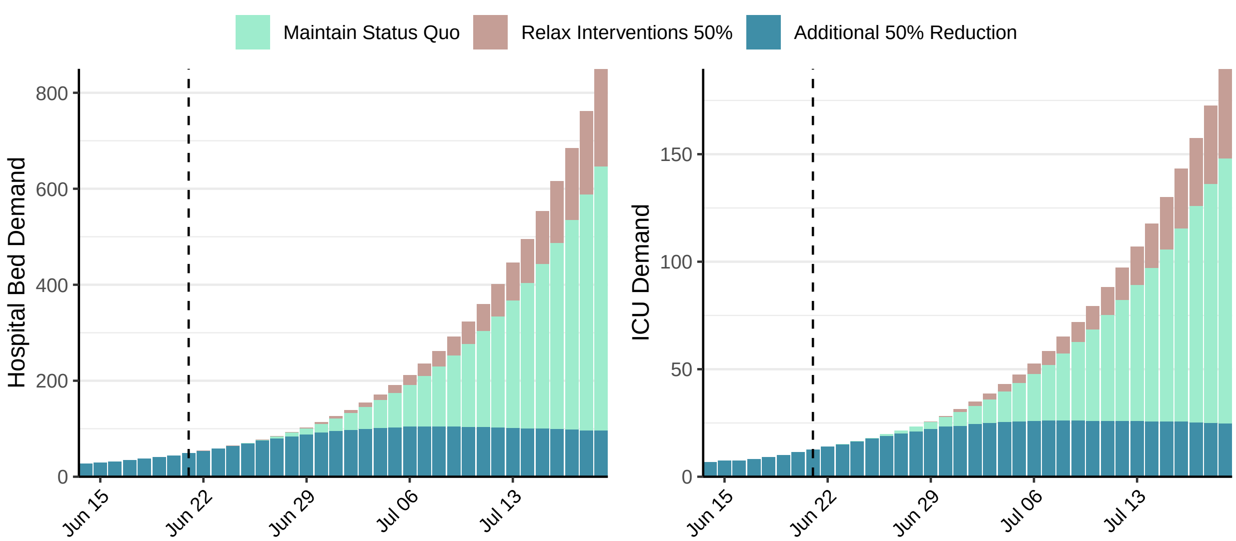


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 521 (95% CI: 464-578) at the current date to 362 (95% CI: 290-435) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 521 (95% CI: 464-578) at the current date to 10,132 (95% CI: 7,976-12,288) by 2020-07-19.

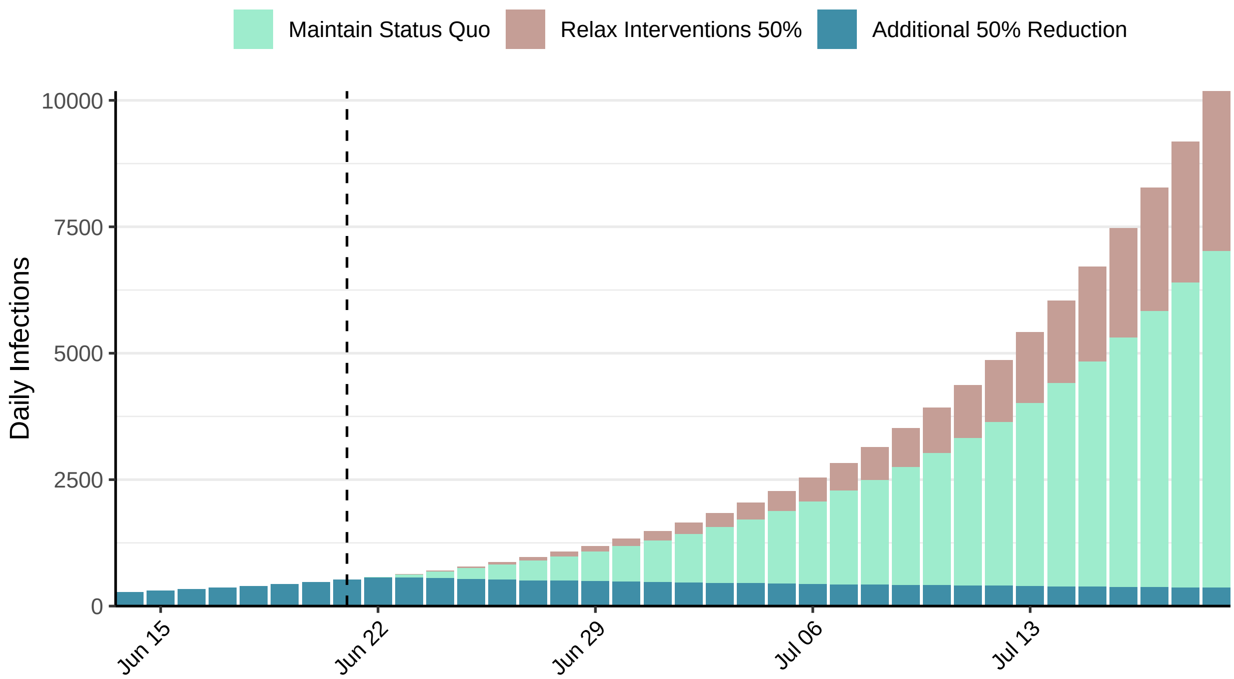


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Sri Lanka, 2020-06-21

**Download the report for Sri Lanka, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,950 | 0 | 11 | 0 | 1.59 (95% CI: 1.25-2.08) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

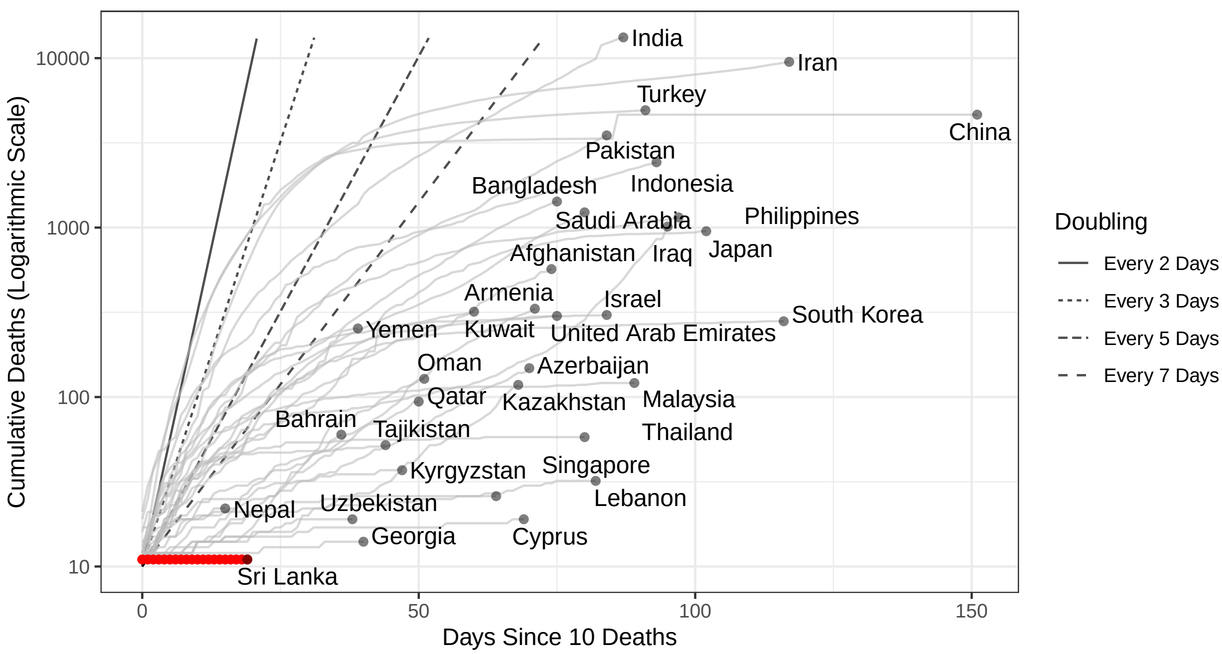


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

## COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,283 (95% CI: 1,102-1,464) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

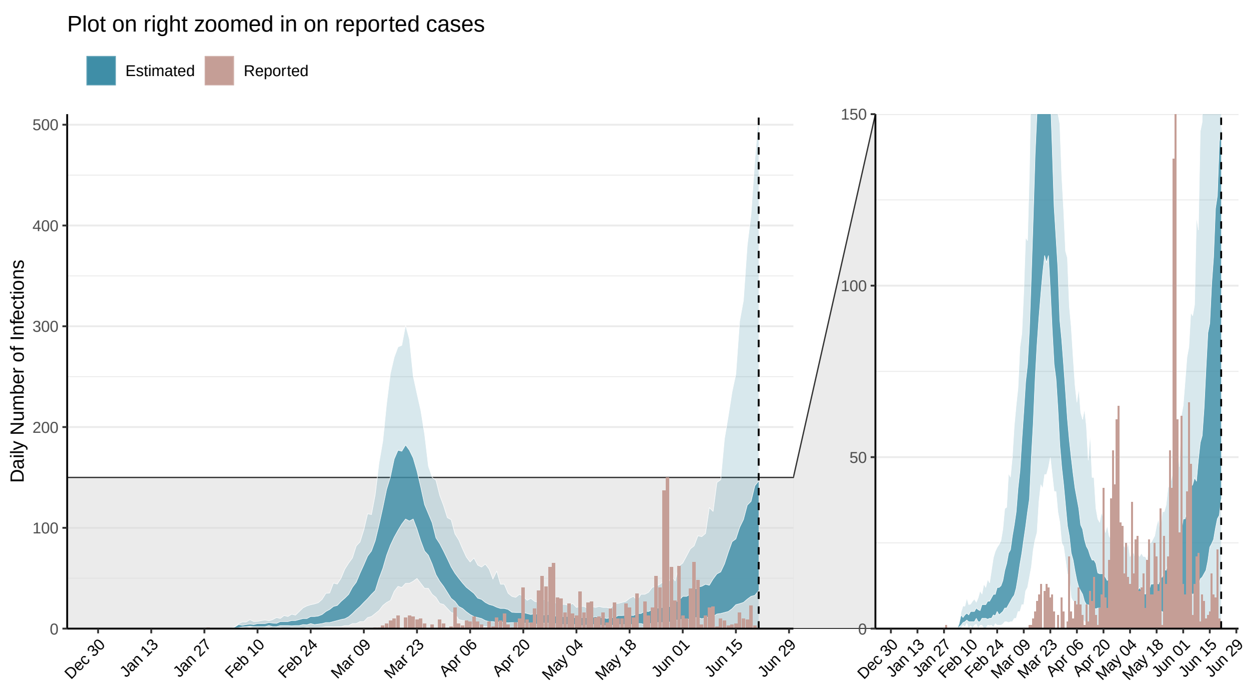


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

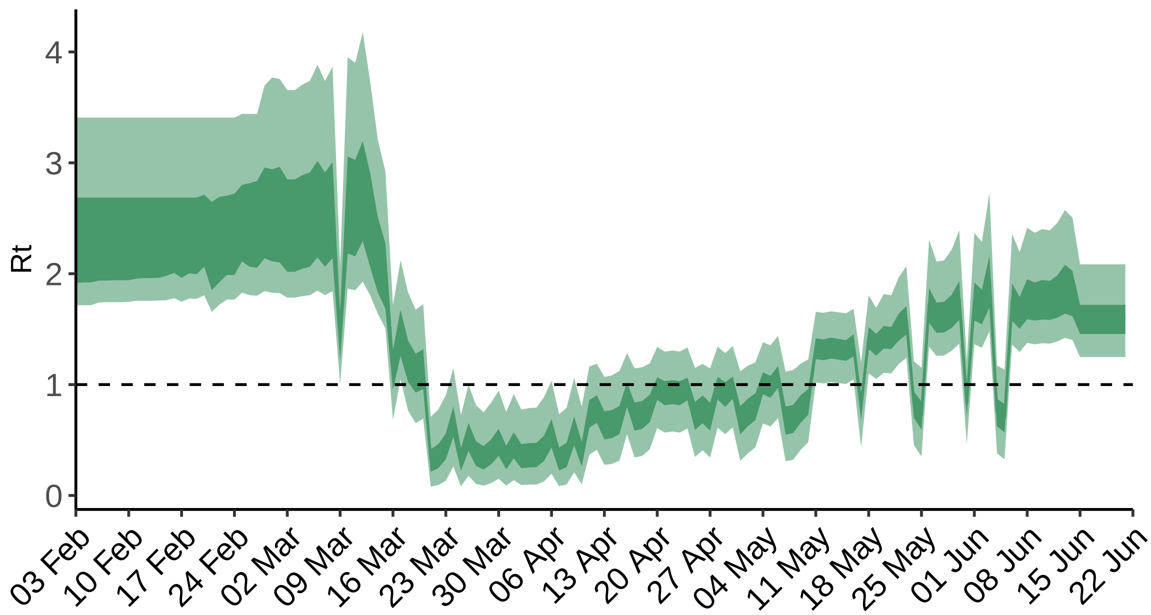


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

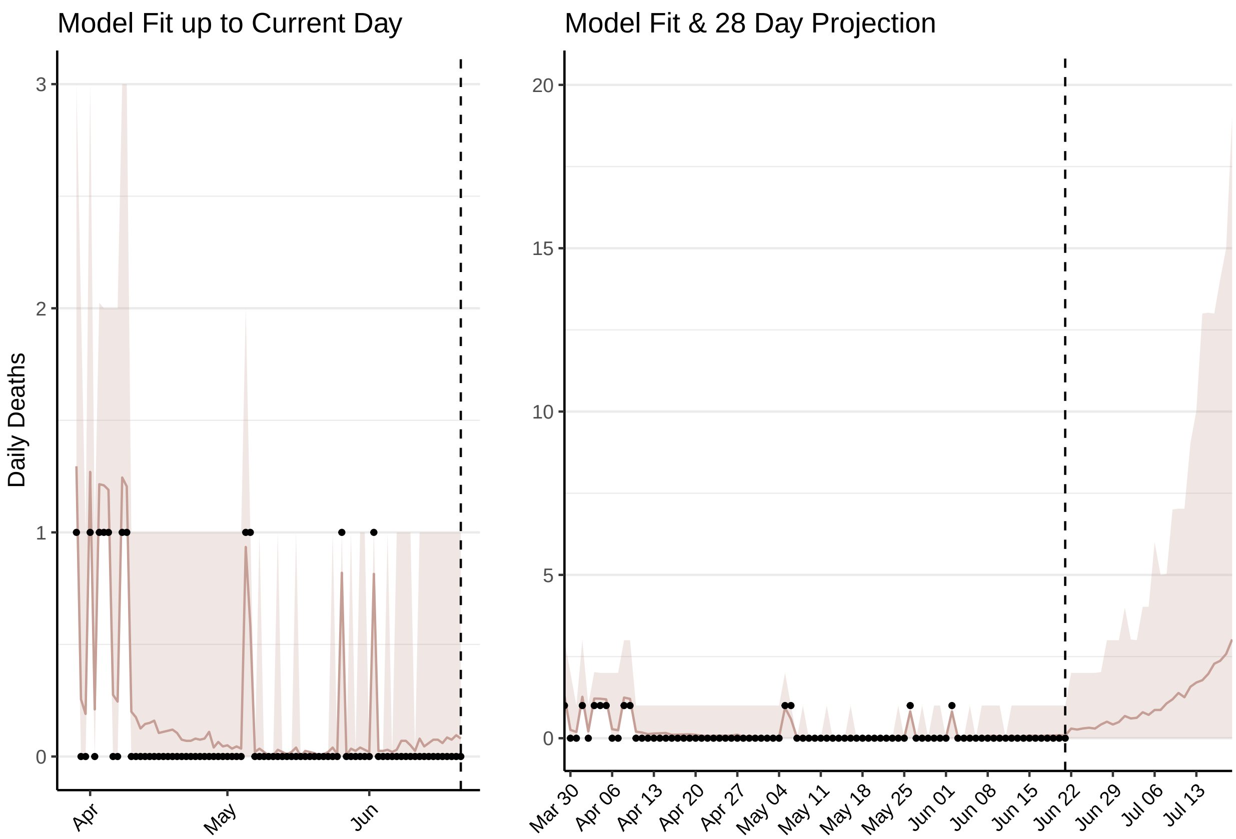


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 11 (95% CI: 10-13) patients requiring treatment with high-pressure oxygen at the current date to 158 (95% CI: 119-197) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4 (95% CI: 3-4) patients requiring treatment with mechanical ventilation at the current date to 53 (95% CI: 40-66) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

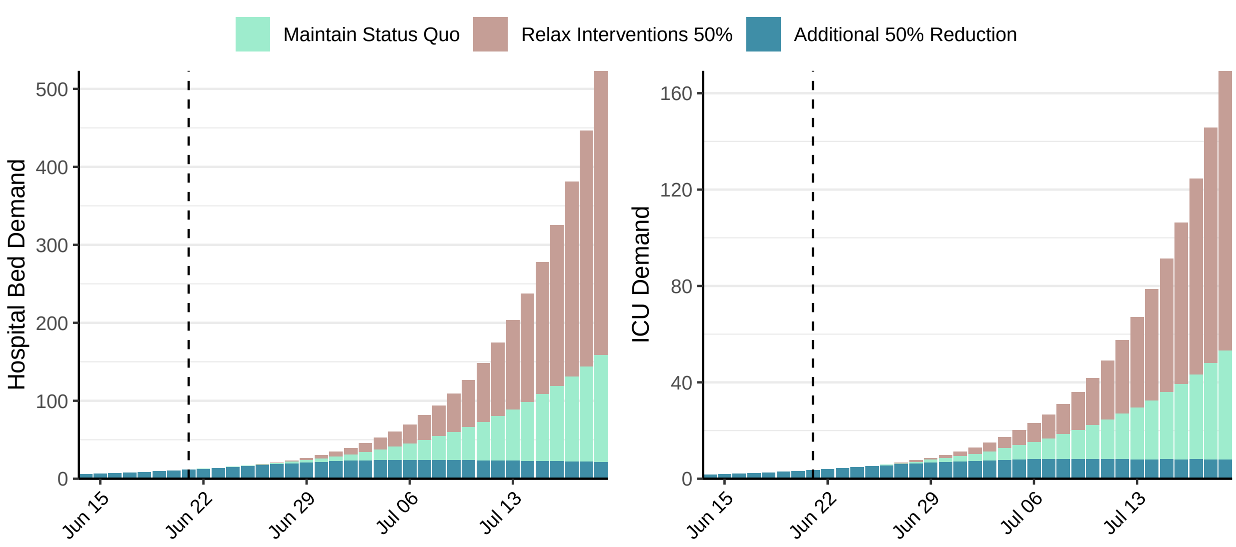


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 120 (95% CI: 101-140) at the current date to 86 (95% CI: 64-109) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 120 (95% CI: 101-140) at the current date to 8,935 (95% CI: 6,339-11,531) by 2020-07-19.

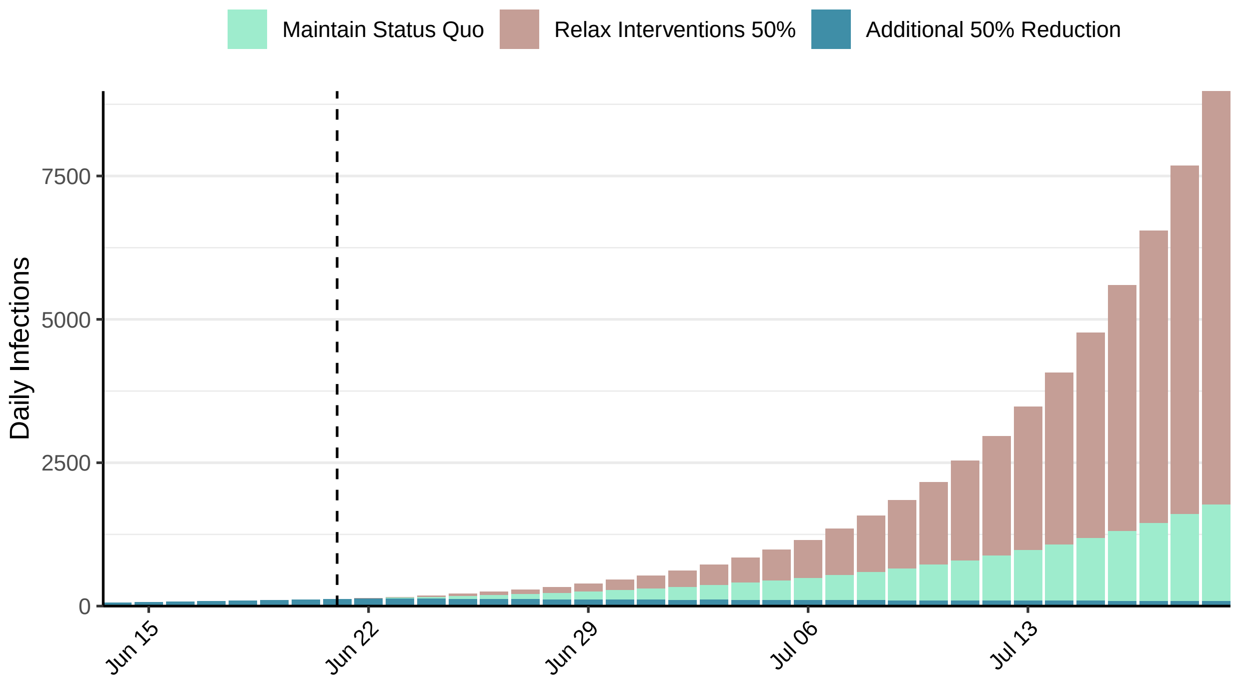


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Morocco, 2020-06-21

**Download the report for Morocco, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 9,801 | 188 | 213 | 0 | 1.25 (95% CI: 1.07-1.4) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

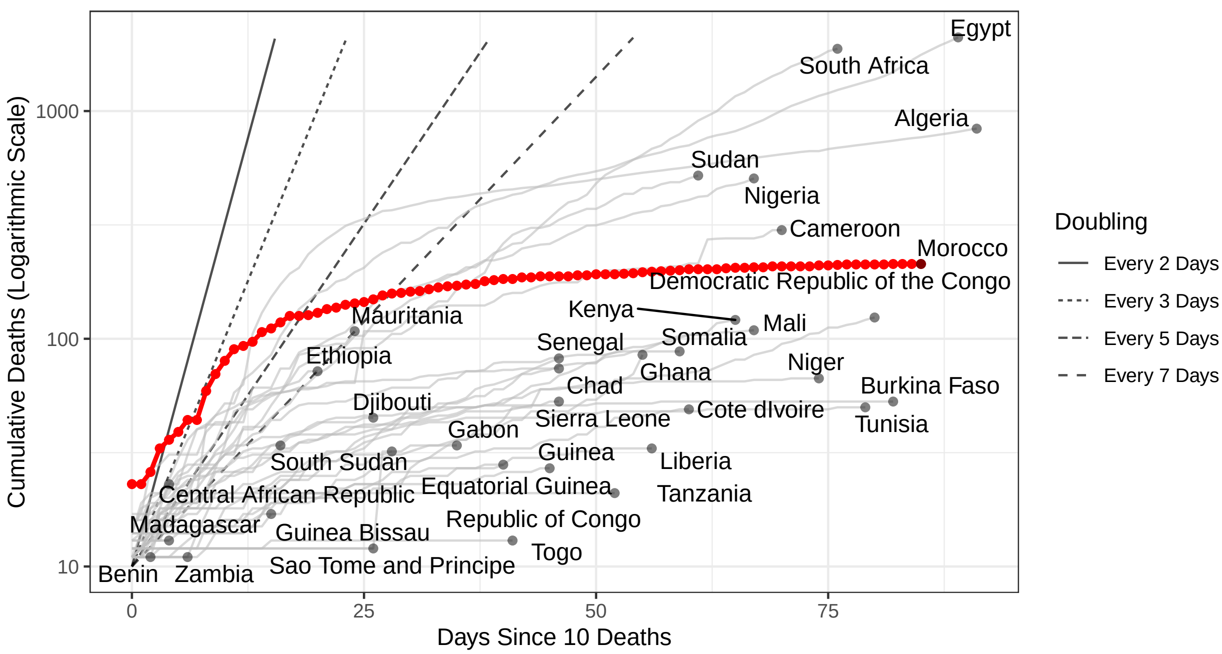


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,552 (95% CI: 3,343-3,761) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

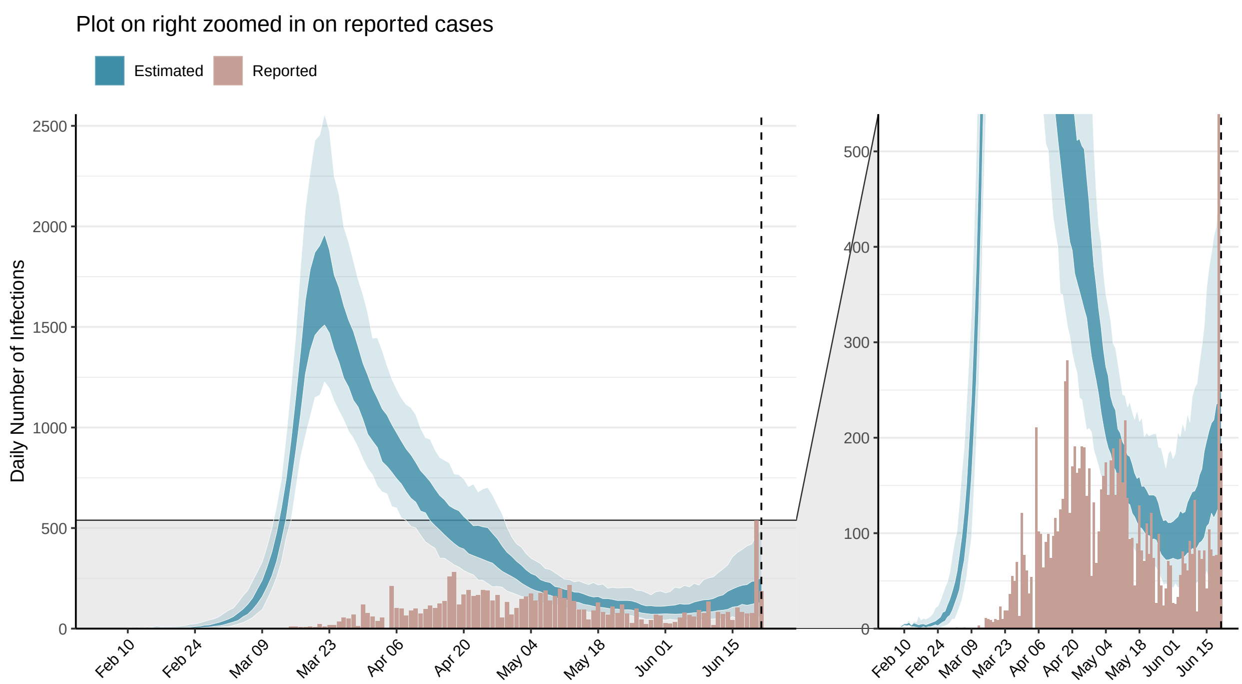


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

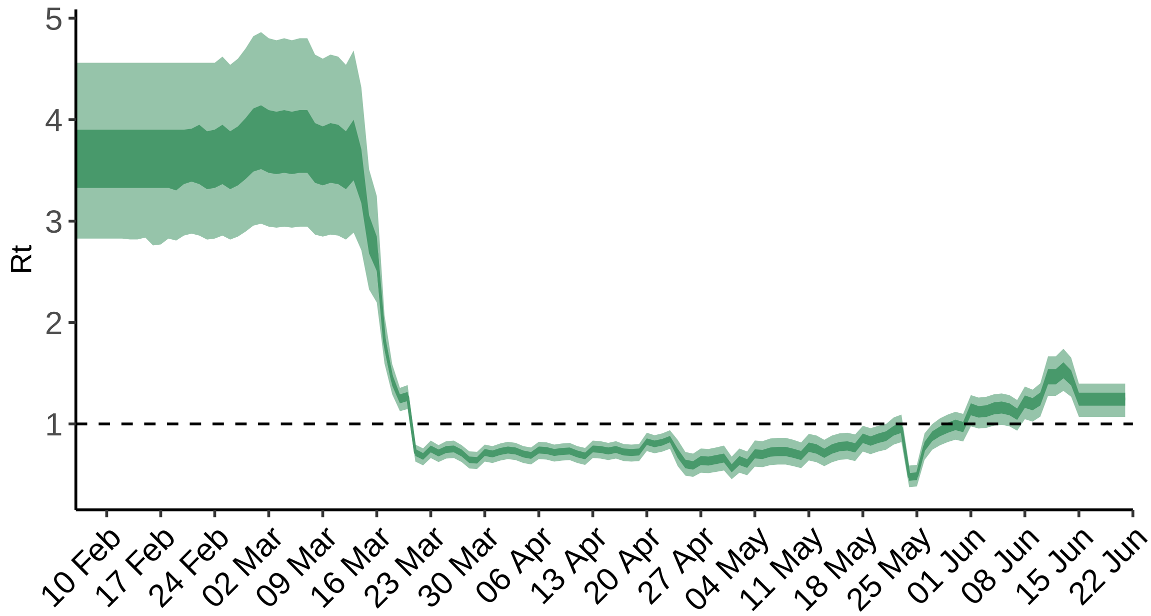


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

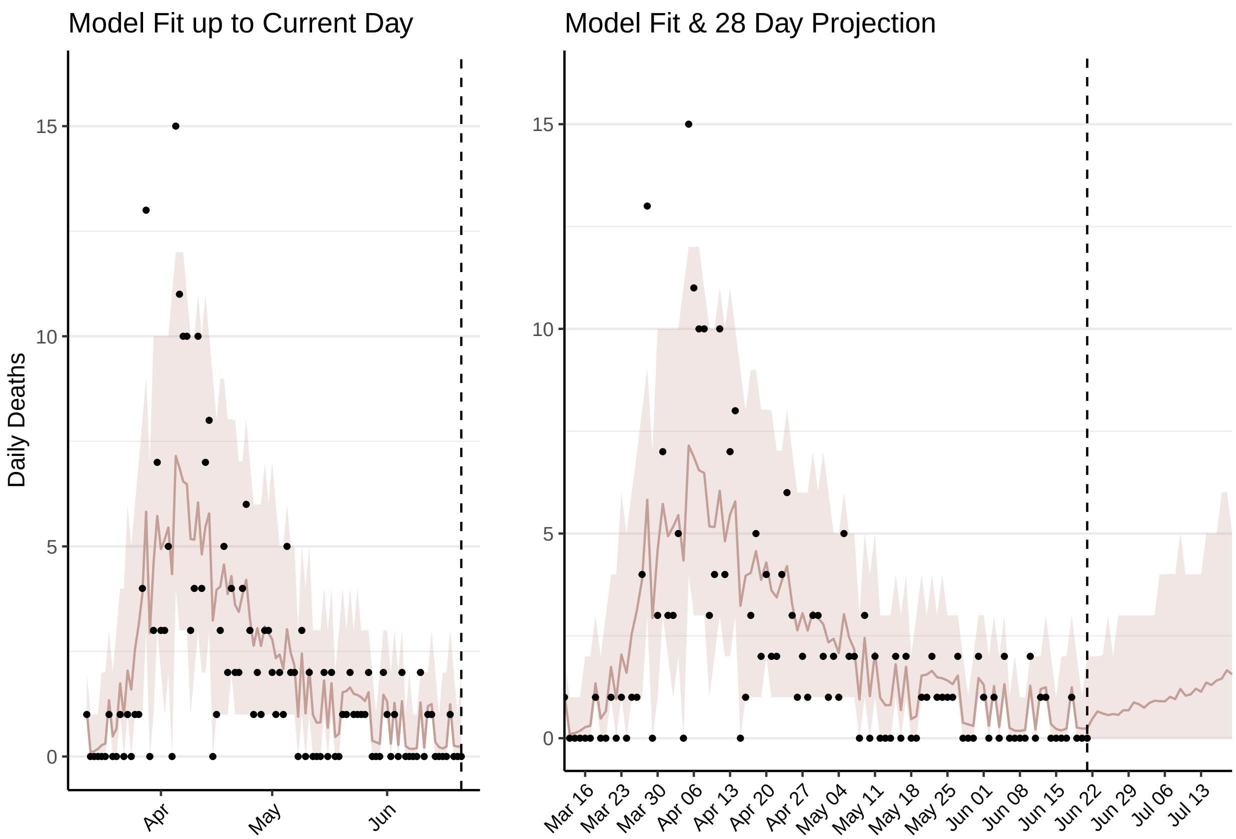


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 31 (95% CI: 29-33) patients requiring treatment with high-pressure oxygen at the current date to 93 (95% CI: 84-103) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 9 (95% CI: 8-9) patients requiring treatment with mechanical ventilation at the current date to 25 (95% CI: 22-28) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

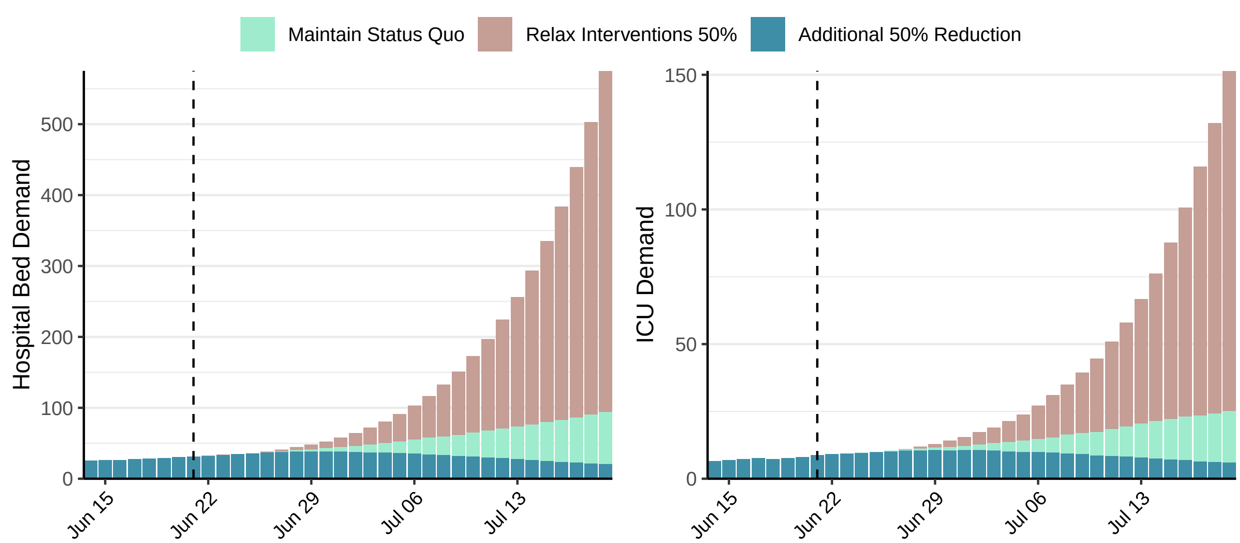


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 201 (95% CI: 186-216) at the current date to 44 (95% CI: 39-49) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 201 (95% CI: 186-216) at the current date to 8,313 (95% CI: 7,279-9,347) by 2020-07-19.

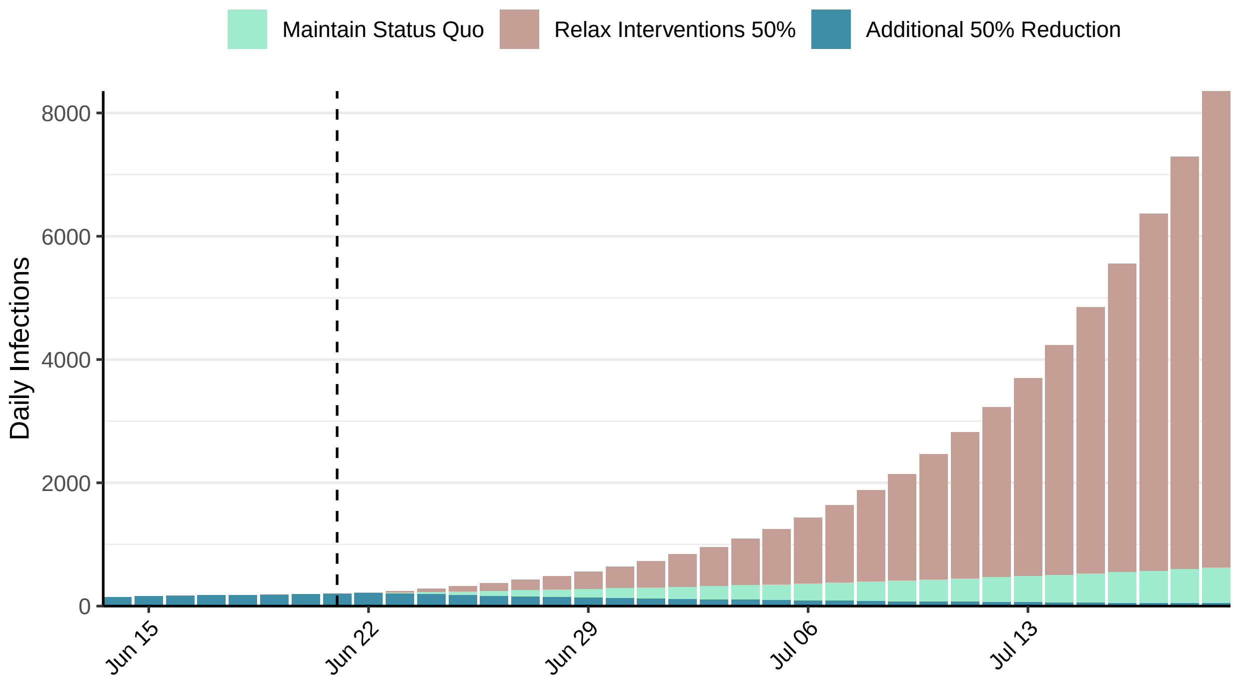


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Moldova, 2020-06-21

**Download the report for Moldova, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 13,953 | 397 | 464 | 14 | 1.7 (95% CI: 1.56-1.9) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

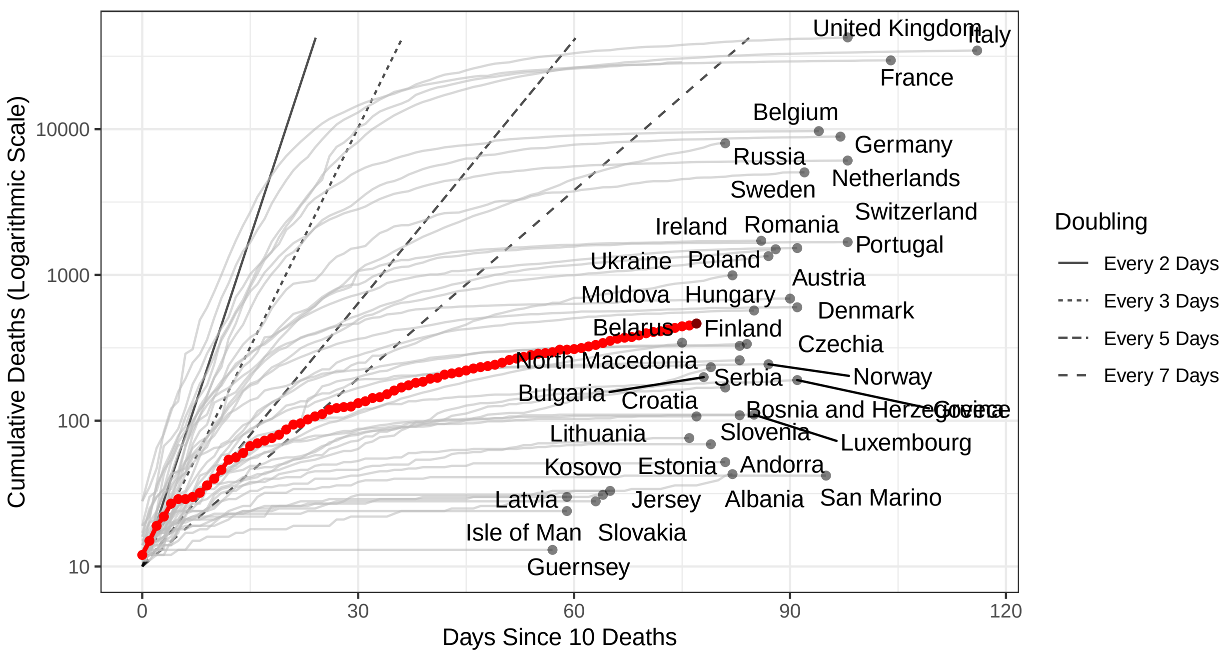


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 135,645 (95% CI: 131,809-139,482) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

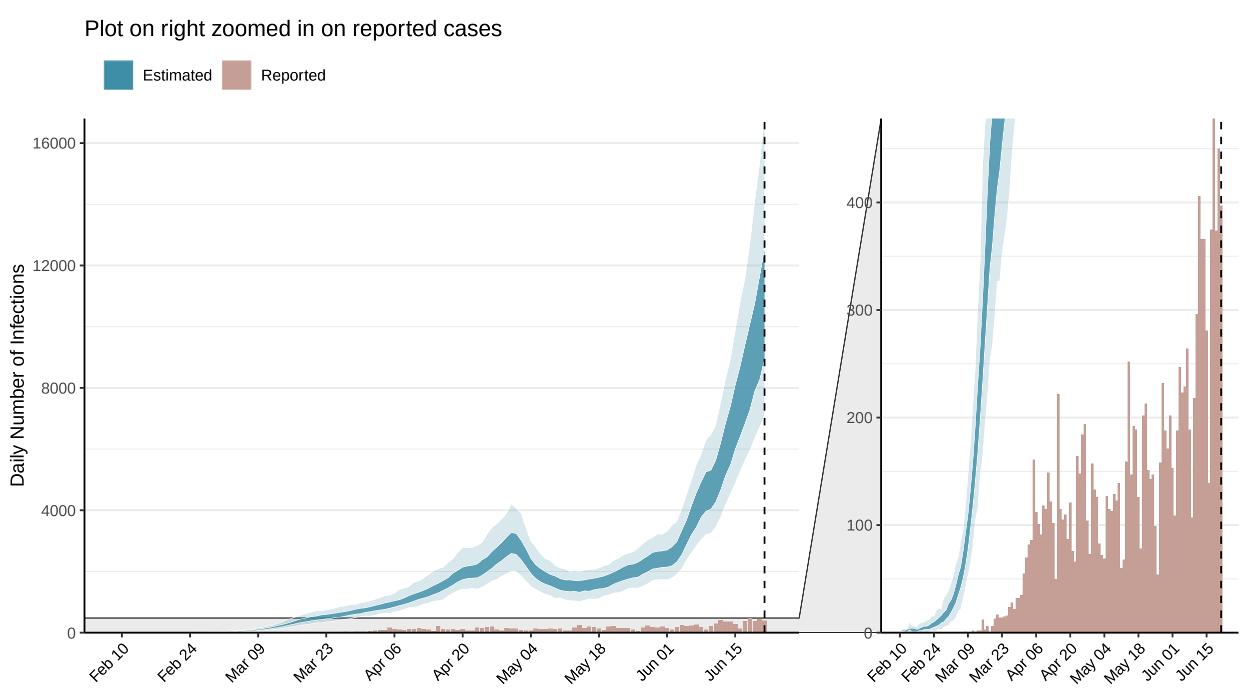


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

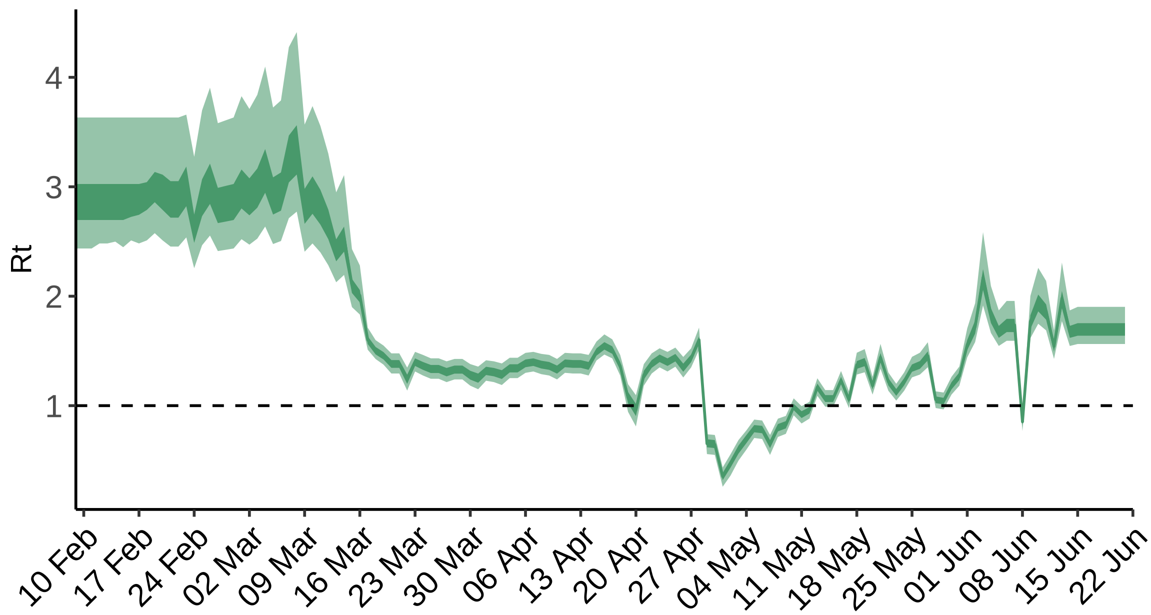


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Moldova is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

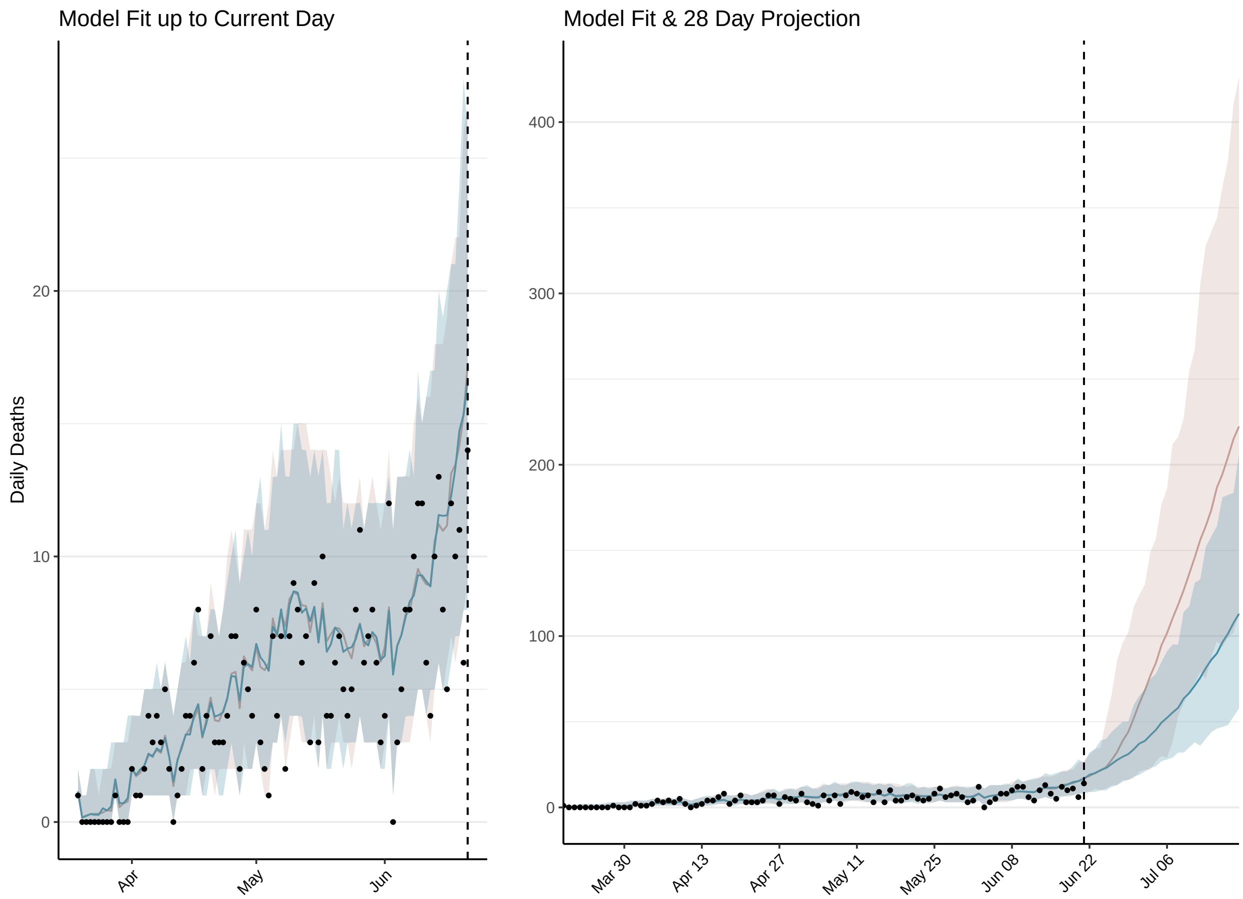


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,119 (95% CI: 1,087-1,152) patients requiring treatment with high-pressure oxygen at the current date to 6,457 (95% CI: 6,190-6,725) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 285 (95% CI: 277-294) patients requiring treatment with mechanical ventilation at the current date to 720 (95% CI: 706-735) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

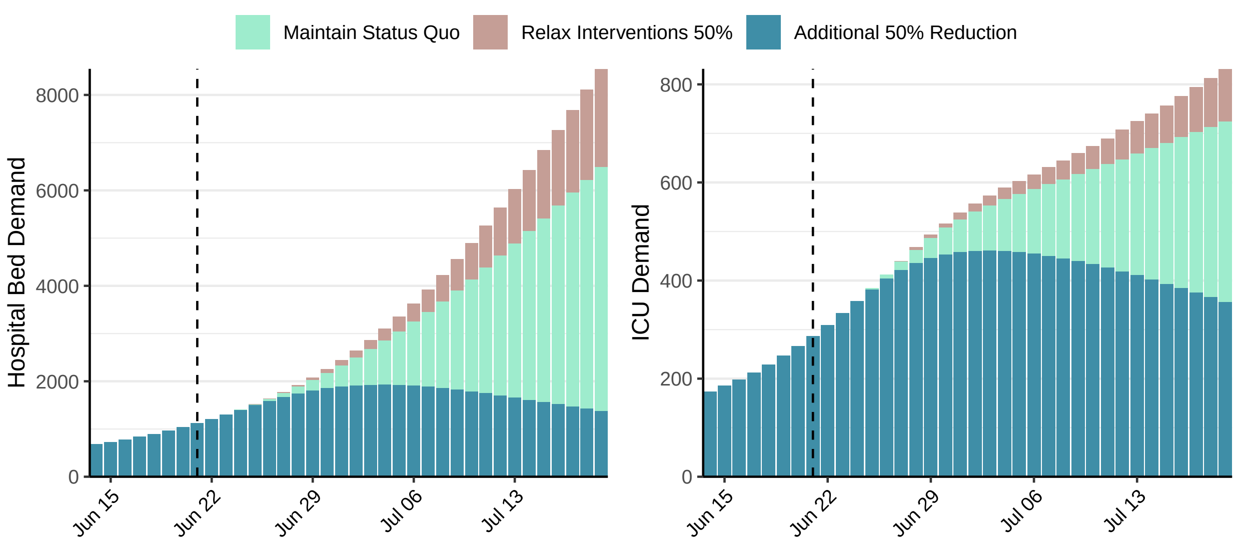


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 10,877 (95% CI: 10,500-11,255) at the current date to 3,769 (95% CI: 3,585-3,952) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 10,877 (95% CI: 10,500-11,255) at the current date to 53,467 (95% CI: 52,003-54,930) by 2020-07-19.

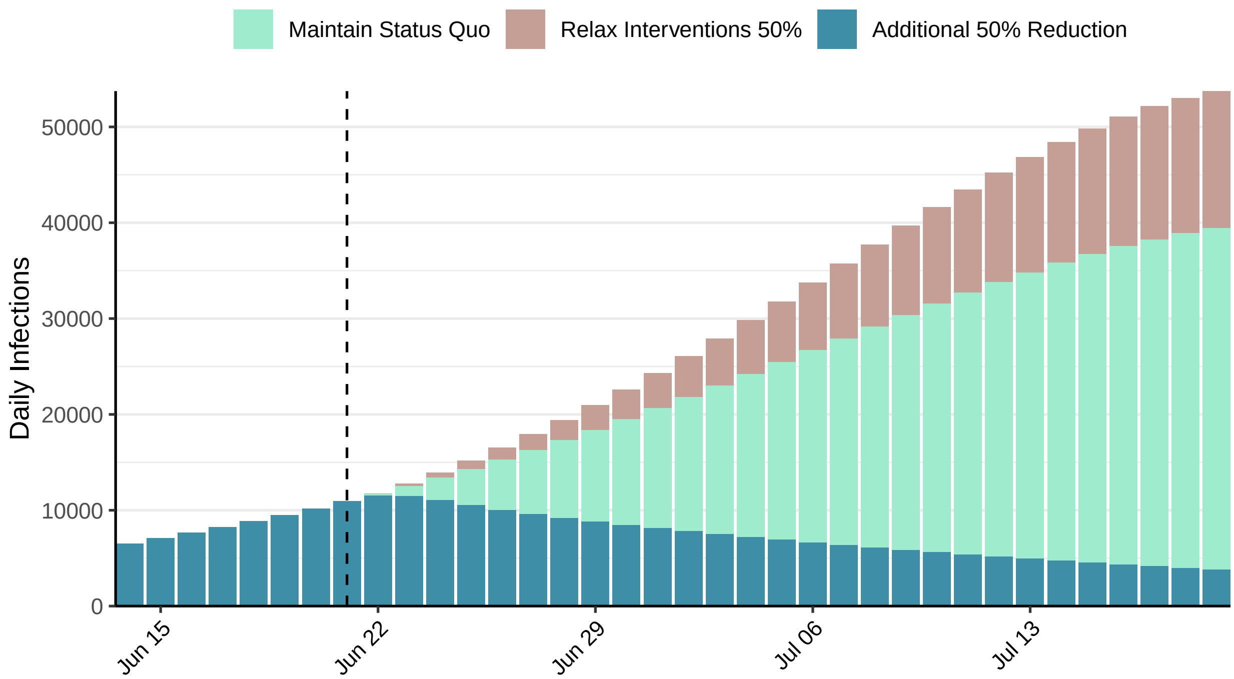


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Madagascar, 2020-06-21

**Download the report for Madagascar, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,503 | 60 | 13 | 0 | 1.26 (95% CI: 0.96-1.62) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

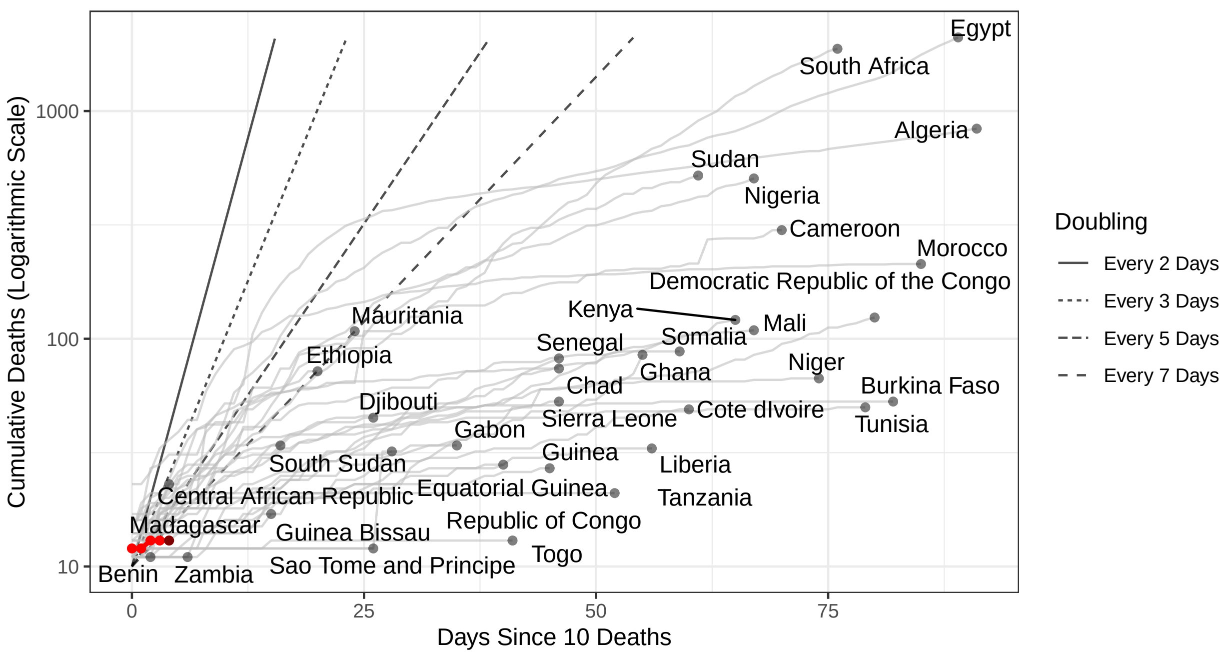


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 8,299 (95% CI: 7,684-8,914) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

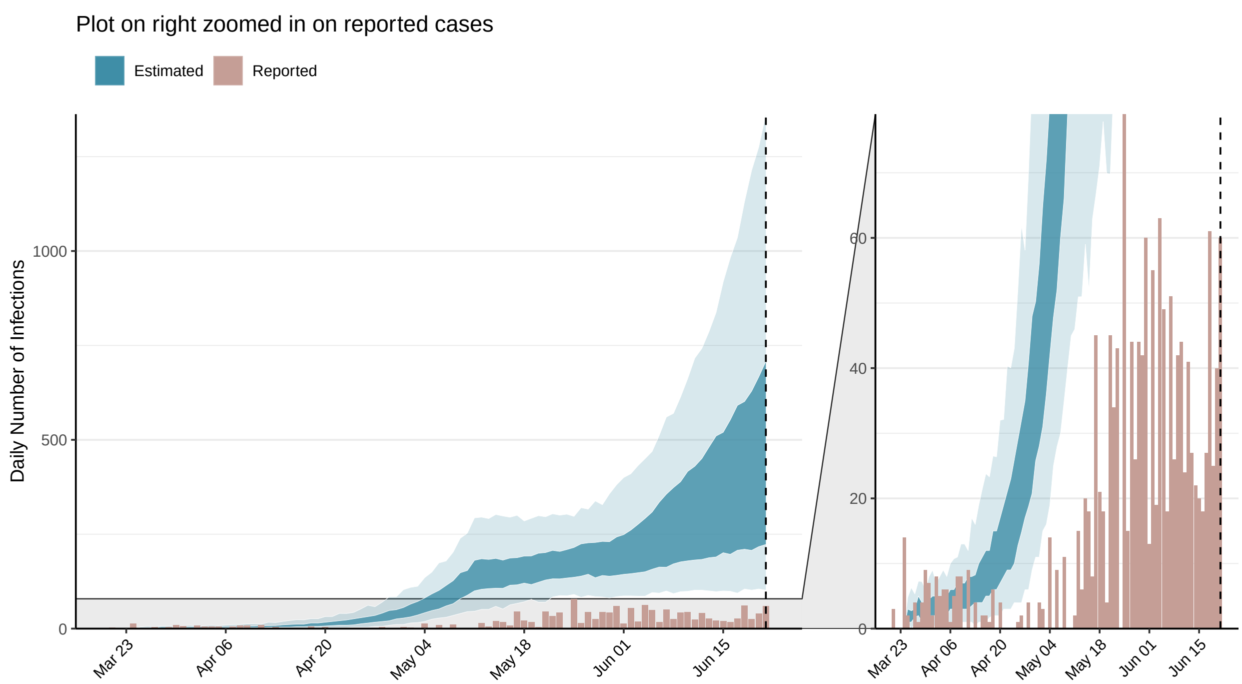


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

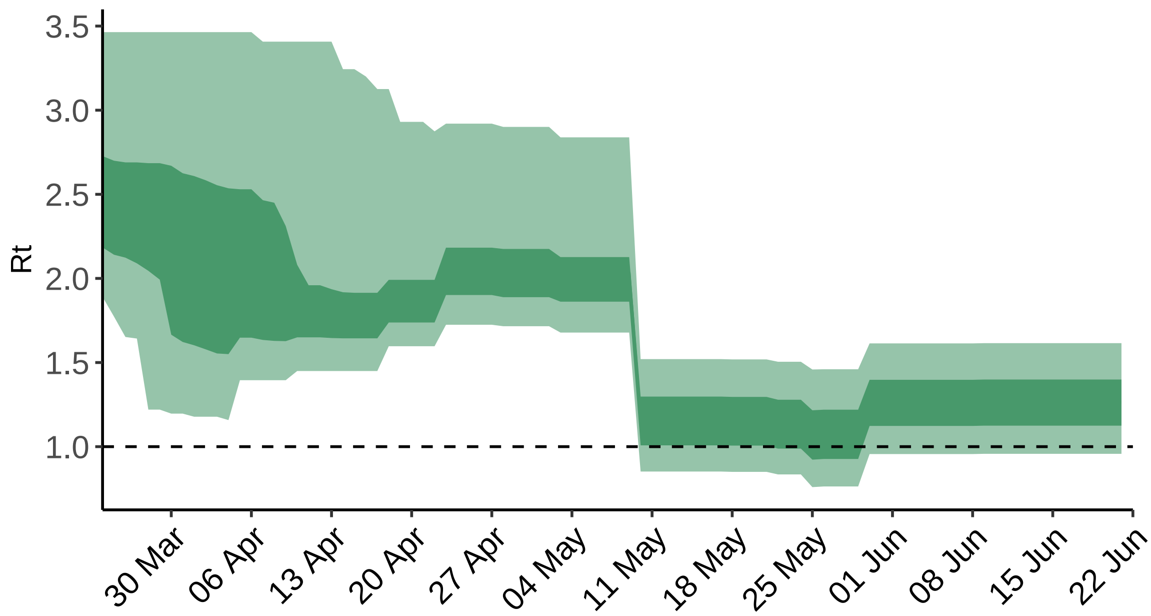


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

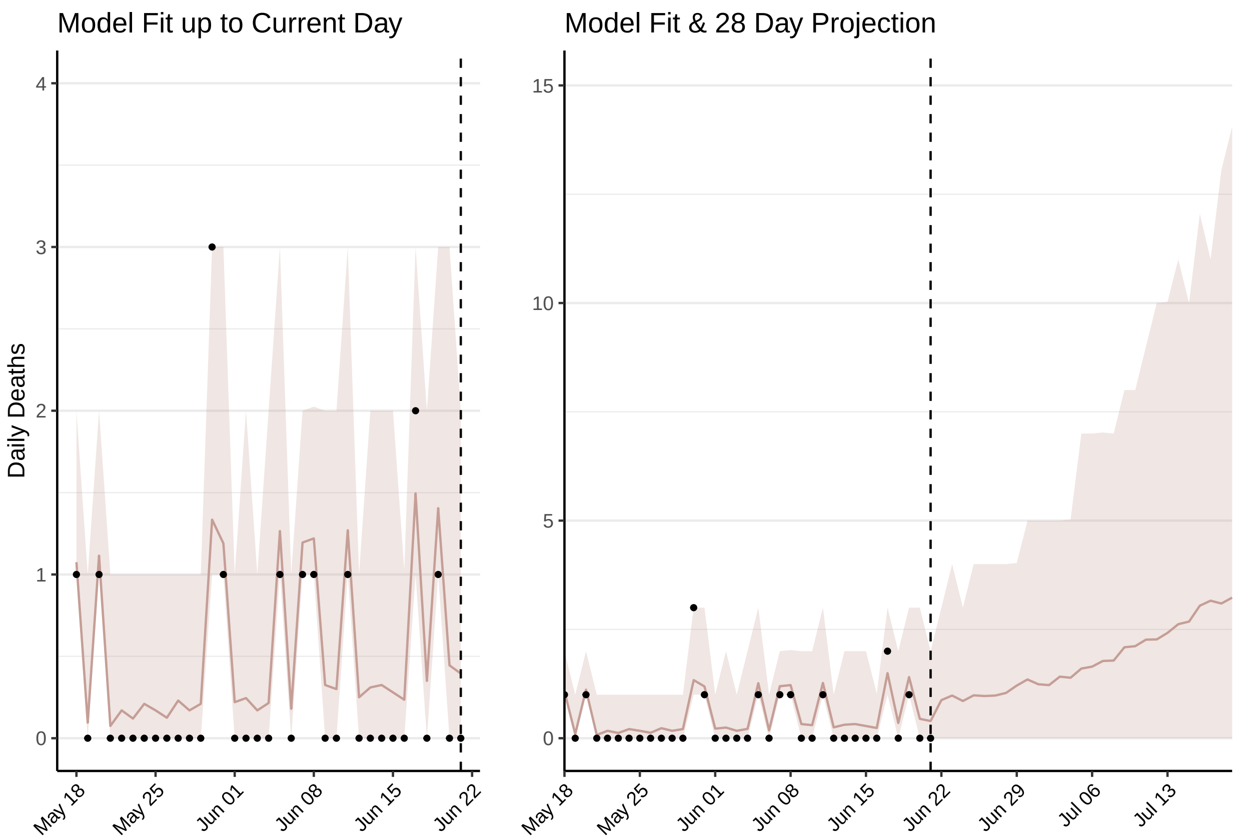


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 47 (95% CI: 43-51) patients requiring treatment with high-pressure oxygen at the current date to 203 (95% CI: 171-234) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 13 (95% CI: 11-14) patients requiring treatment with mechanical ventilation at the current date to 54 (95% CI: 46-62) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

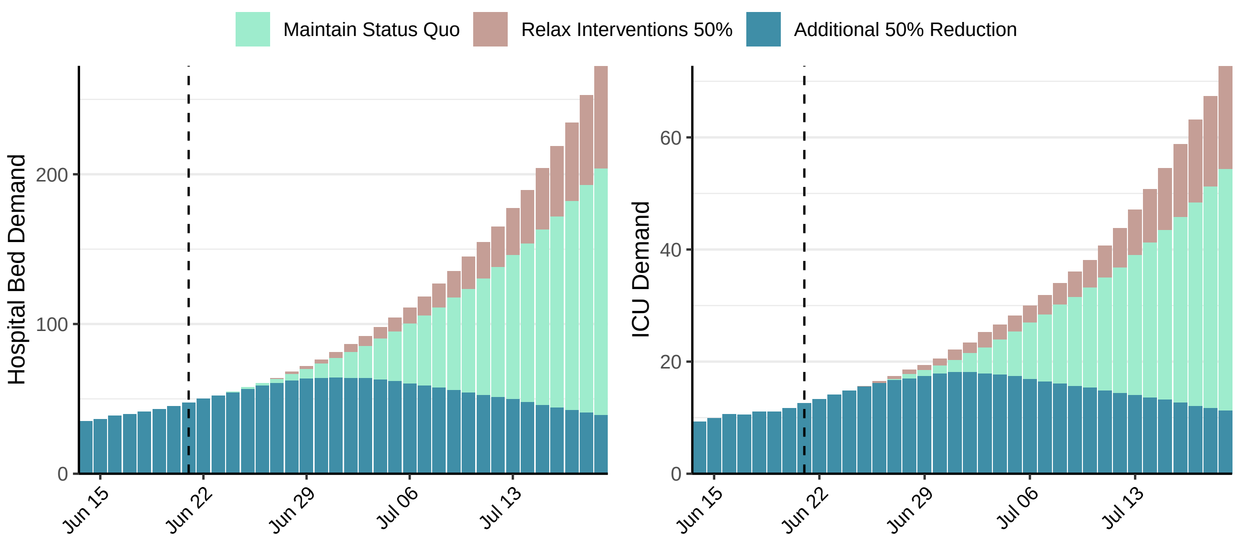


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 512 (95% CI: 460-564) at the current date to 148 (95% CI: 123-172) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 512 (95% CI: 460-564) at the current date to 3,756 (95% CI: 3,061-4,450) by 2020-07-19.

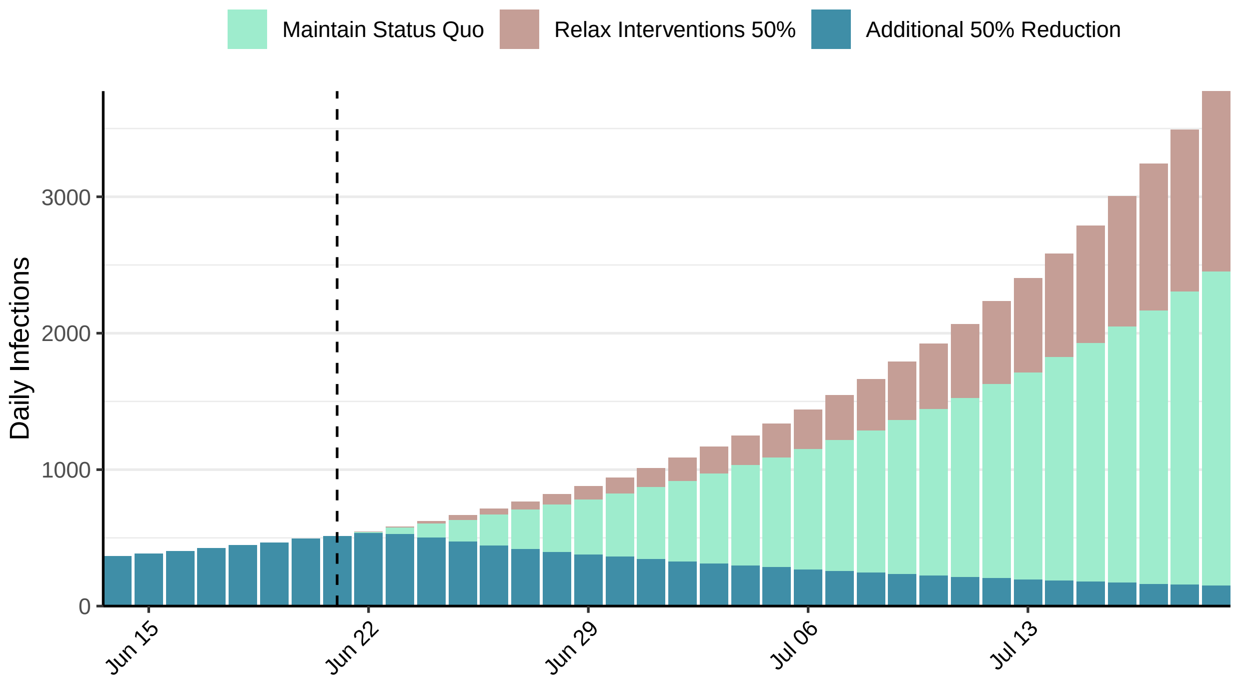


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Maldives, 2020-06-21

**Download the report for Maldives, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,187 | 37 | 8 | 0 | 0.62 (95% CI: 0.06-1.94) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Maldives is not shown in the following plot as only 8 deaths have been reported to date**

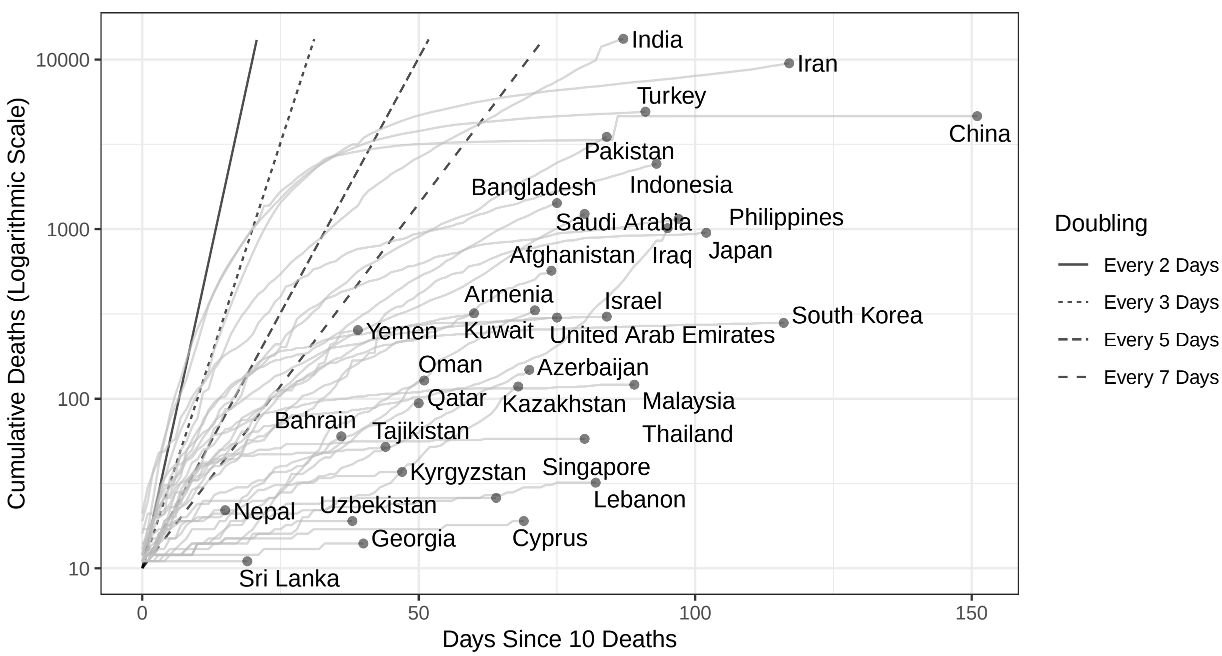


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 917 (95% CI: 787-1,048) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

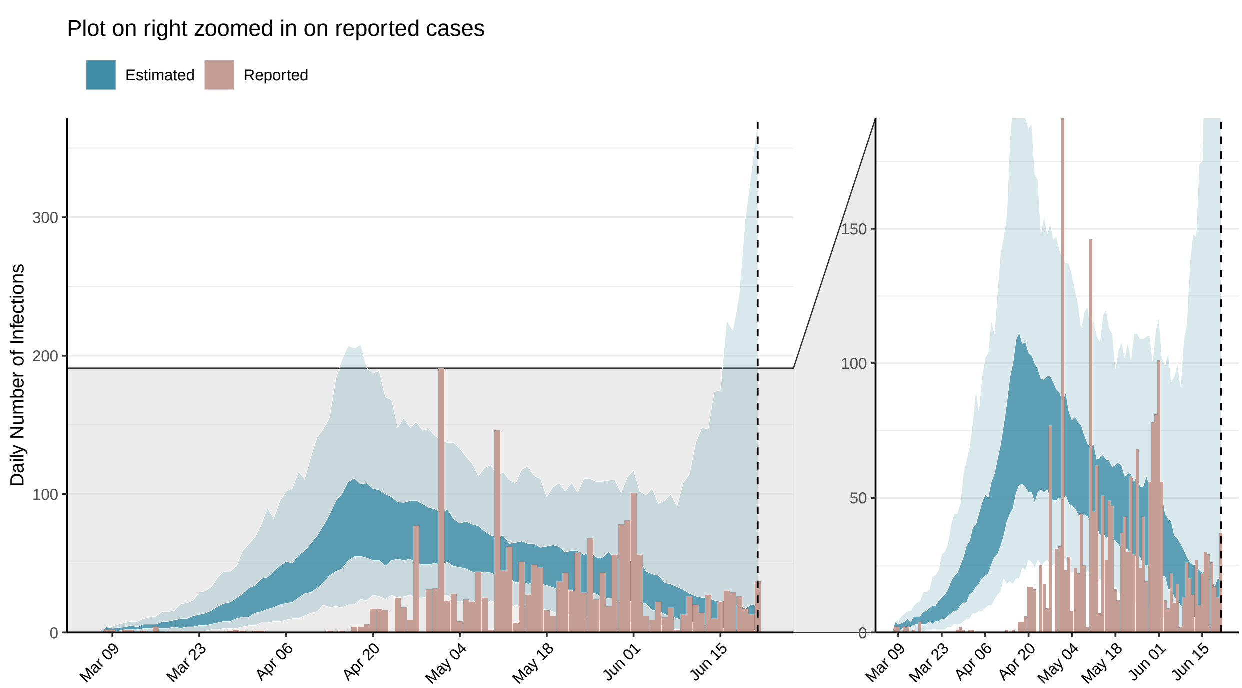


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

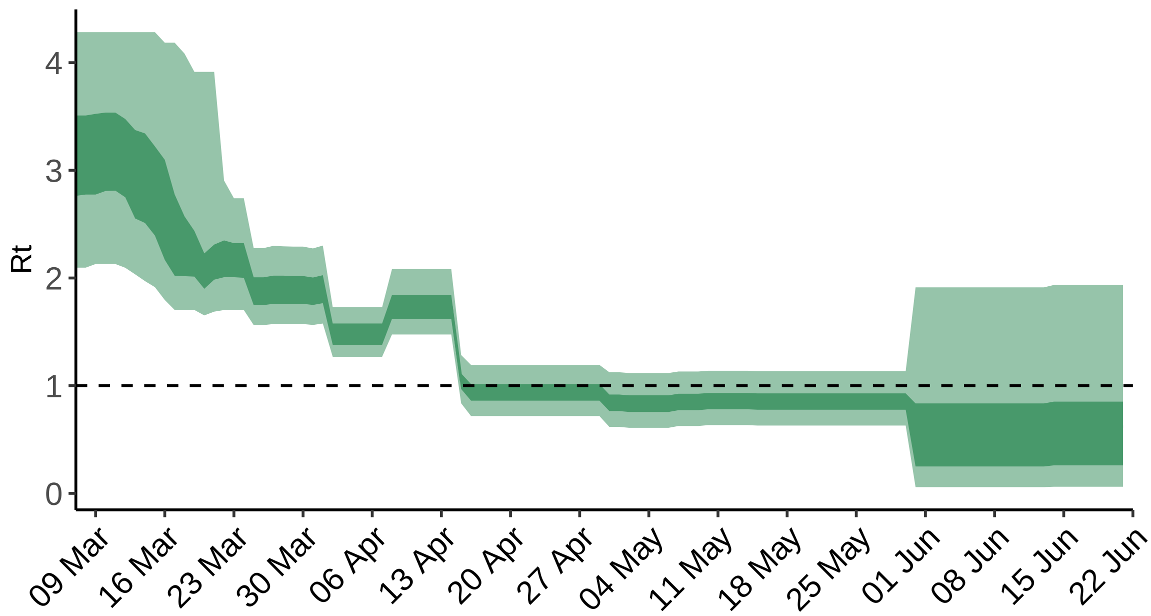


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

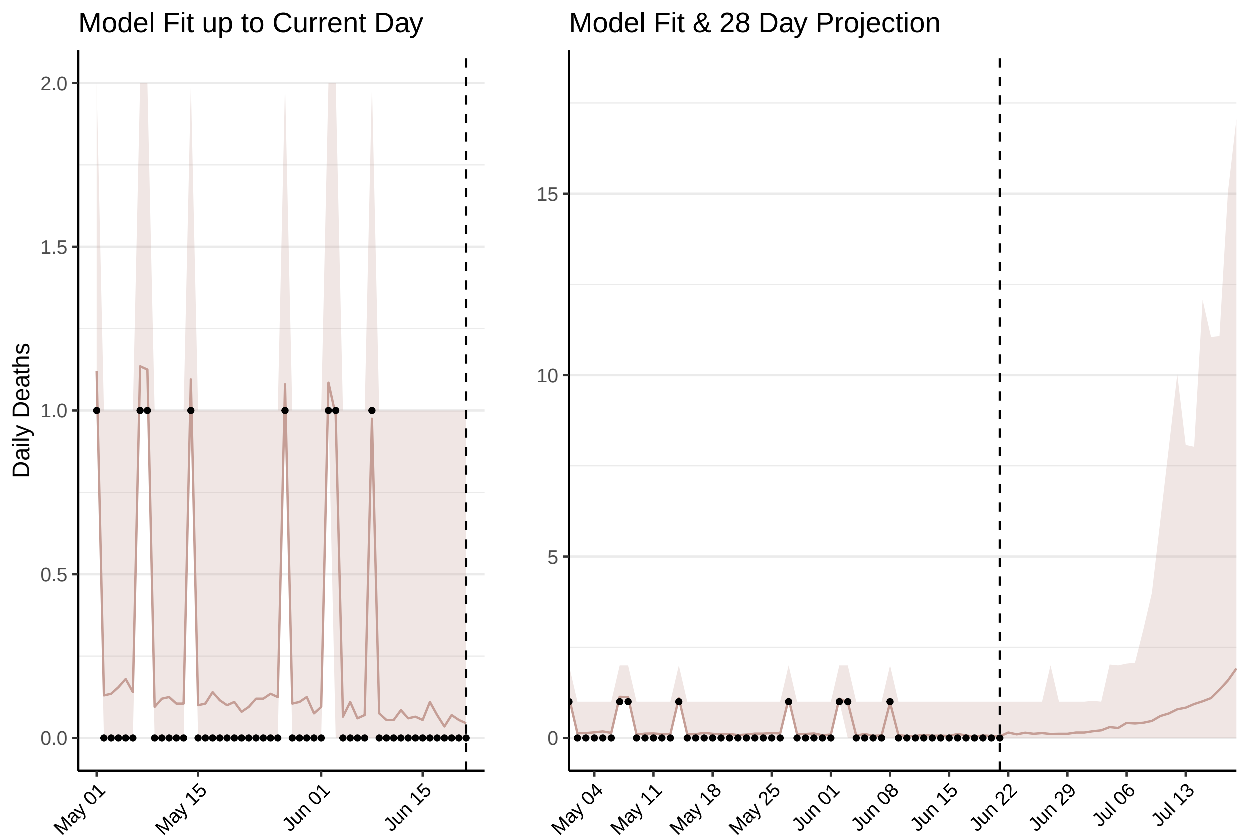


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 5 (95% CI: 4-6) patients requiring treatment with high-pressure oxygen at the current date to 36 (95% CI: 9-62) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2 (95% CI: 1-2) patients requiring treatment with mechanical ventilation at the current date to 4 (95% CI: 2-6) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

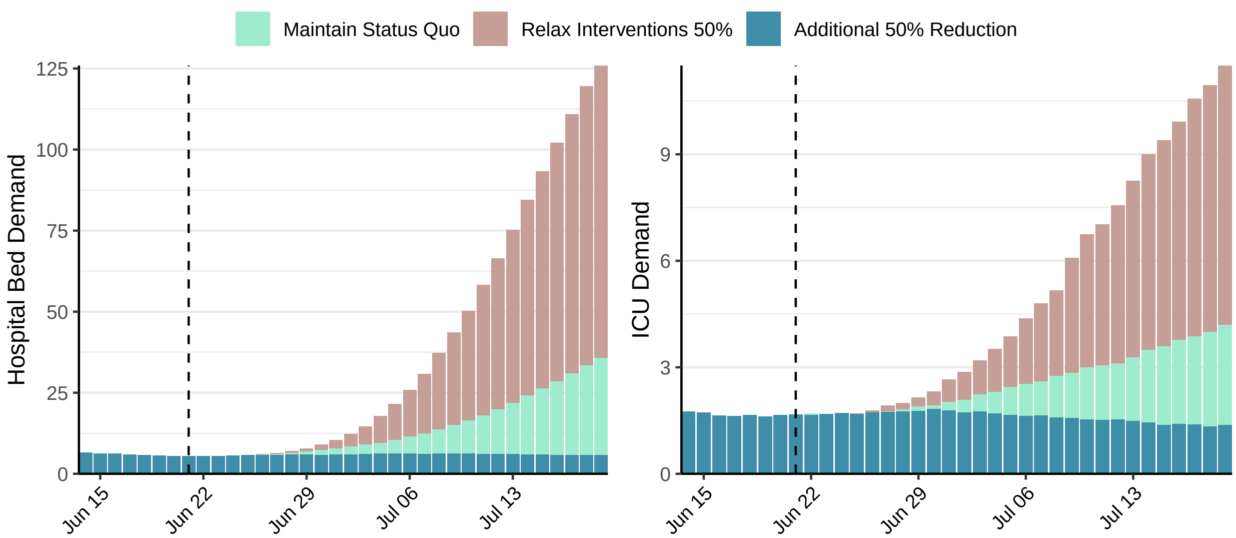


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 35 (95% CI: 20-50) at the current date to 32 (95% CI: 4-61) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 35 (95% CI: 20-50) at the current date to 1,343 (95% CI: 682-2,004) by 2020-07-19.

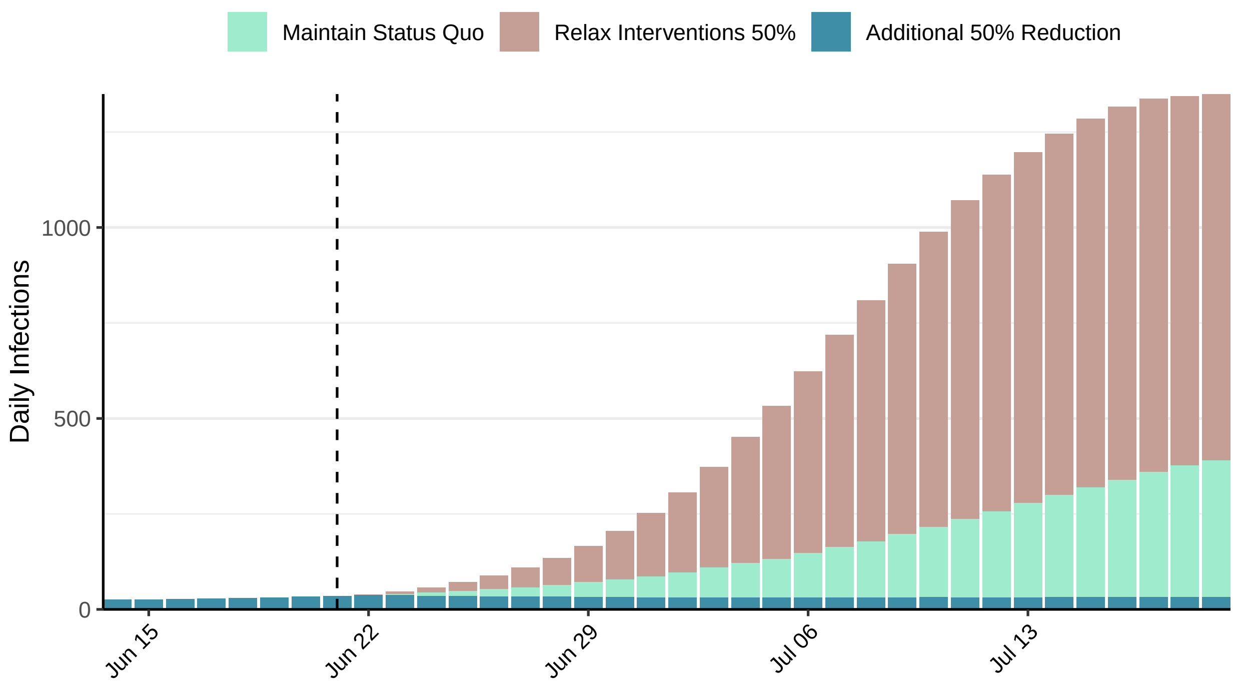


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Mexico, 2020-06-21

**Download the report for Mexico, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 175,202 | 4,717 | 20,781 | 387 | 1.28 (95% CI: 1.21-1.35) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

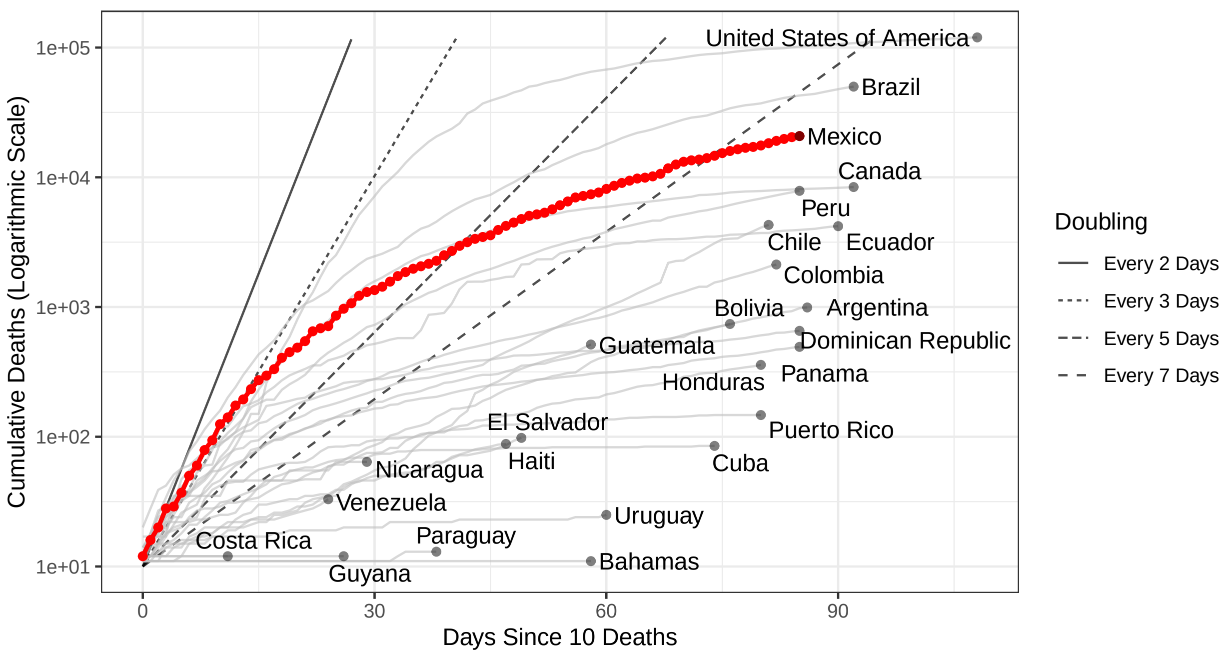


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 4,959,132 (95% CI: 4,866,914-5,051,351) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

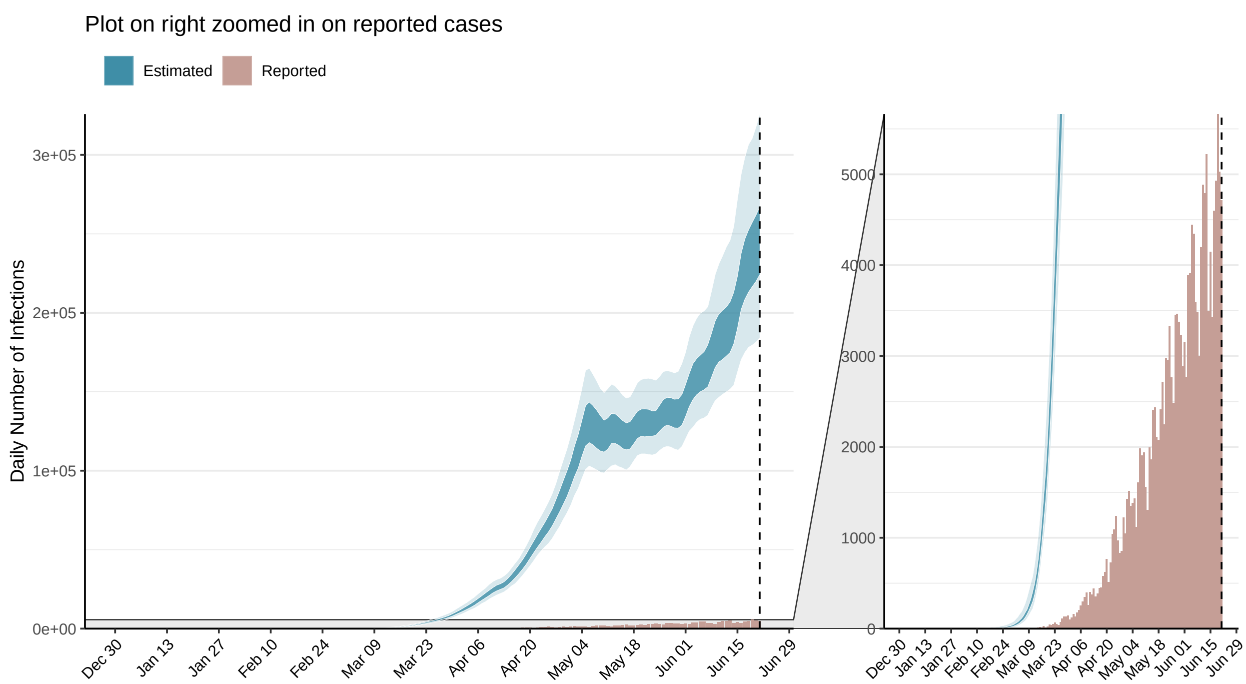


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

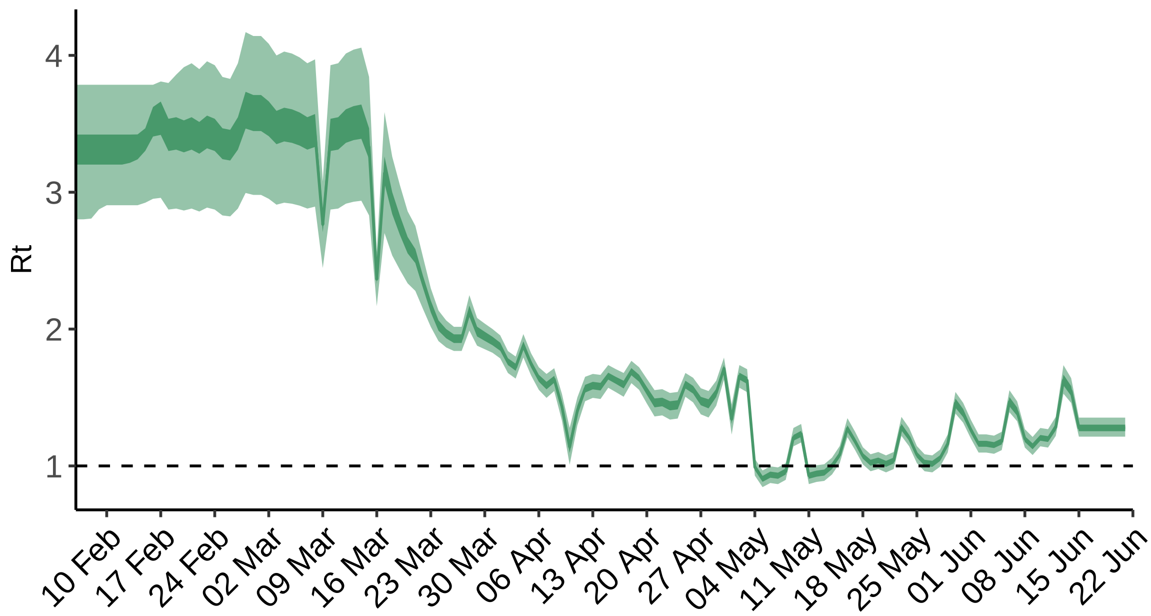


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Mexico is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

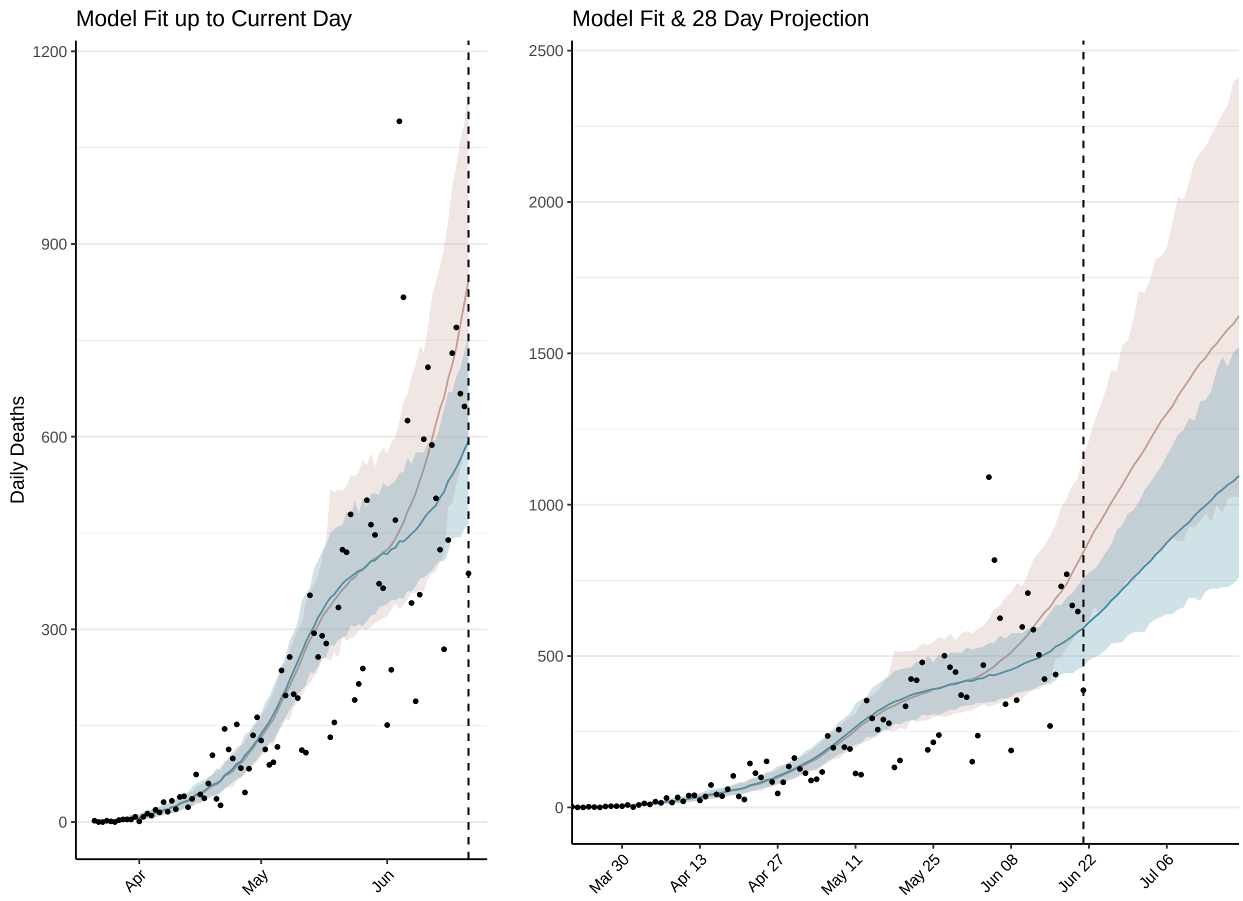


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 28,319 (95% CI: 27,784-28,854) patients requiring treatment with high-pressure oxygen at the current date to 49,894 (95% CI: 48,534-51,253) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 6,454 (95% CI: 6,386-6,522) patients requiring treatment with mechanical ventilation at the current date to 7,276 (95% CI: 7,185-7,368) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

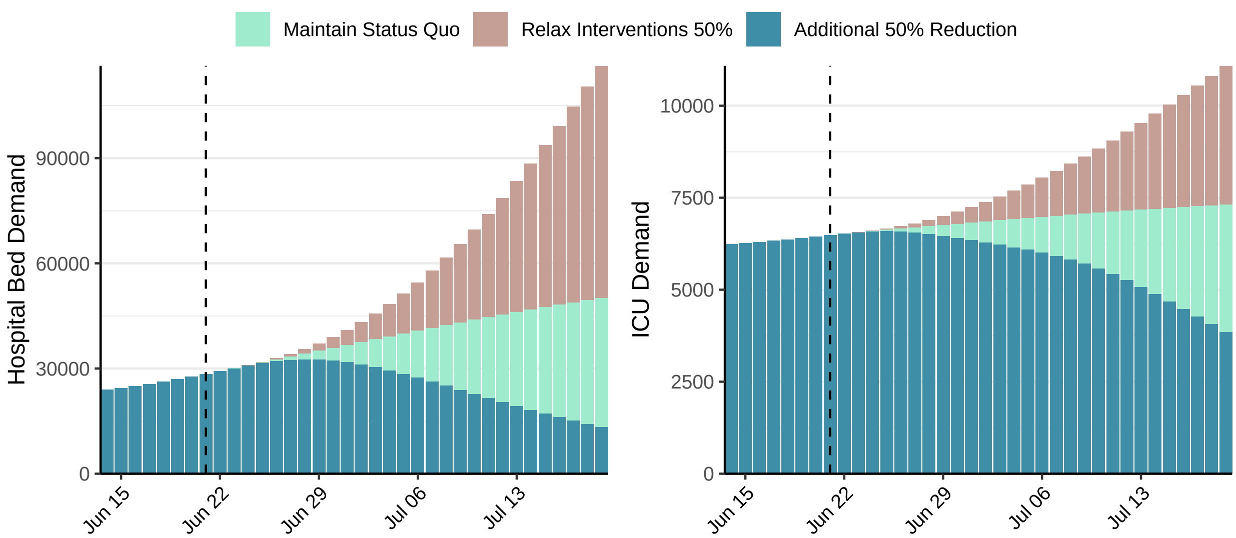


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 245,580 (95% CI: 240,137-251,023) at the current date to 30,613 (95% CI: 29,703-31,523) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 245,580 (95% CI: 240,137-251,023) at the current date to 1,095,095 (95% CI: 1,069,168-1,121,021) by 2020-07-19.

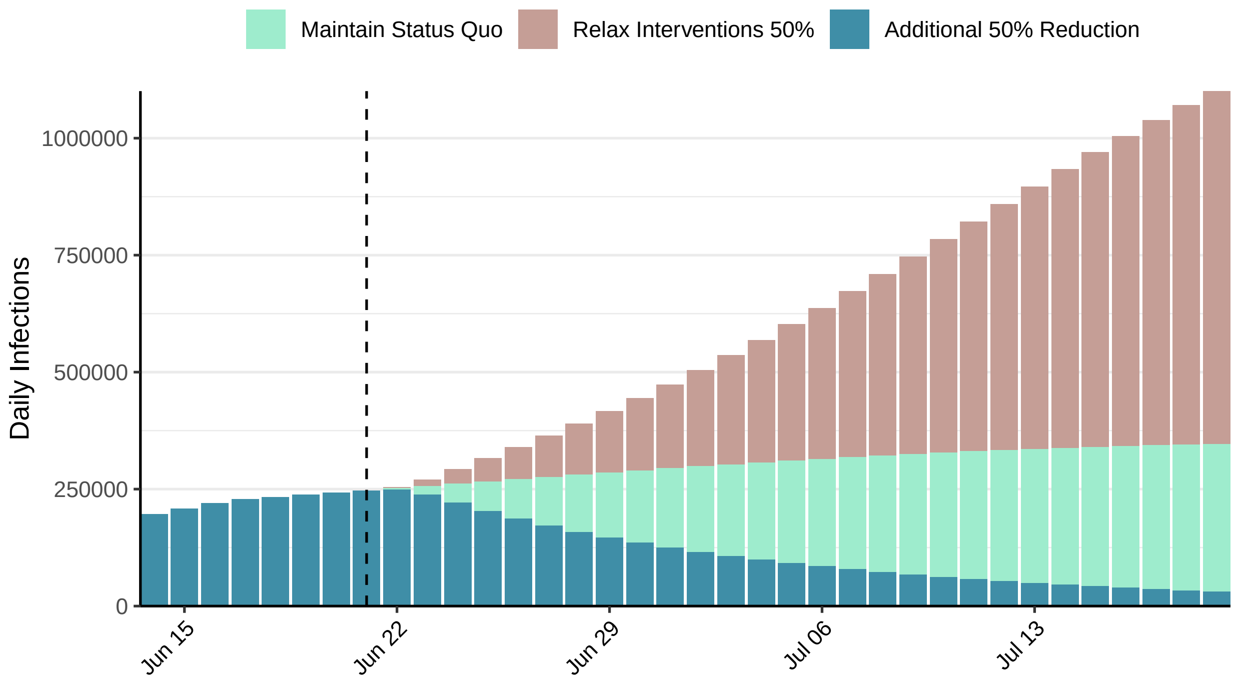


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: North Macedonia, 2020-06-21

**Download the report for North Macedonia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 5,005 | 185 | 233 | 11 | 1.55 (95% CI: 1.45-1.69) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

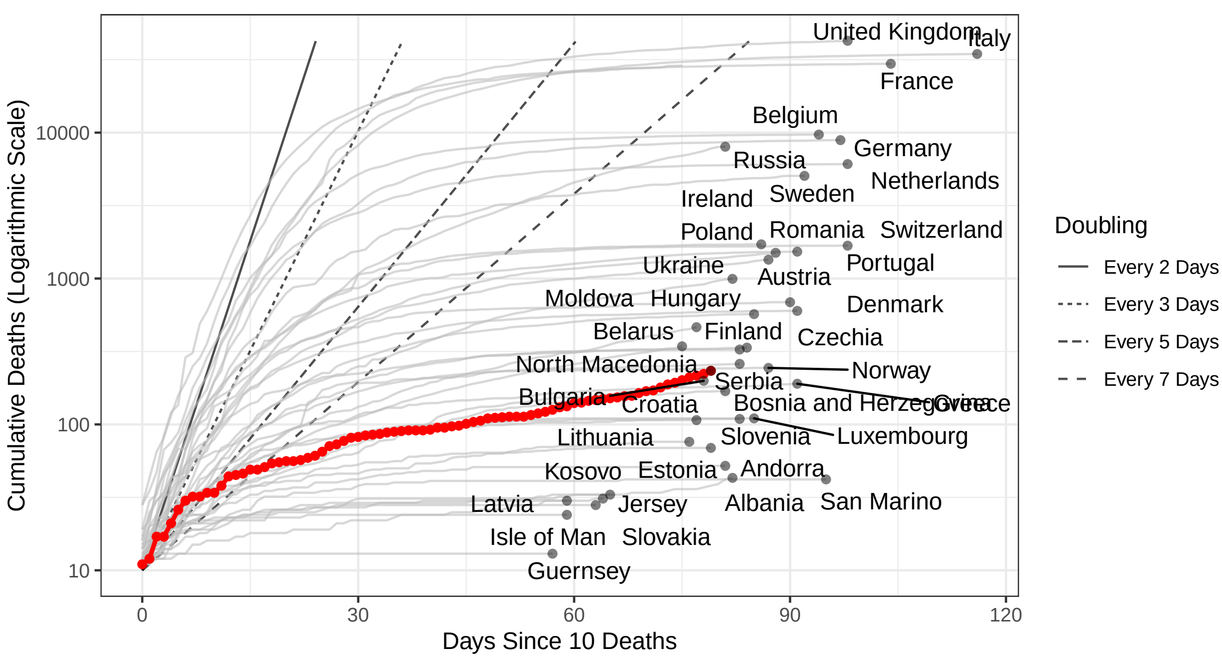


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 86,319 (95% CI: 83,835-88,803) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

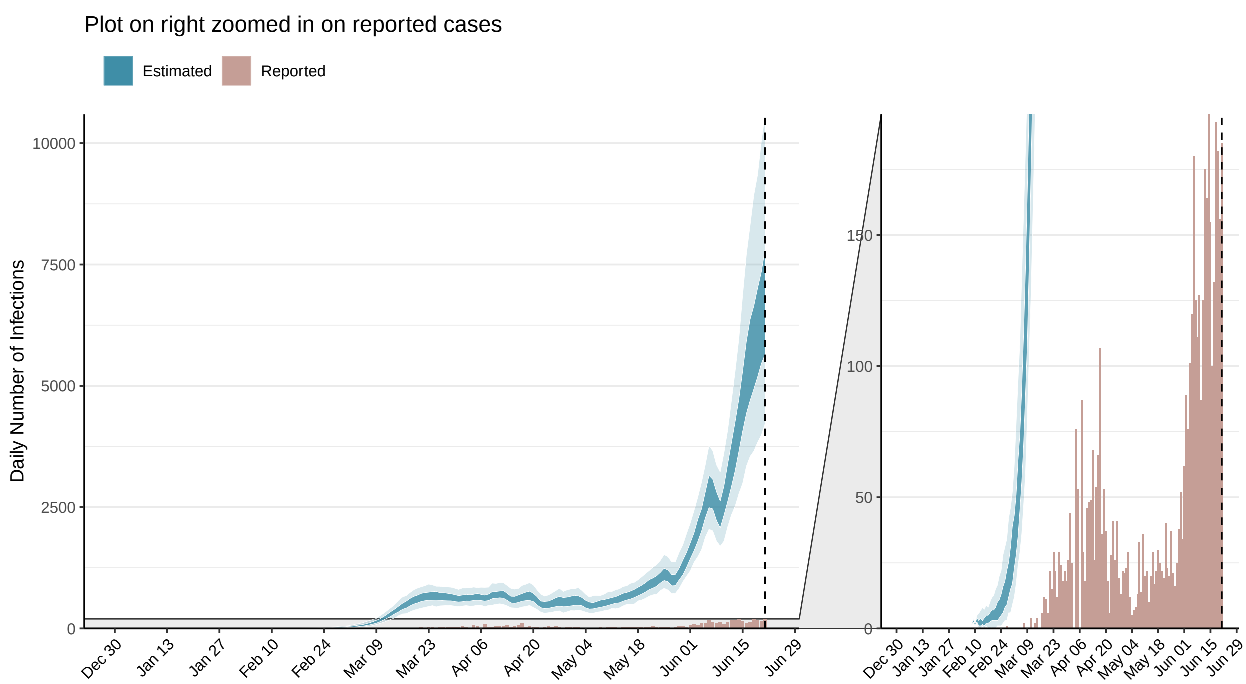


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

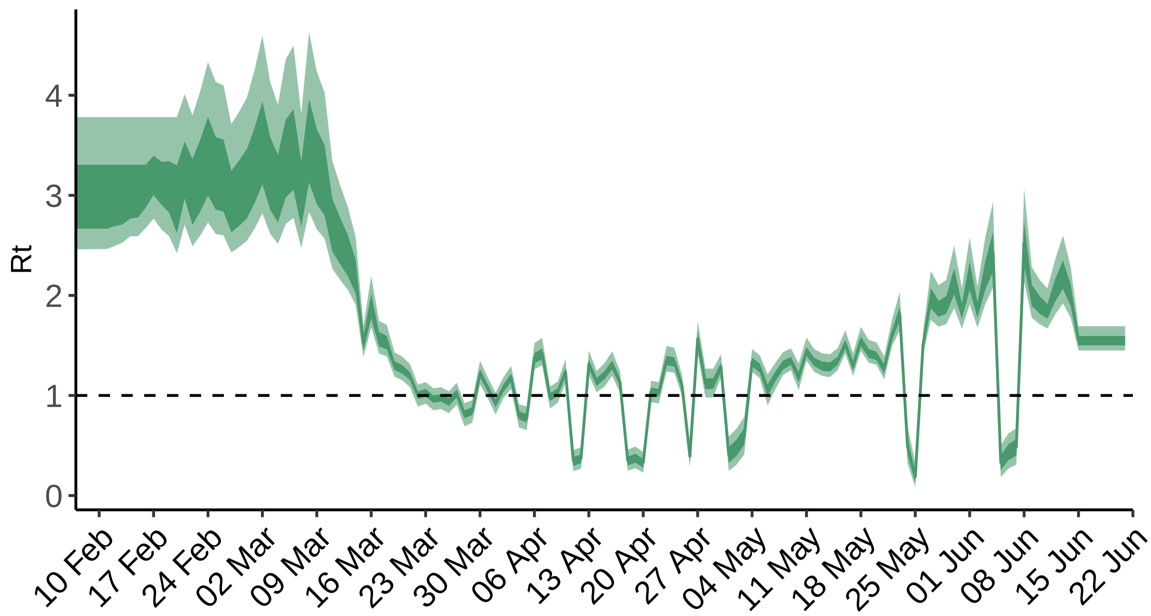


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. North Macedonia is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

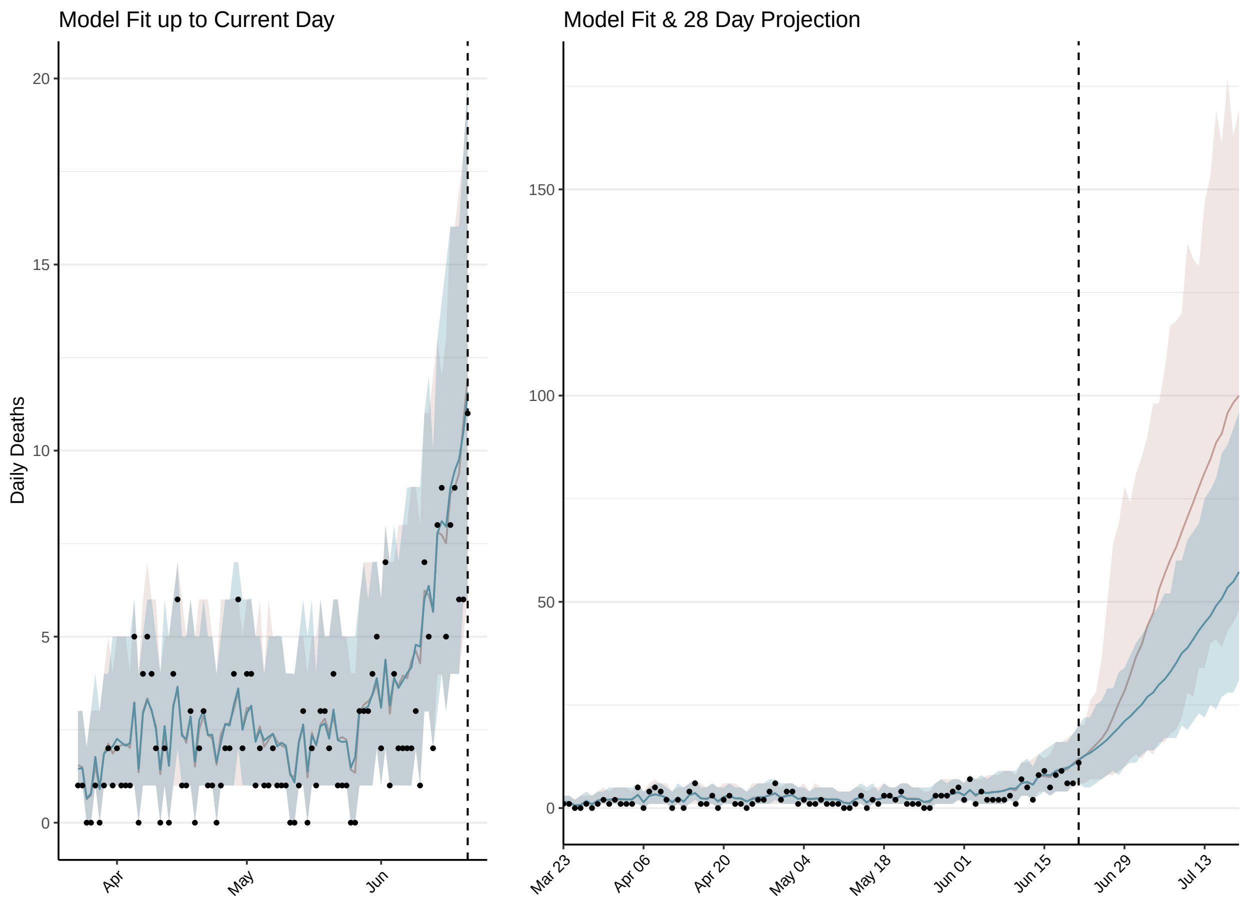


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 728 (95% CI: 706-751) patients requiring treatment with high-pressure oxygen at the current date to 3,026 (95% CI: 2,914-3,138) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 194 (95% CI: 188-200) patients requiring treatment with mechanical ventilation at the current date to 426 (95% CI: 420-433) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

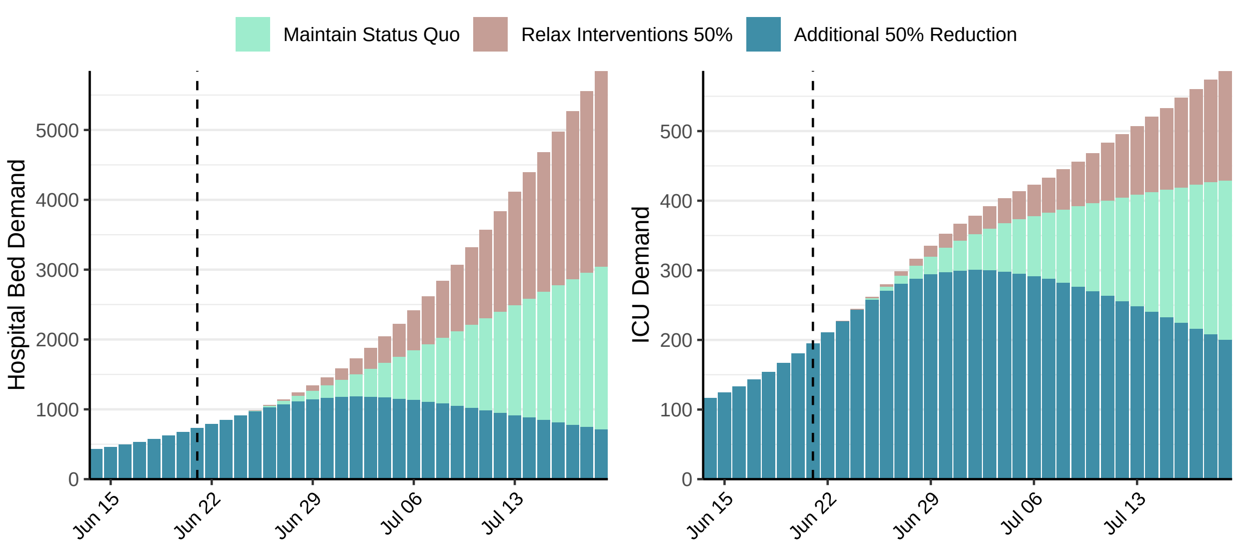


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 6,798 (95% CI: 6,555-7,040) at the current date to 1,587 (95% CI: 1,521-1,653) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 6,798 (95% CI: 6,555-7,040) at the current date to 32,910 (95% CI: 32,333-33,488) by 2020-07-19.

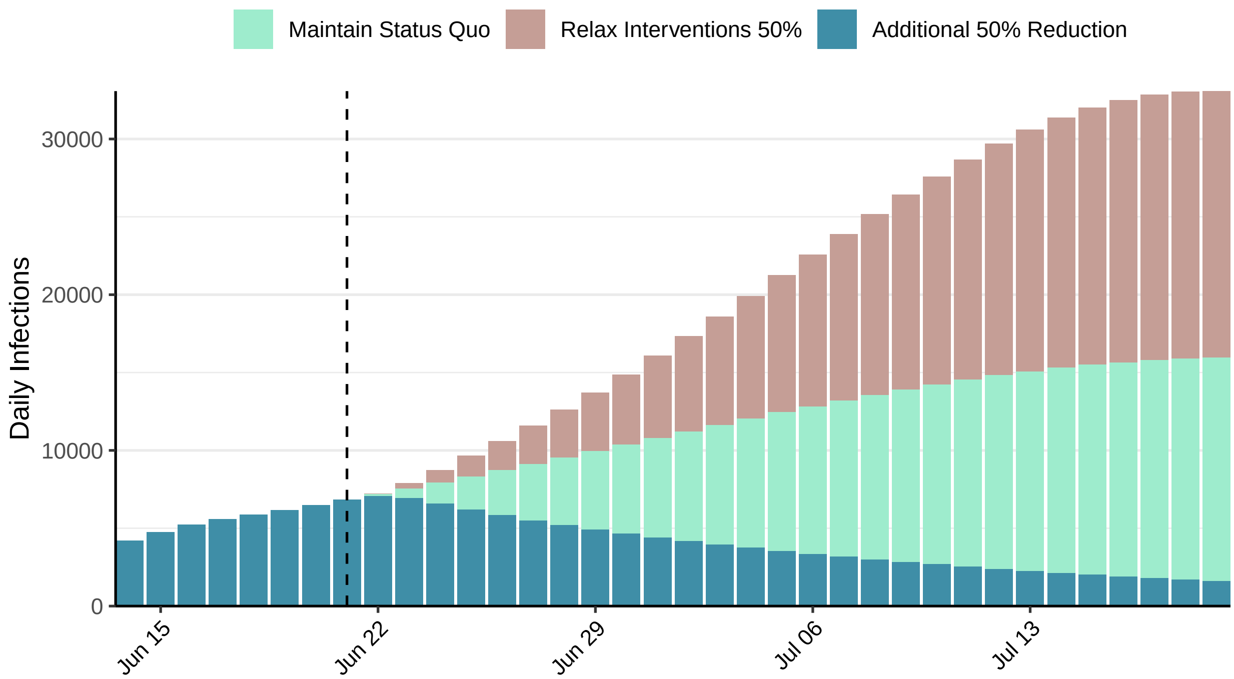


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Mali, 2020-06-21

**Download the report for Mali, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,933 | 10 | 109 | 1 | 1.32 (95% CI: 1.19-1.44) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

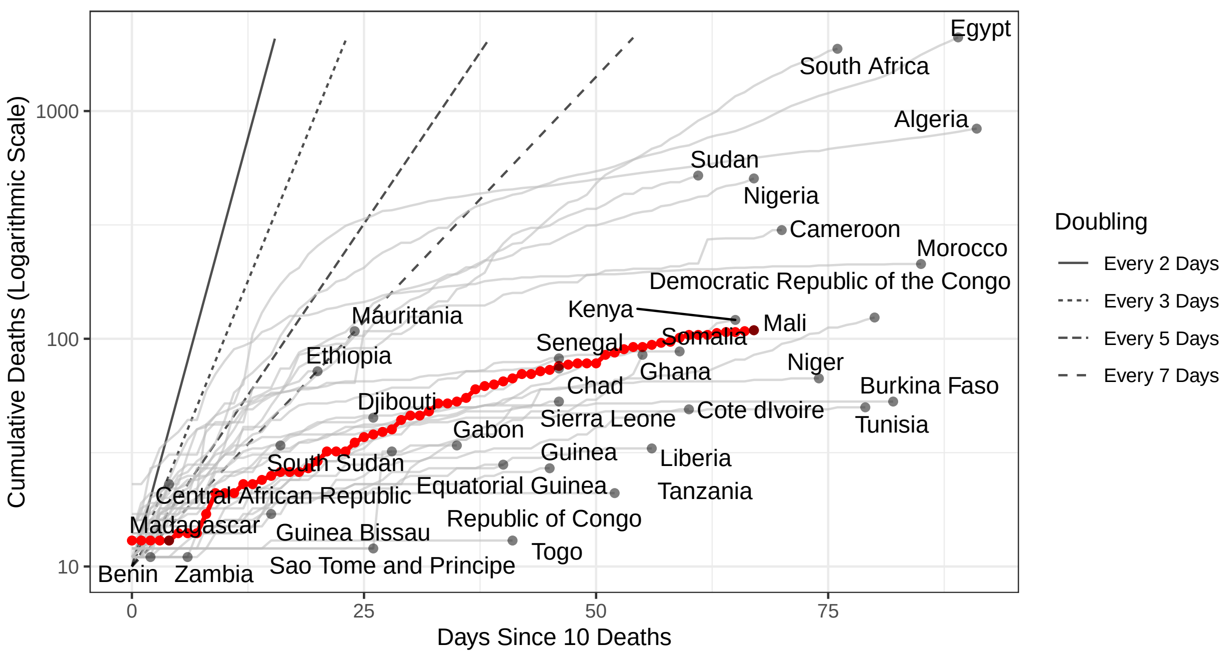


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 33,944 (95% CI: 32,599-35,289) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

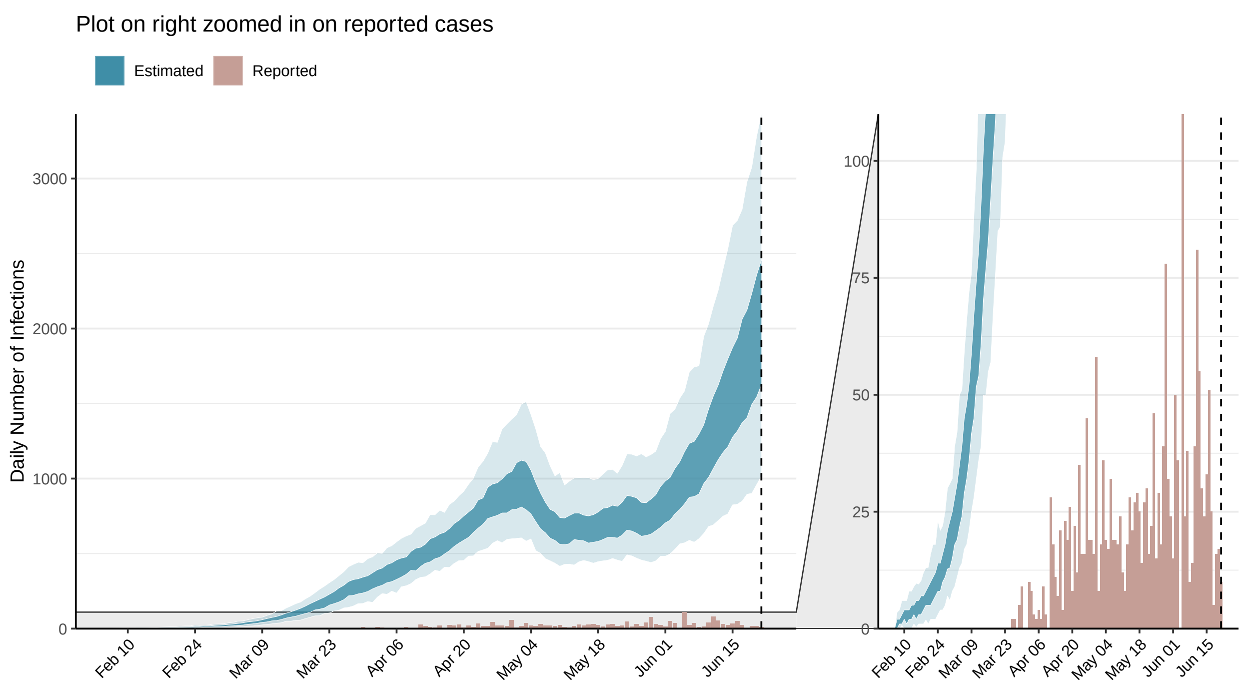


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

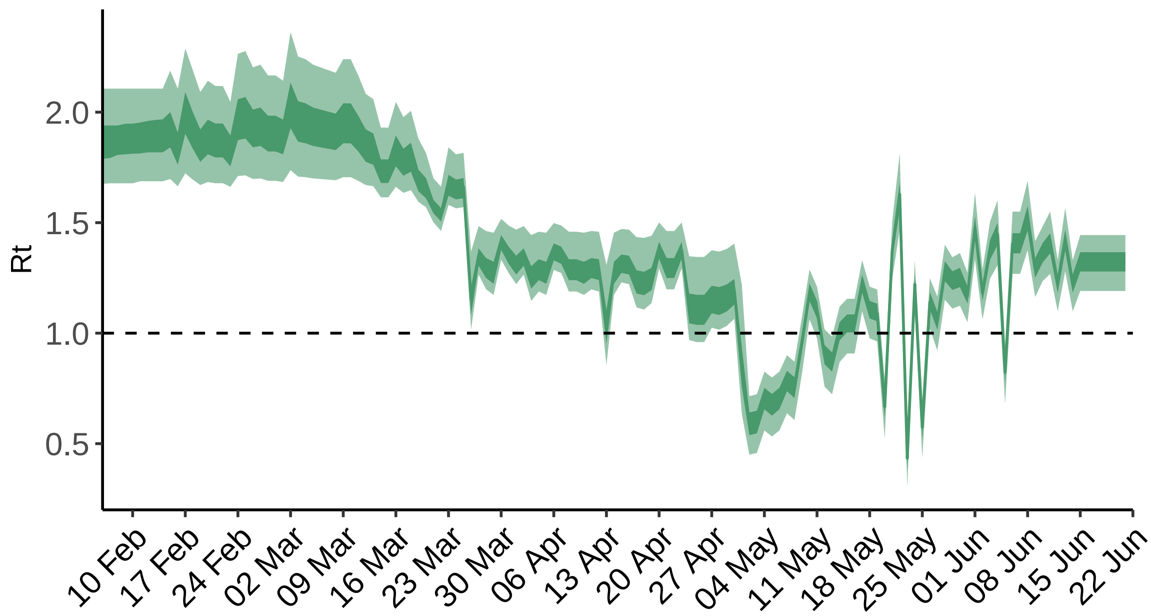


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

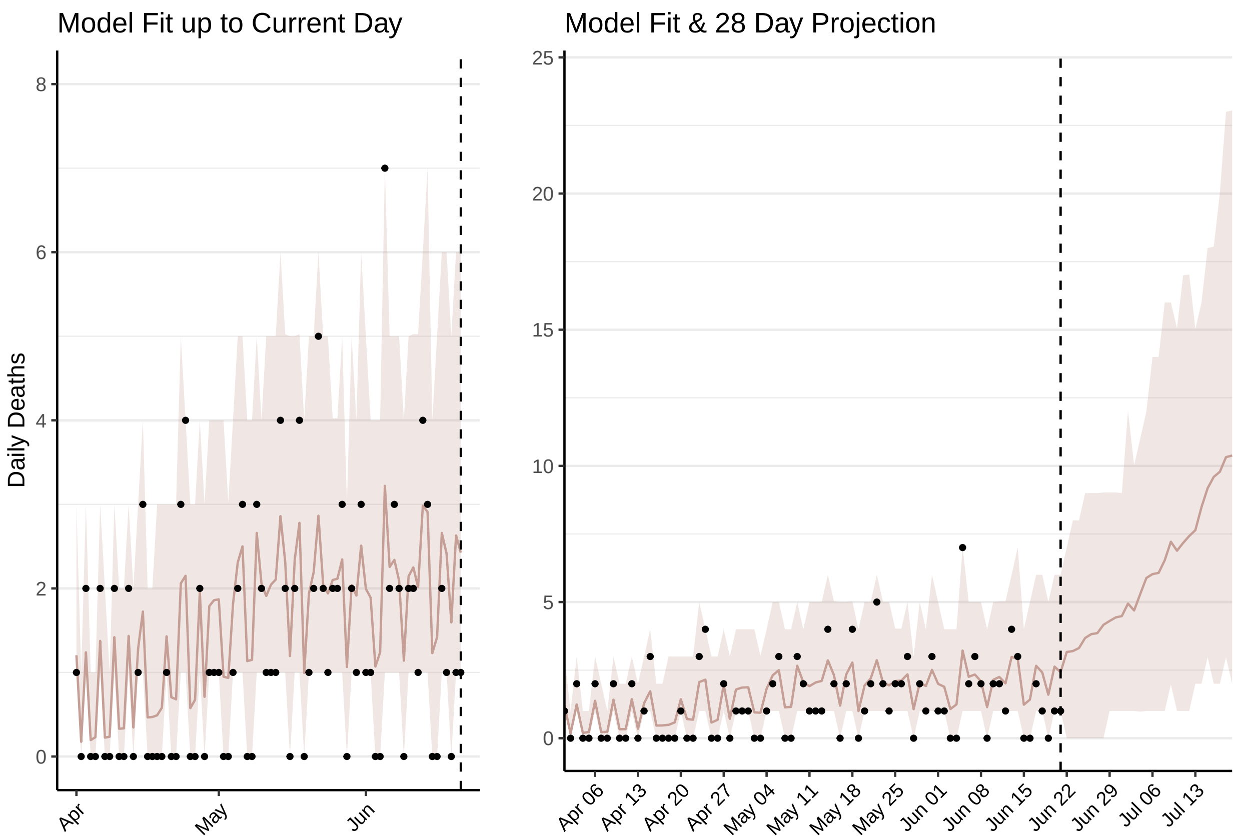


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 180 (95% CI: 172-187) patients requiring treatment with high-pressure oxygen at the current date to 630 (95% CI: 590-670) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 48 (95% CI: 46-50) patients requiring treatment with mechanical ventilation at the current date to 162 (95% CI: 152-172) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

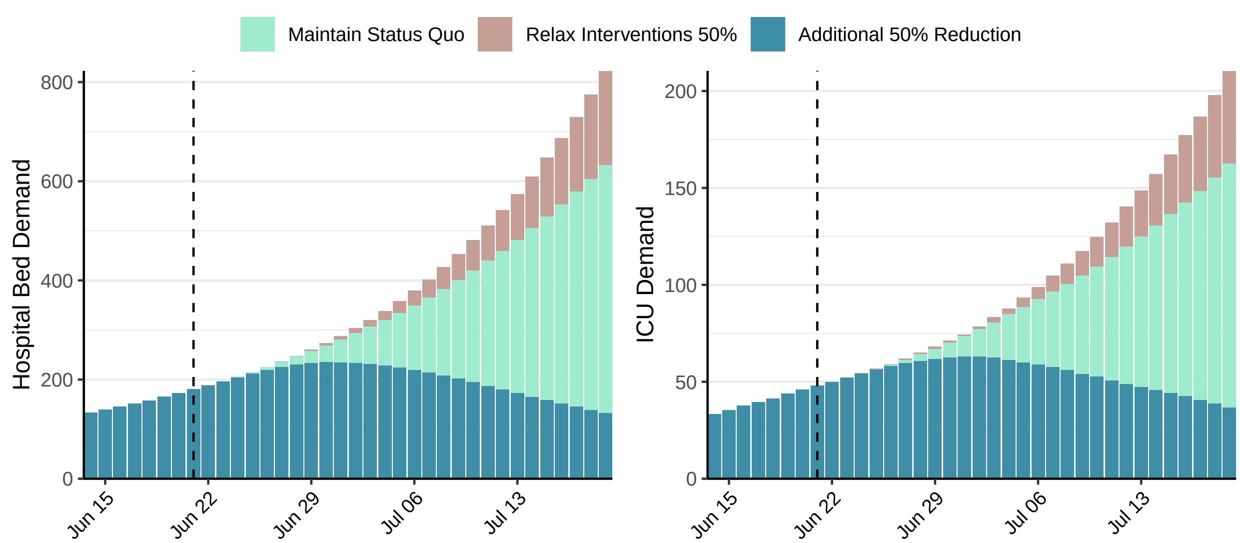


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,062 (95% CI: 1,966-2,158) at the current date to 488 (95% CI: 456-521) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,062 (95% CI: 1,966-2,158) at the current date to 10,810 (95% CI: 10,016-11,604) by 2020-07-19.

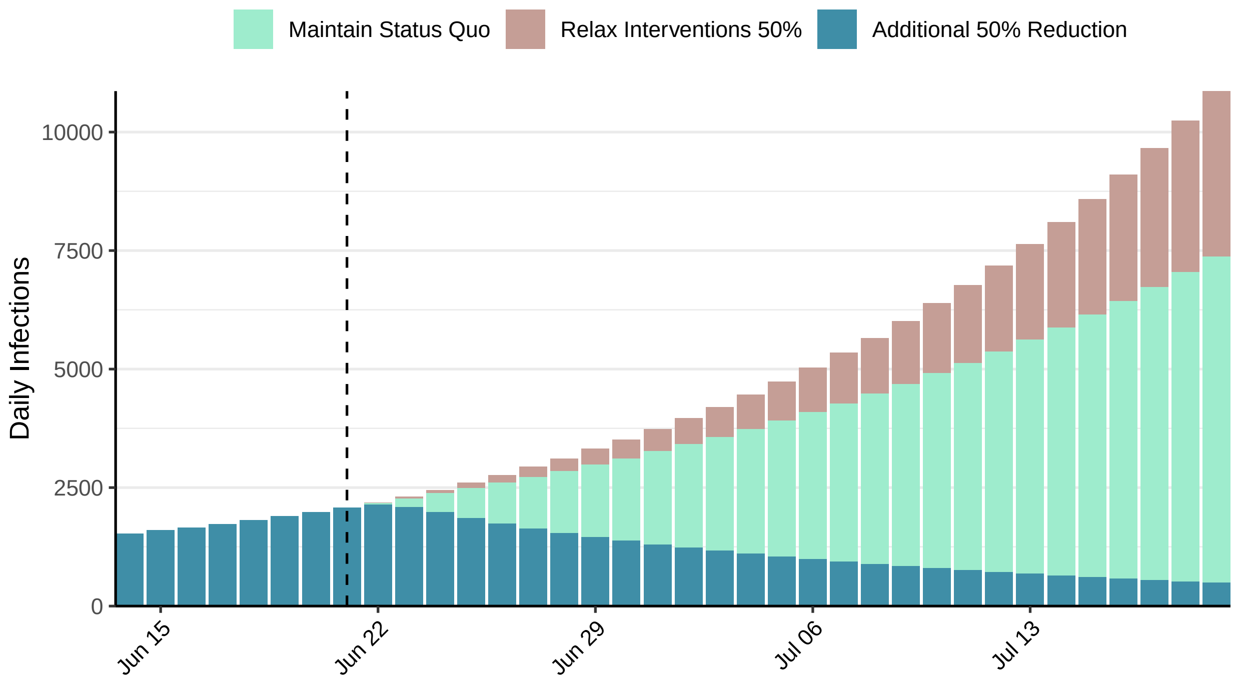


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Myanmar, 2020-06-21

**Download the report for Myanmar, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 287 | 1 | 6 | 0 | 1.41 (95% CI: 0.76-2.14) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Myanmar is not shown in the following plot as only 6 deaths have been reported to date**

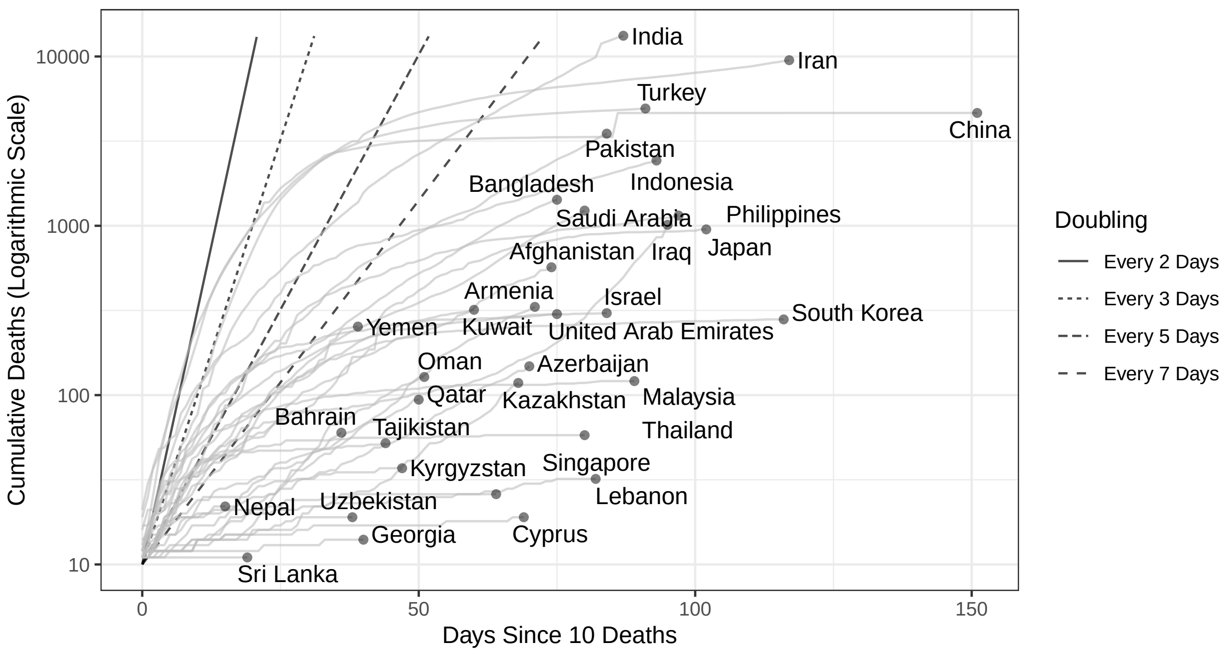


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 78 (95% CI: 42-114) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

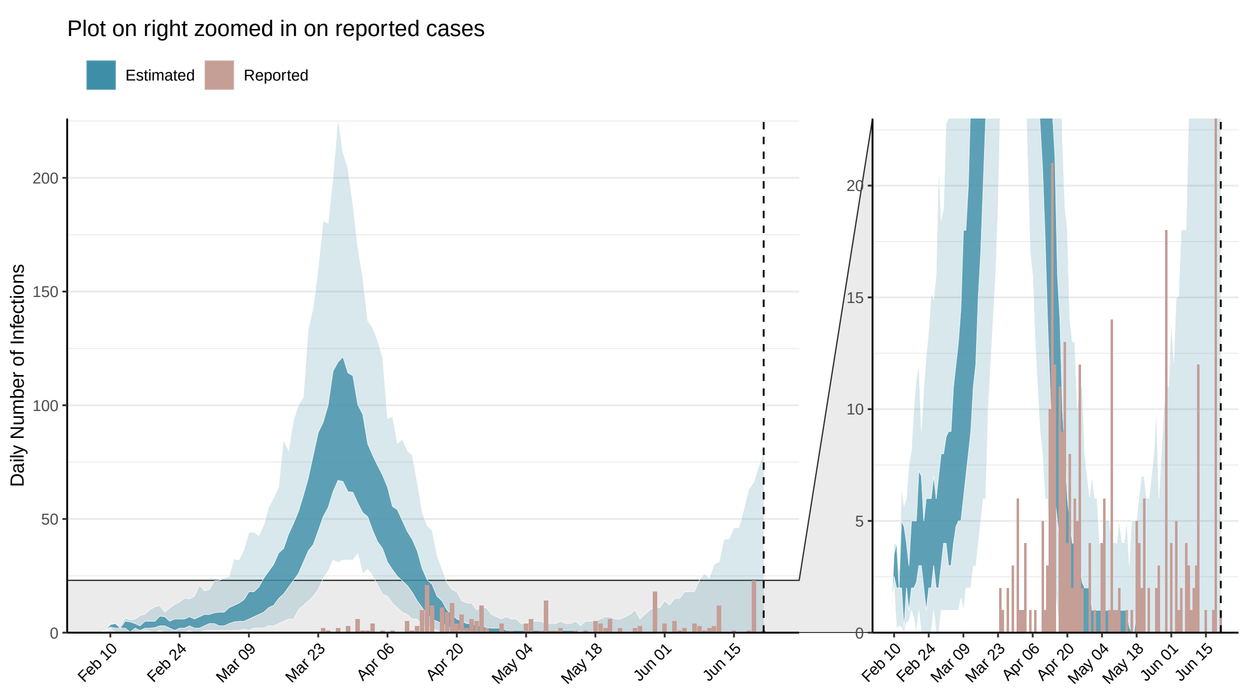


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

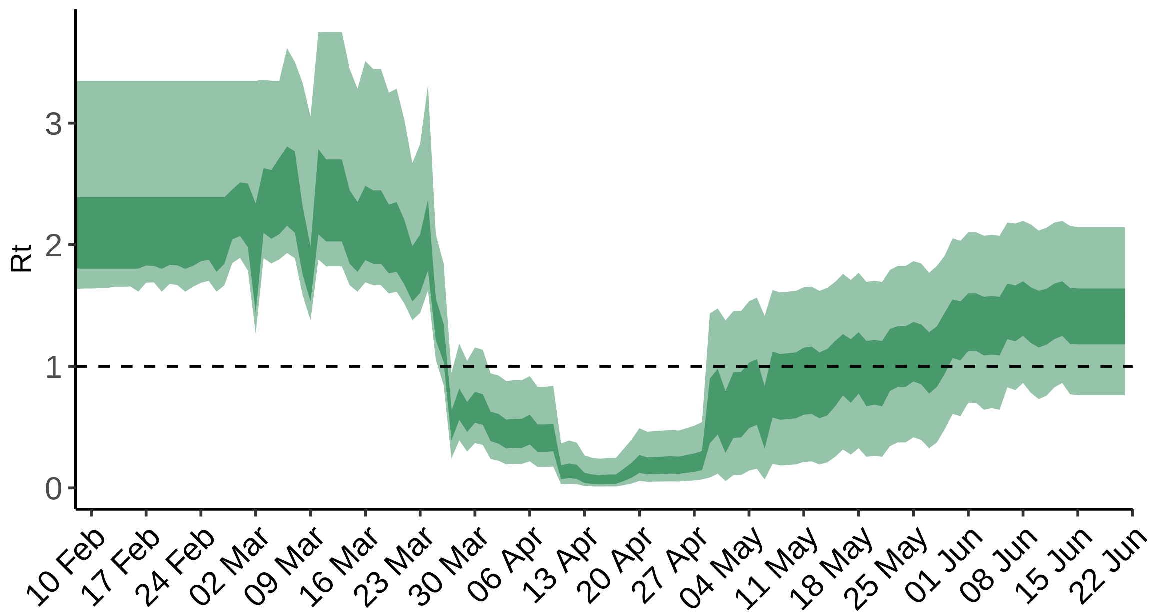


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

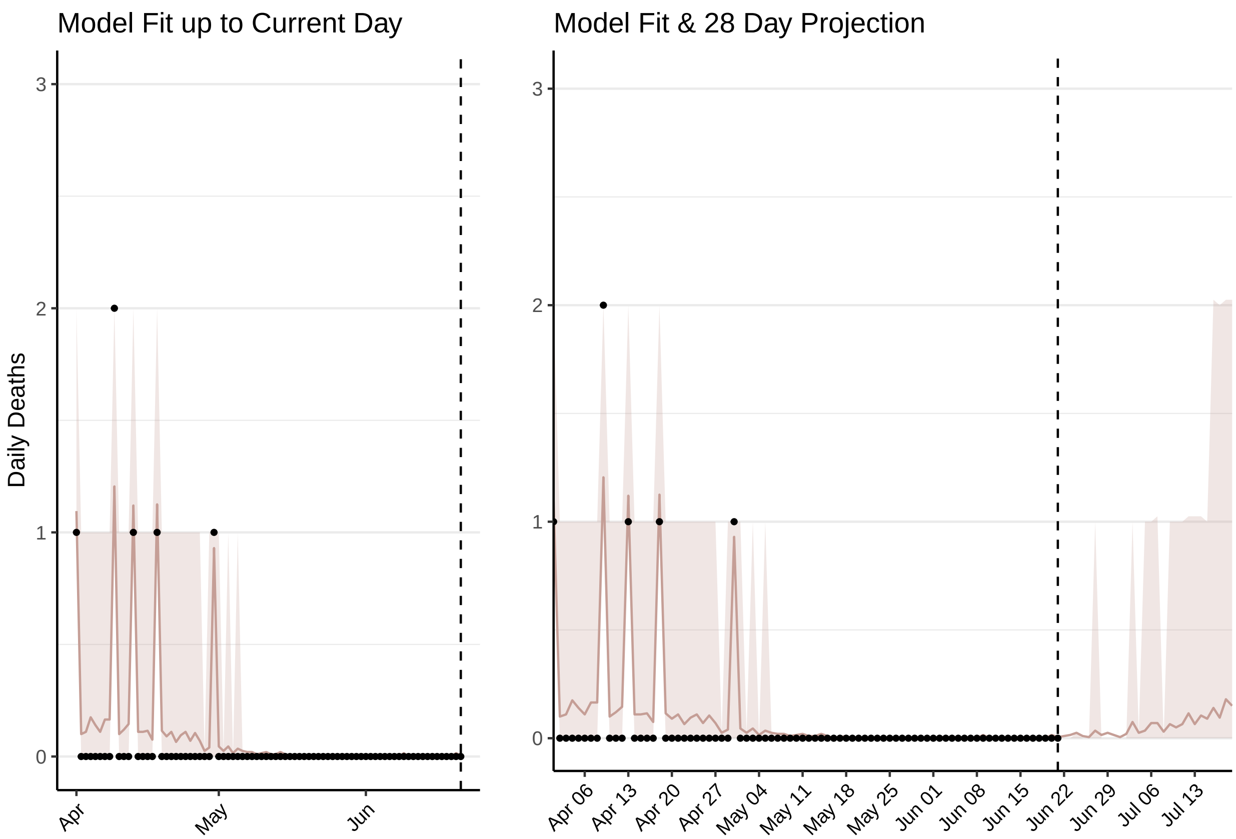


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1 (95% CI: 0-1) patients requiring treatment with high-pressure oxygen at the current date to 11 (95% CI: 4-17) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 3 (95% CI: 1-4) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

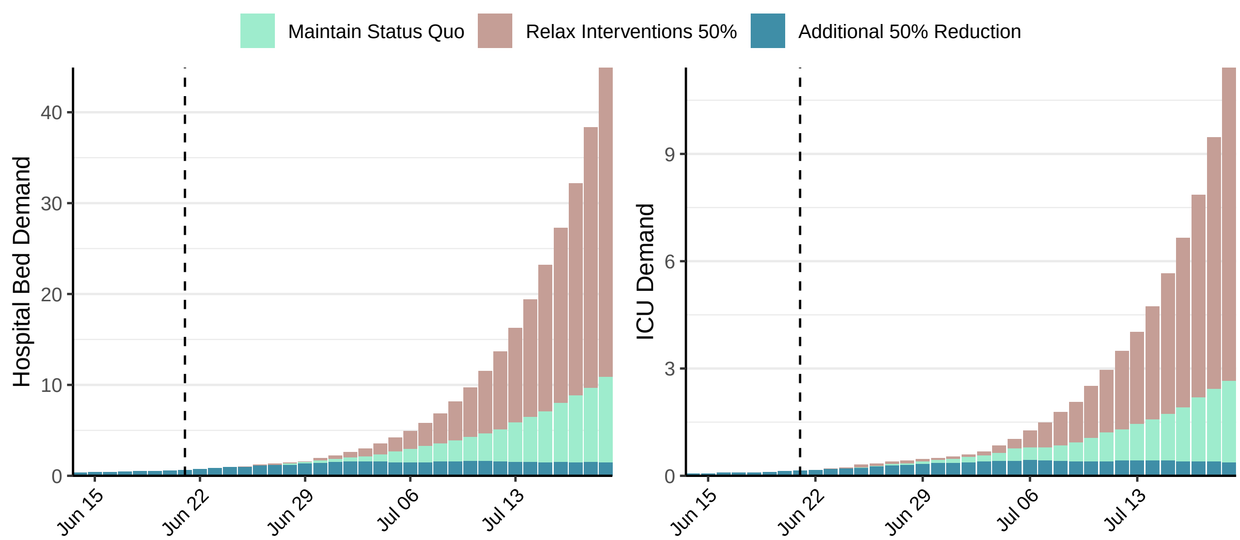


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 7 (95% CI: 4-11) at the current date to 6 (95% CI: 2-9) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 7 (95% CI: 4-11) at the current date to 875 (95% CI: 294-1,456) by 2020-07-19.

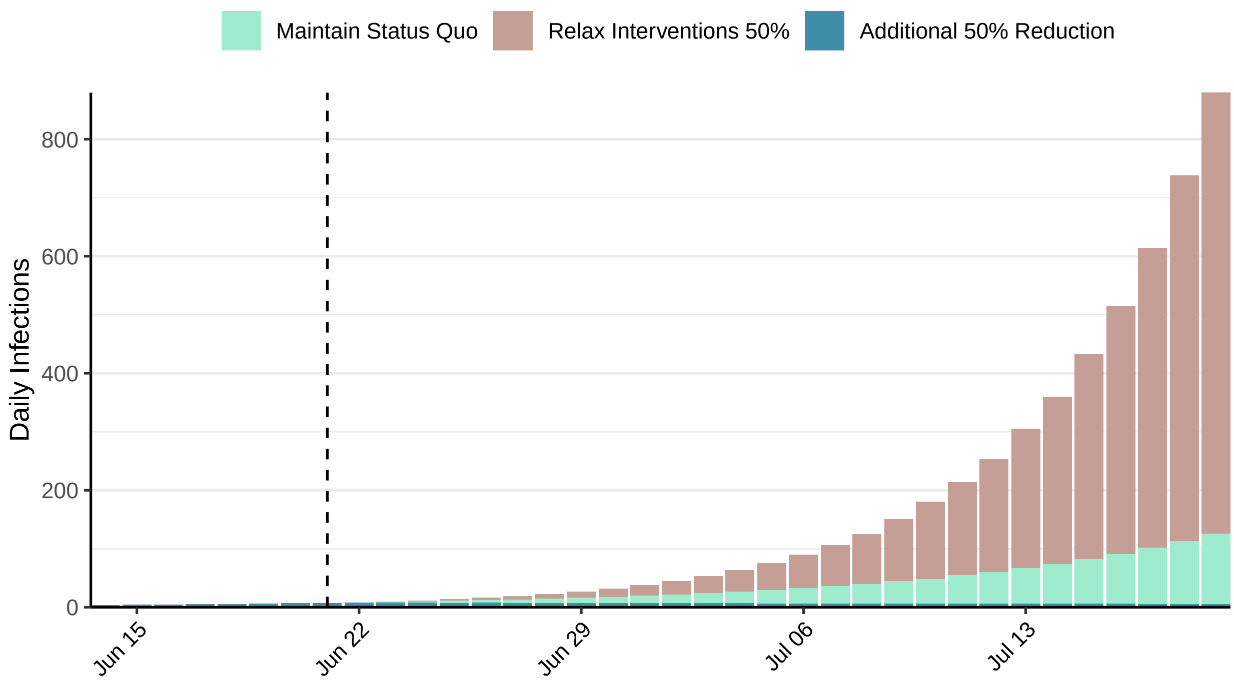


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Montenegro, 2020-06-21

**Download the report for Montenegro, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 359 | 4 | 9 | 0 | 0.82 (95% CI: 0.41-1.47) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Montenegro is not shown in the following plot as only 9 deaths have been reported to date**

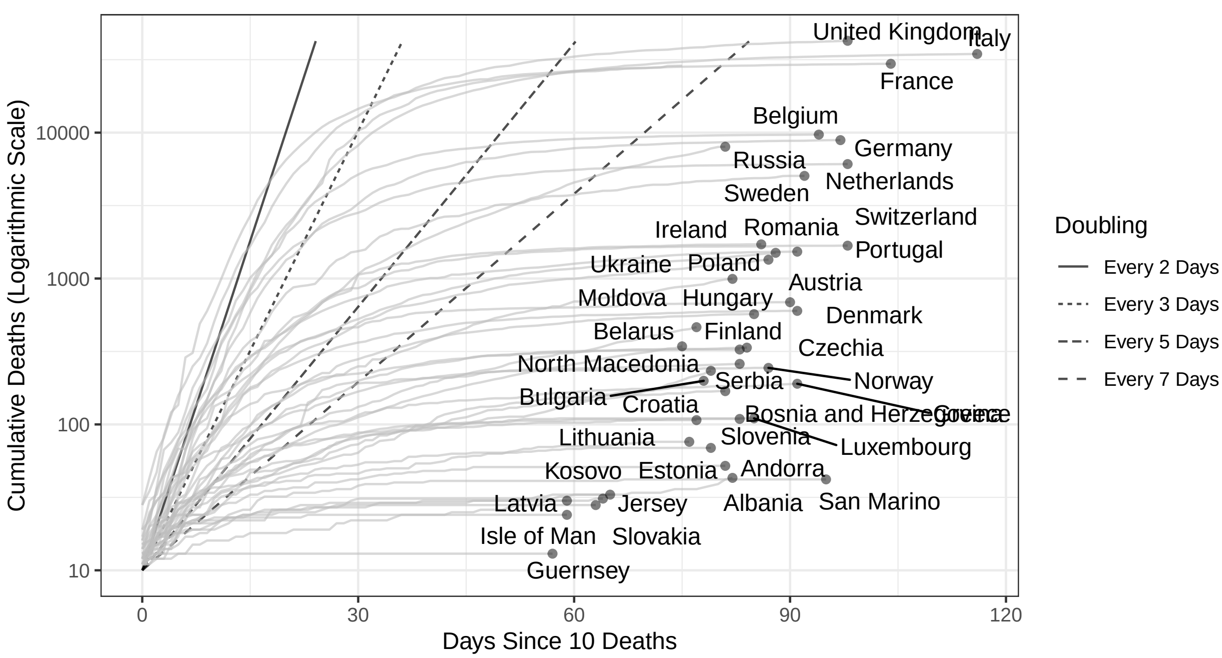


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 129 (95% CI: 94-164) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

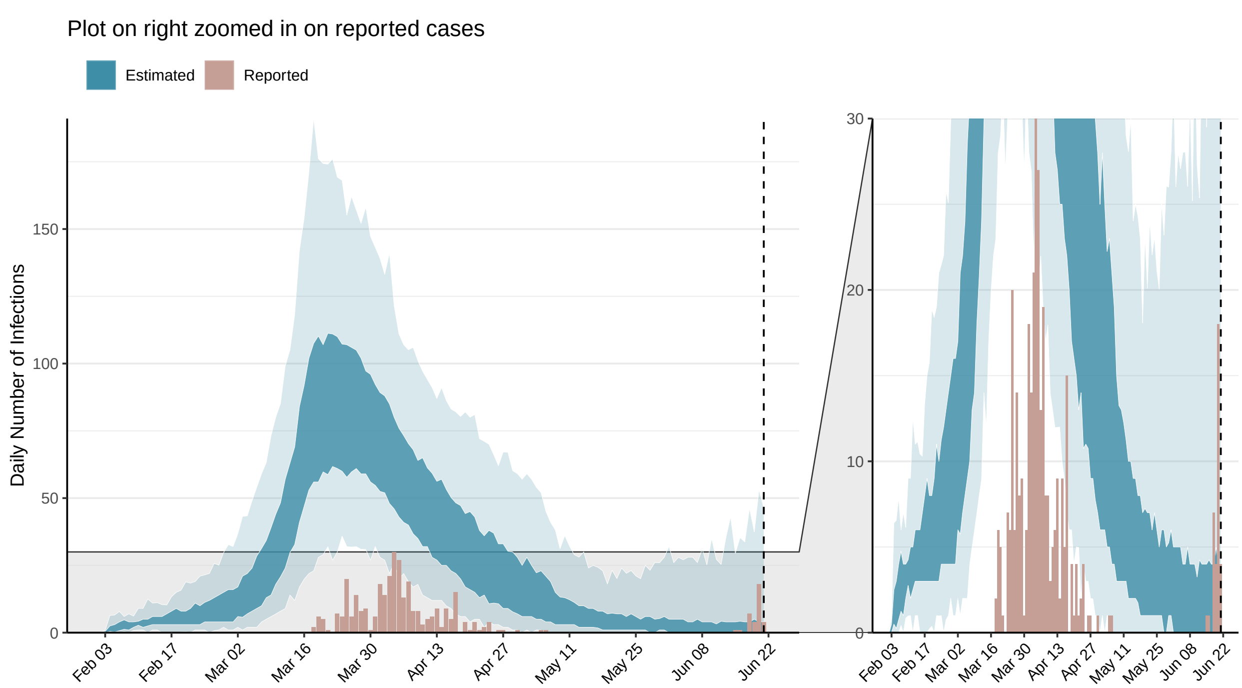


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

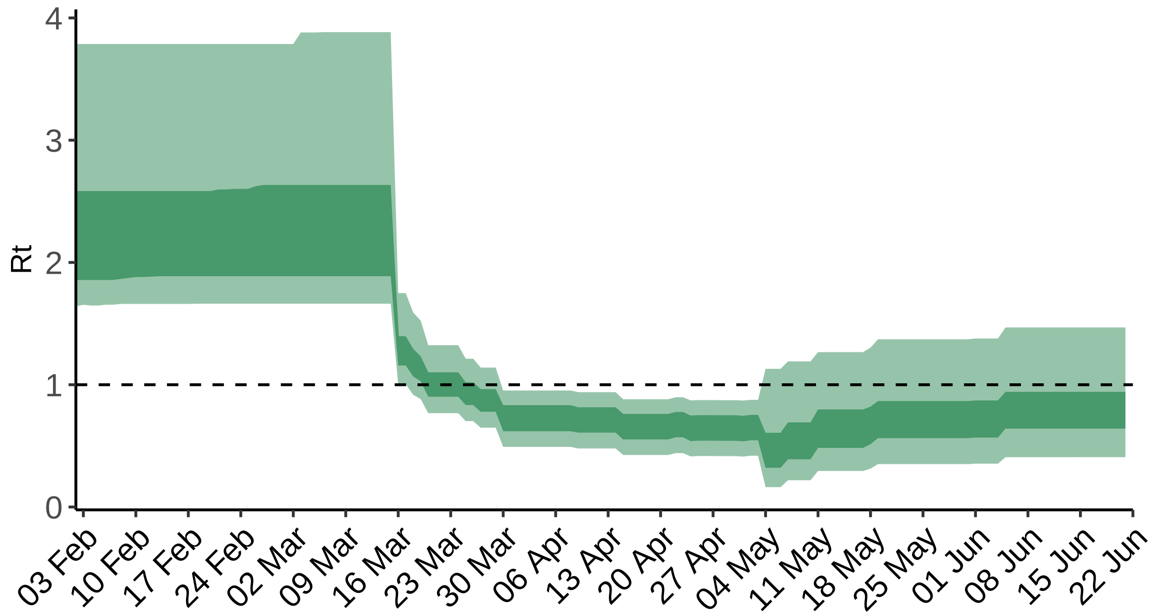


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

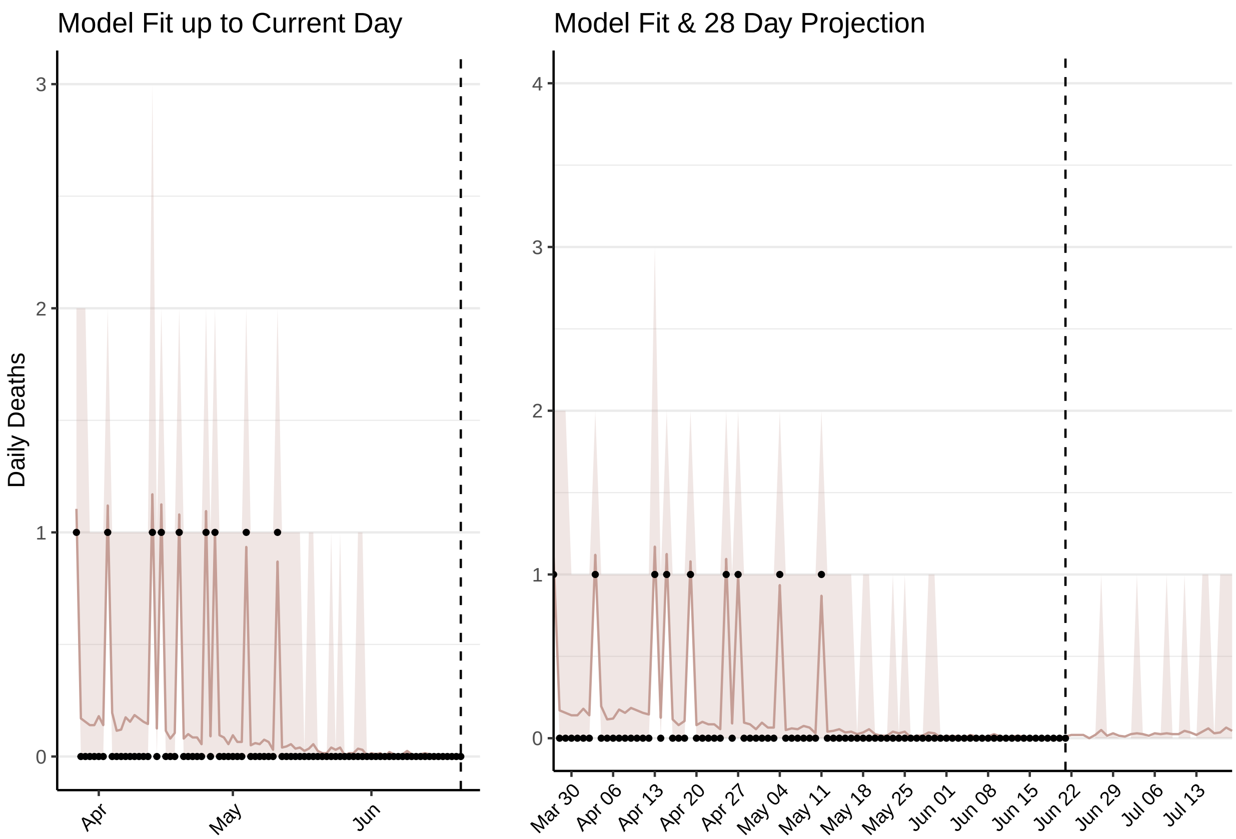


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1 (95% CI: 1-1) patients requiring treatment with high-pressure oxygen at the current date to 2 (95% CI: 1-4) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 0-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

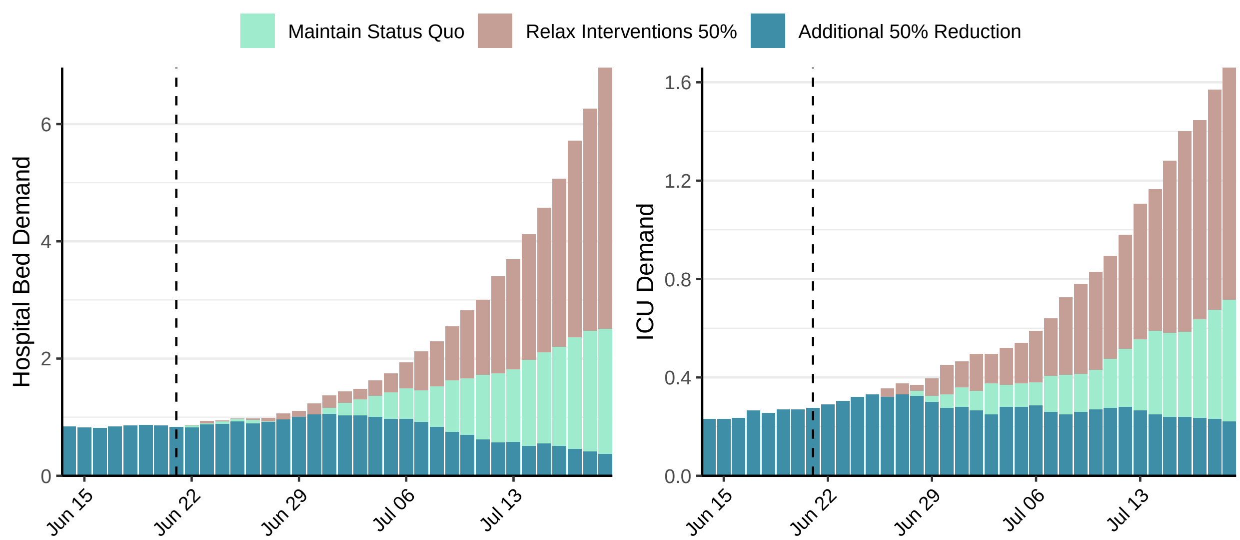


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 6 (95% CI: 3-8) at the current date to 1 (95% CI: 0-2) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 6 (95% CI: 3-8) at the current date to 87 (95% CI: 26-147) by 2020-07-19.

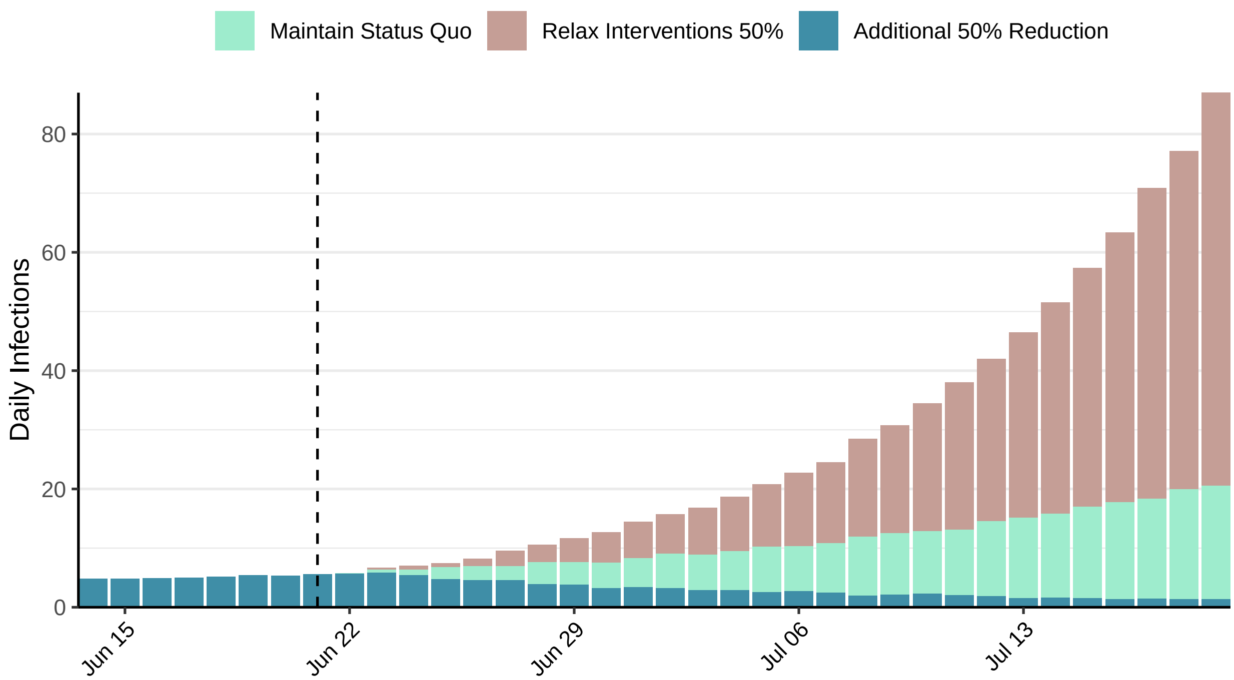


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Mozambique, 2020-06-21

**Download the report for Mozambique, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 688 | 20 | 4 | 0 | 1.67 (95% CI: 1.18-2.21) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Mozambique is not shown in the following plot as only 4 deaths have been reported to date**

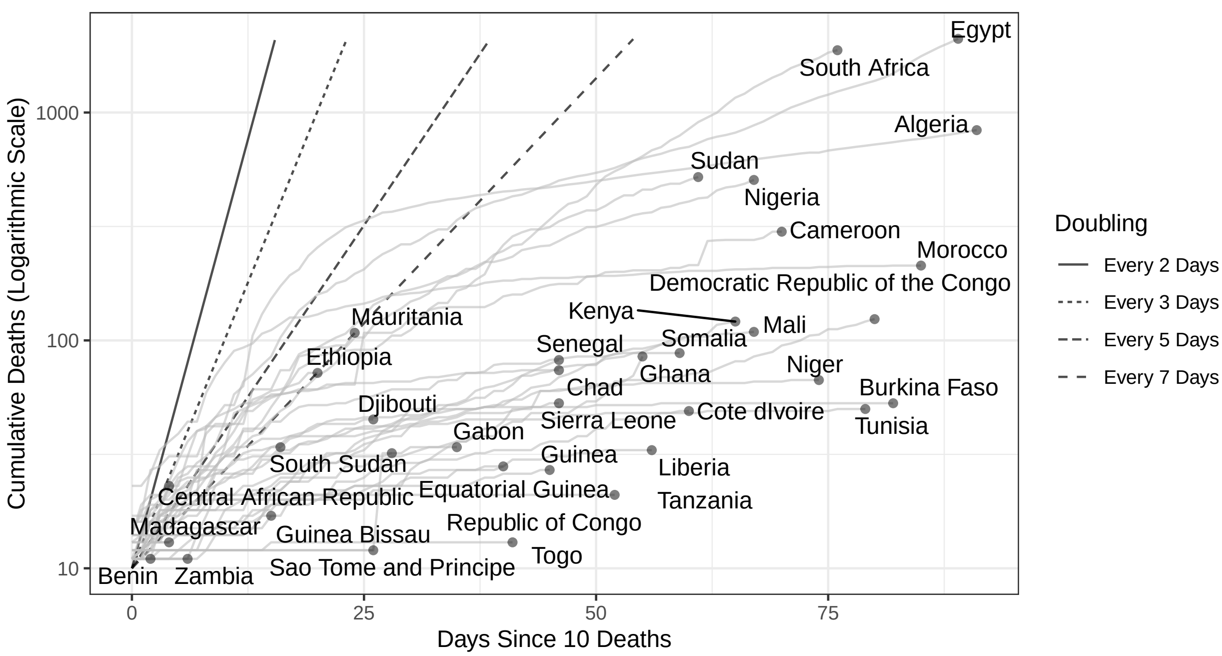


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 5,311 (95% CI: 4,794-5,828) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

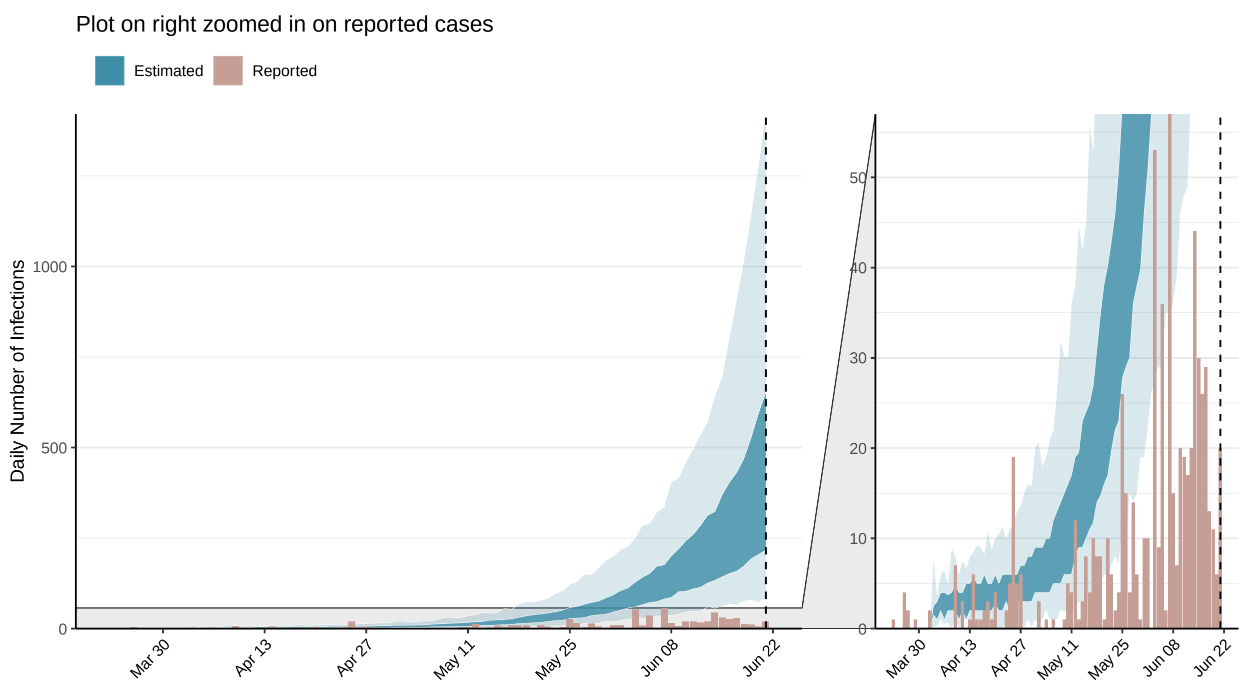


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

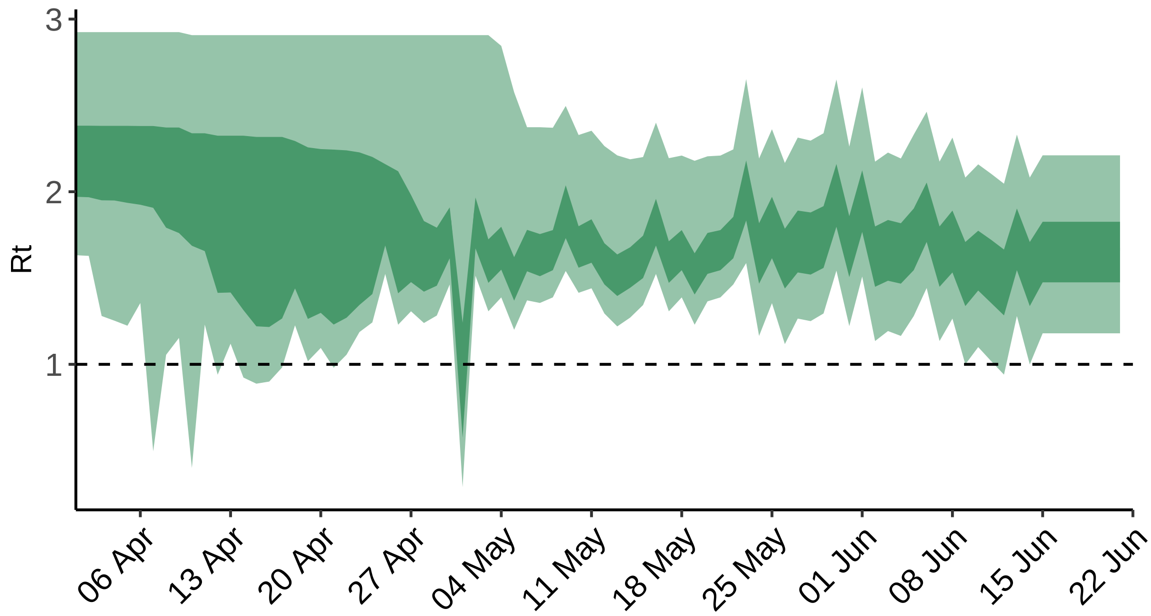


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

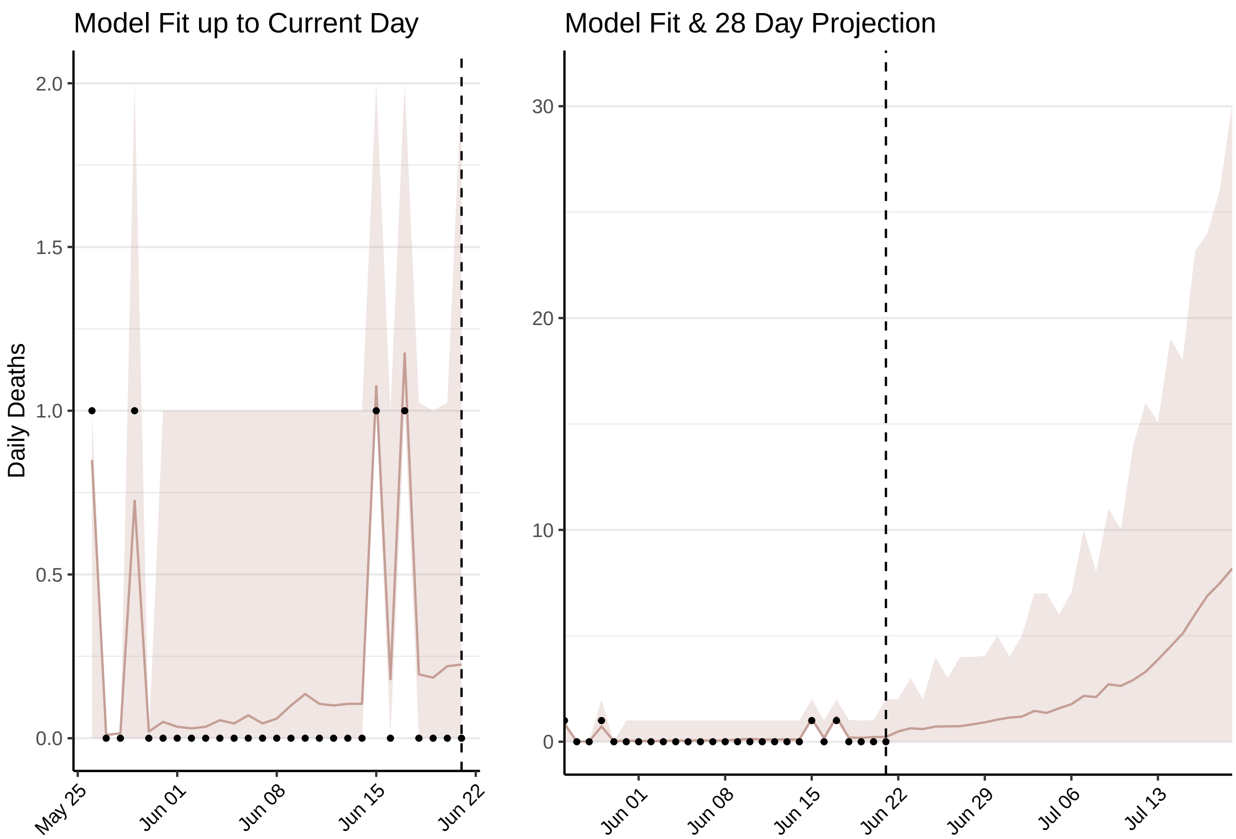


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 30 (95% CI: 27-33) patients requiring treatment with high-pressure oxygen at the current date to 469 (95% CI: 373-565) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 8 (95% CI: 7-9) patients requiring treatment with mechanical ventilation at the current date to 122 (95% CI: 100-144) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

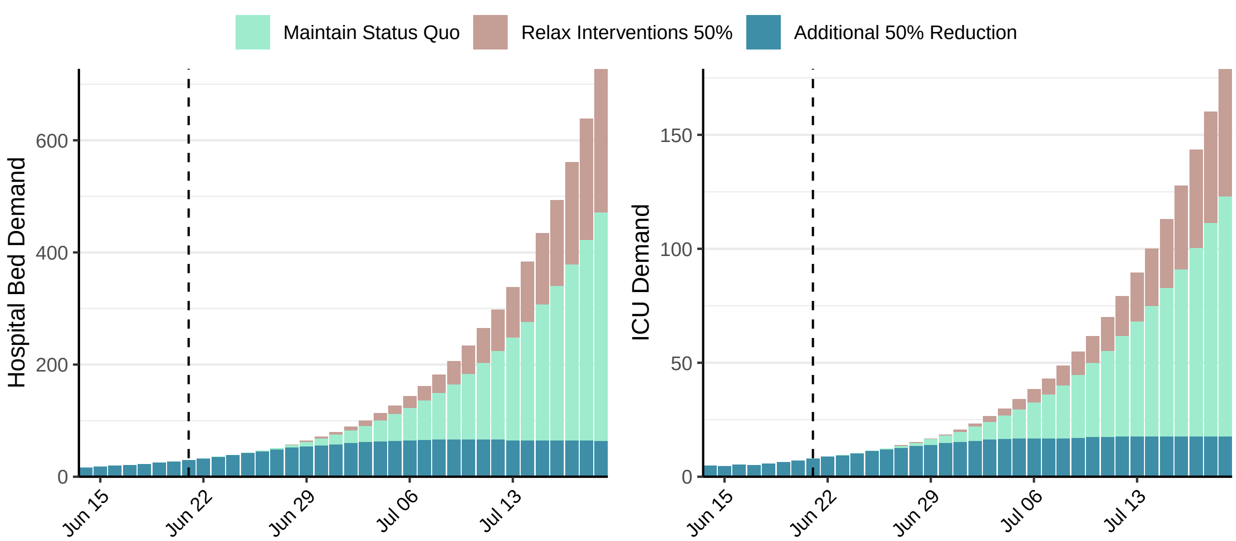


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 496 (95% CI: 435-557) at the current date to 421 (95% CI: 330-511) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 496 (95% CI: 435-557) at the current date to 16,384 (95% CI: 12,529-20,239) by 2020-07-19.

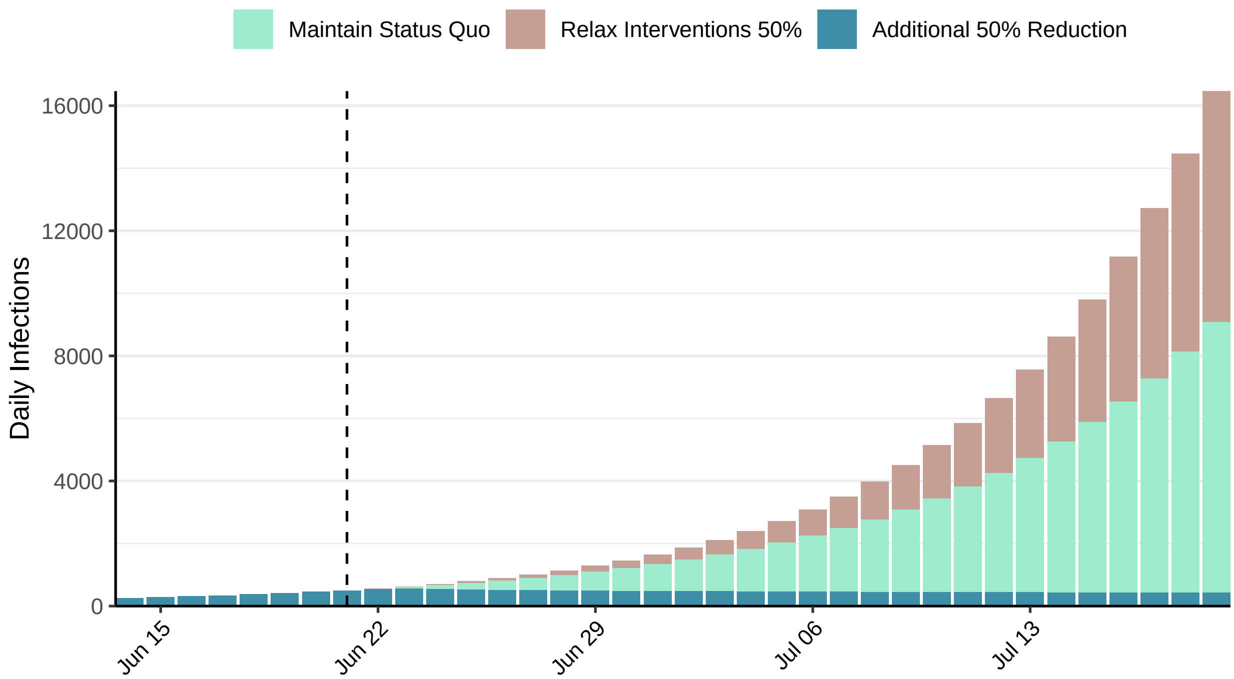


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Mauritania, 2020-06-21

**Download the report for Mauritania, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,813 | 590 | 108 | 13 | 1.44 (95% CI: 1.28-1.57) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

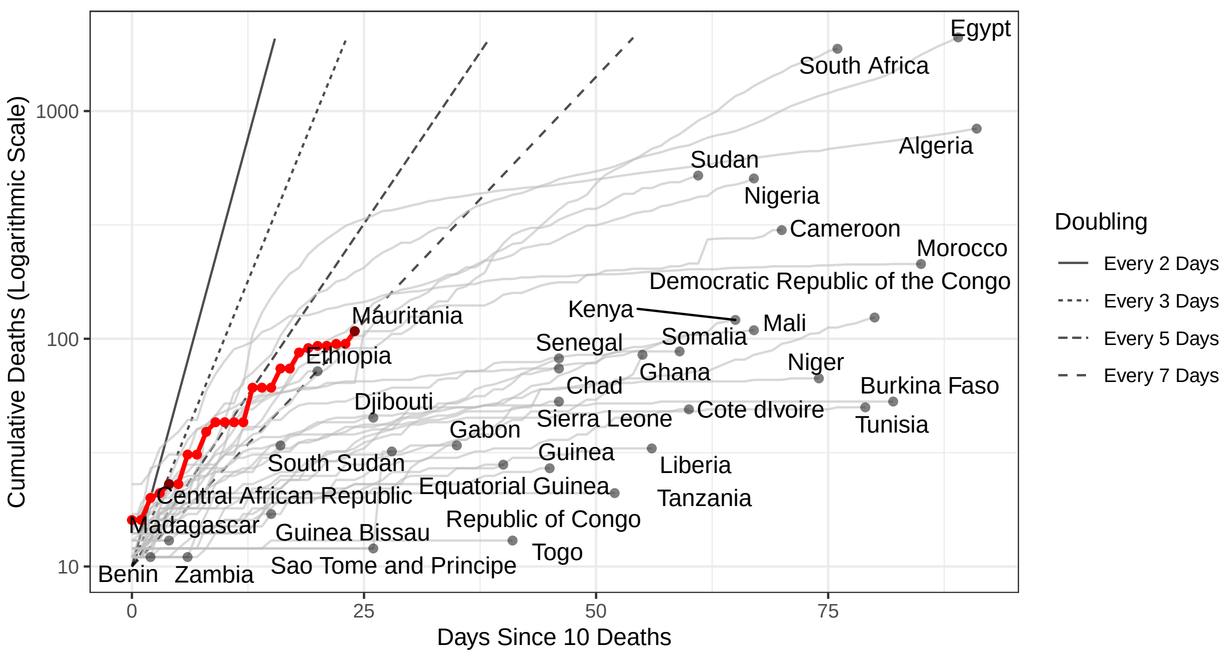


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 56,742 (95% CI: 54,749-58,735) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

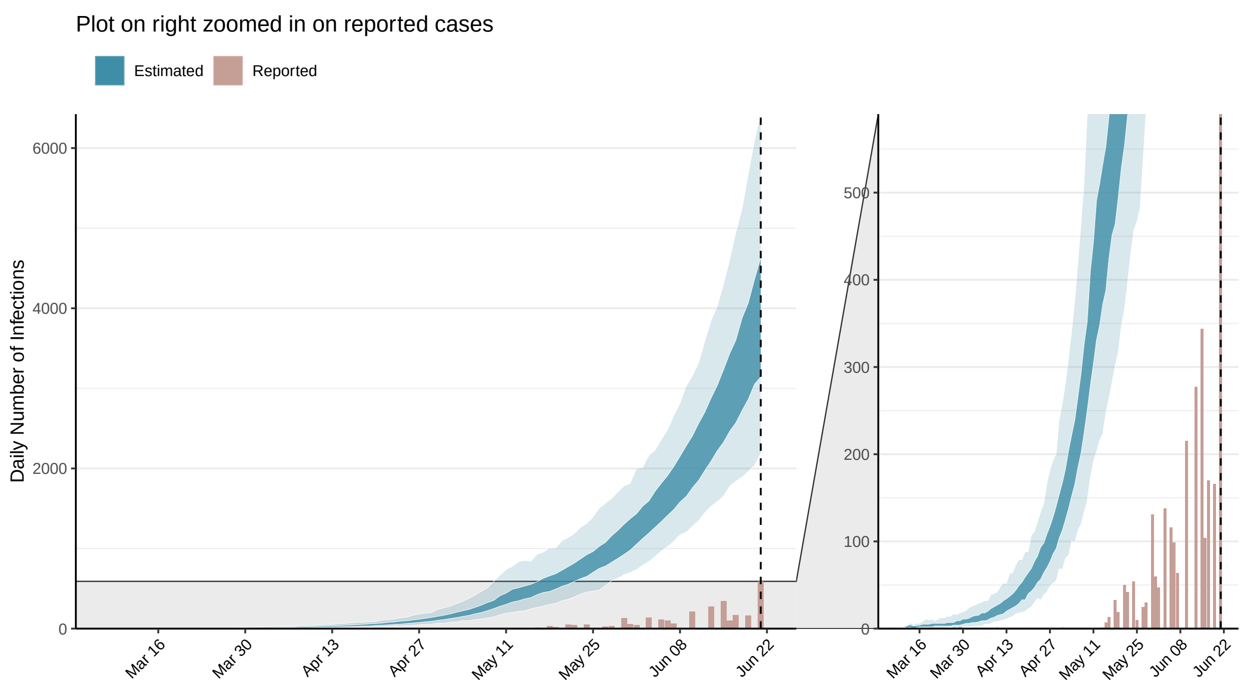


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

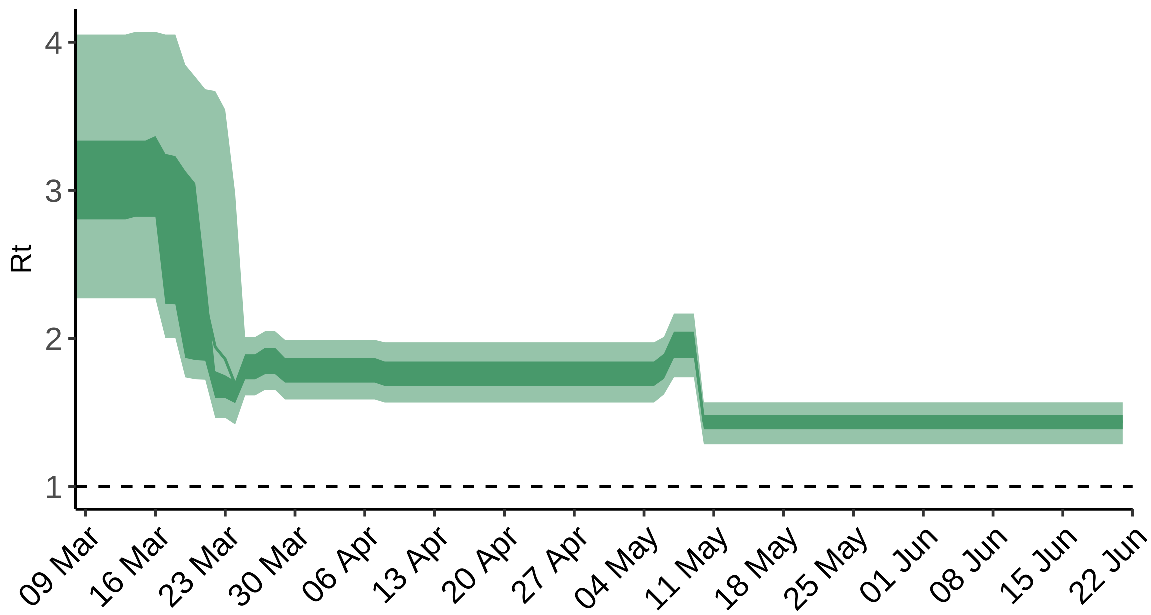


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Mauritania is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

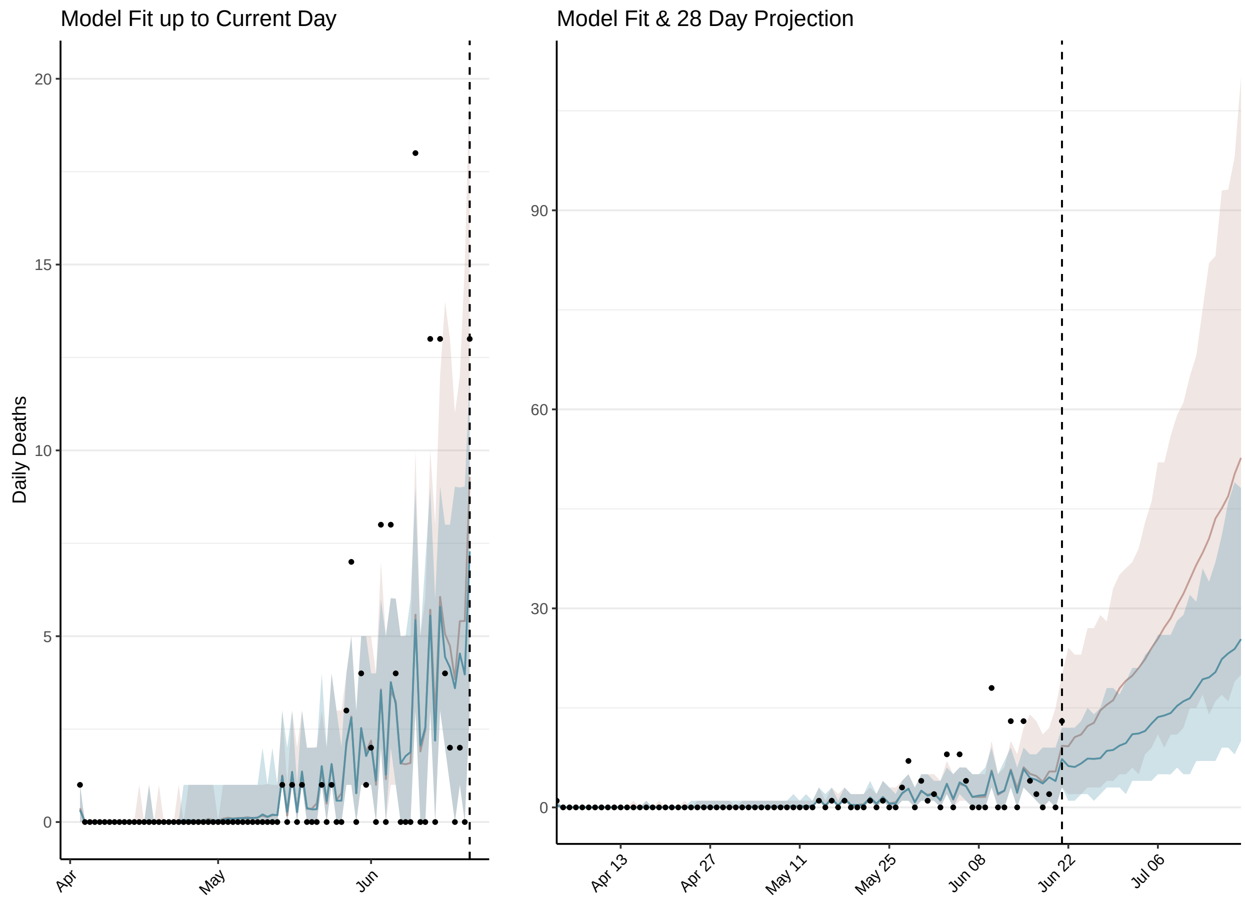


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 339 (95% CI: 327-351) patients requiring treatment with high-pressure oxygen at the current date to 1,489 (95% CI: 1,416-1,563) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 80 (95% CI: 78-82) patients requiring treatment with mechanical ventilation at the current date to 135 (95% CI: 132-139) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

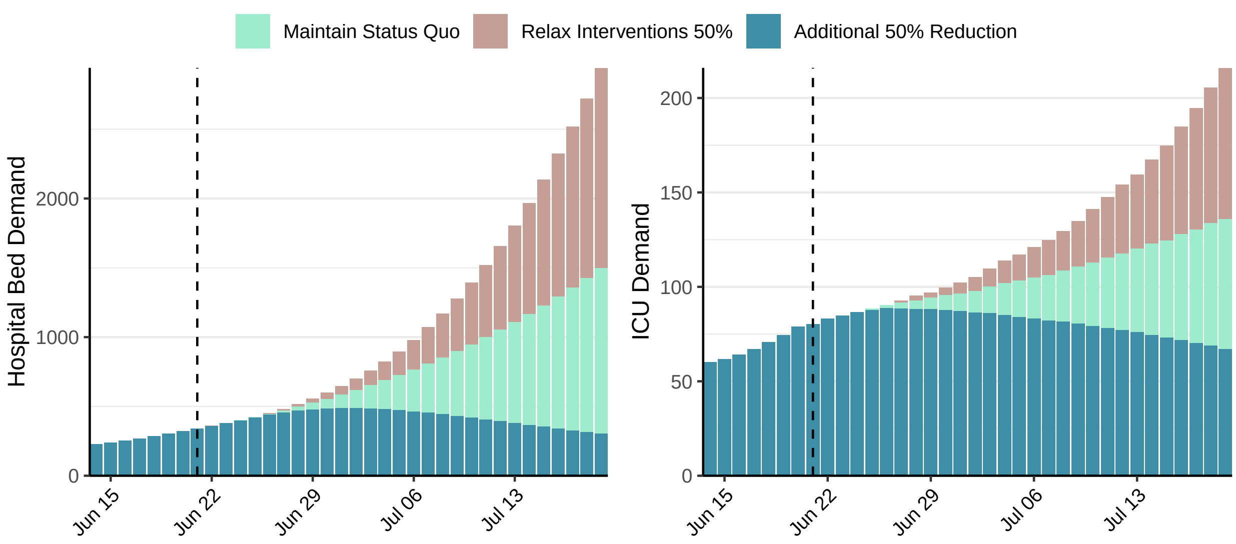


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 3,926 (95% CI: 3,772-4,081) at the current date to 1,146 (95% CI: 1,084-1,209) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 3,926 (95% CI: 3,772-4,081) at the current date to 41,497 (95% CI: 39,495-43,499) by 2020-07-19.

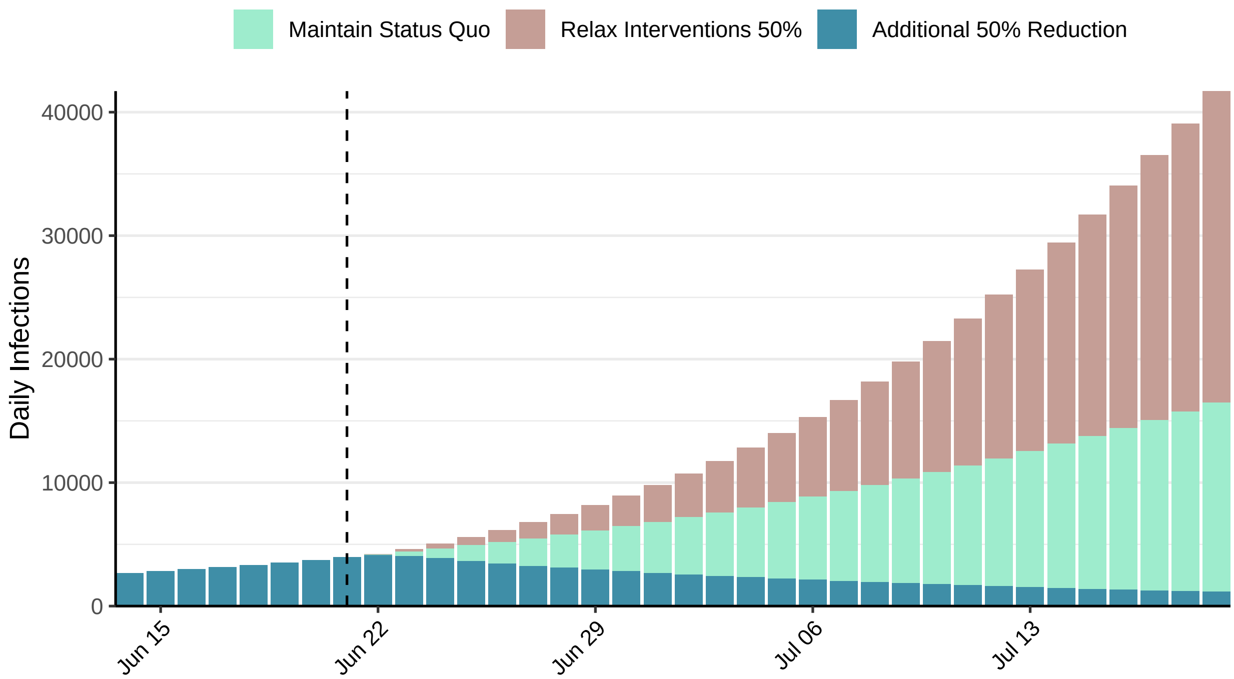


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Mauritius, 2020-06-21

**Download the report for Mauritius, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 337 | 0 | 10 | 0 | 1.27 (95% CI: 0.69-2.22) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

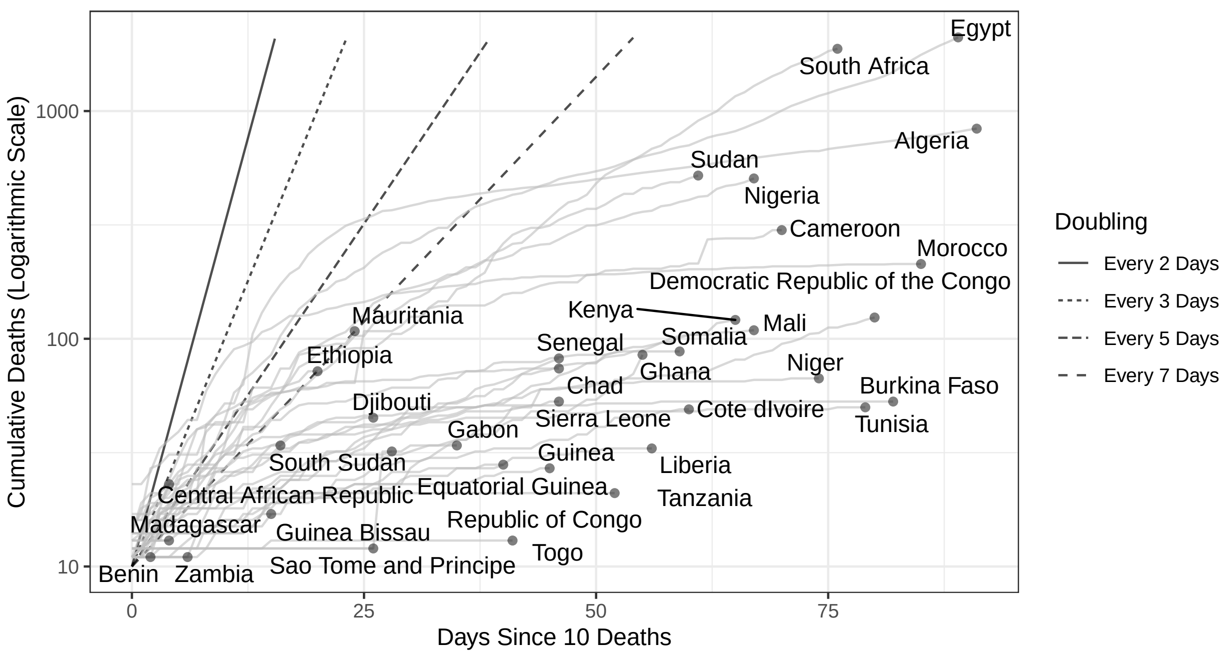


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 17 (95% CI: 6-28) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

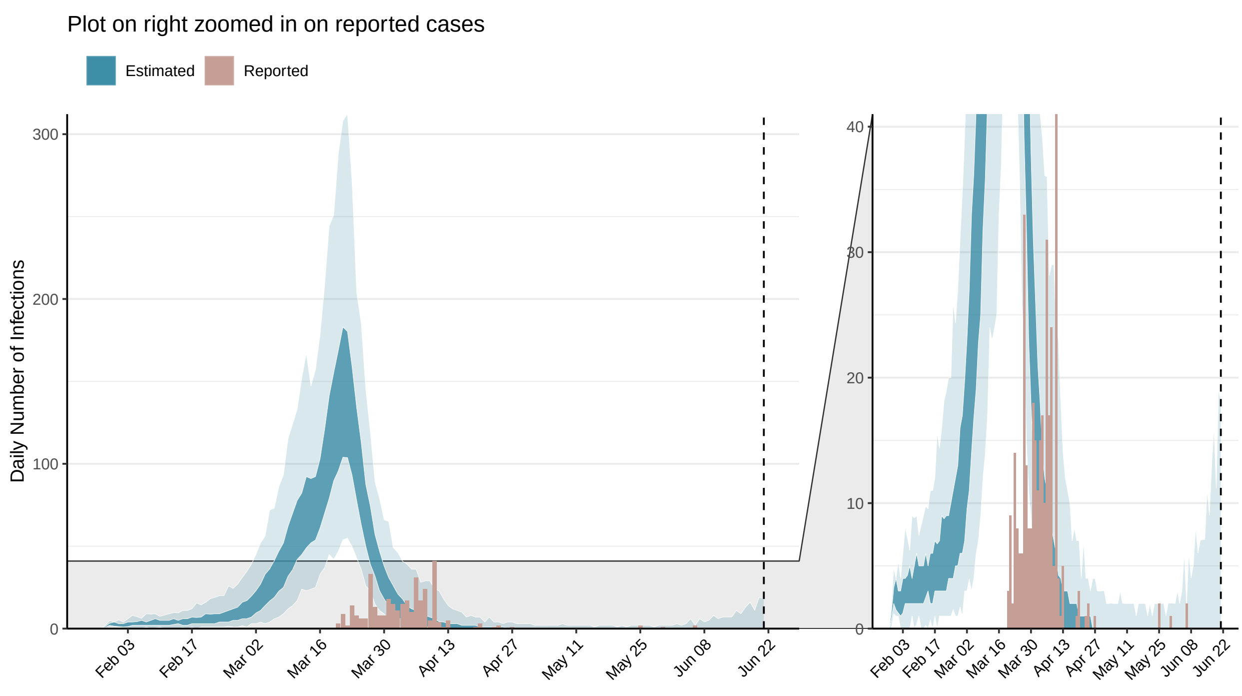


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

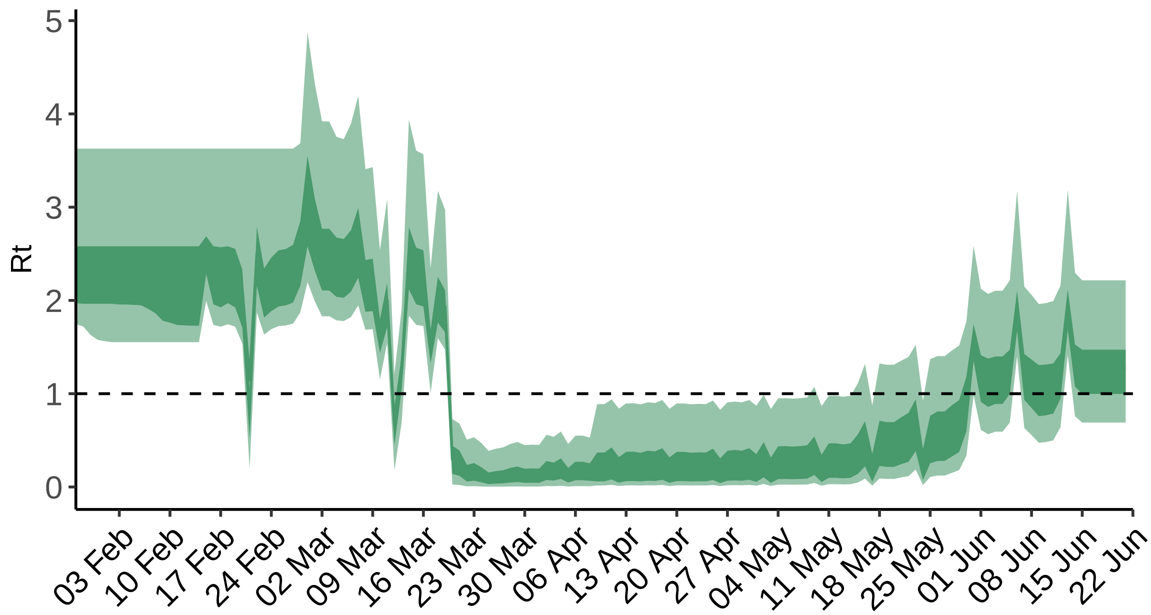


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

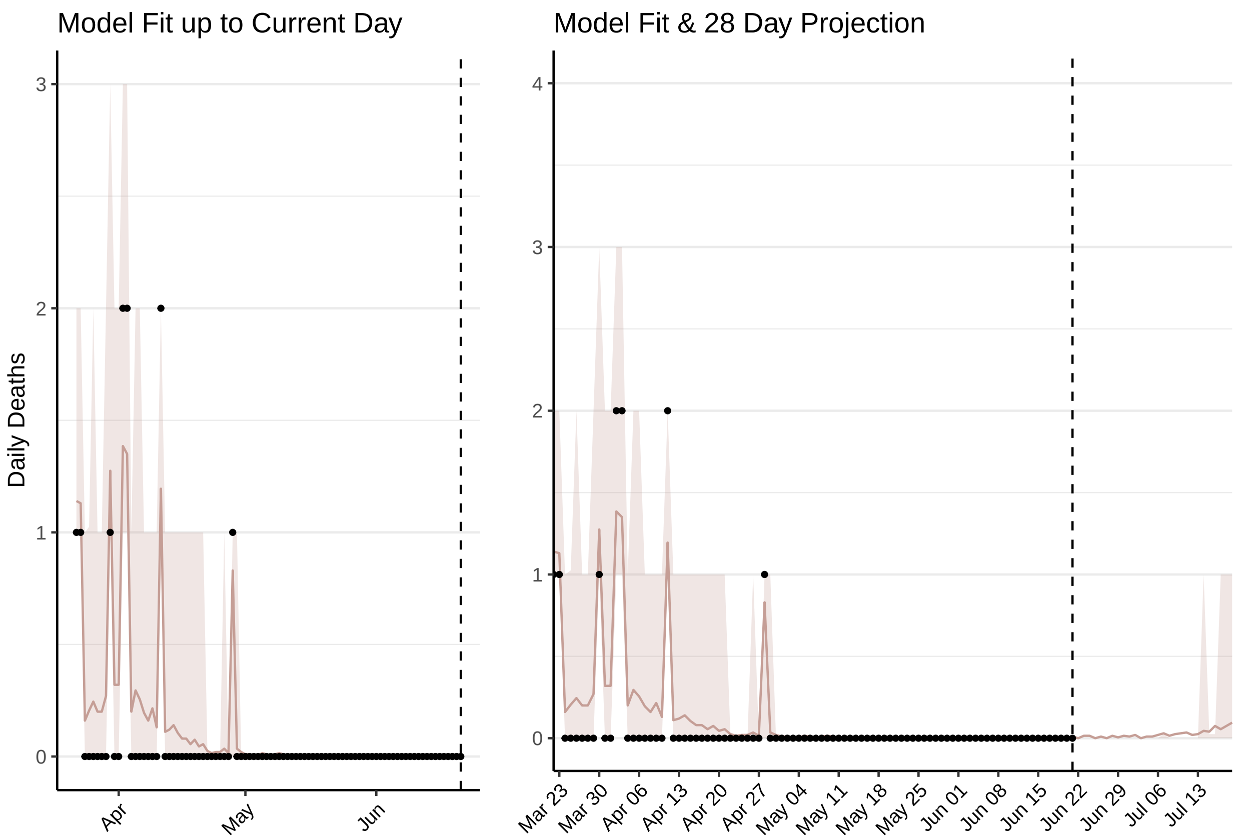


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 0 (95% CI: 0-0) patients requiring treatment with high-pressure oxygen at the current date to 5 (95% CI: 0-9) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 2 (95% CI: 0-3) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

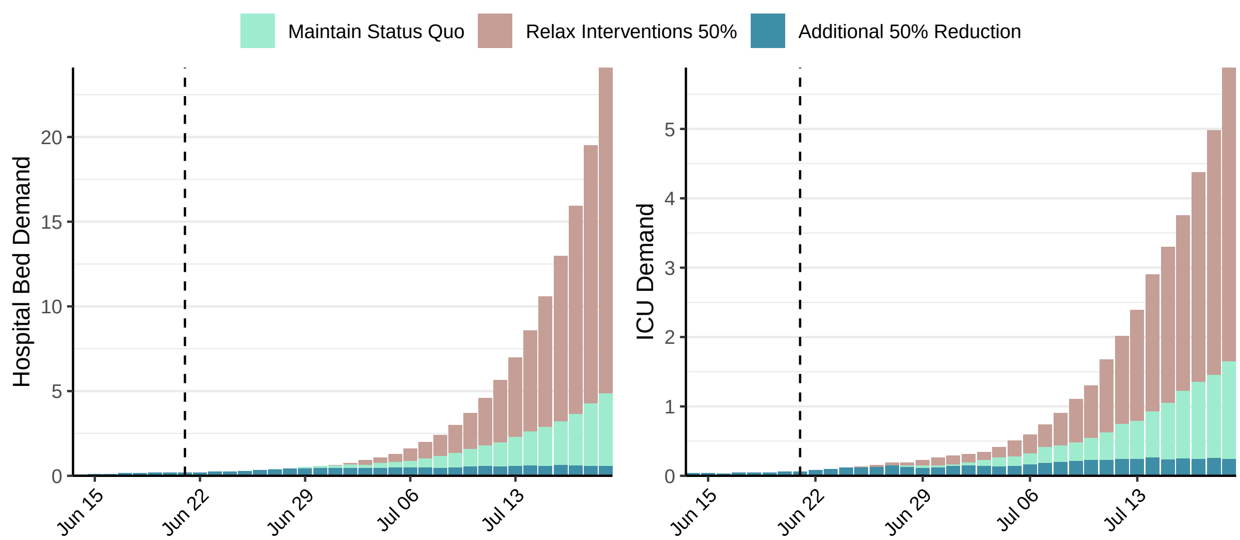


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2 (95% CI: 1-3) at the current date to 3 (95% CI: 0-5) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2 (95% CI: 1-3) at the current date to 452 (95% CI: -3-907) by 2020-07-19.

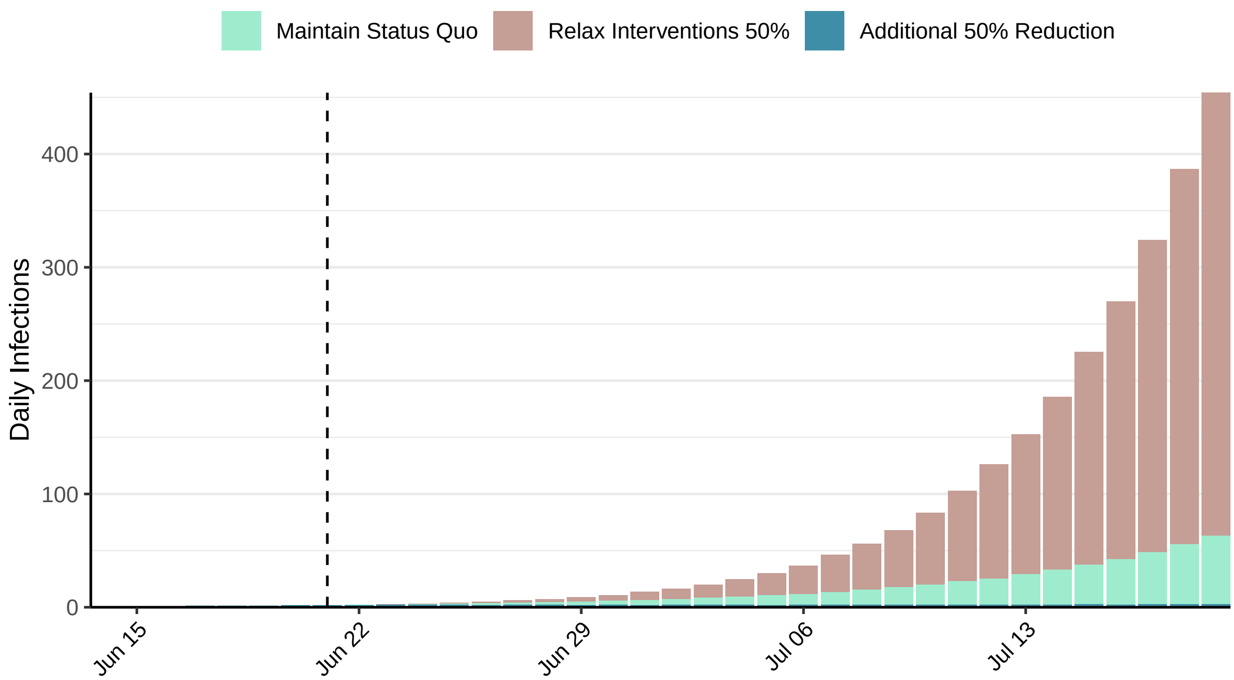


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Malawi, 2020-06-21

**Download the report for Malawi, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 620 | 0 | 8 | 0 | 1.4 (95% CI: 1.12-1.69) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Malawi is not shown in the following plot as only 8 deaths have been reported to date**

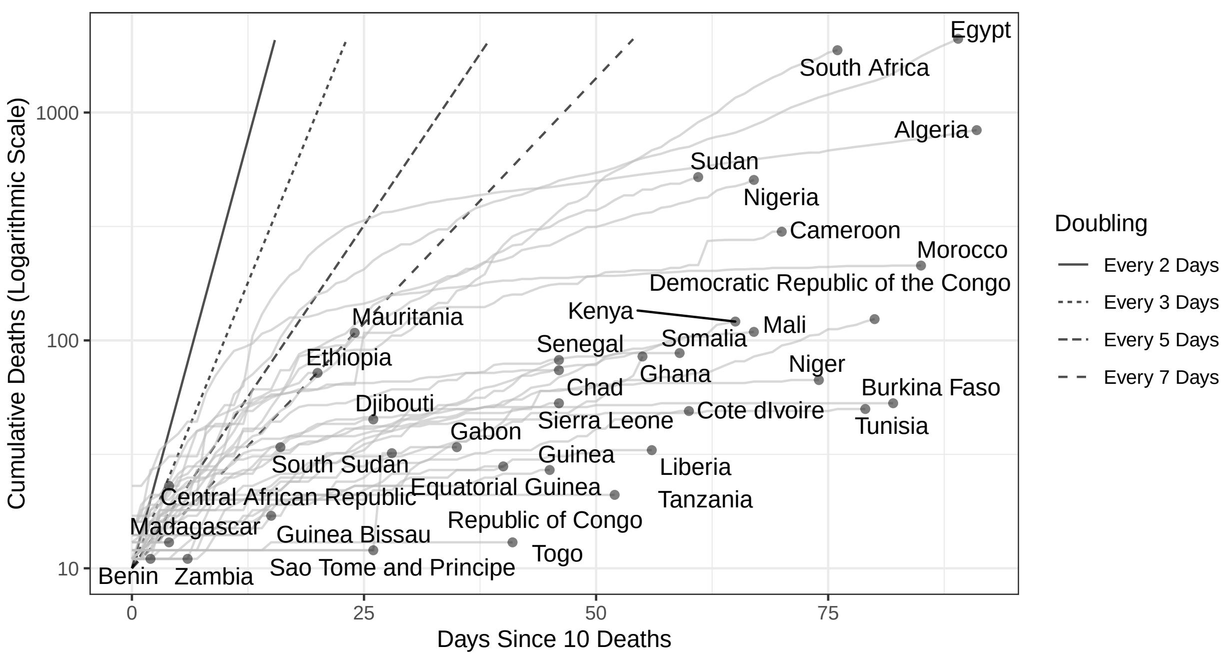


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 4,506 (95% CI: 4,139-4,873) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

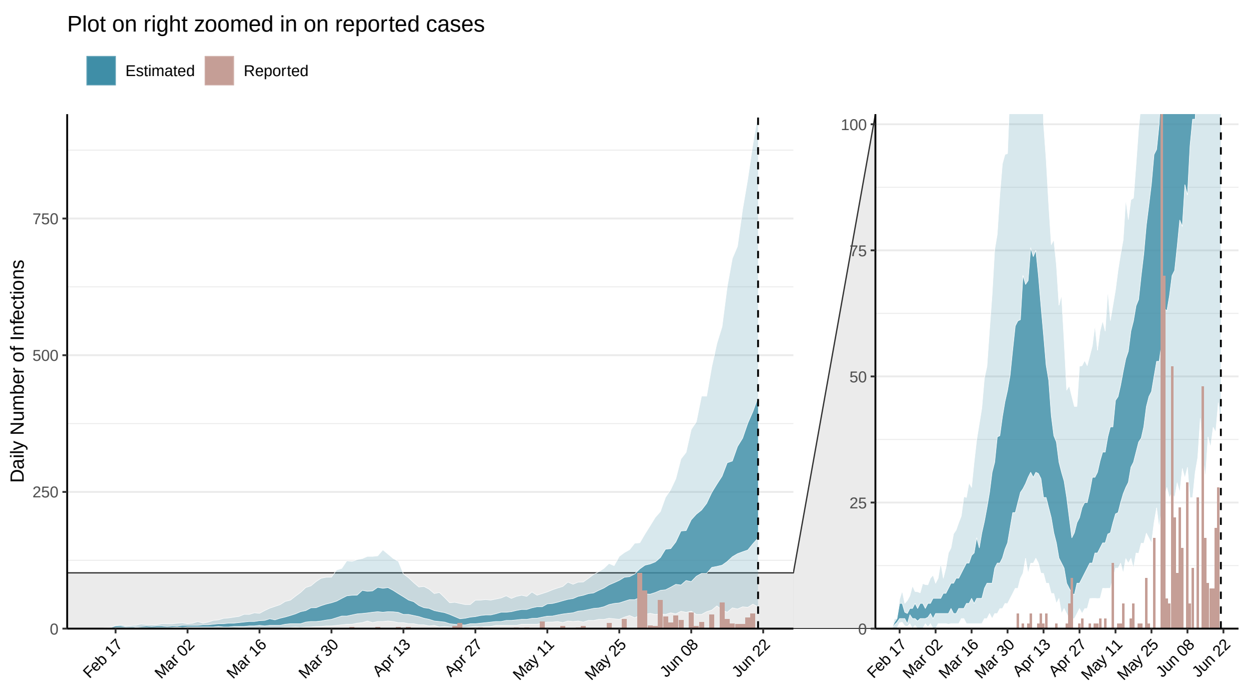


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

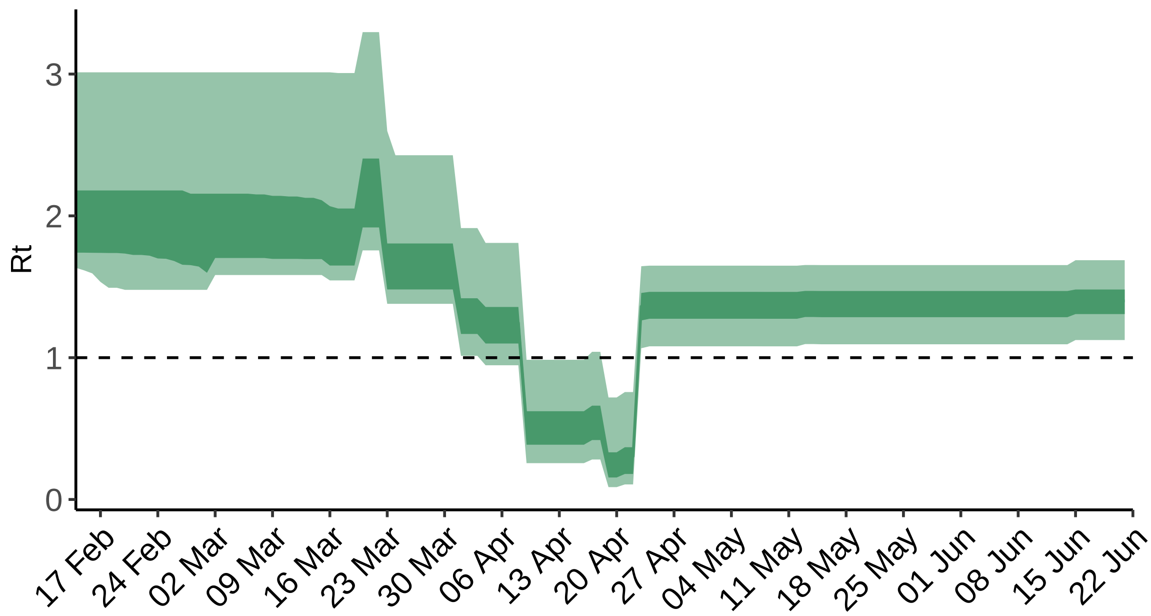


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

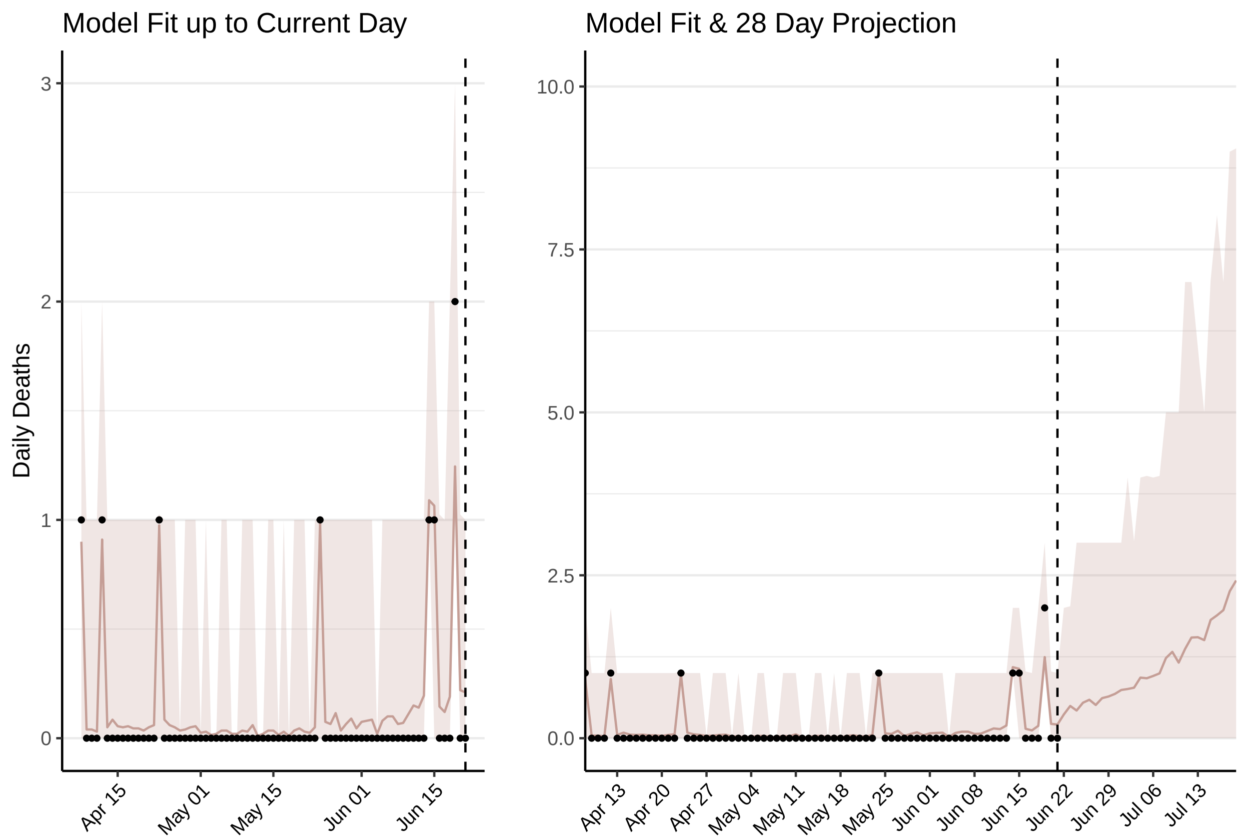


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 24 (95% CI: 22-26) patients requiring treatment with high-pressure oxygen at the current date to 146 (95% CI: 121-172) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 6 (95% CI: 6-7) patients requiring treatment with mechanical ventilation at the current date to 38 (95% CI: 32-44) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

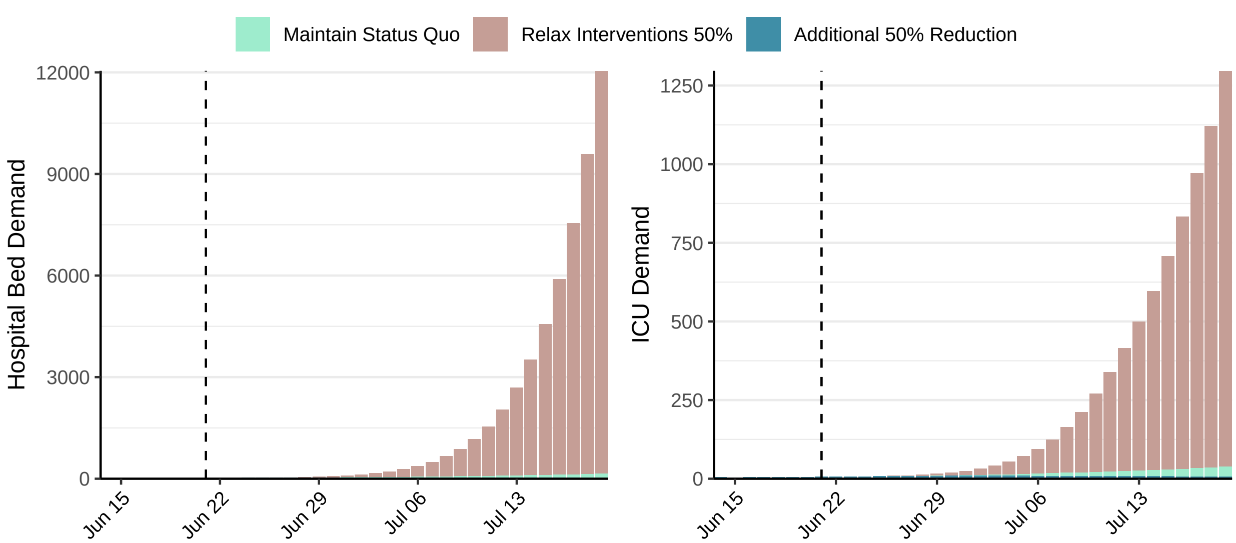


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 320 (95% CI: 287-354) at the current date to 116 (95% CI: 95-138) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 320 (95% CI: 287-354) at the current date to 474,689 (95% CI: 422,580-526,797) by 2020-07-19.

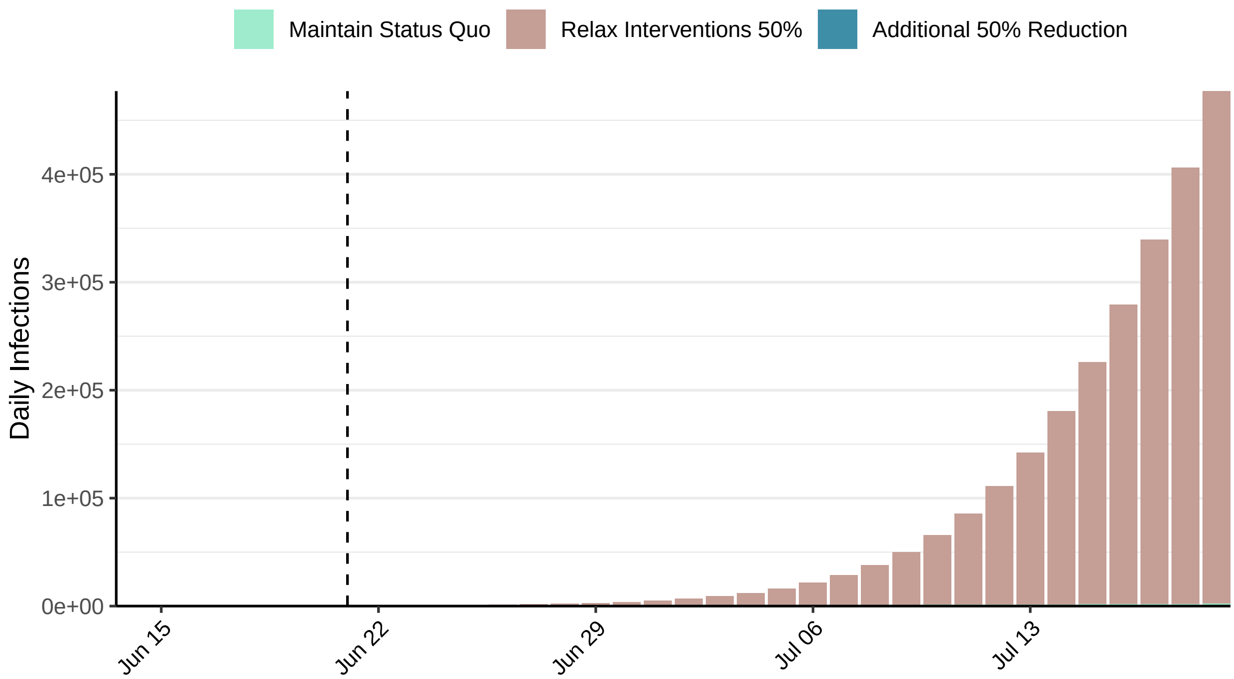


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Malaysia, 2020-06-21

**Download the report for Malaysia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 8,556 | 21 | 121 | 0 | 1.39 (95% CI: 1.23-1.65) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

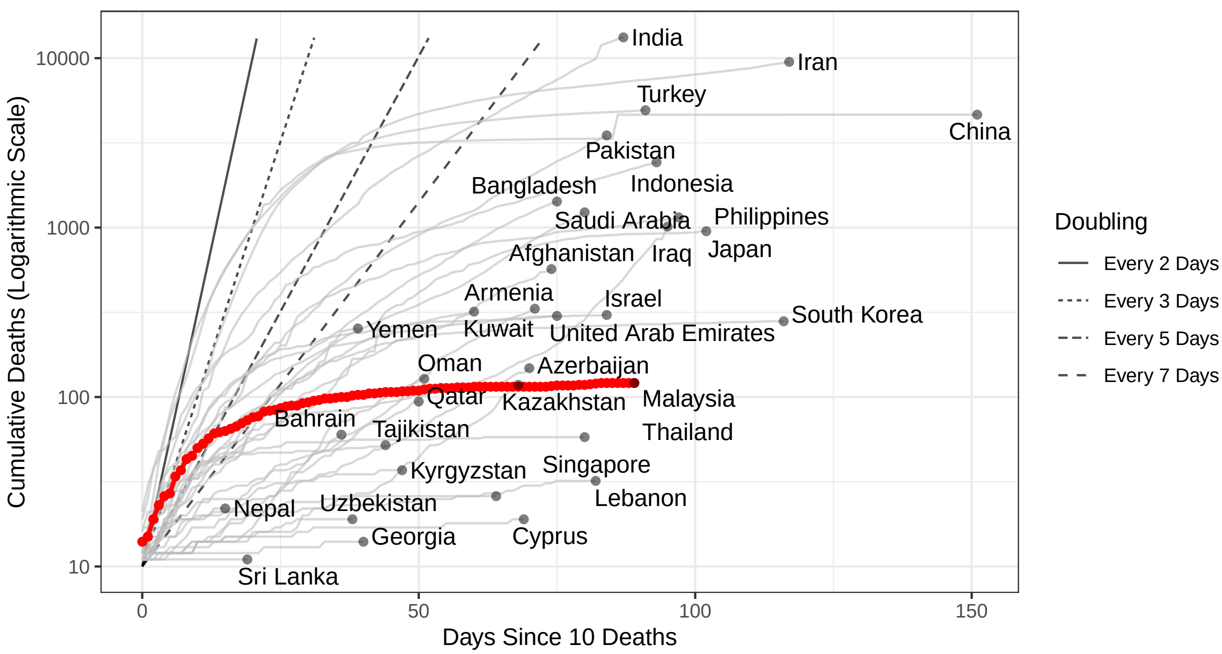


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,601 (95% CI: 3,393-3,809) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

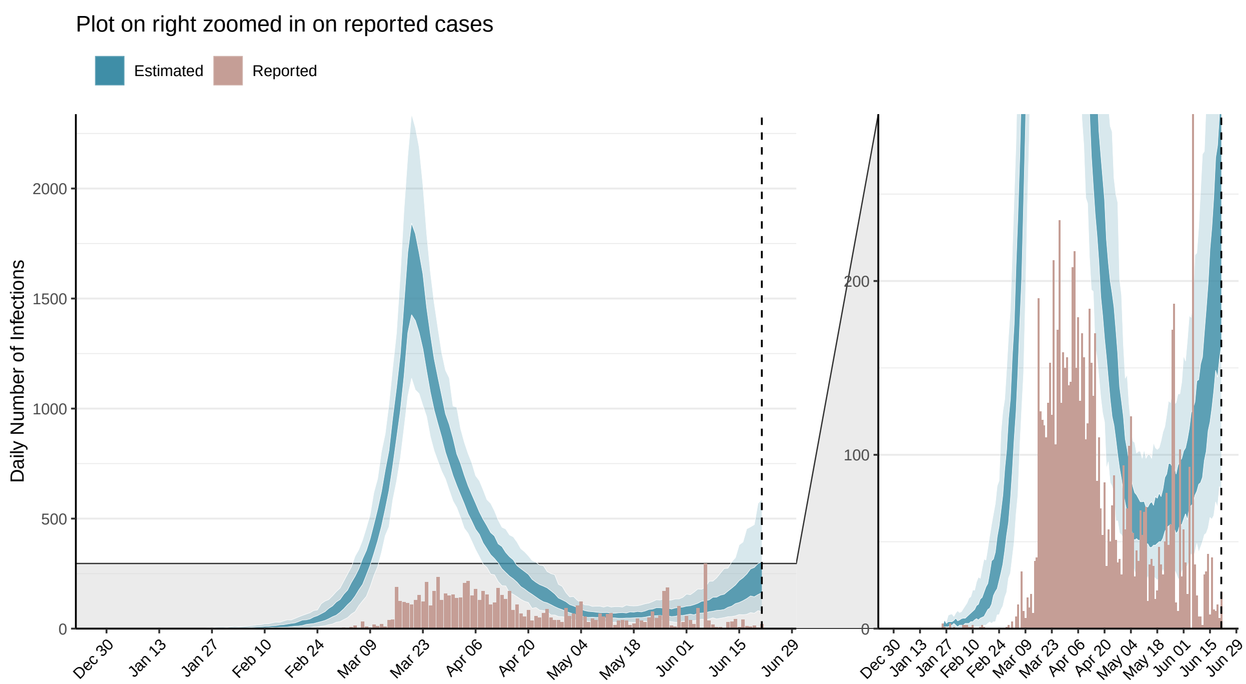


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

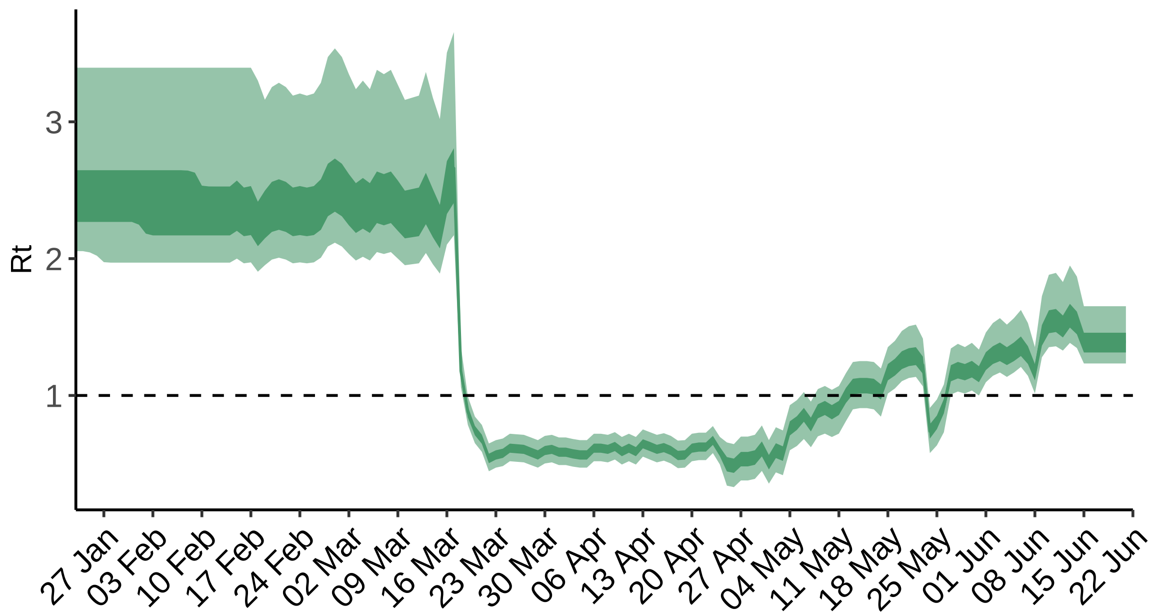


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

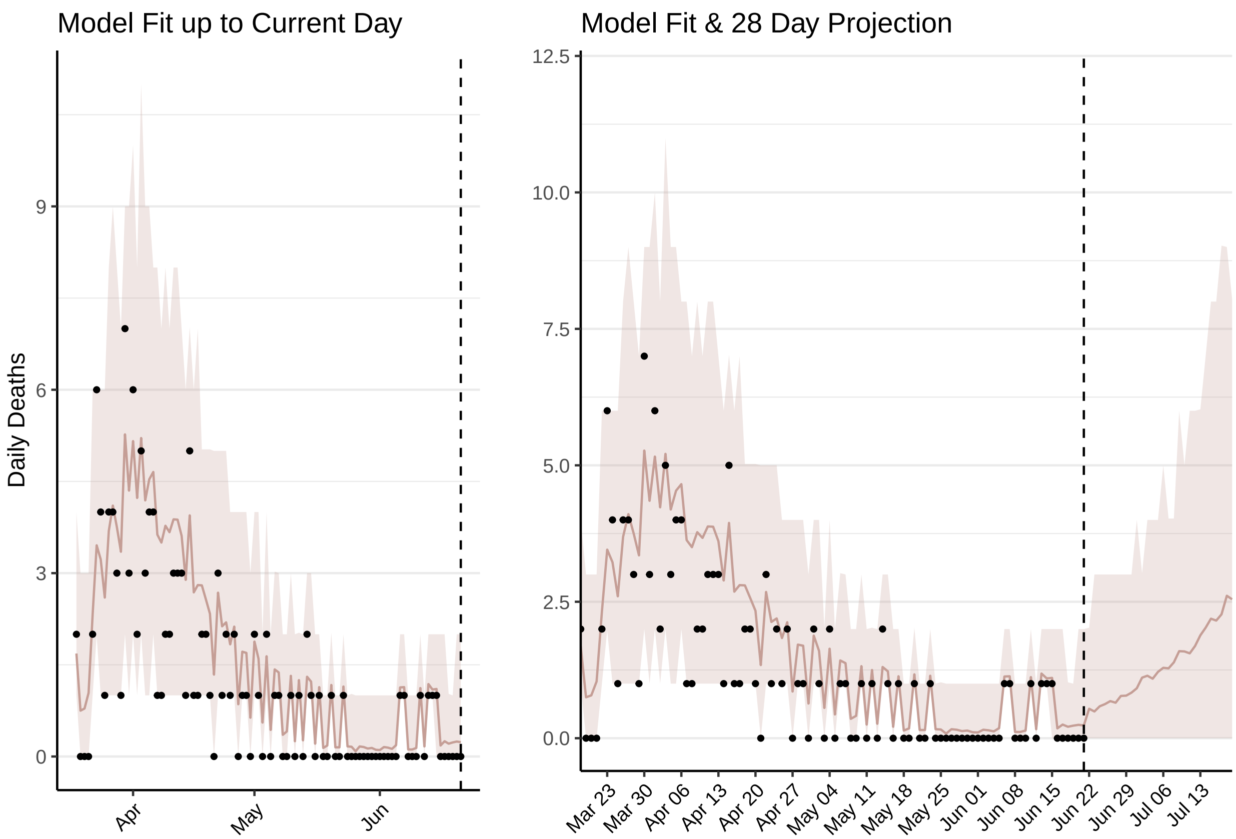


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 32 (95% CI: 30-34) patients requiring treatment with high-pressure oxygen at the current date to 168 (95% CI: 148-188) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 8 (95% CI: 8-9) patients requiring treatment with mechanical ventilation at the current date to 44 (95% CI: 38-49) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

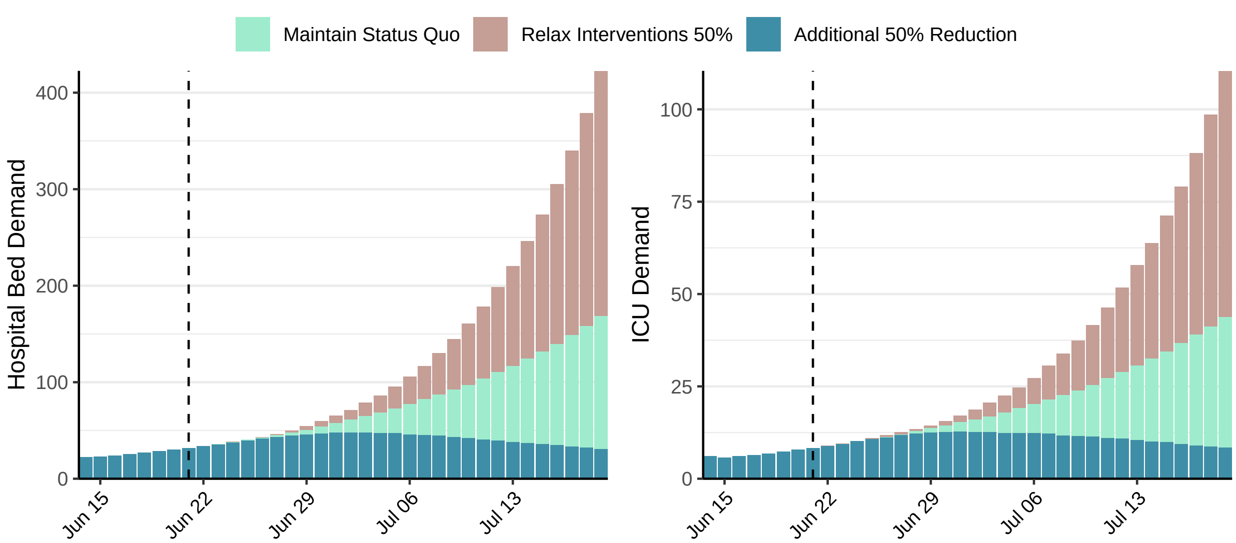


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 248 (95% CI: 230-266) at the current date to 80 (95% CI: 70-90) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 248 (95% CI: 230-266) at the current date to 5,057 (95% CI: 4,262-5,851) by 2020-07-19.

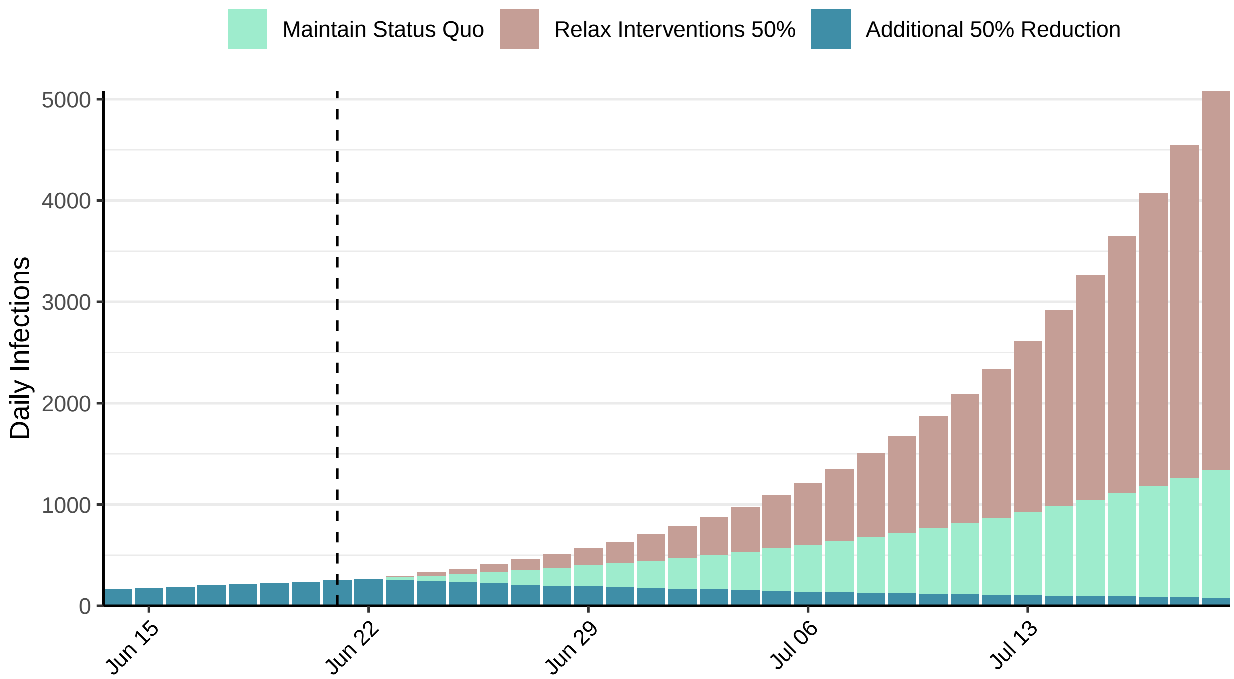


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Niger, 2020-06-21

**Download the report for Niger, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,035 | 15 | 67 | 0 | 1.75 (95% CI: 1.68-1.86) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

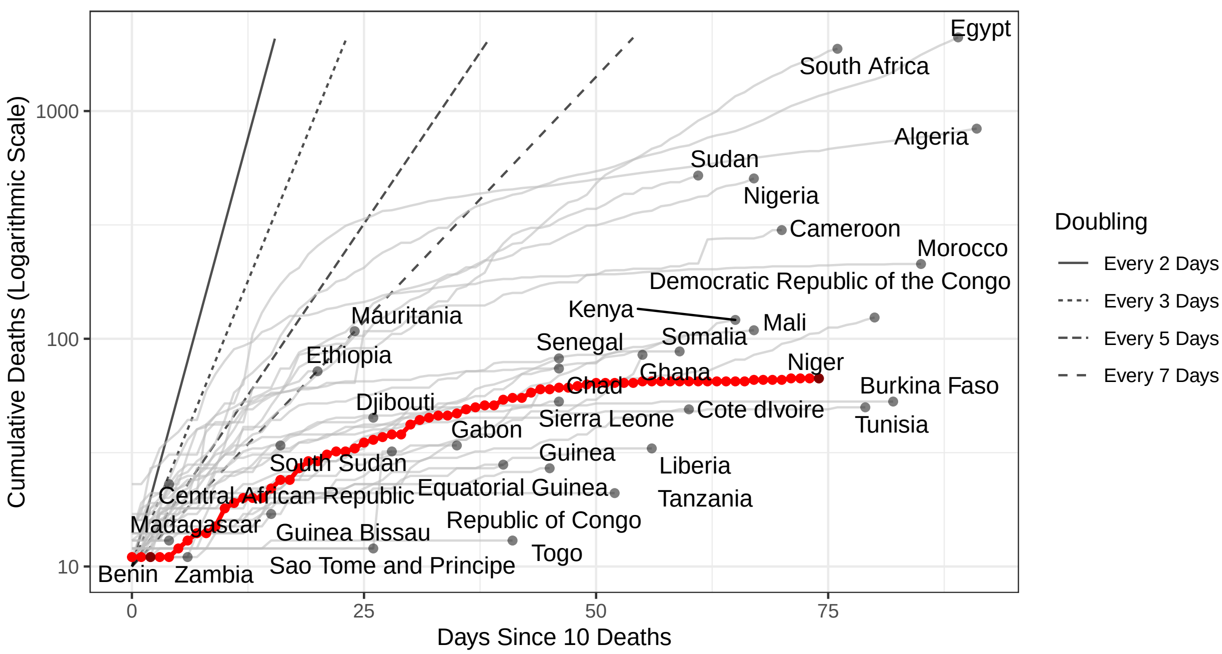


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 29,025 (95% CI: 27,563-30,487) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

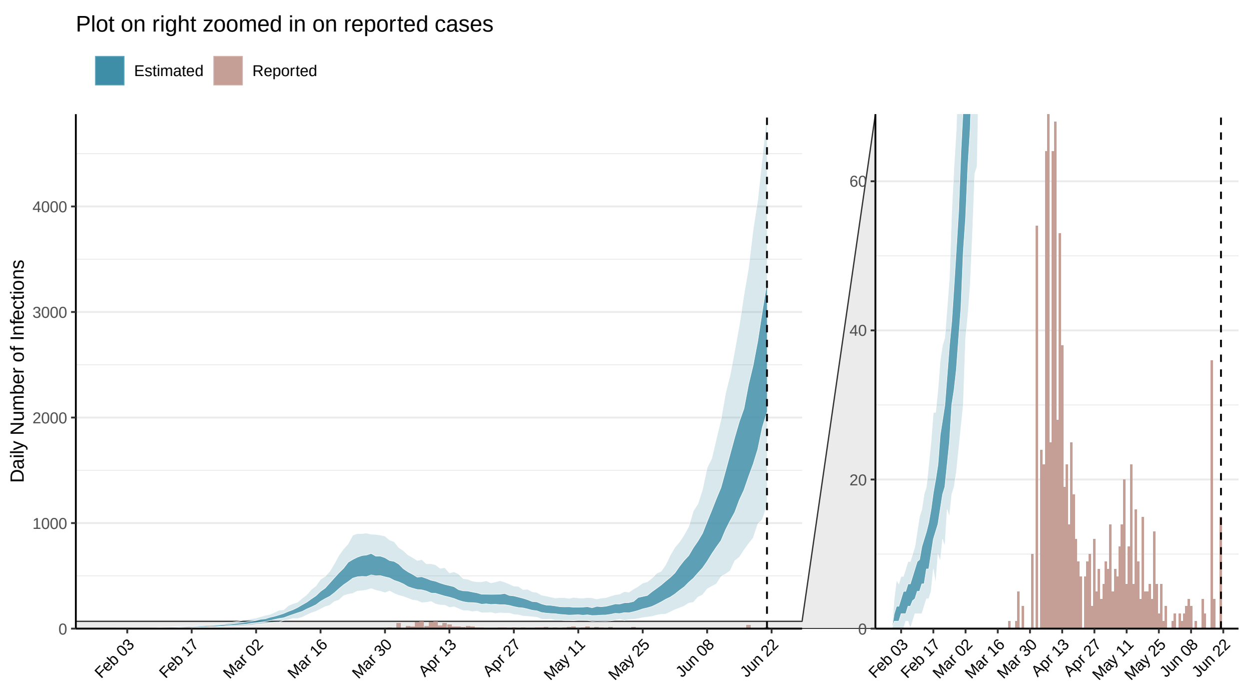


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

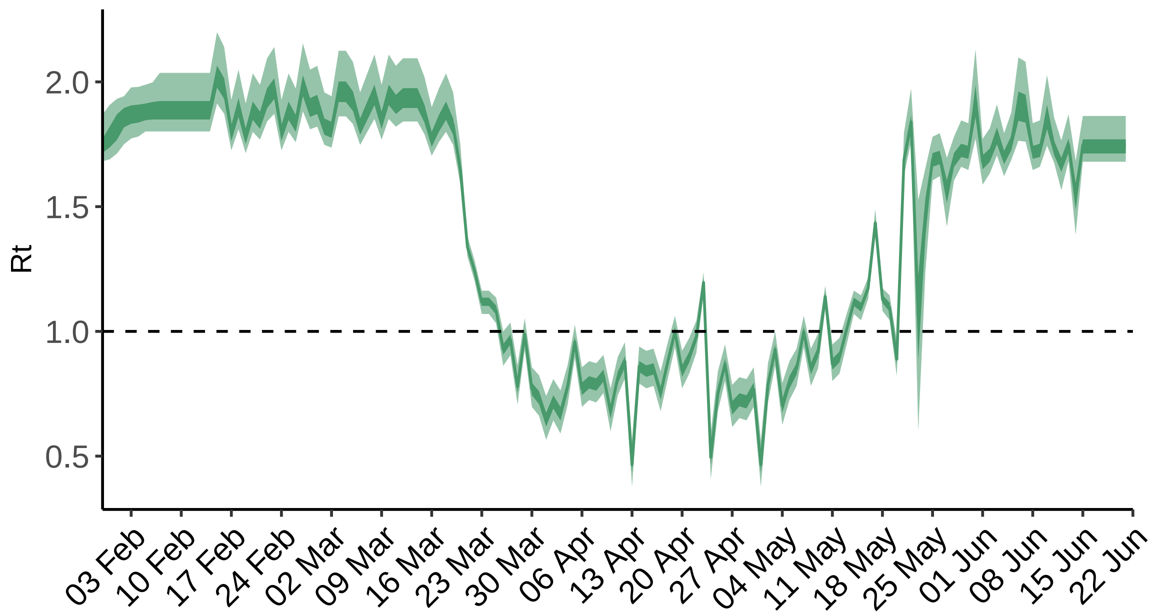


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Niger is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

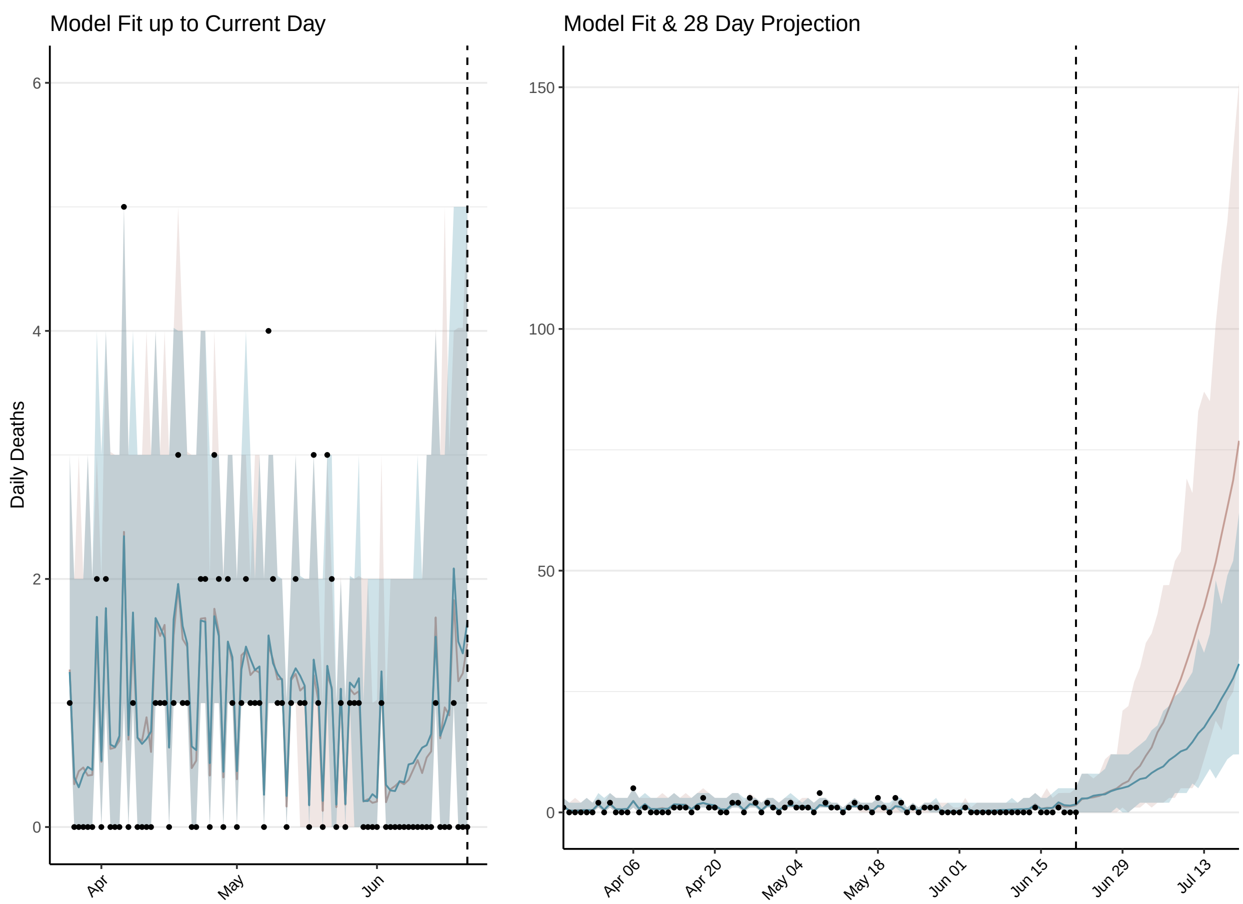


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 158 (95% CI: 150-166) patients requiring treatment with high-pressure oxygen at the current date to 1,934 (95% CI: 1,827-2,042) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 41 (95% CI: 39-43) patients requiring treatment with mechanical ventilation at the current date to 200 (95% CI: 194-205) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

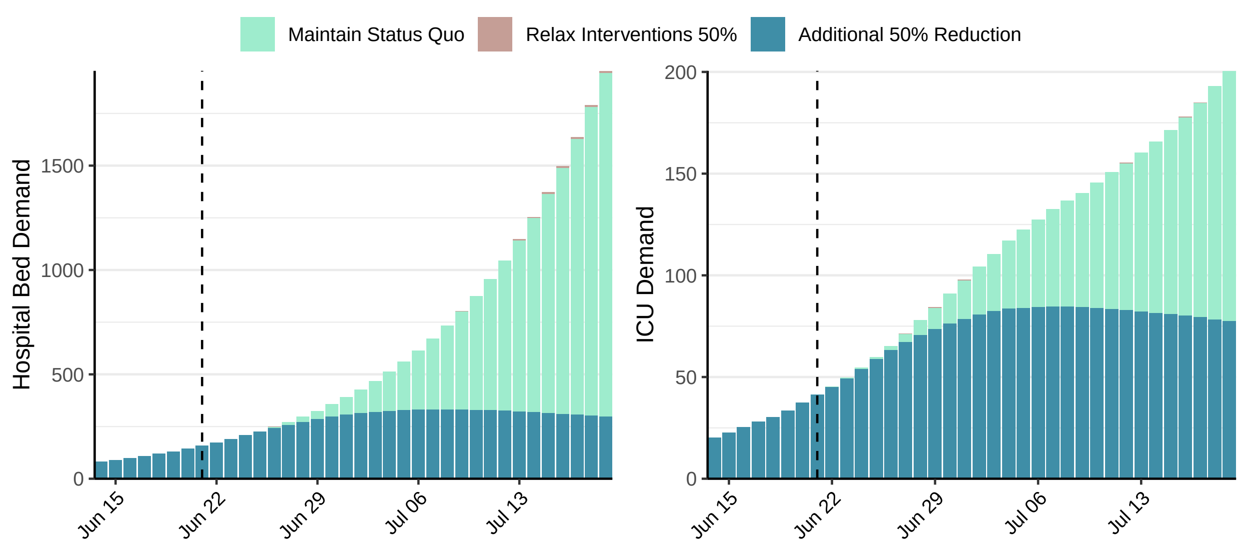


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2,731 (95% CI: 2,591-2,872) at the current date to 1,788 (95% CI: 1,685-1,891) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2,731 (95% CI: 2,591-2,872) at the current date to 34,157 (95% CI: 32,205-36,108) by 2020-07-19.

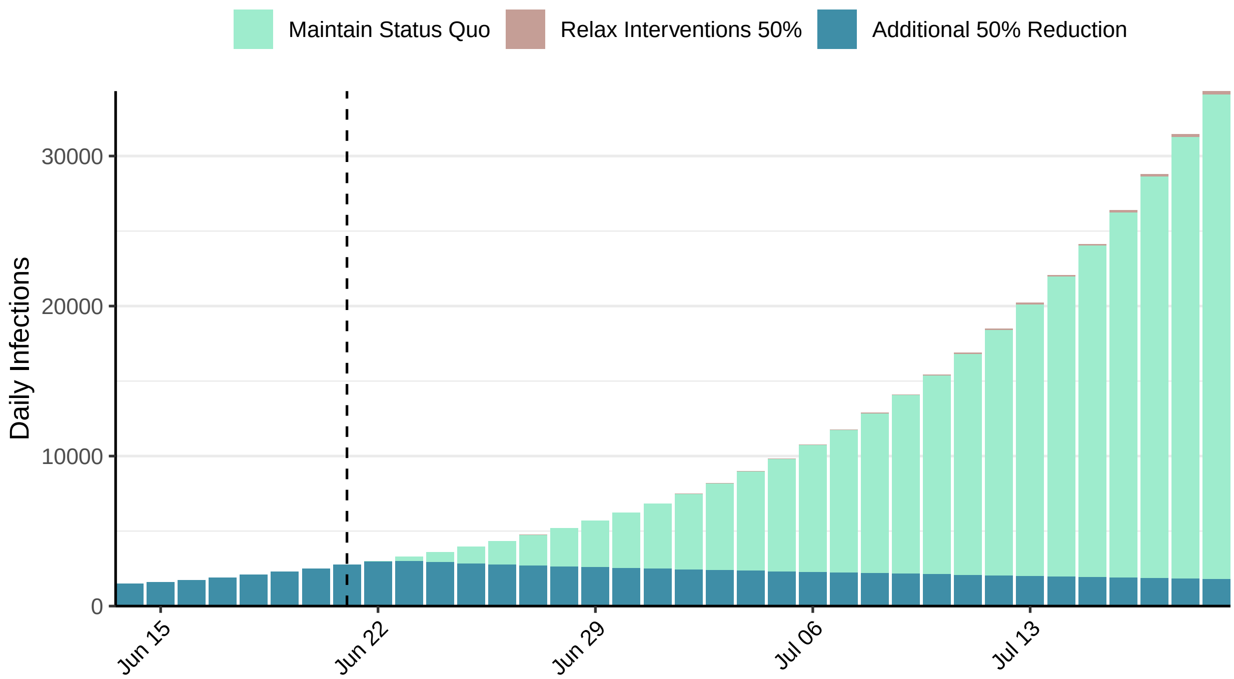


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Nigeria, 2020-06-21

**Download the report for Nigeria, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 19,808 | 661 | 506 | 19 | 1.36 (95% CI: 1.23-1.48) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

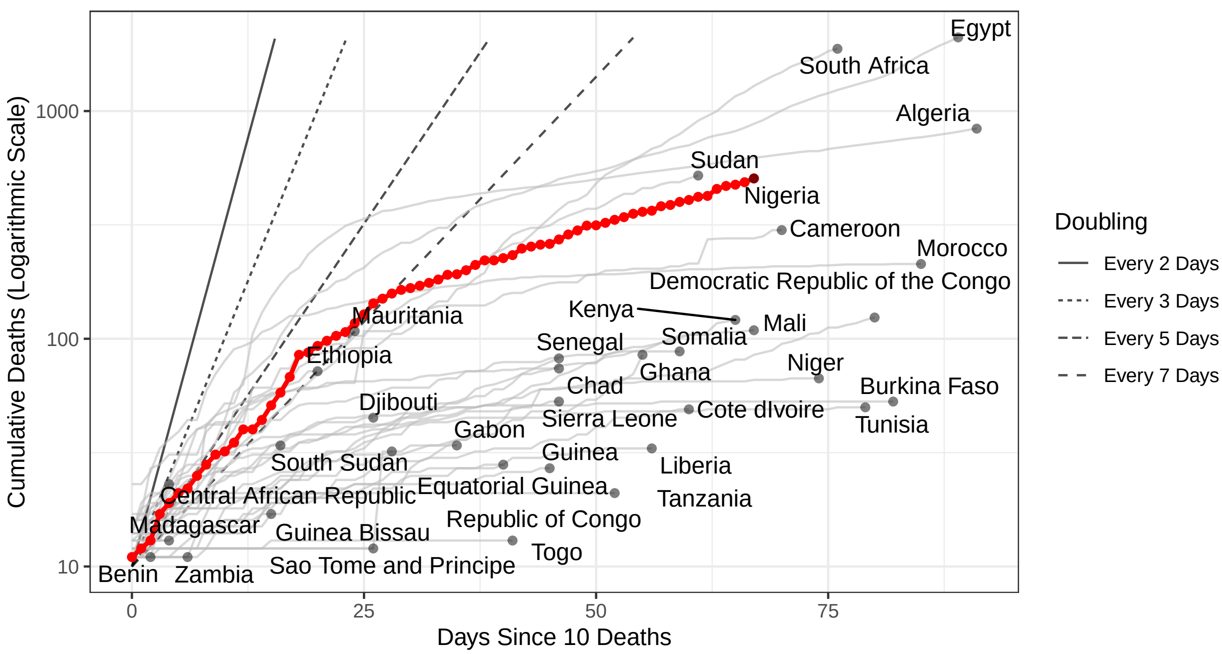


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 193,359 (95% CI: 186,444-200,274) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

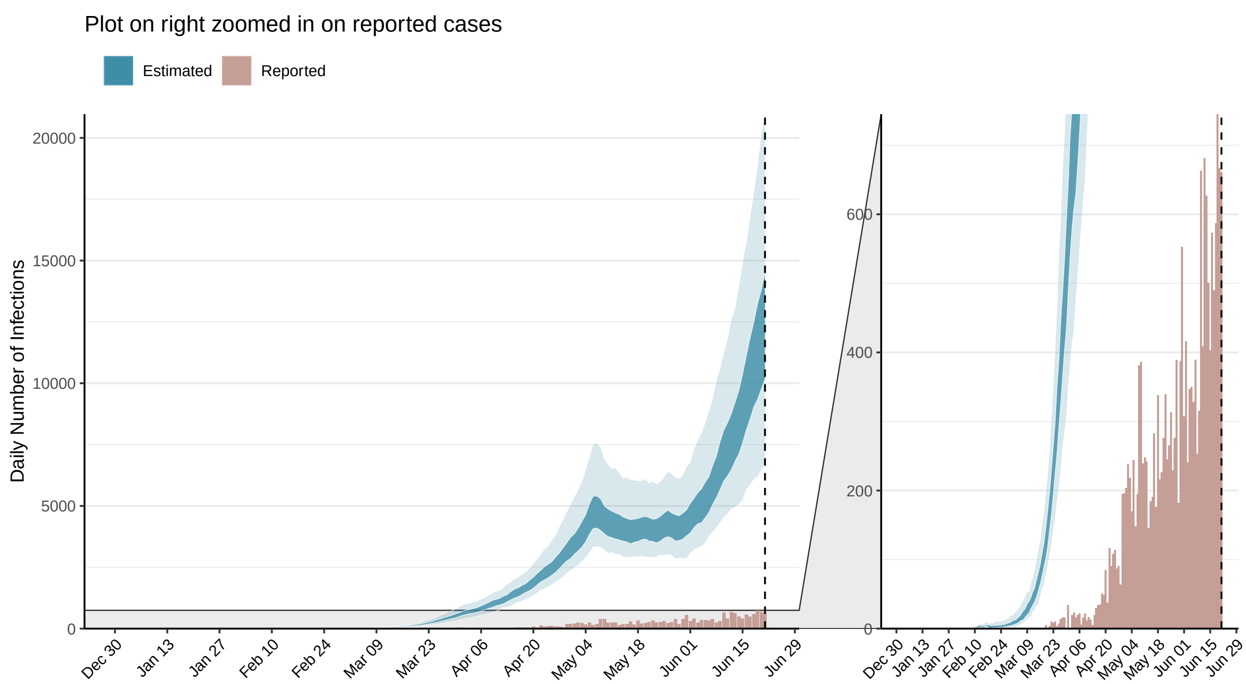


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

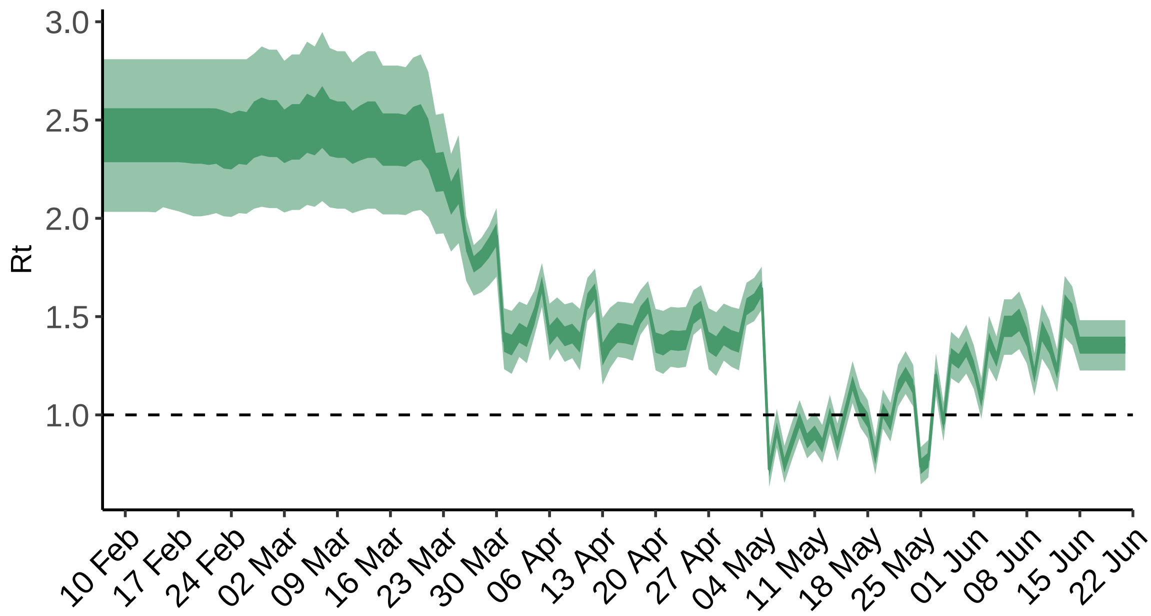


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

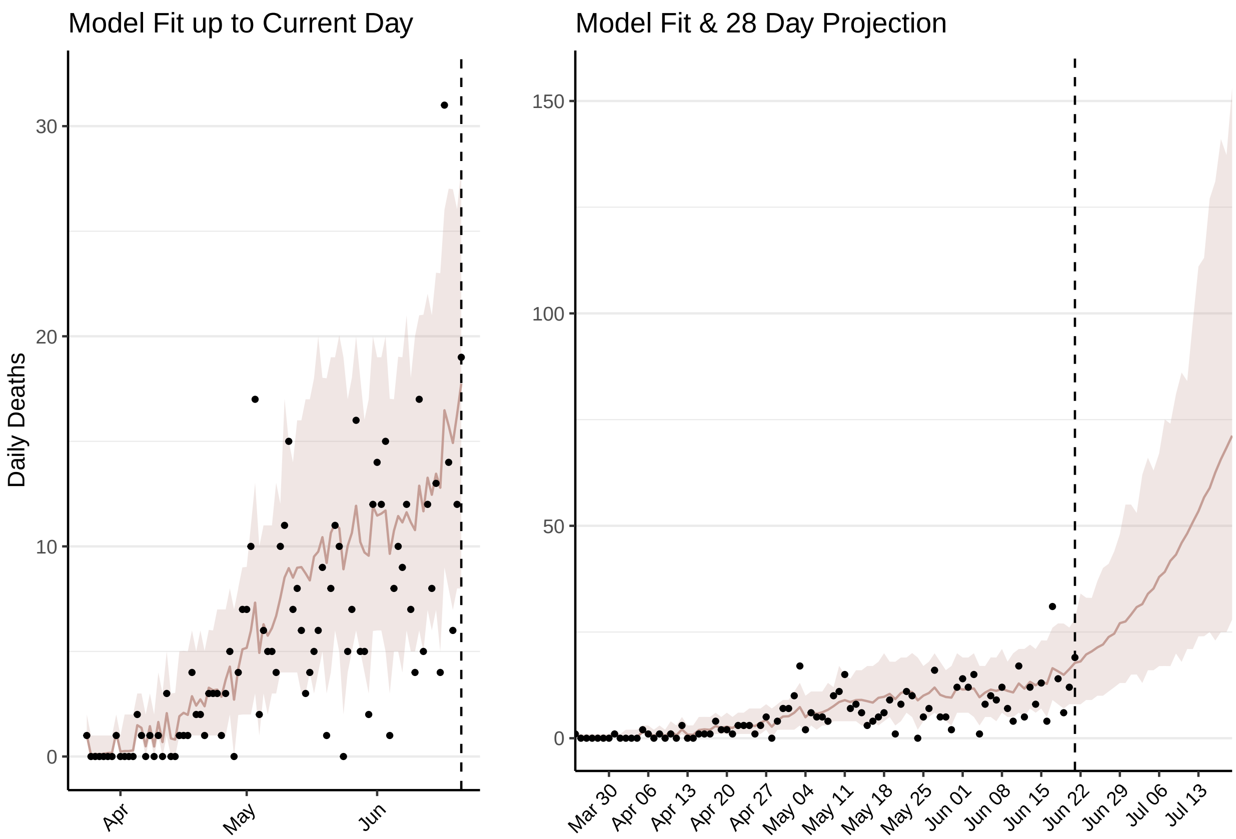


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,080 (95% CI: 1,041-1,119) patients requiring treatment with high-pressure oxygen at the current date to 4,467 (95% CI: 4,180-4,755) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 279 (95% CI: 268-289) patients requiring treatment with mechanical ventilation at the current date to 1,147 (95% CI: 1,074-1,220) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

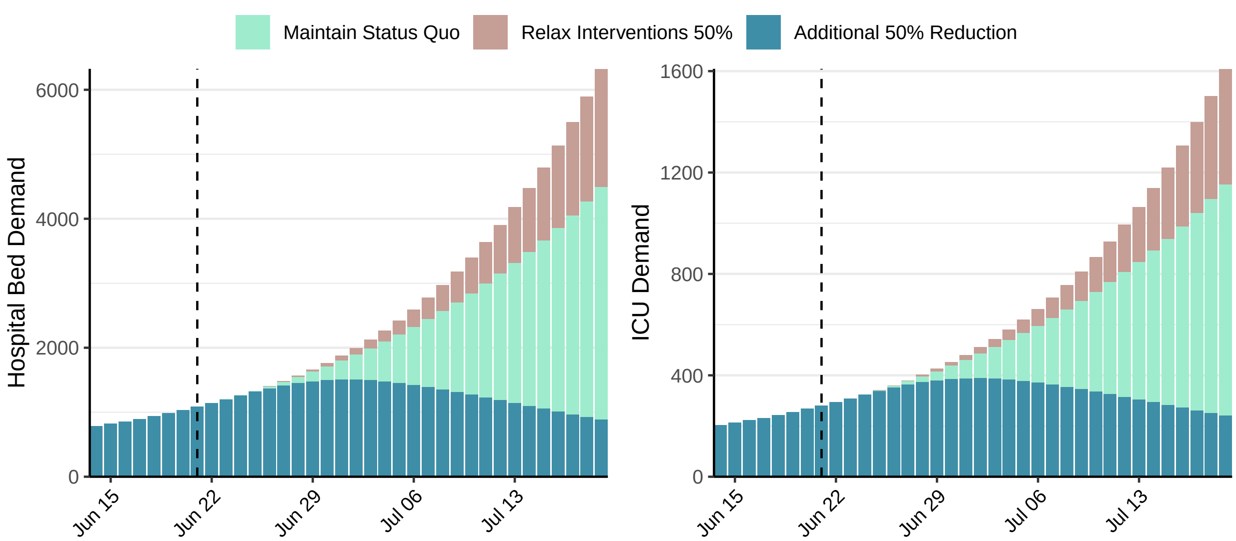


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 12,487 (95% CI: 11,936-13,038) at the current date to 3,312 (95% CI: 3,084-3,539) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 12,487 (95% CI: 11,936-13,038) at the current date to 85,656 (95% CI: 79,155-92,157) by 2020-07-19.

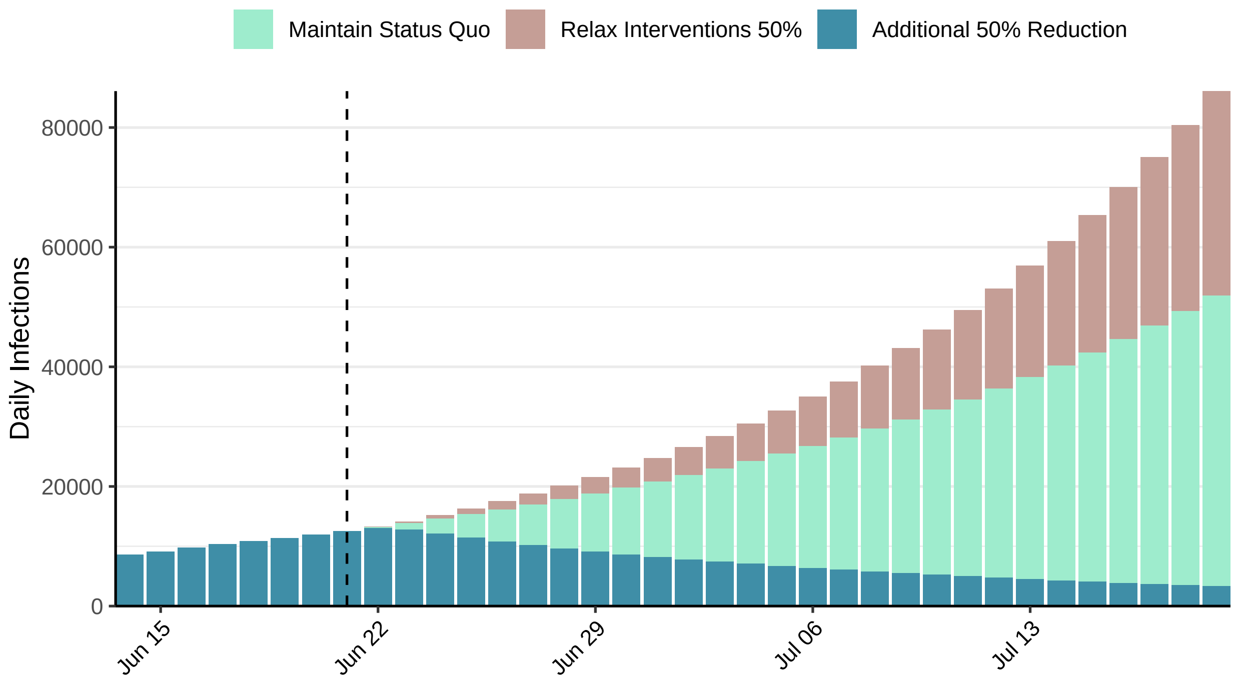


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Nicaragua, 2020-06-21

**Download the report for Nicaragua, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,014 | 0 | 64 | 0 | 1.26 (95% CI: 0.49-2.37) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

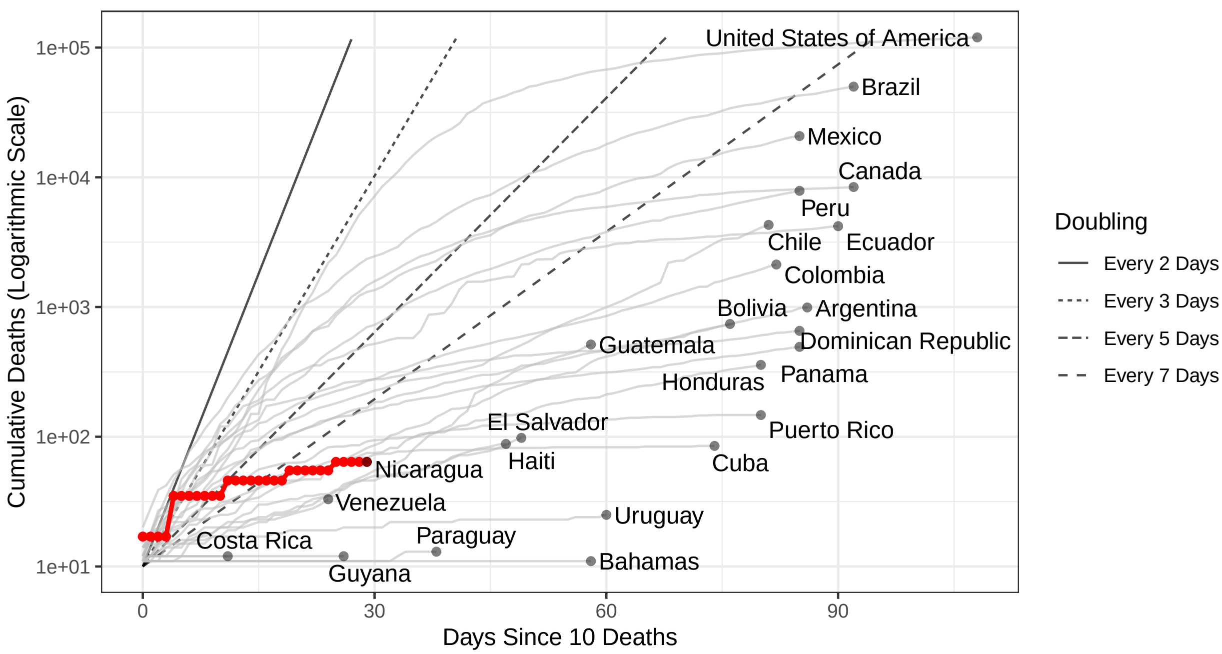


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 21,816 (95% CI: 20,309-23,323) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

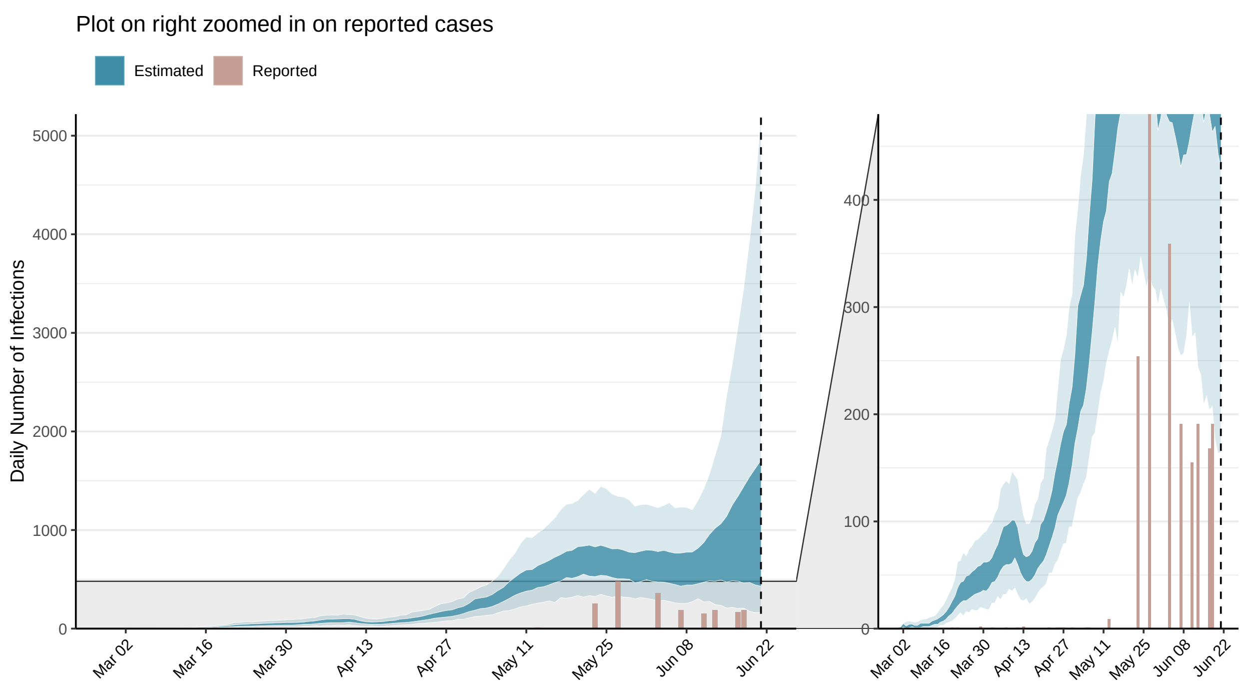


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

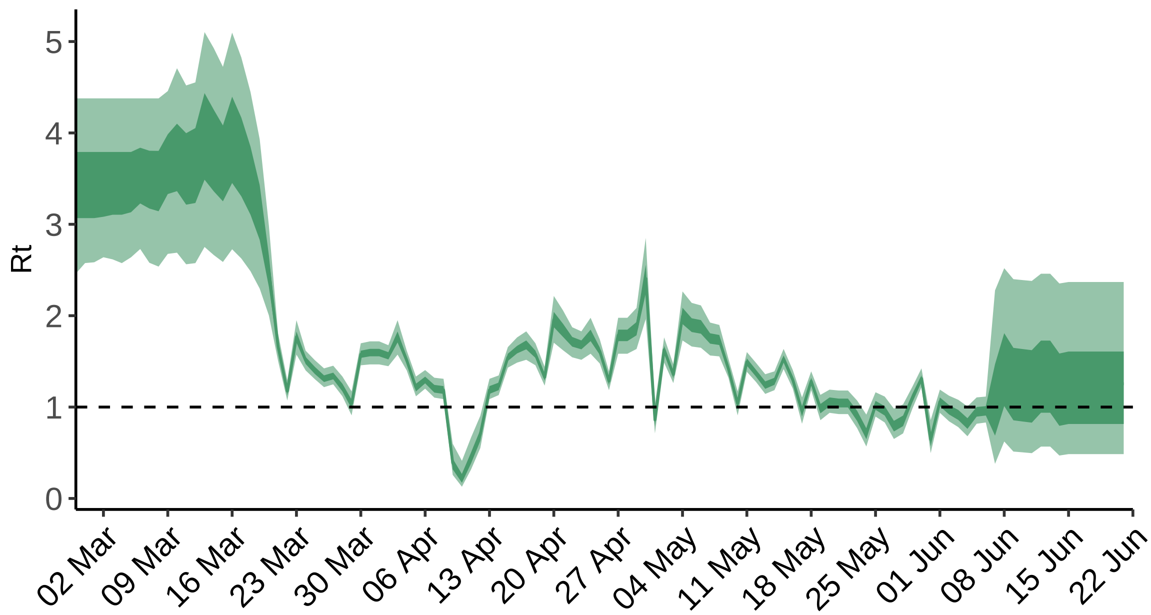


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Nicaragua is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

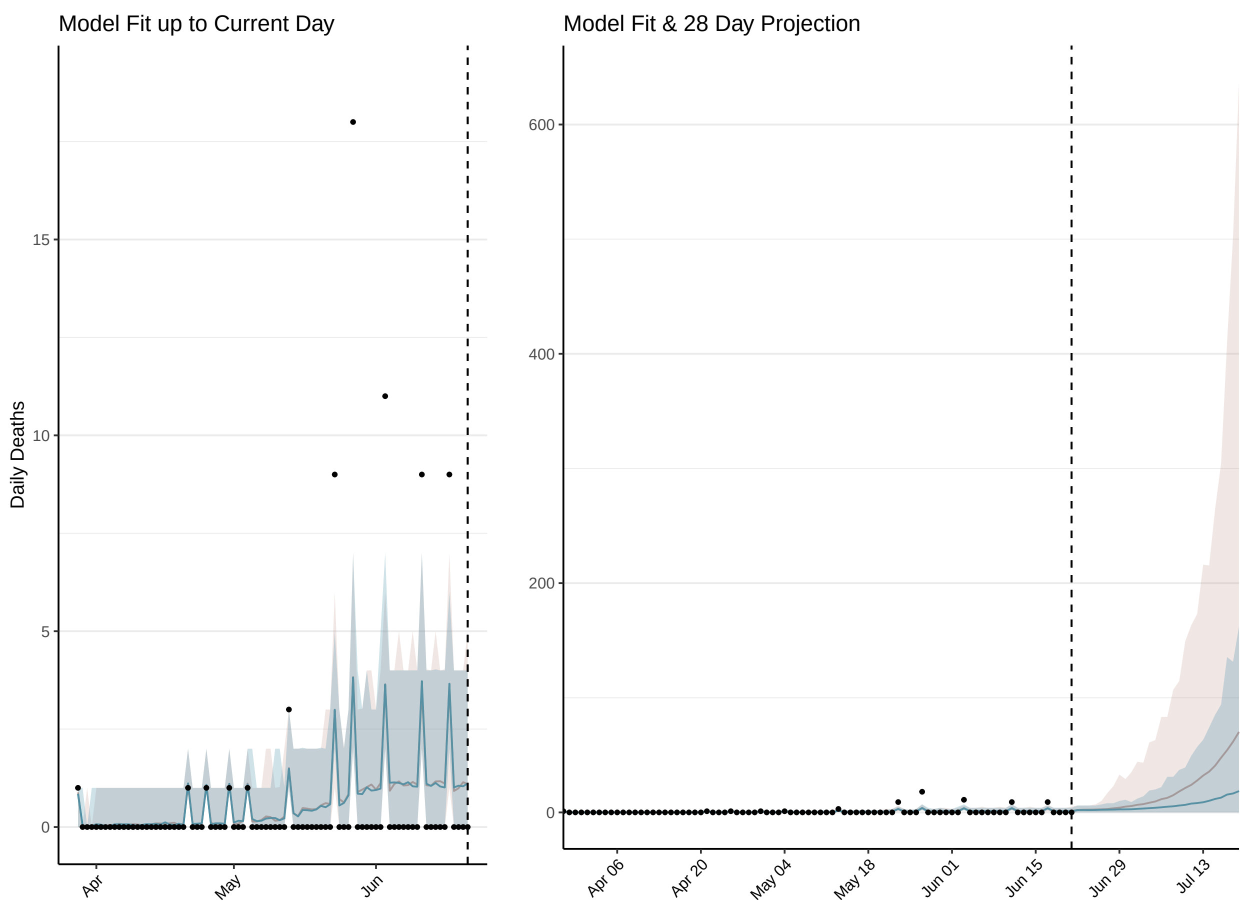


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 104 (95% CI: 97-112) patients requiring treatment with high-pressure oxygen at the current date to 1,064 (95% CI: 745-1,383) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 30 (95% CI: 28-32) patients requiring treatment with mechanical ventilation at the current date to 111 (95% CI: 86-136) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

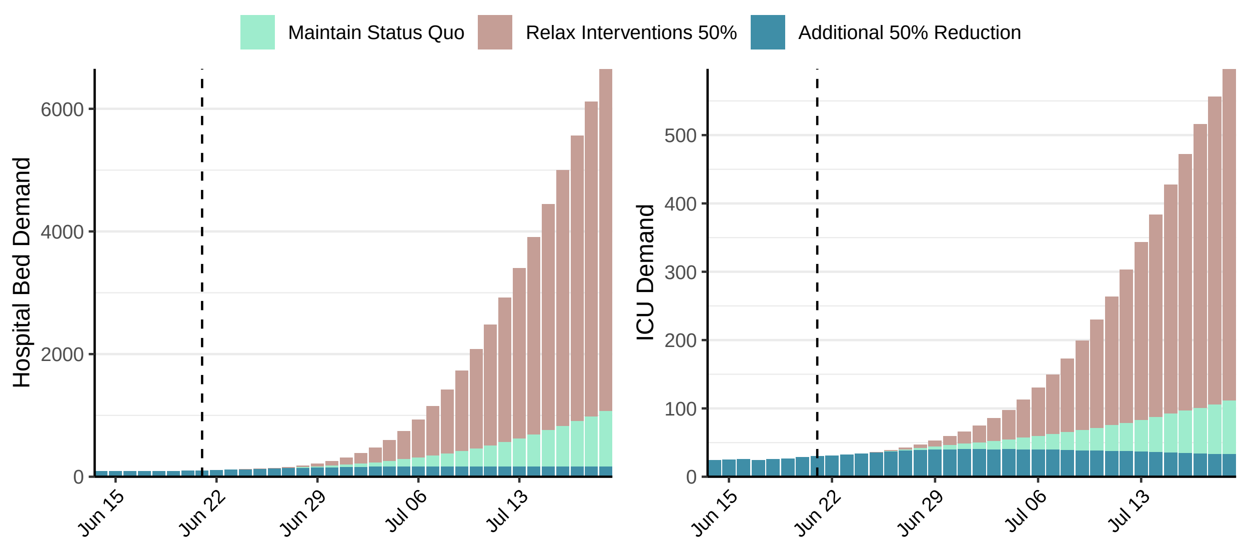


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 1,349 (95% CI: 1,143-1,556) at the current date to 1,279 (95% CI: 690-1,868) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 1,349 (95% CI: 1,143-1,556) at the current date to 106,264 (95% CI: 89,601-122,927) by 2020-07-19.

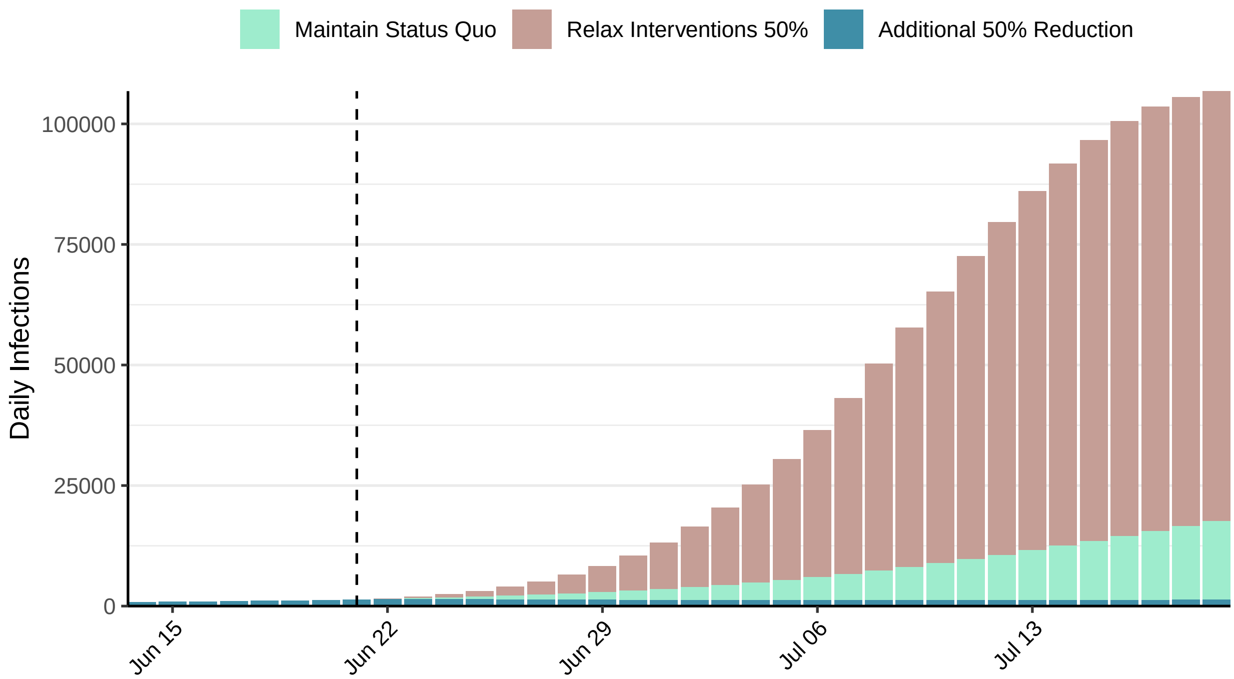


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Nepal, 2020-06-21

**Download the report for Nepal, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 8,605 | 331 | 22 | 0 | 1.38 (95% CI: 1.1-1.68) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

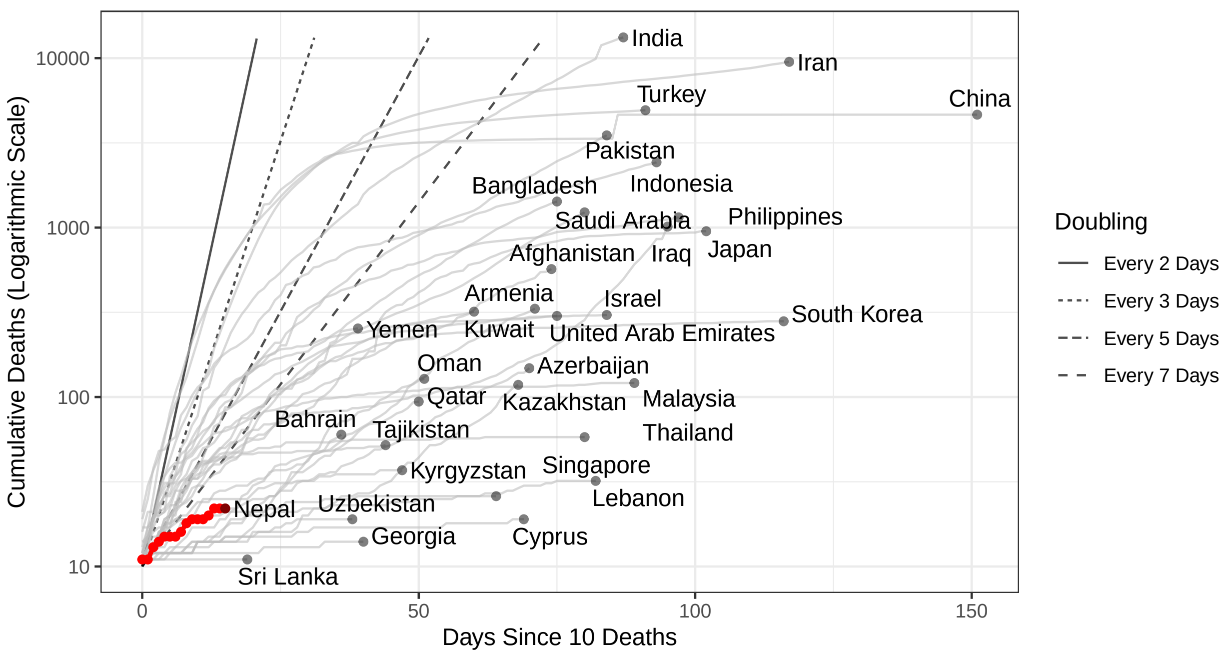


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

## COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 9,969 (95% CI: 9,367-10,571) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

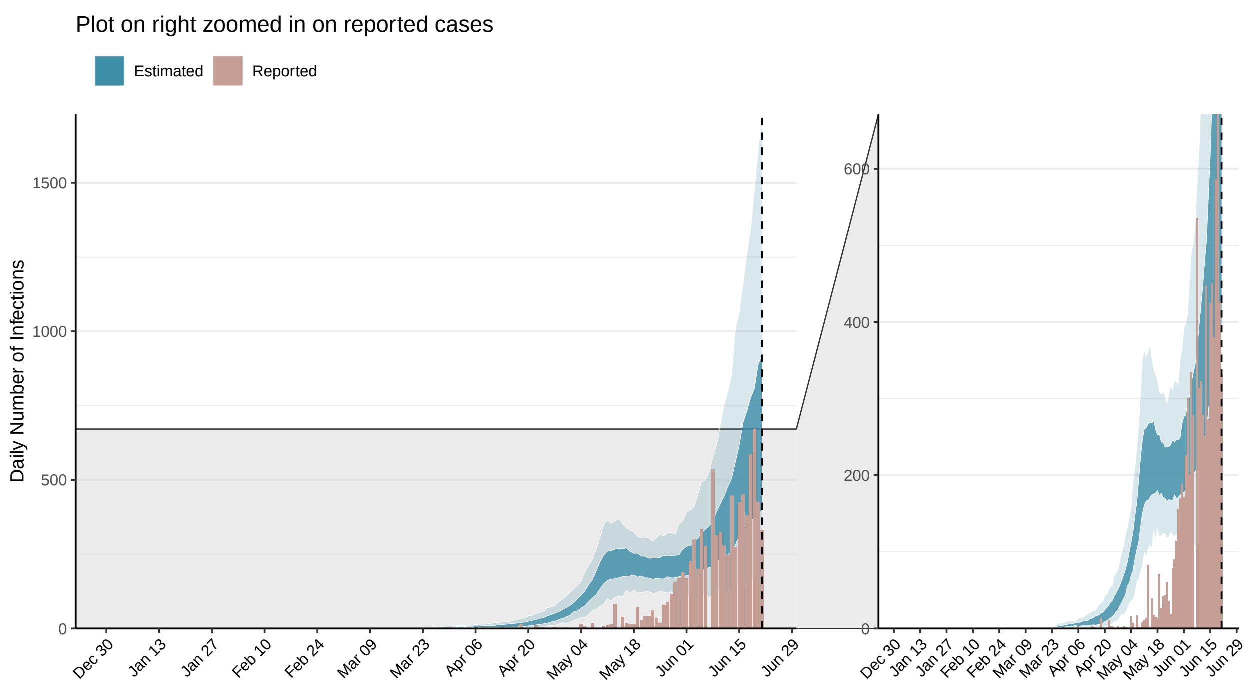


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

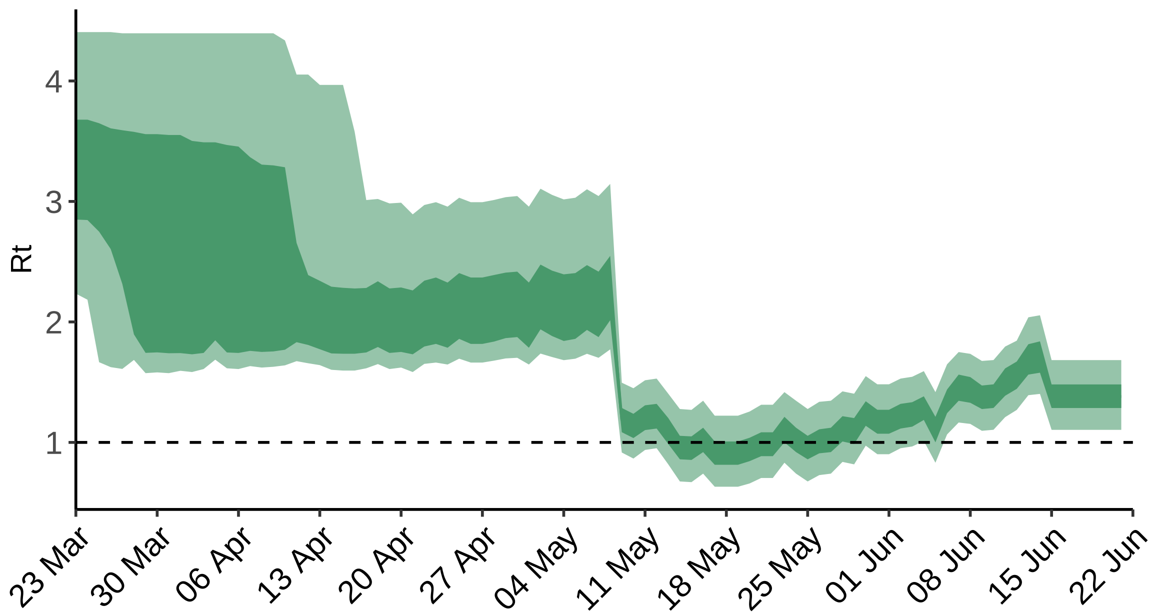


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

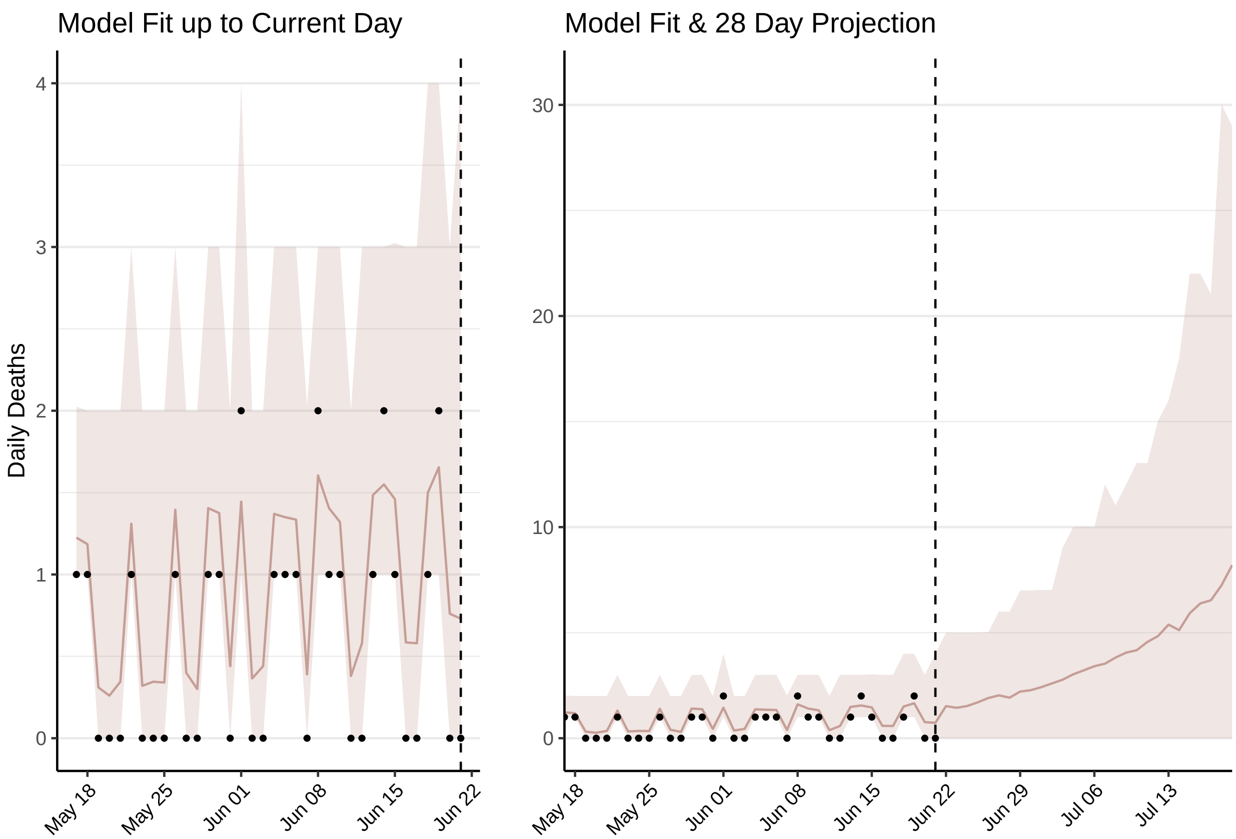


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 70 (95% CI: 66-75) patients requiring treatment with high-pressure oxygen at the current date to 405 (95% CI: 353-458) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 21 (95% CI: 20-23) patients requiring treatment with mechanical ventilation at the current date to 122 (95% CI: 107-137) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

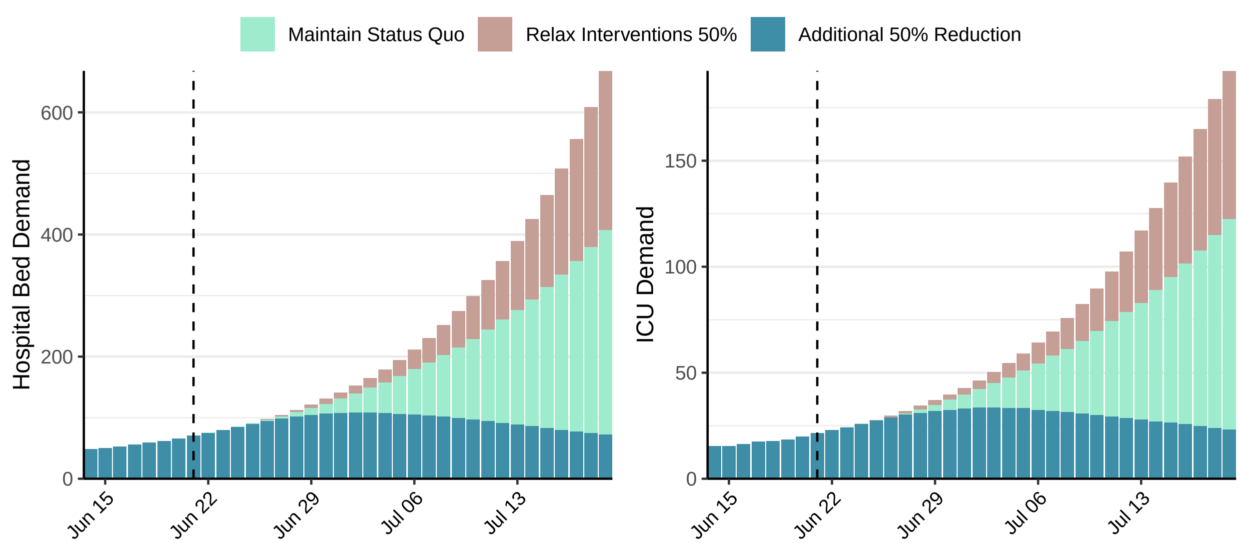


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 711 (95% CI: 653-769) at the current date to 248 (95% CI: 214-283) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 711 (95% CI: 653-769) at the current date to 8,556 (95% CI: 7,213-9,899) by 2020-07-19.

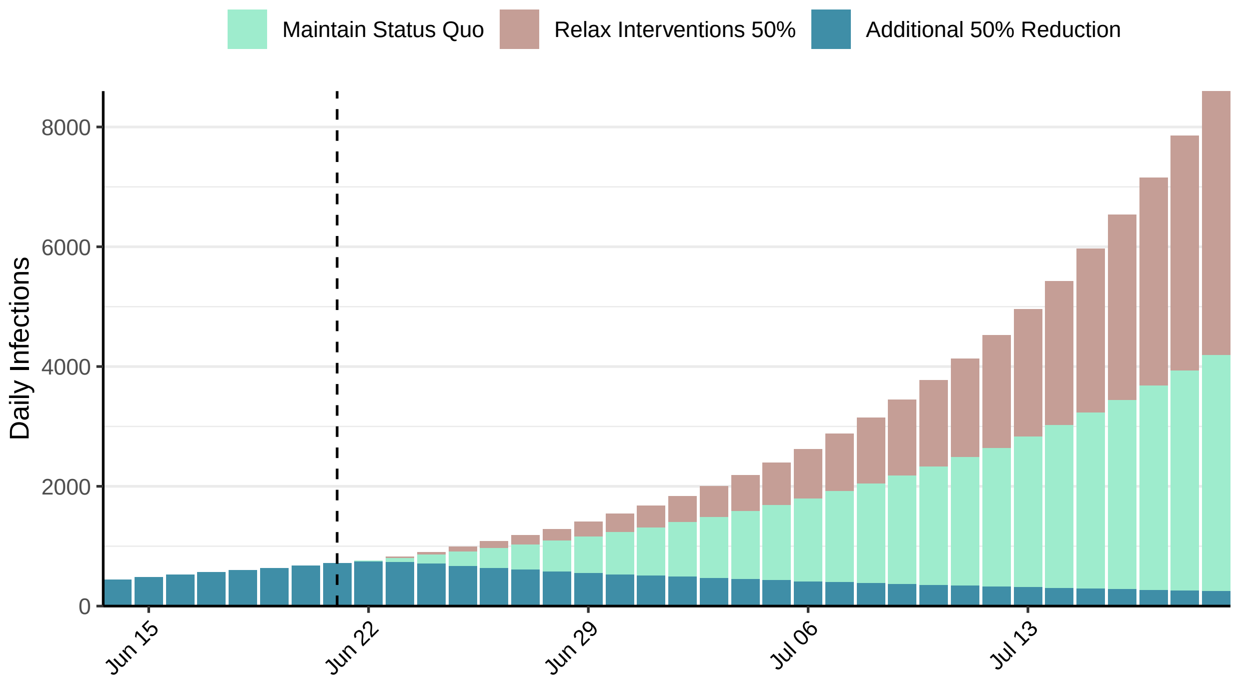


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Pakistan, 2020-06-21

**Download the report for Pakistan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 176,617 | 4,951 | 3,501 | 119 | 1.54 (95% CI: 1.49-1.59) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

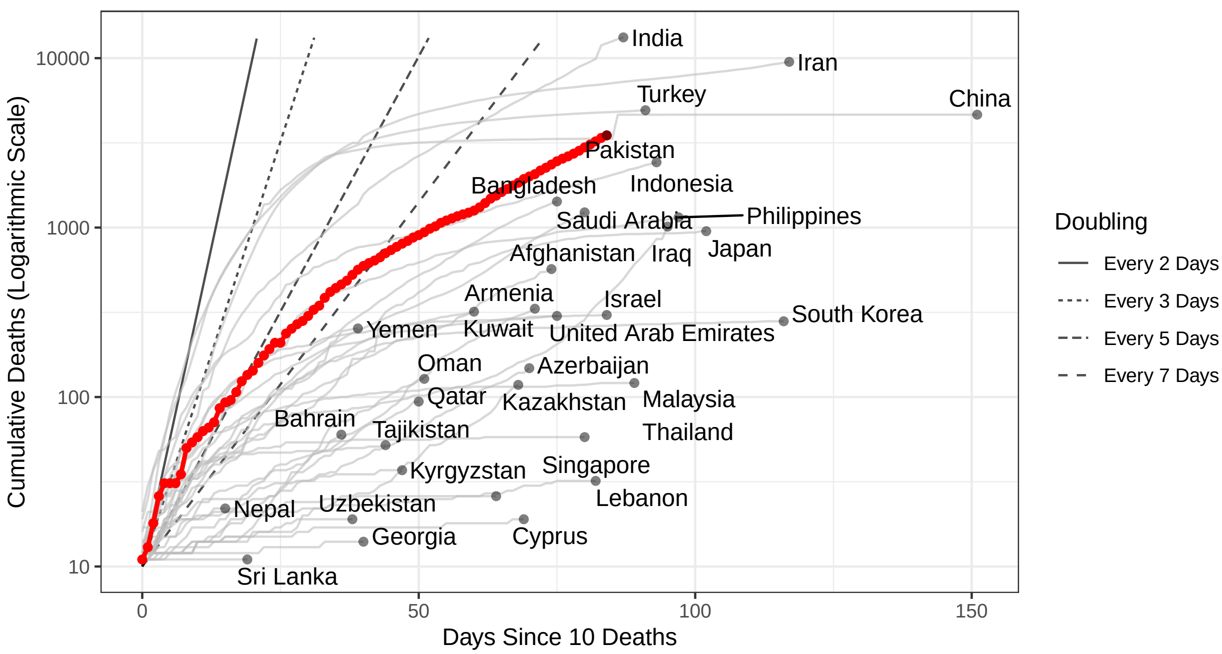


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,599,234 (95% CI: 1,563,384-1,635,083) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

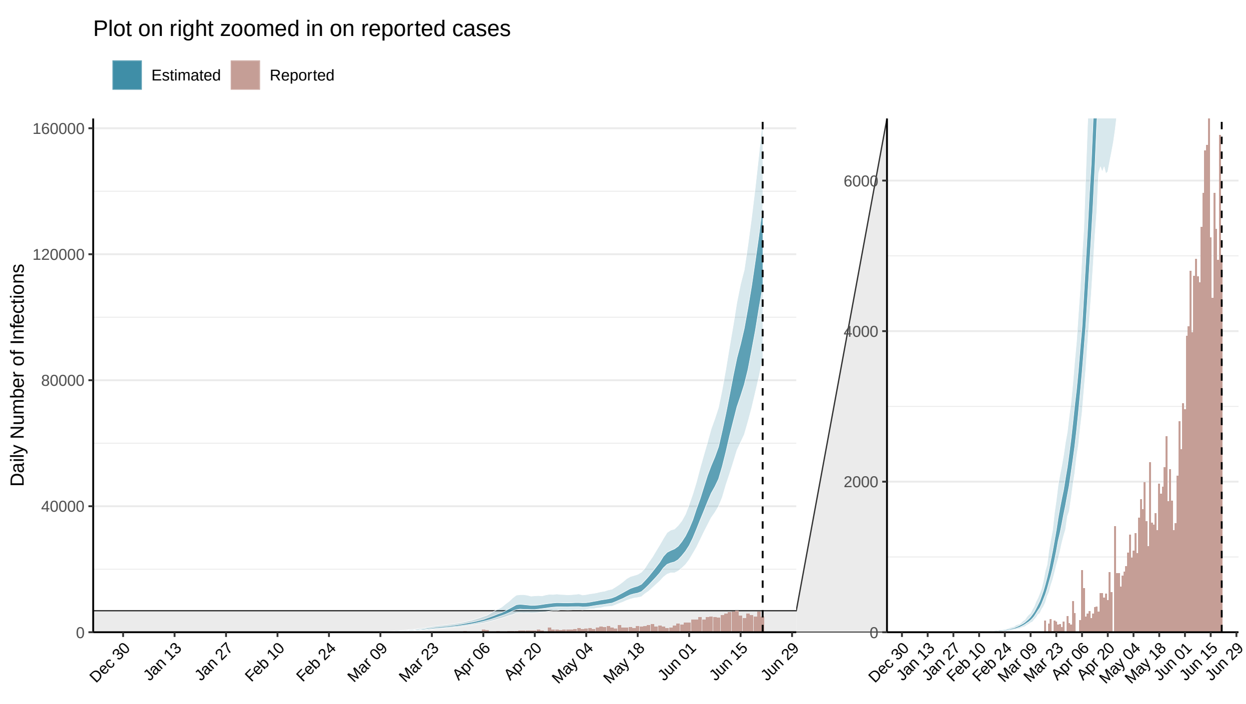


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

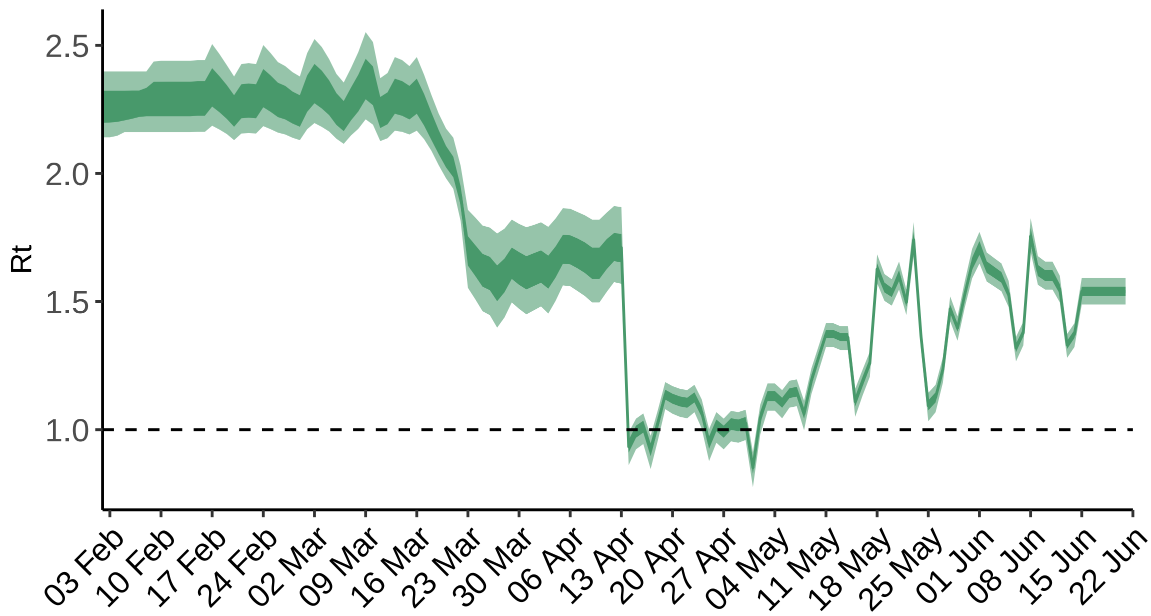


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Pakistan is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

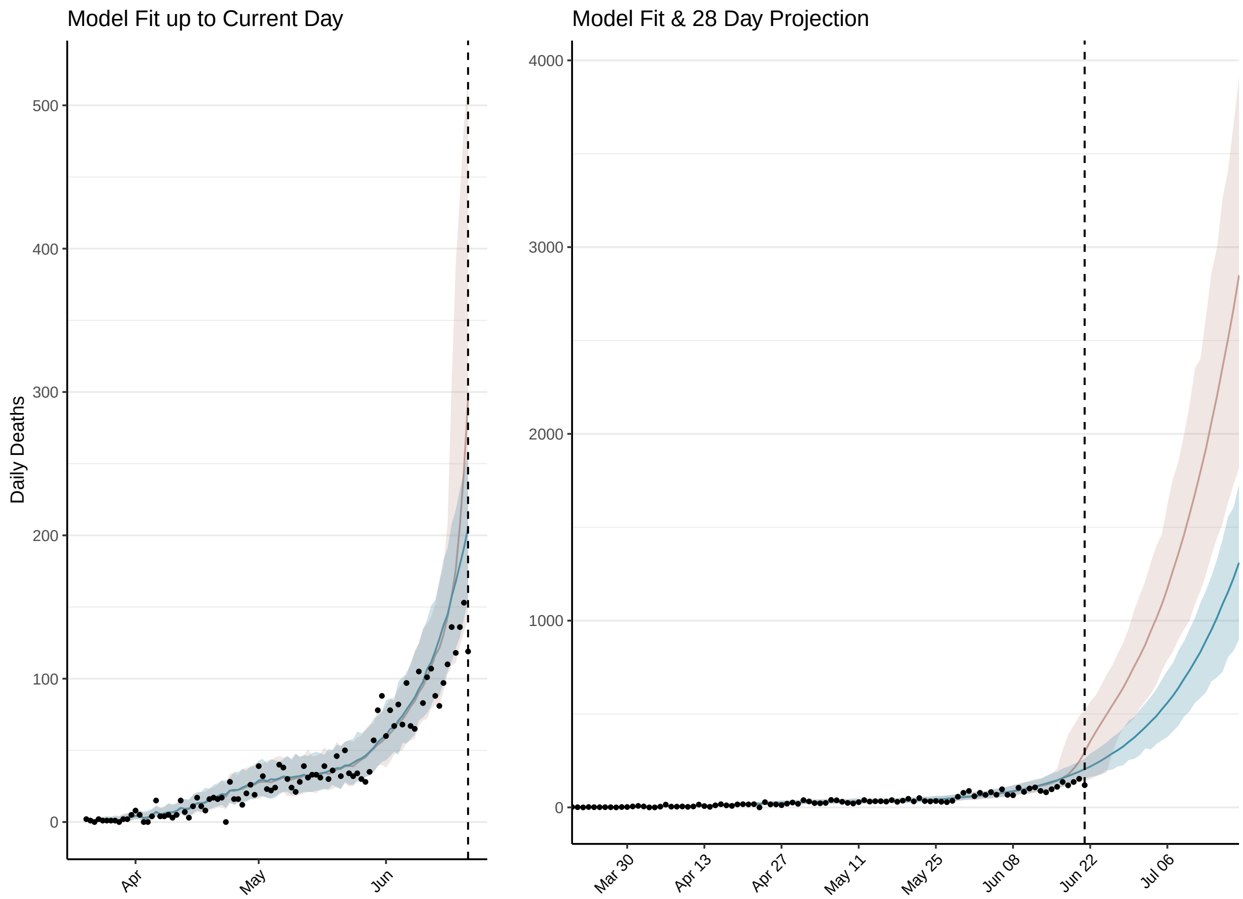


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 11,034 (95% CI: 10,785-11,282) patients requiring treatment with high-pressure oxygen at the current date to 67,587 (95% CI: 65,744-69,431) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 3,045 (95% CI: 2,999-3,091) patients requiring treatment with mechanical ventilation at the current date to 6,023 (95% CI: 5,916-6,130) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

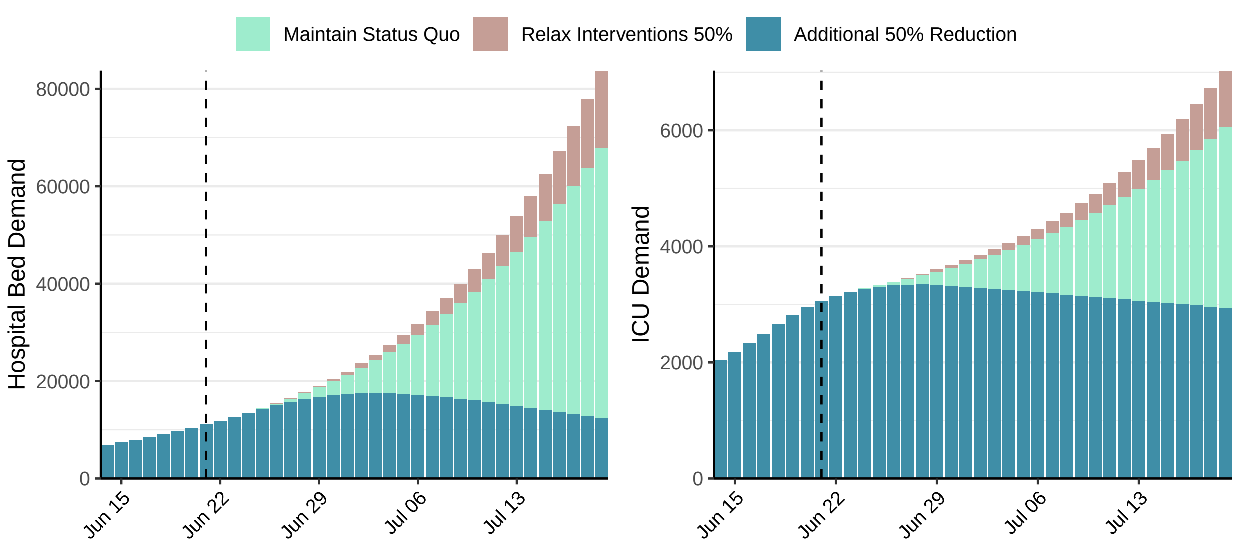


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 122,000 (95% CI: 119,066-124,934) at the current date to 46,743 (95% CI: 45,388-48,097) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 122,000 (95% CI: 119,066-124,934) at the current date to 987,940 (95% CI: 960,120-1,015,761) by 2020-07-19.

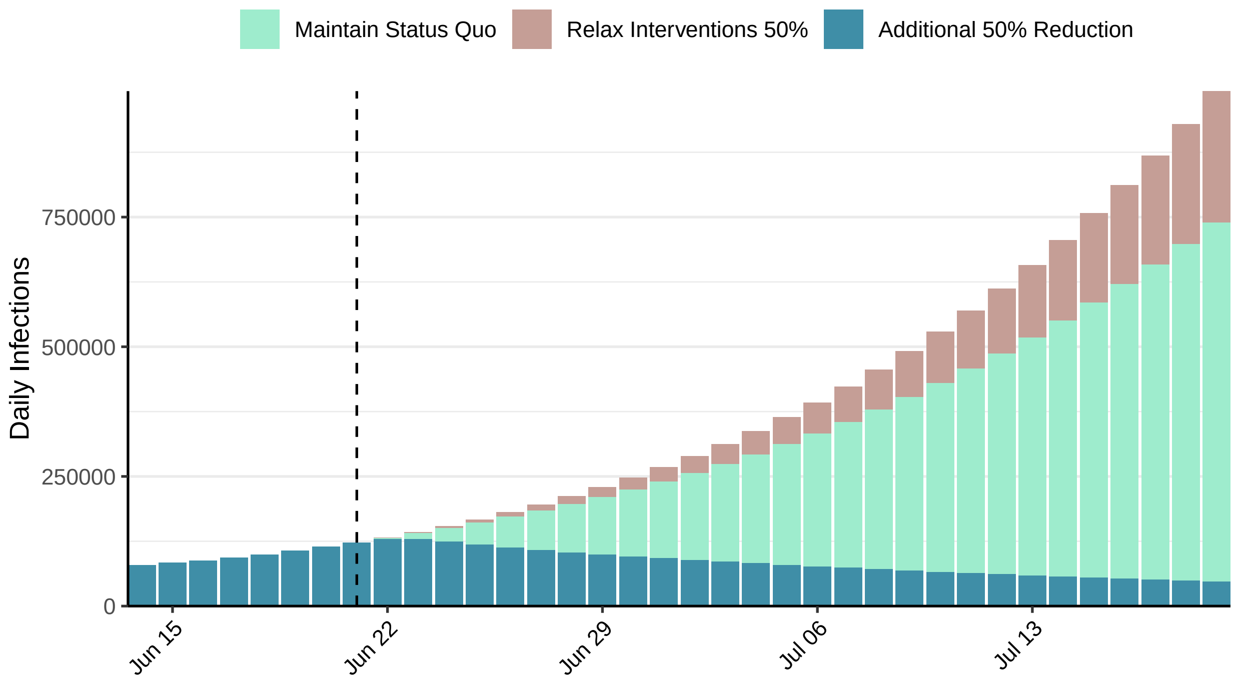


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Panama, 2020-06-21

**Download the report for Panama, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 25,222 | 948 | 493 | 8 | 1.41 (95% CI: 1.3-1.52) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

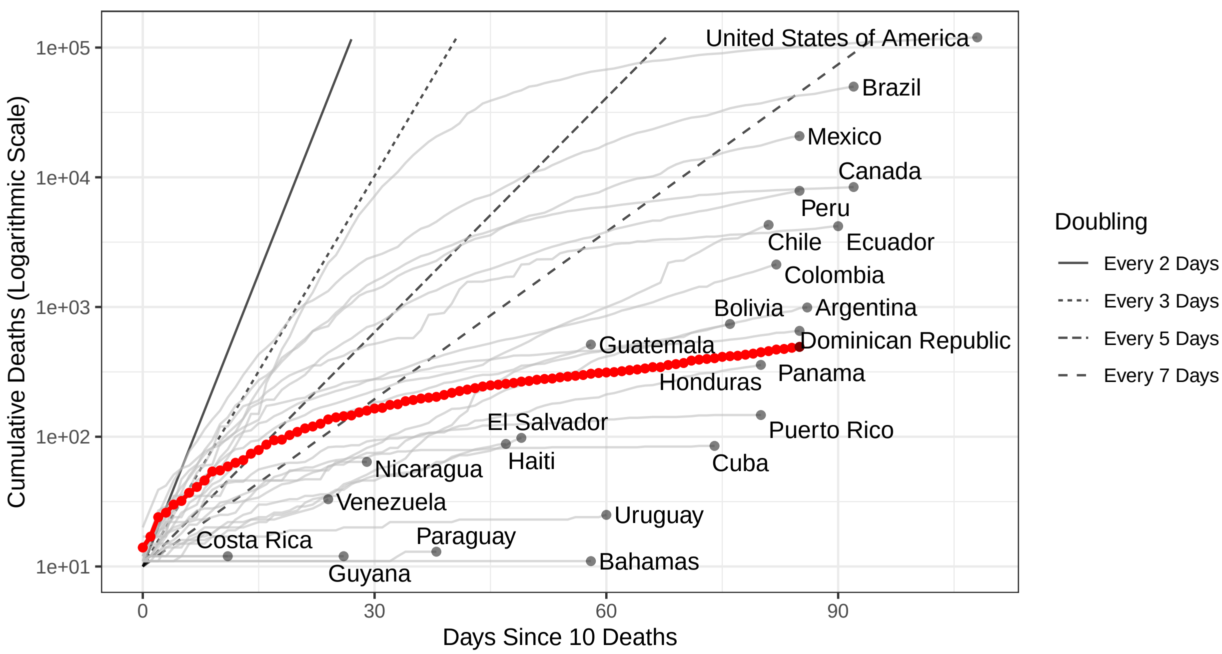


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 100,229 (95% CI: 97,166-103,292) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

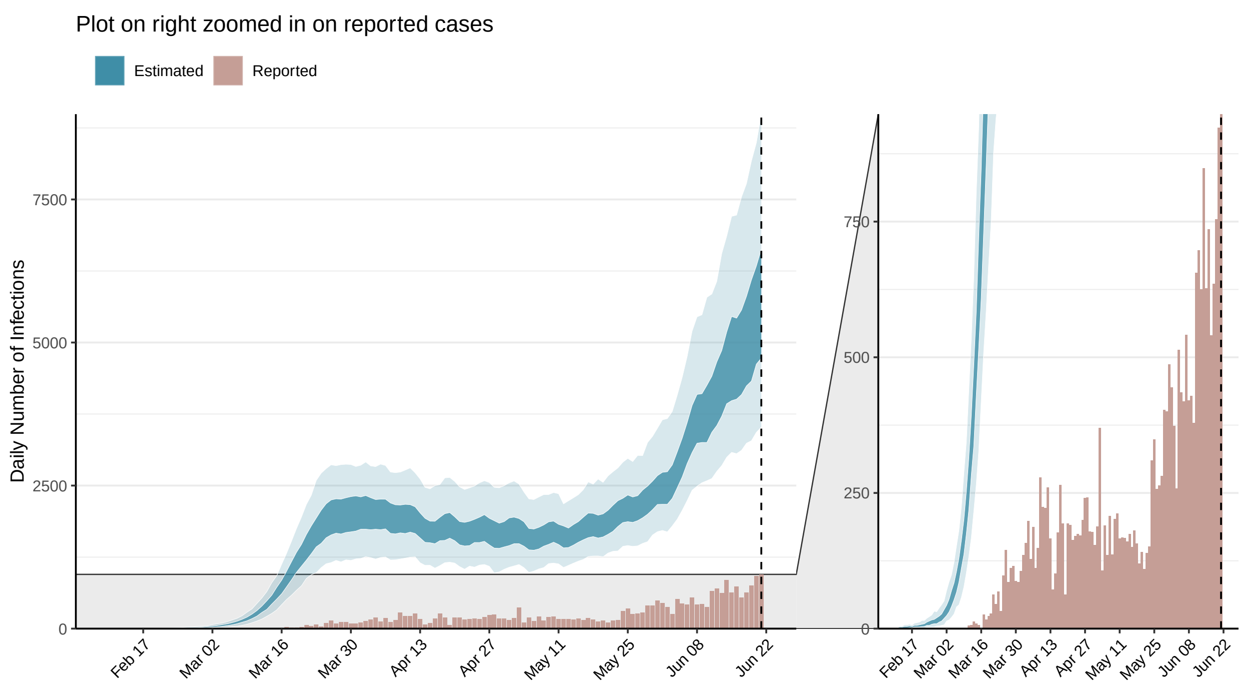


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

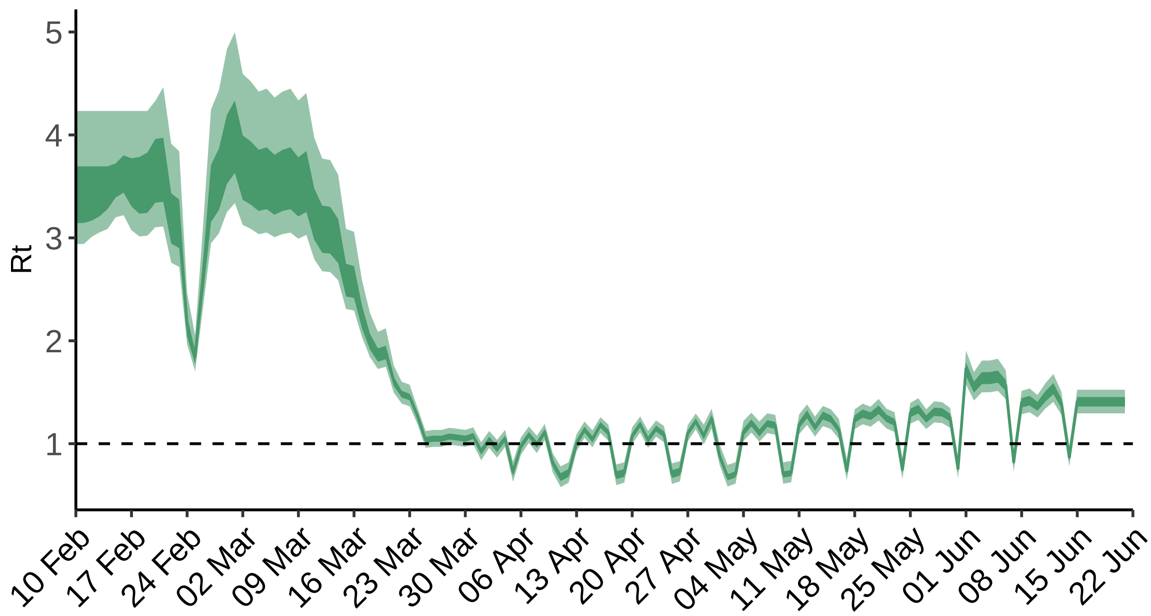


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Panama is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

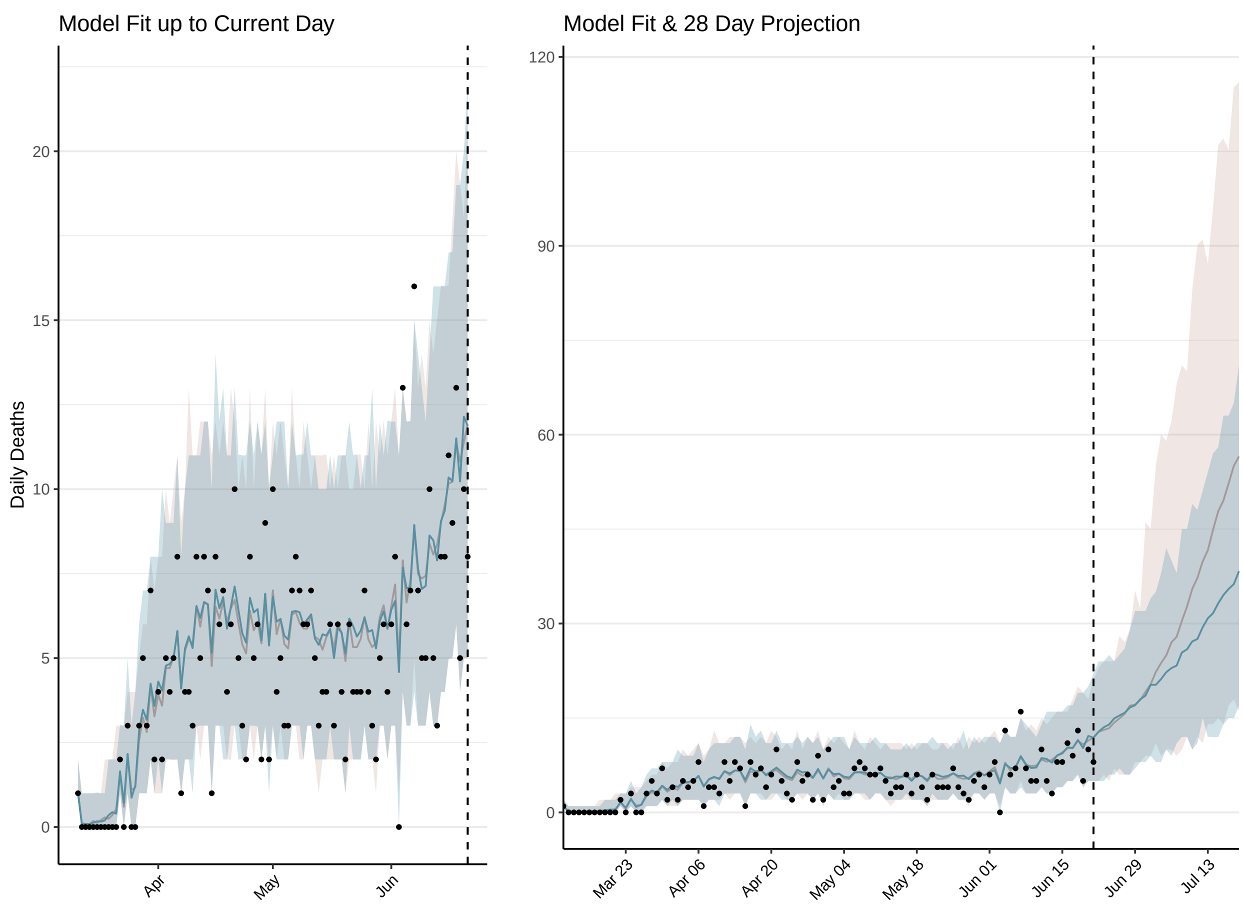


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 602 (95% CI: 582-621) patients requiring treatment with high-pressure oxygen at the current date to 1,760 (95% CI: 1,680-1,841) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 191 (95% CI: 184-197) patients requiring treatment with mechanical ventilation at the current date to 417 (95% CI: 409-425) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

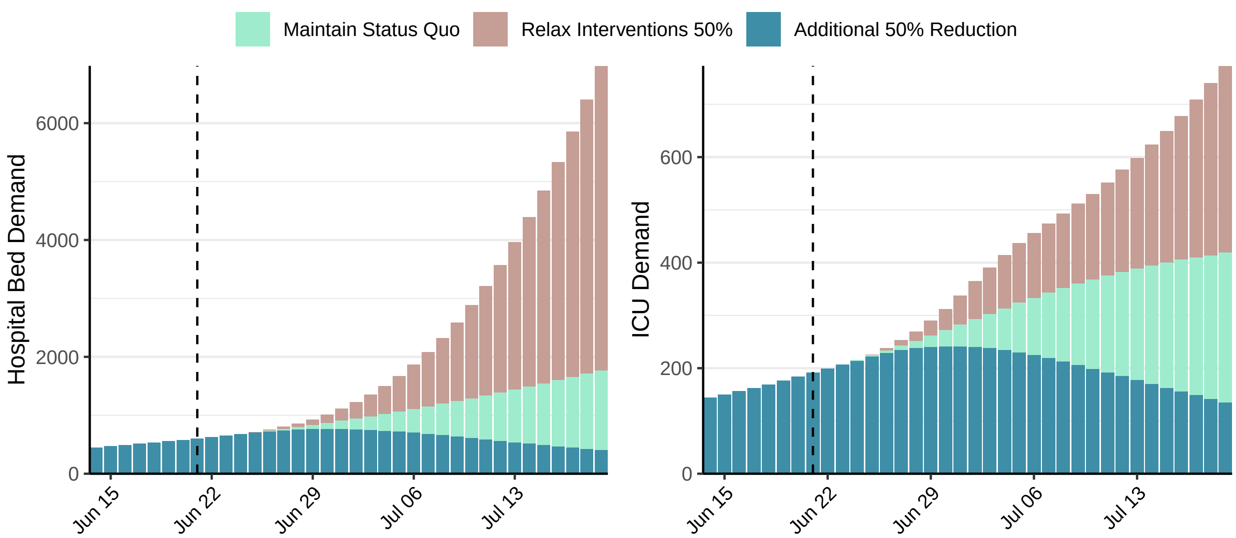


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 5,822 (95% CI: 5,608-6,037) at the current date to 1,180 (95% CI: 1,122-1,238) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 5,822 (95% CI: 5,608-6,037) at the current date to 78,153 (95% CI: 76,035-80,272) by 2020-07-19.

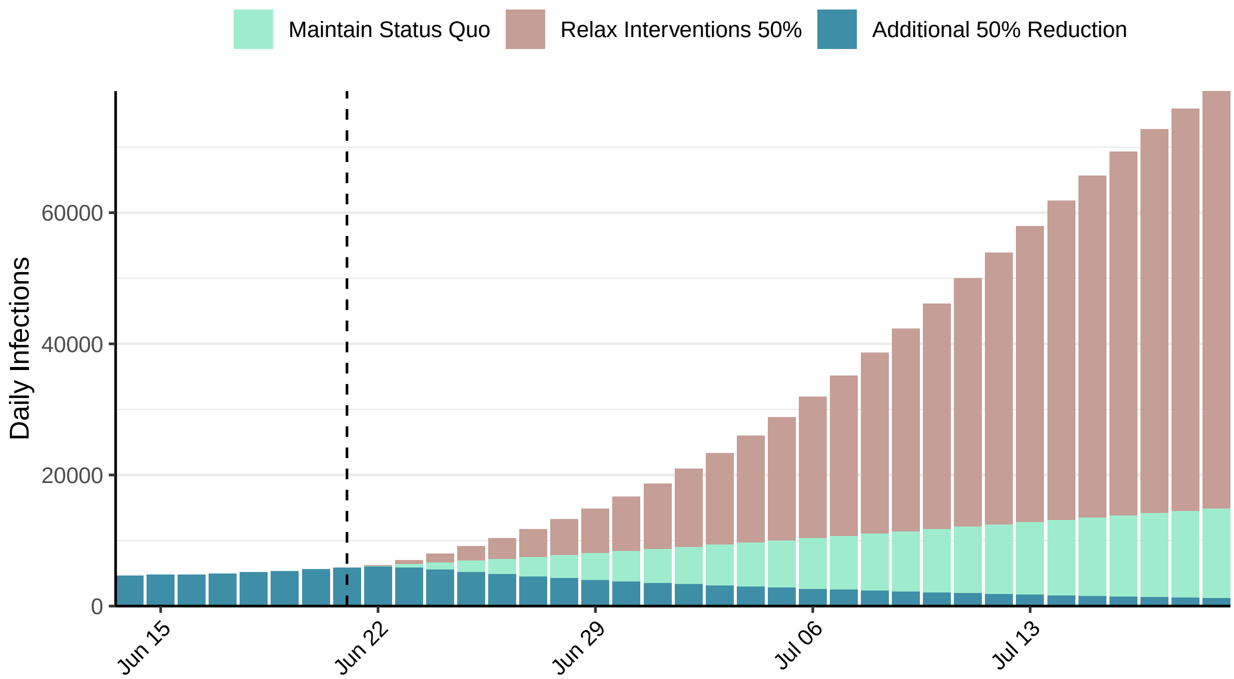


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Peru, 2020-06-21

**Download the report for Peru, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 251,338 | 3,413 | 7,861 | 201 | 1.25 (95% CI: 1.2-1.3) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

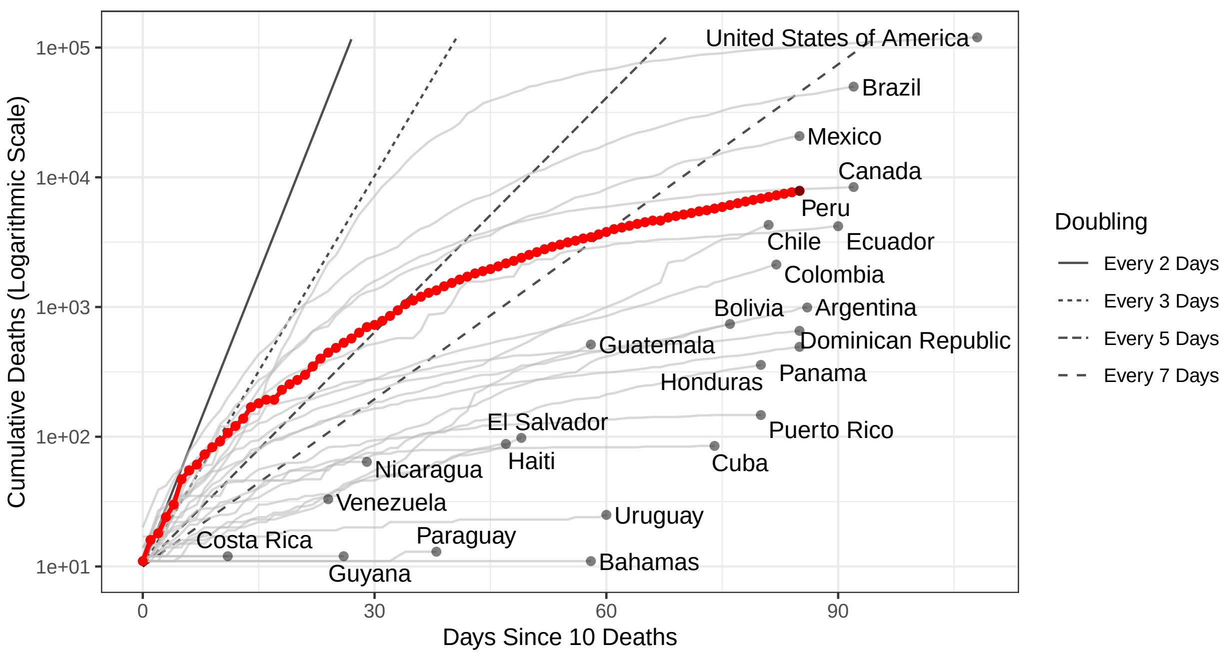


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,431,857 (95% CI: 1,410,070-1,453,645) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

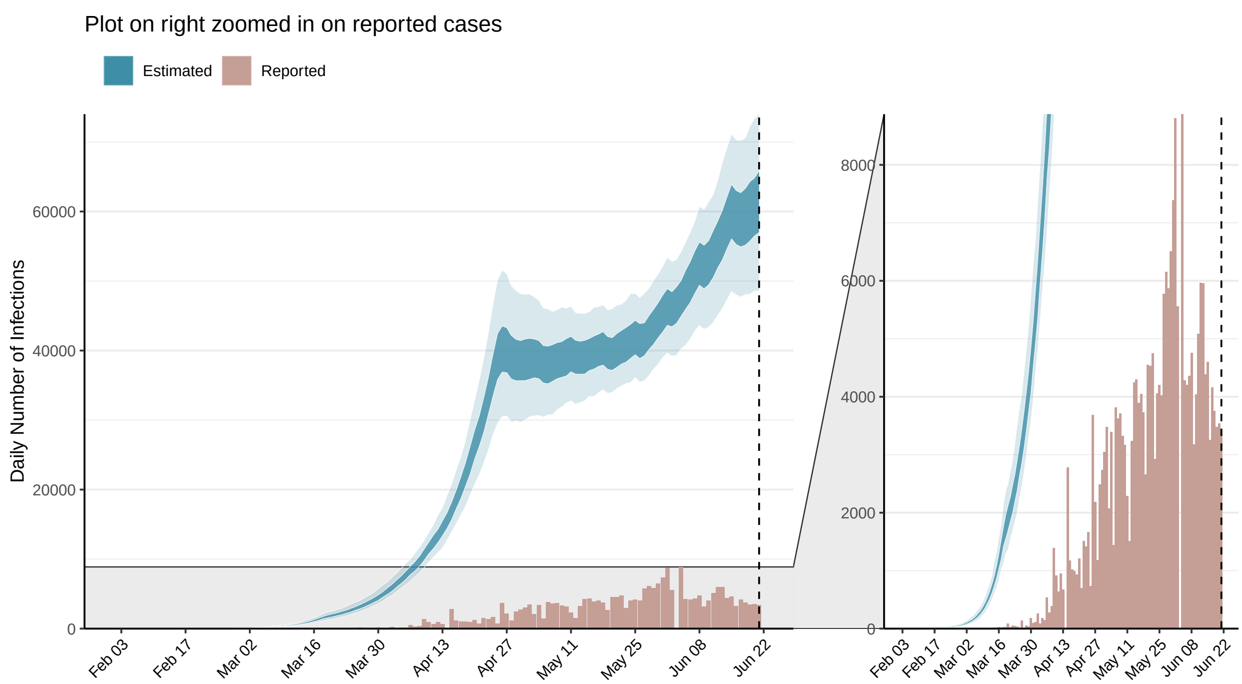


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

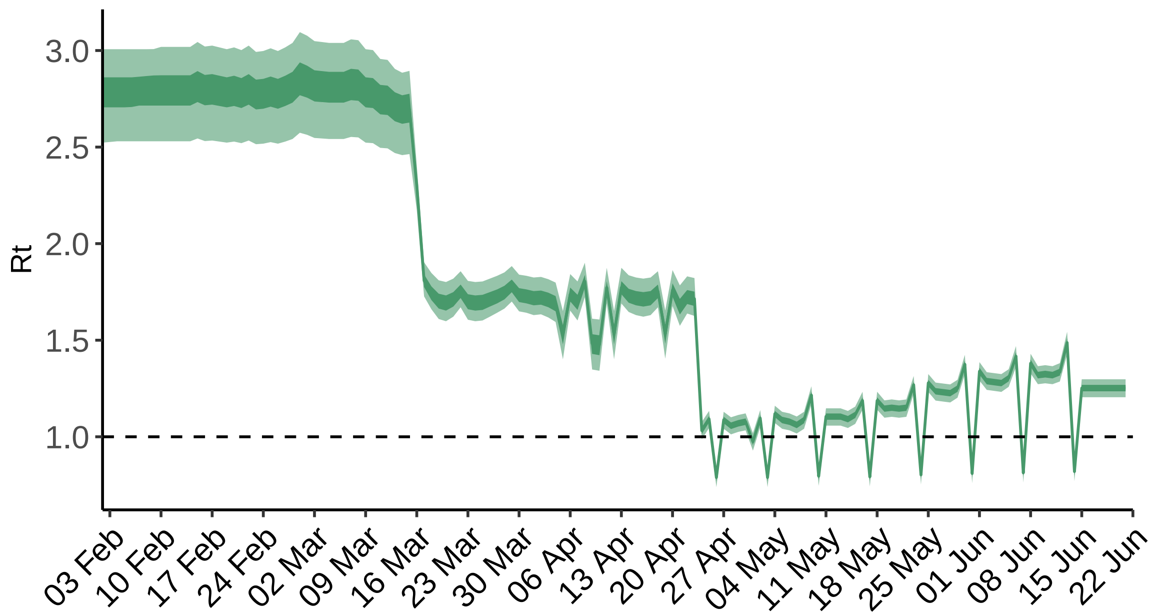


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Peru is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

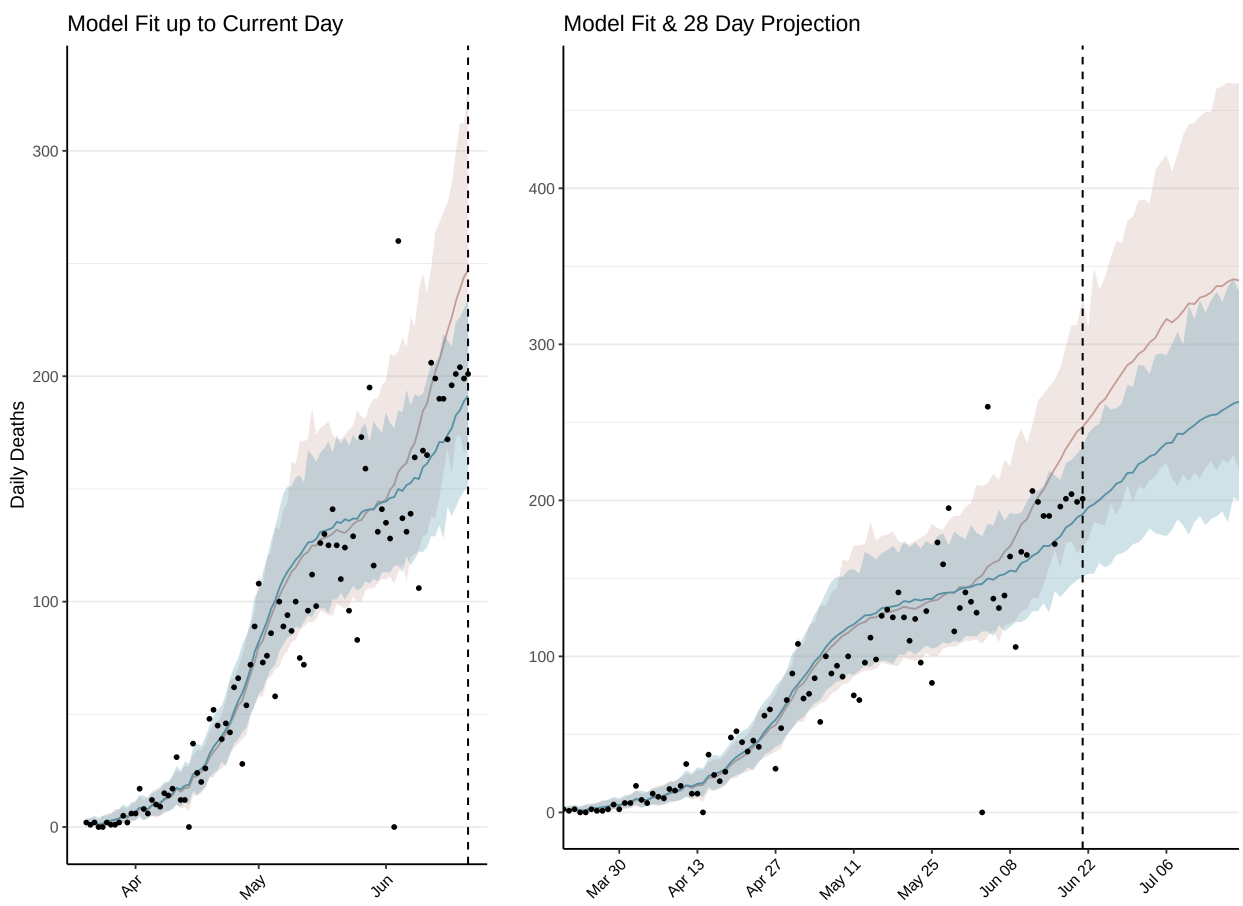


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 8,710 (95% CI: 8,574-8,846) patients requiring treatment with high-pressure oxygen at the current date to 11,485 (95% CI: 11,245-11,725) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2,179 (95% CI: 2,157-2,202) patients requiring treatment with mechanical ventilation at the current date to 2,274 (95% CI: 2,250-2,299) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

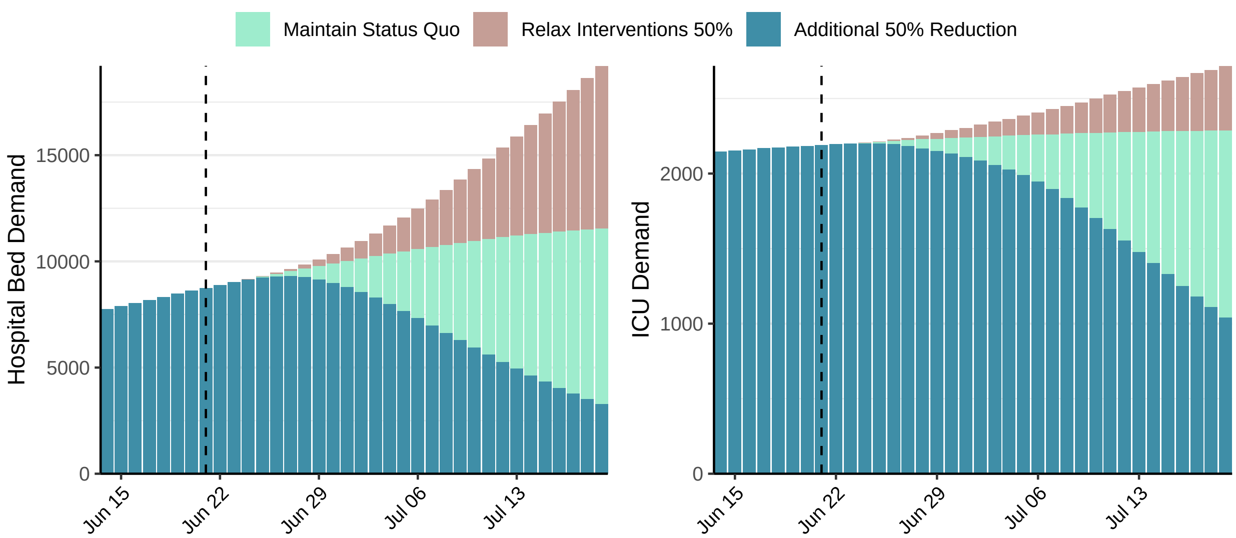


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 61,370 (95% CI: 60,287-62,452) at the current date to 6,196 (95% CI: 6,053-6,338) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 61,370 (95% CI: 60,287-62,452) at the current date to 144,201 (95% CI: 141,138-147,263) by 2020-07-19.

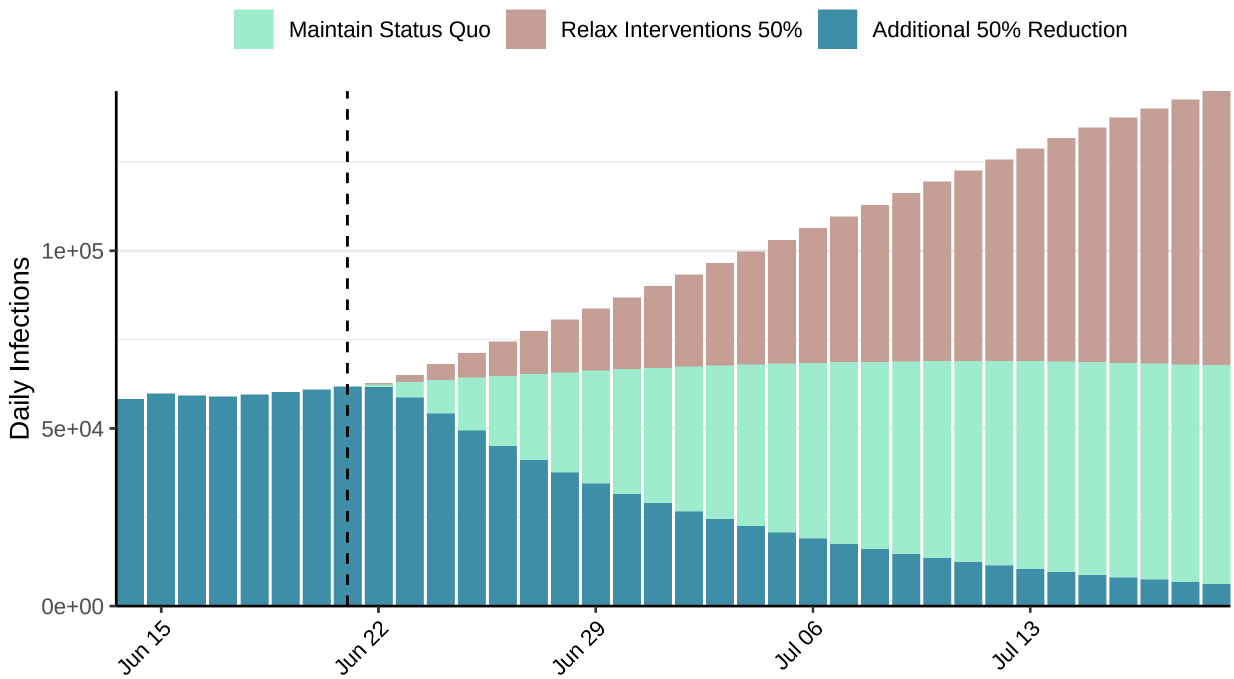


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Philippines, 2020-06-21

**Download the report for Philippines, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 29,400 | 941 | 1,149 | 20 | 1.28 (95% CI: 1.18-1.37) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

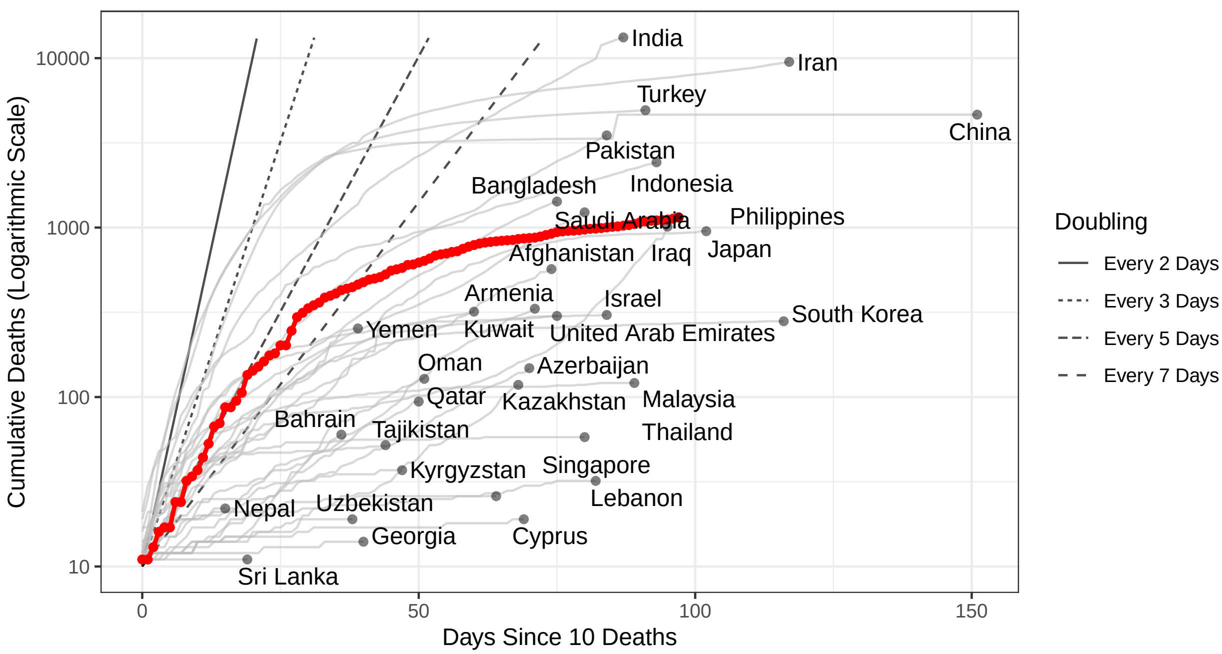


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 103,311 (95% CI: 100,210-106,412) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

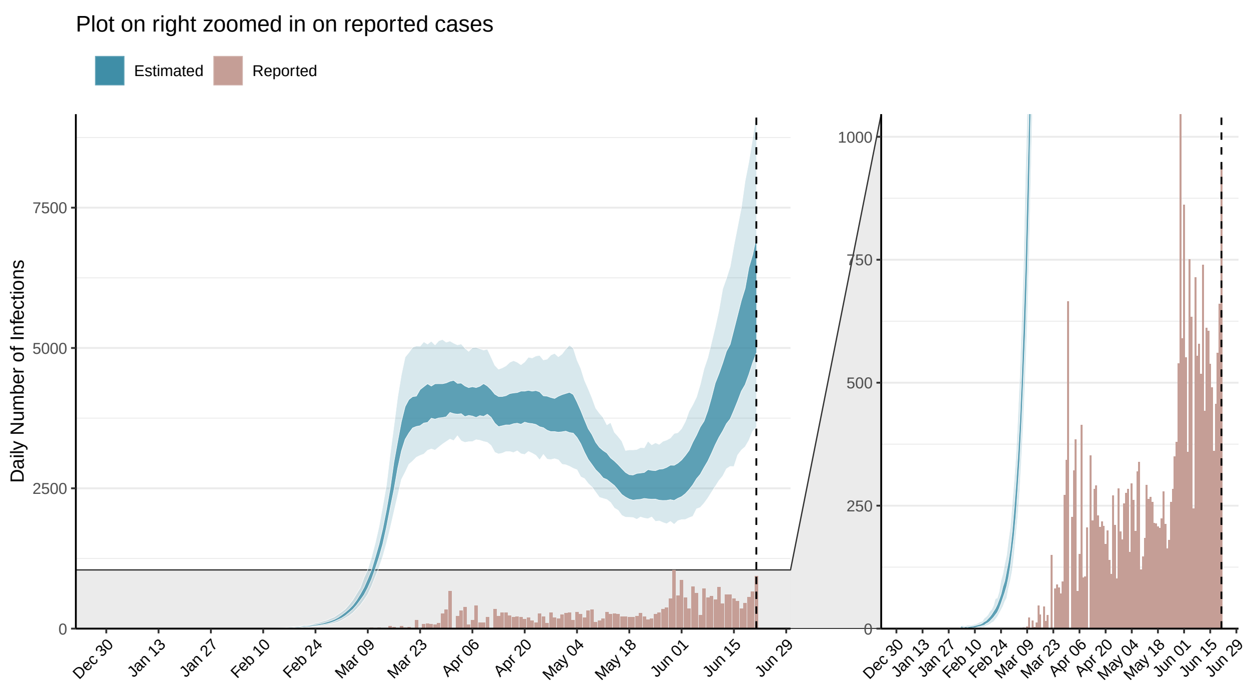


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

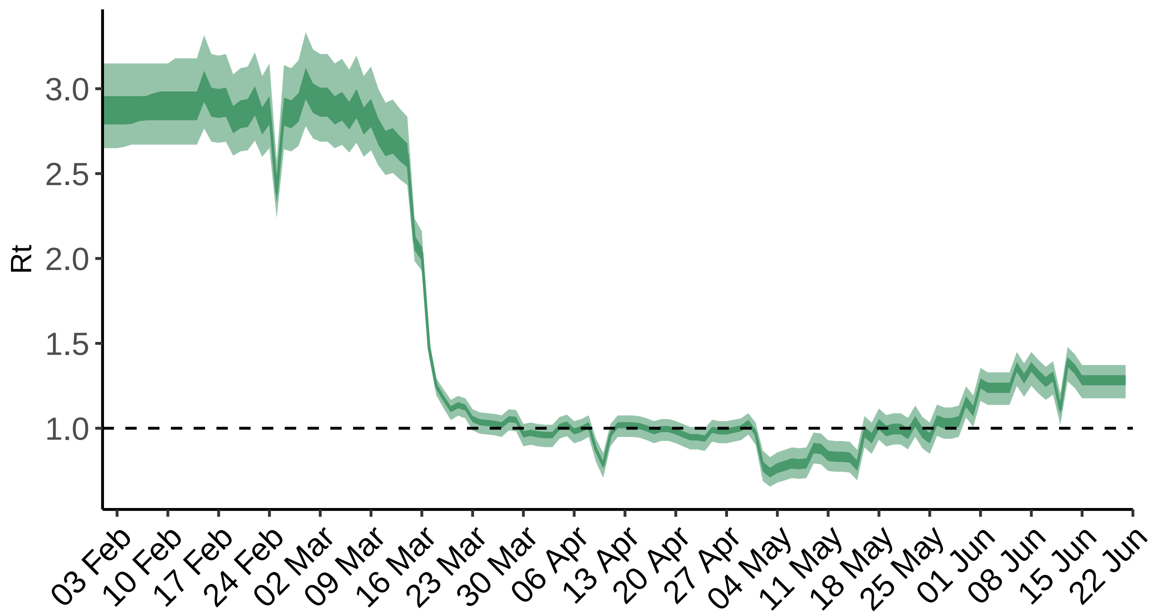


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

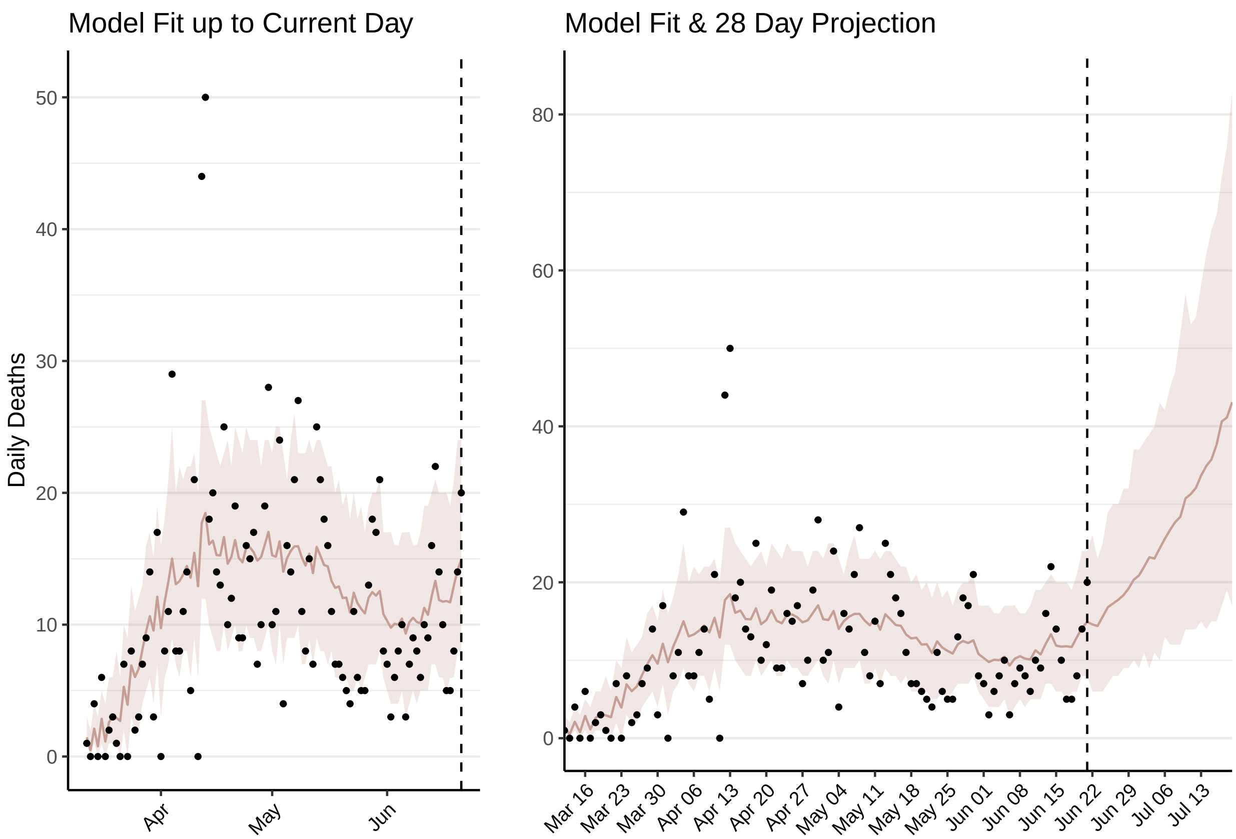


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 848 (95% CI: 821-875) patients requiring treatment with high-pressure oxygen at the current date to 2,586 (95% CI: 2,456-2,716) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 221 (95% CI: 214-228) patients requiring treatment with mechanical ventilation at the current date to 672 (95% CI: 639-705) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

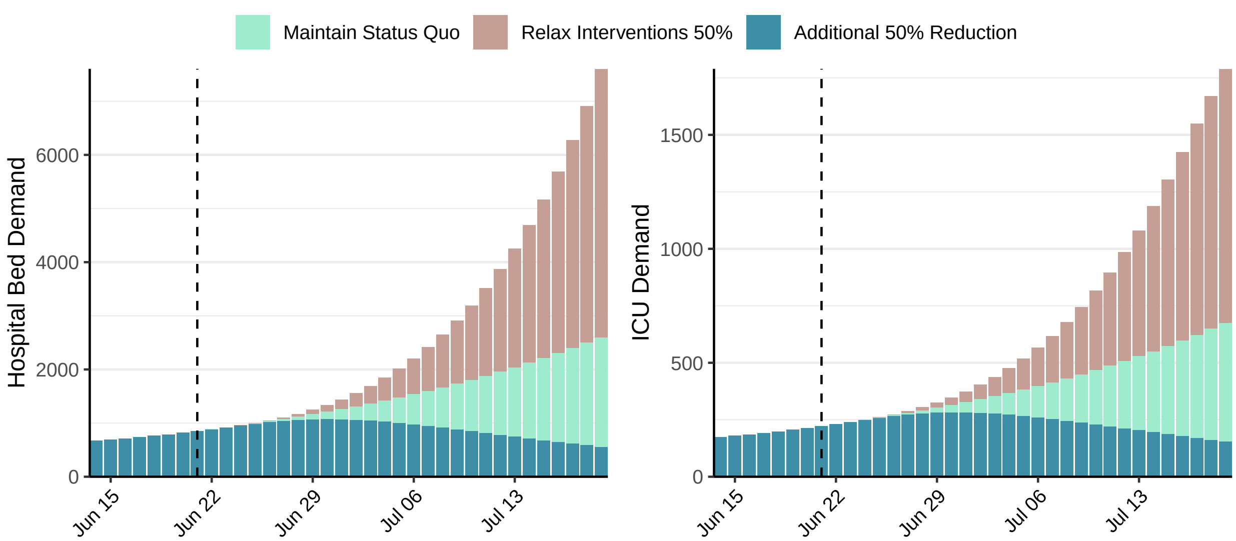


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 5,923 (95% CI: 5,702-6,143) at the current date to 1,257 (95% CI: 1,189-1,324) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 5,923 (95% CI: 5,702-6,143) at the current date to 87,981 (95% CI: 82,725-93,238) by 2020-07-19.

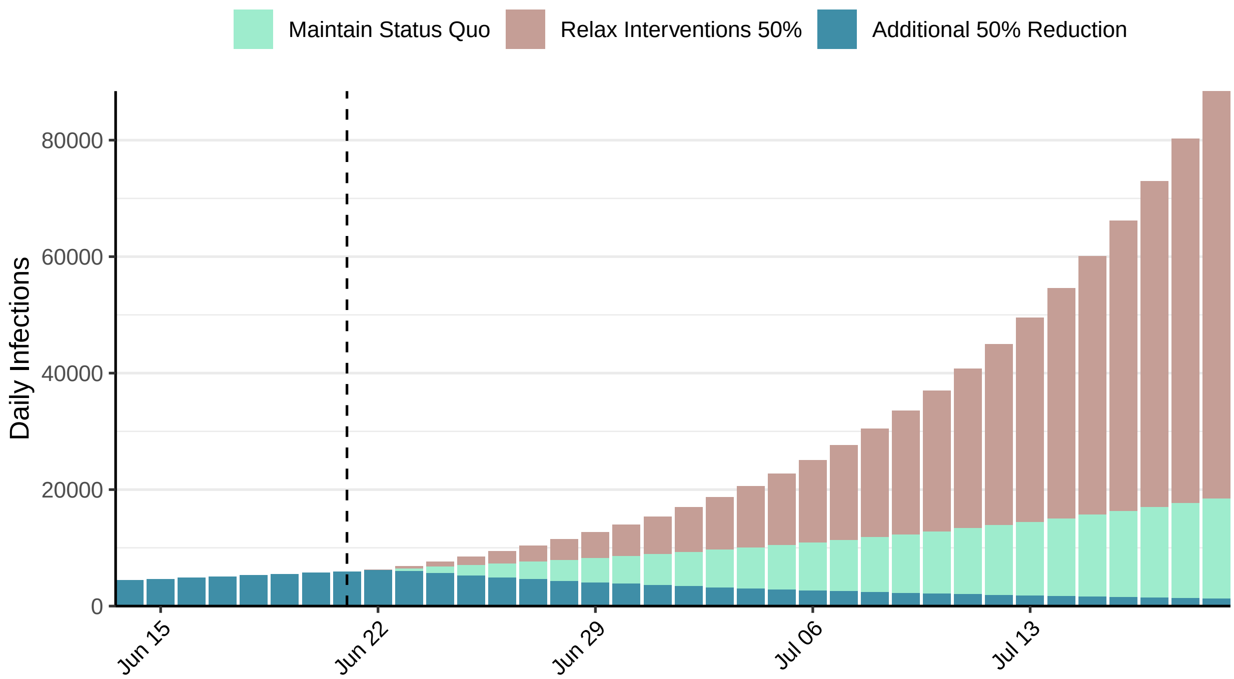


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Paraguay, 2020-06-21

**Download the report for Paraguay, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,362 | 26 | 13 | 0 | 1.48 (95% CI: 1.13-1.97) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

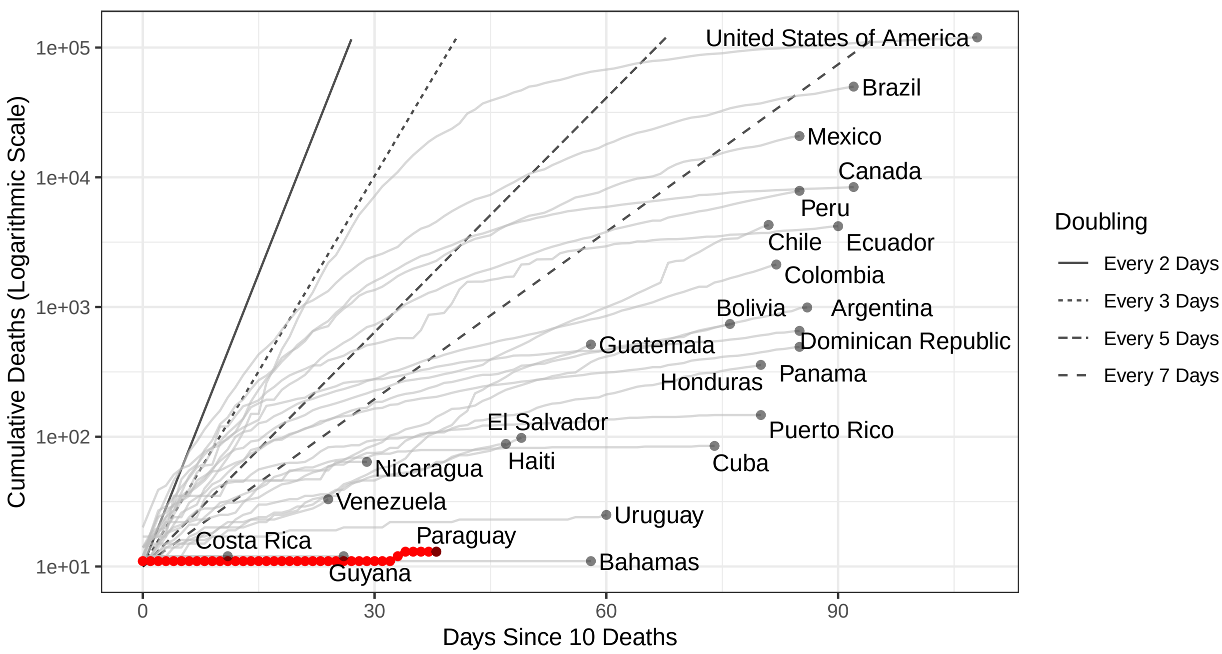


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 2,640 (95% CI: 2,308-2,971) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

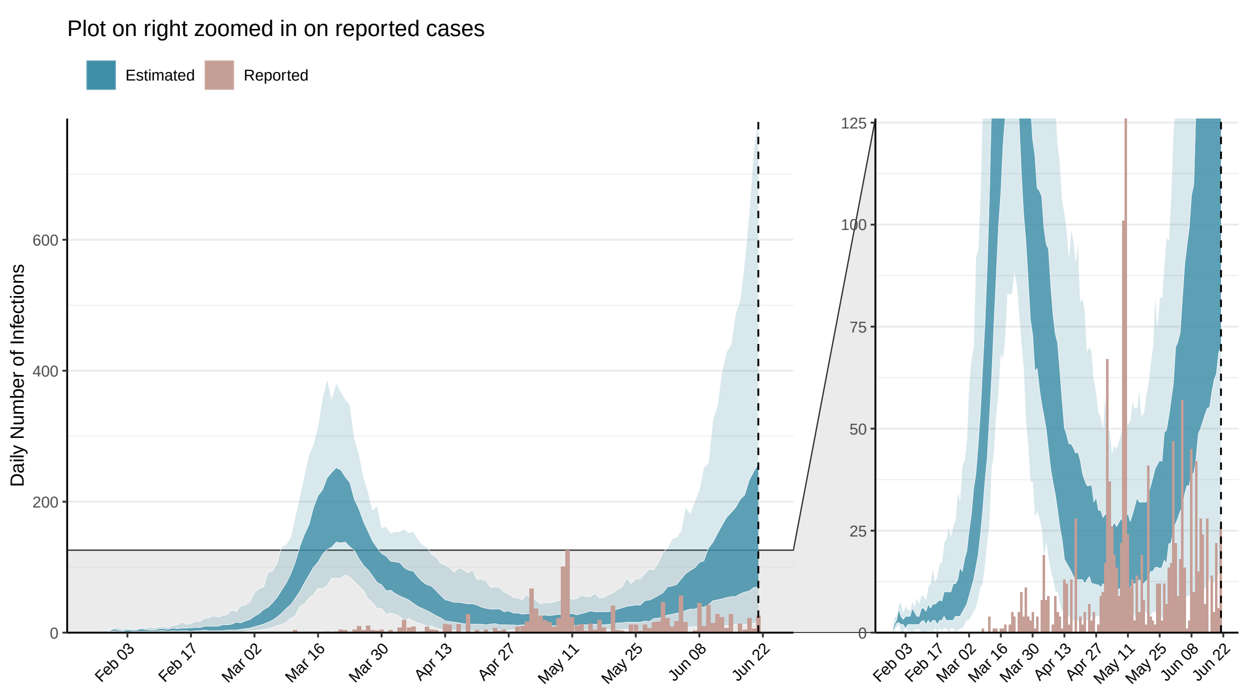


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

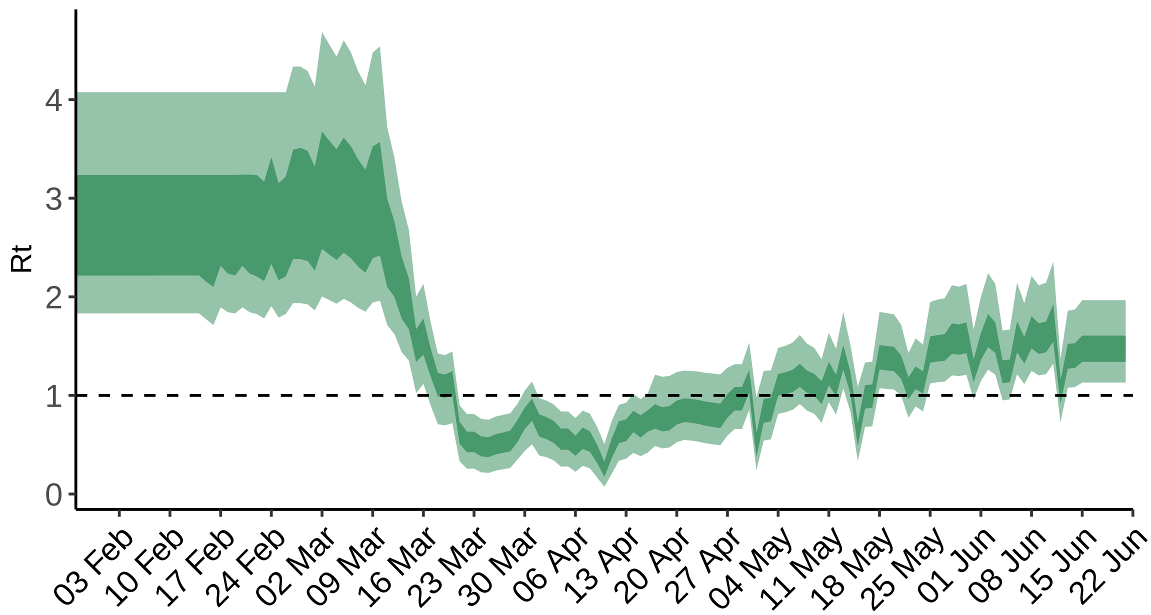


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

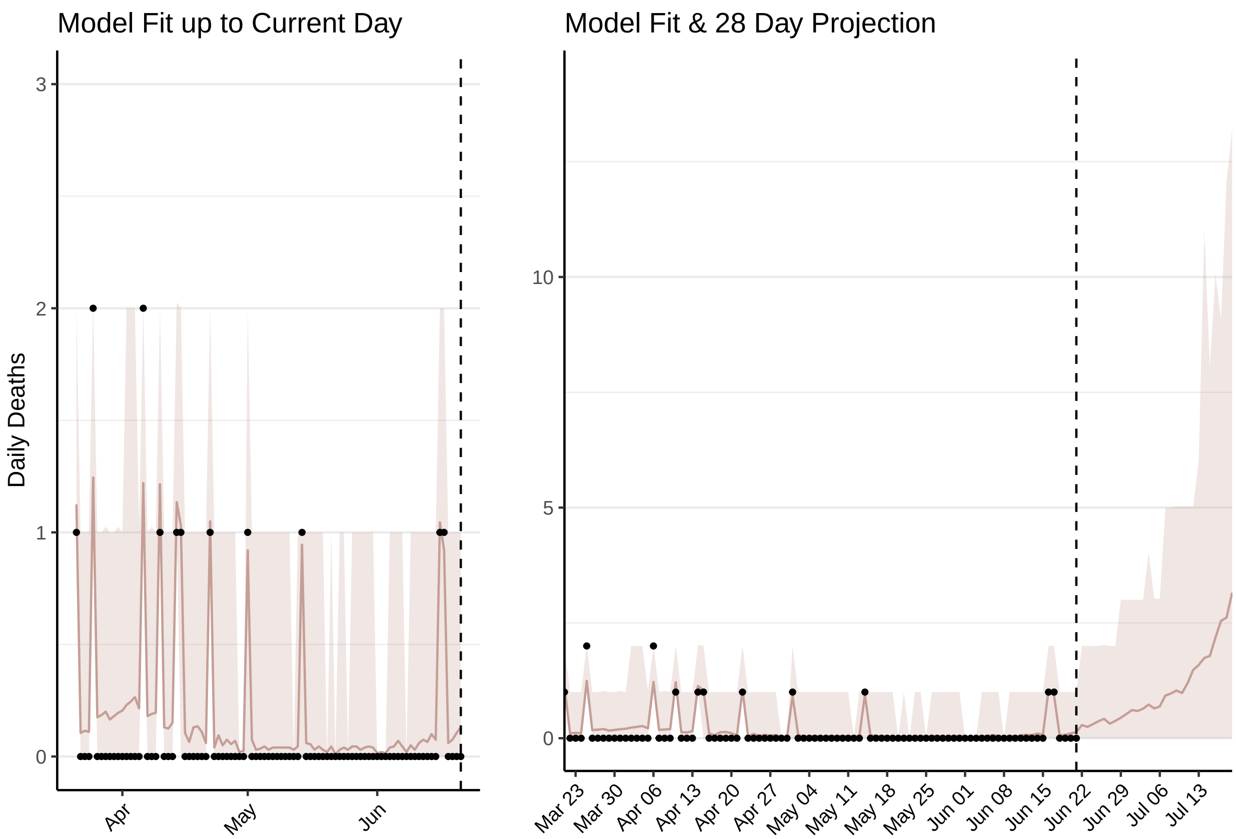


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 14 (95% CI: 12-16) patients requiring treatment with high-pressure oxygen at the current date to 136 (95% CI: 99-172) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4 (95% CI: 4-5) patients requiring treatment with mechanical ventilation at the current date to 37 (95% CI: 29-45) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

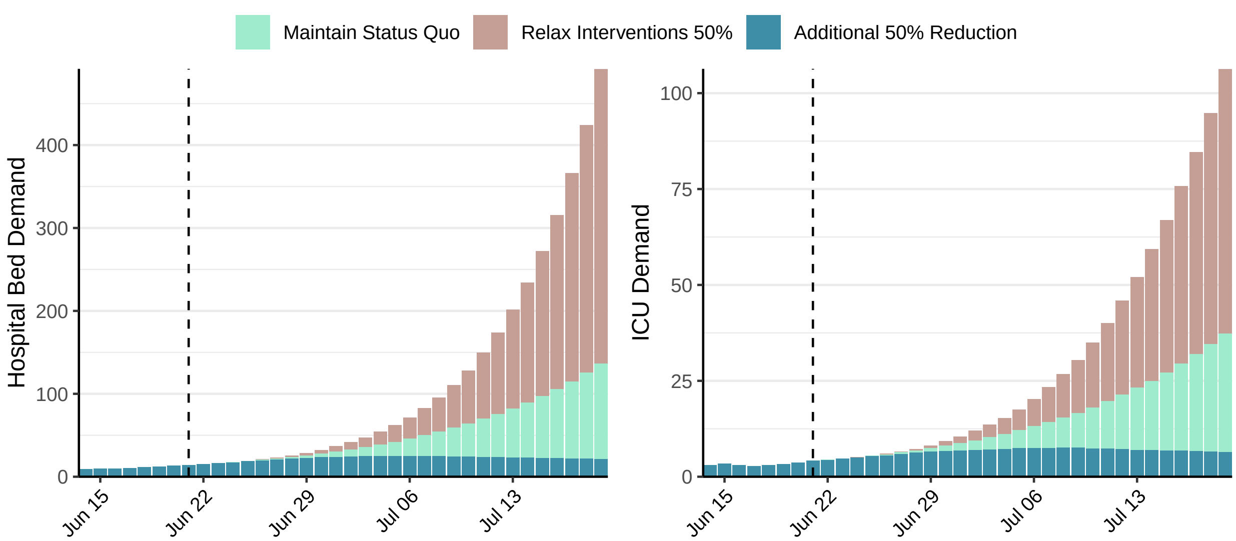


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 217 (95% CI: 182-252) at the current date to 124 (95% CI: 88-160) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 217 (95% CI: 182-252) at the current date to 12,308 (95% CI: 8,996-15,620) by 2020-07-19.

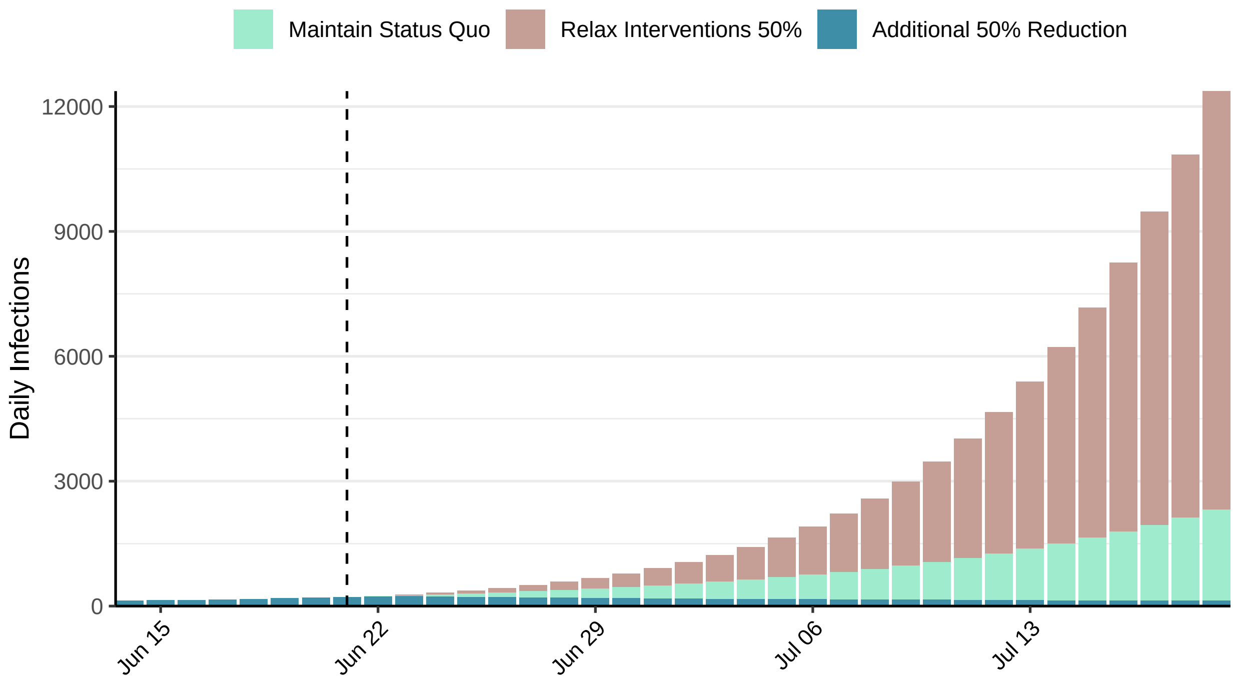


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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# Situation Report for COVID-19: State of Palestine, 2020-06-21

**Download the report for State of Palestine, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 979 | 121 | 5 | 0 | 1.19 (95% CI: 0.52-2.18) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. State of Palestine is not shown in the following plot as only 5 deaths have been reported to date**

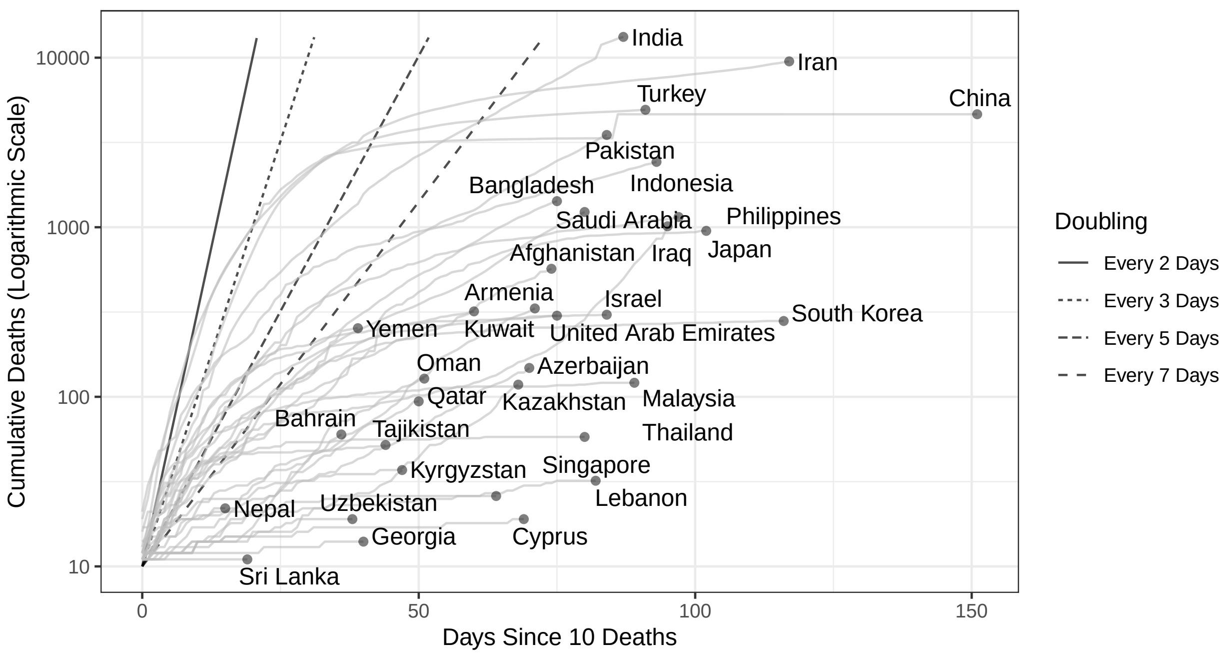


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 508 (95% CI: 399-617) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

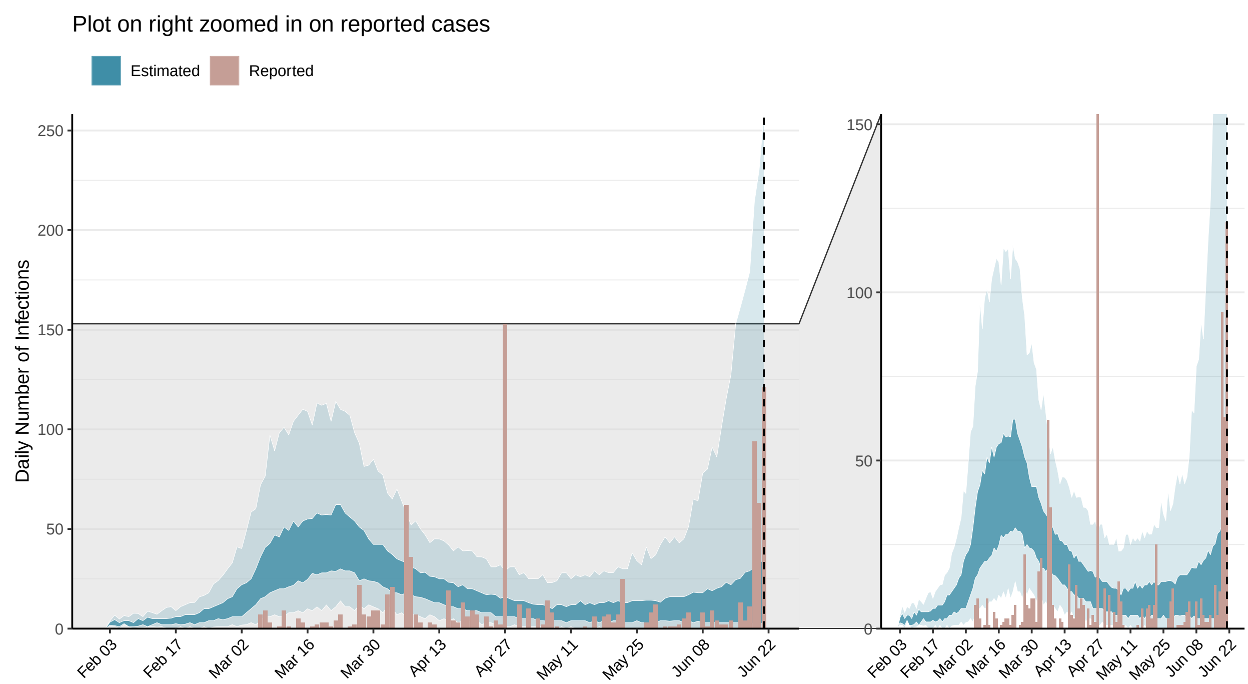


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

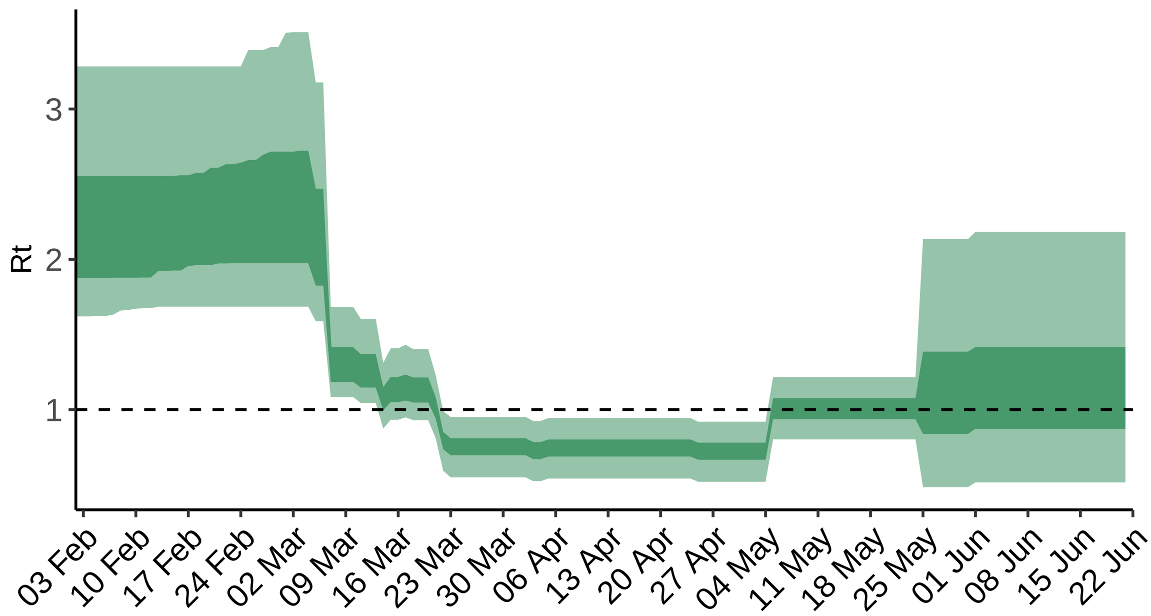


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

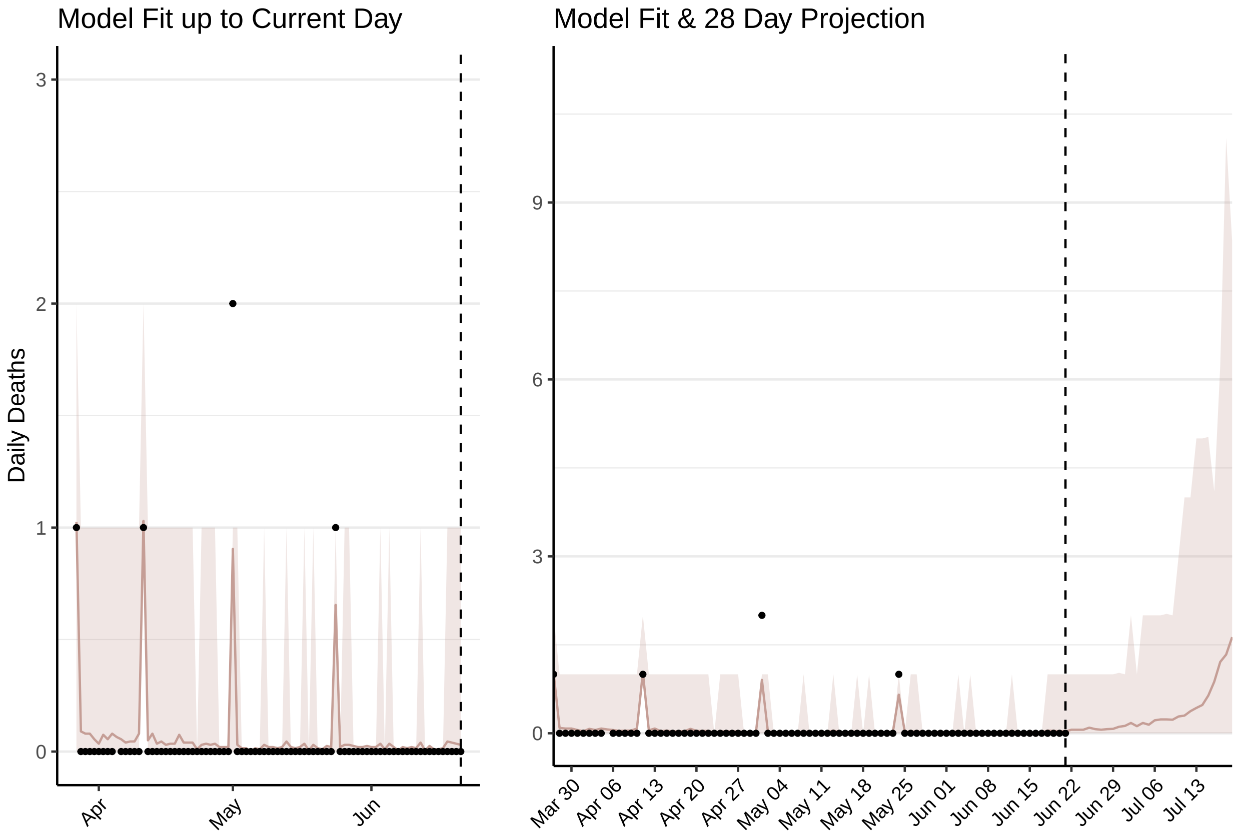


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4 (95% CI: 3-4) patients requiring treatment with high-pressure oxygen at the current date to 59 (95% CI: 27-90) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1 (95% CI: 1-1) patients requiring treatment with mechanical ventilation at the current date to 11 (95% CI: 6-17) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

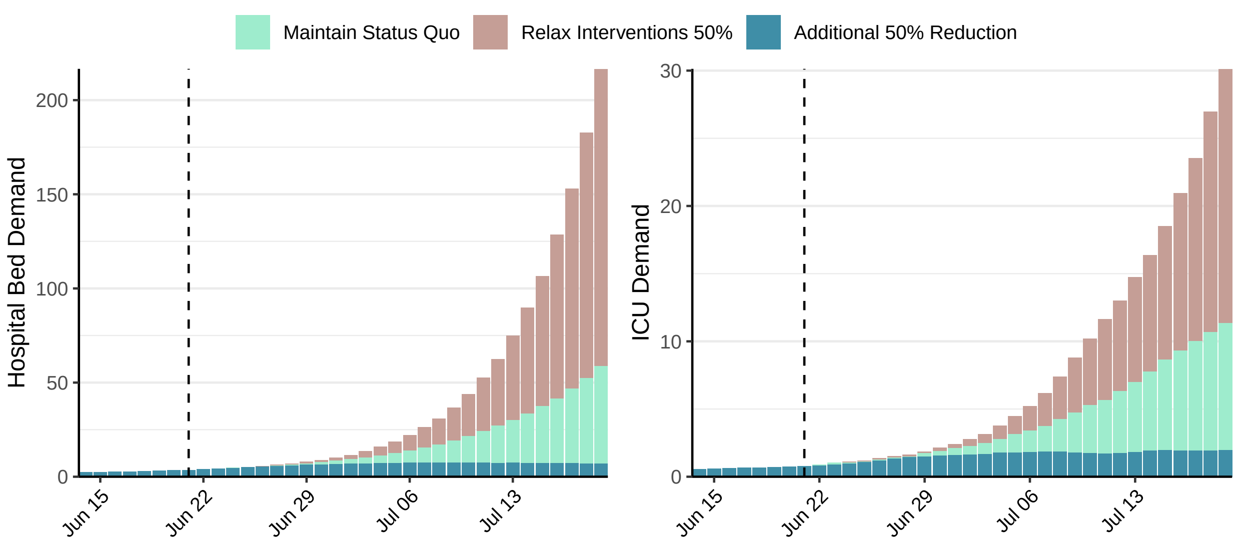


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 40 (95% CI: 27-54) at the current date to 39 (95% CI: 17-61) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 40 (95% CI: 27-54) at the current date to 4,630 (95% CI: 2,026-7,234) by 2020-07-19.

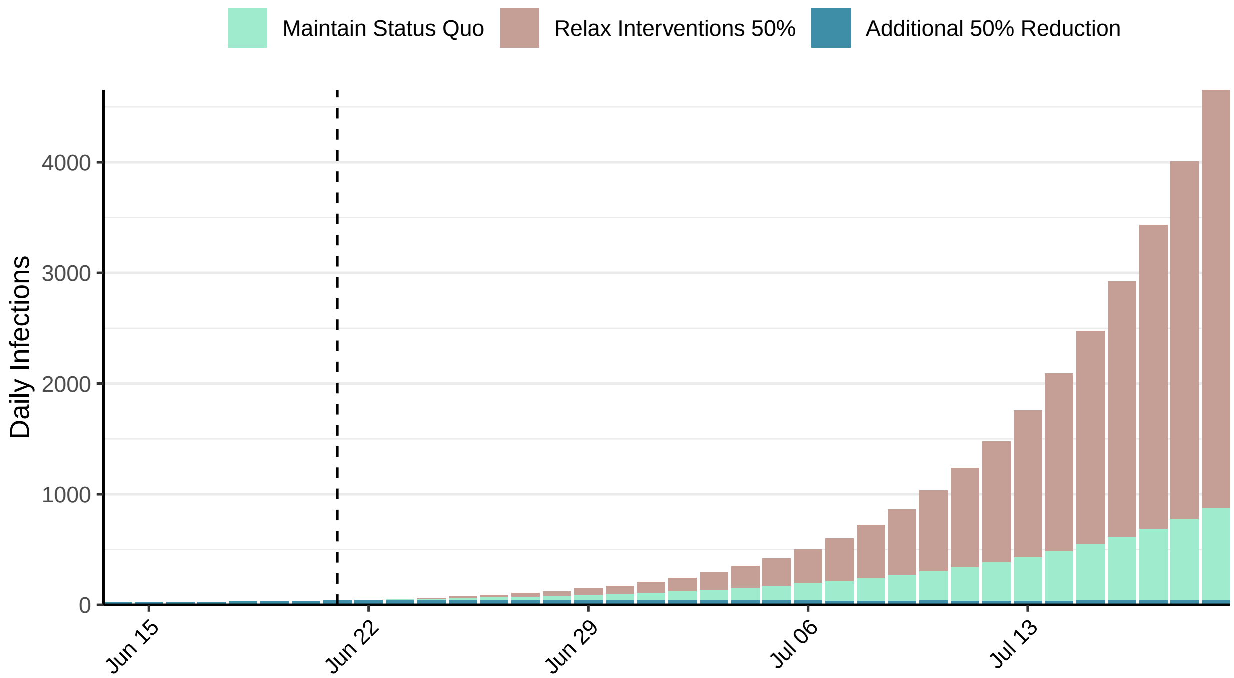


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Romania, 2020-06-21

**Download the report for Romania, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 23,730 | 330 | 1,500 | 16 | 1.63 (95% CI: 1.51-1.8) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

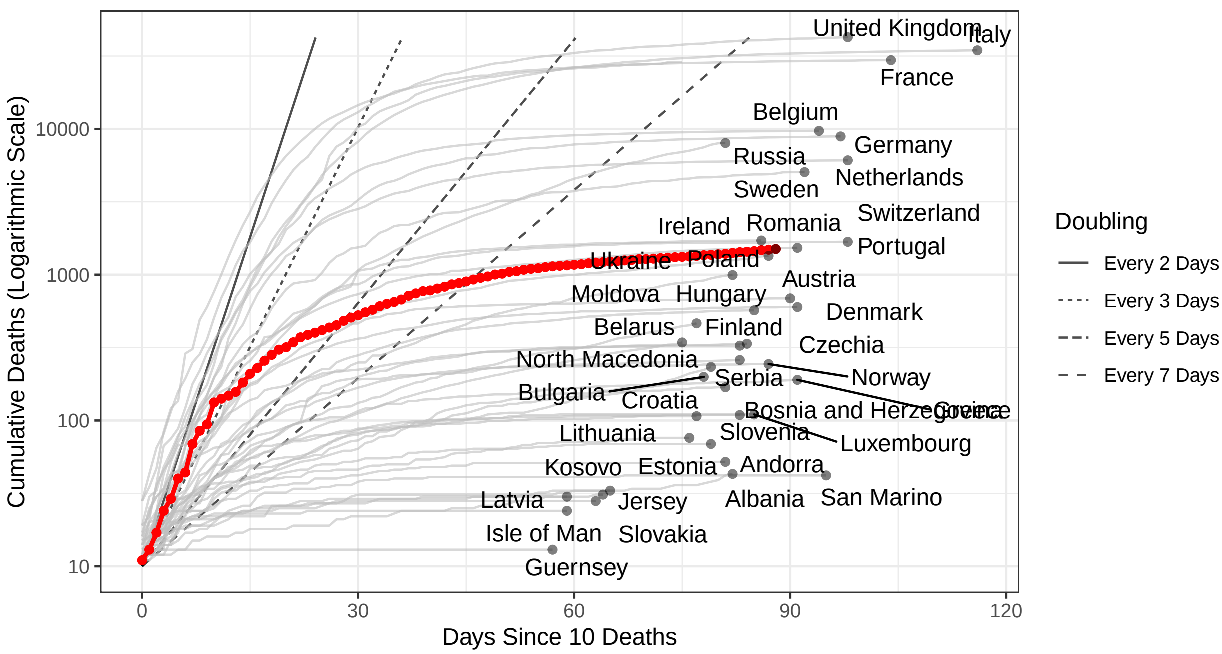


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 146,982 (95% CI: 142,692-151,271) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

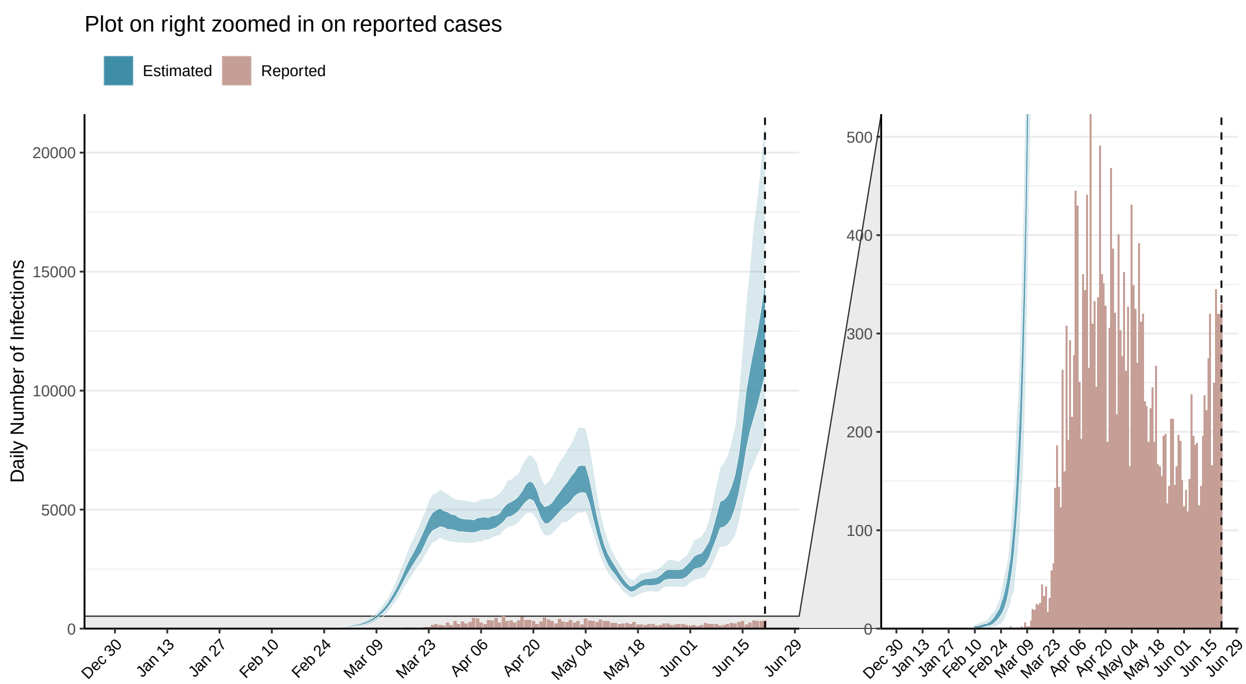


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

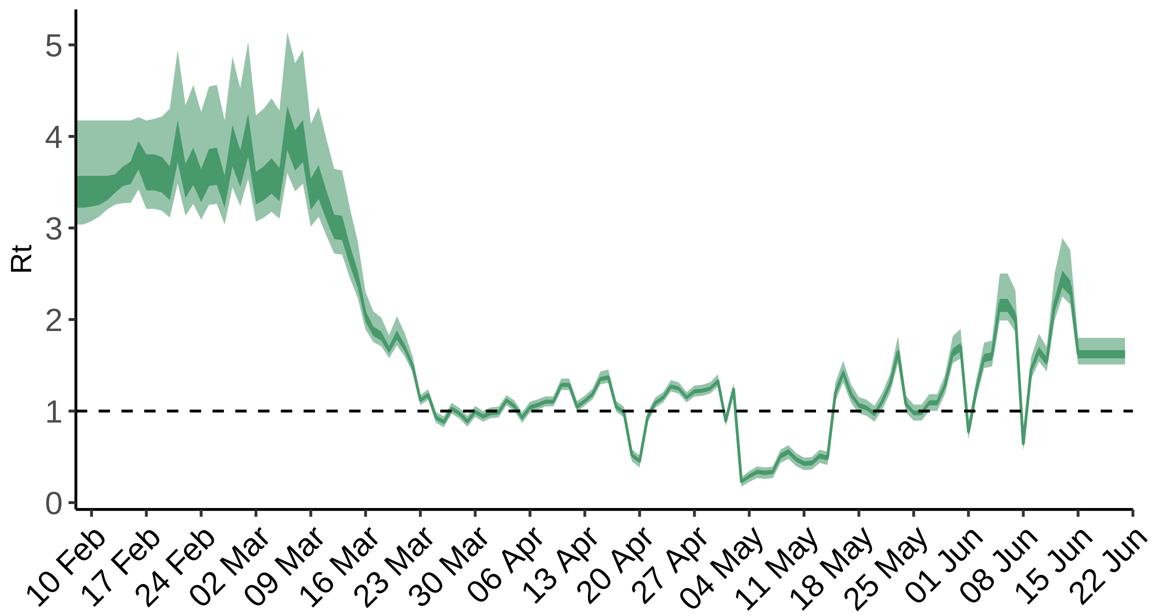


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

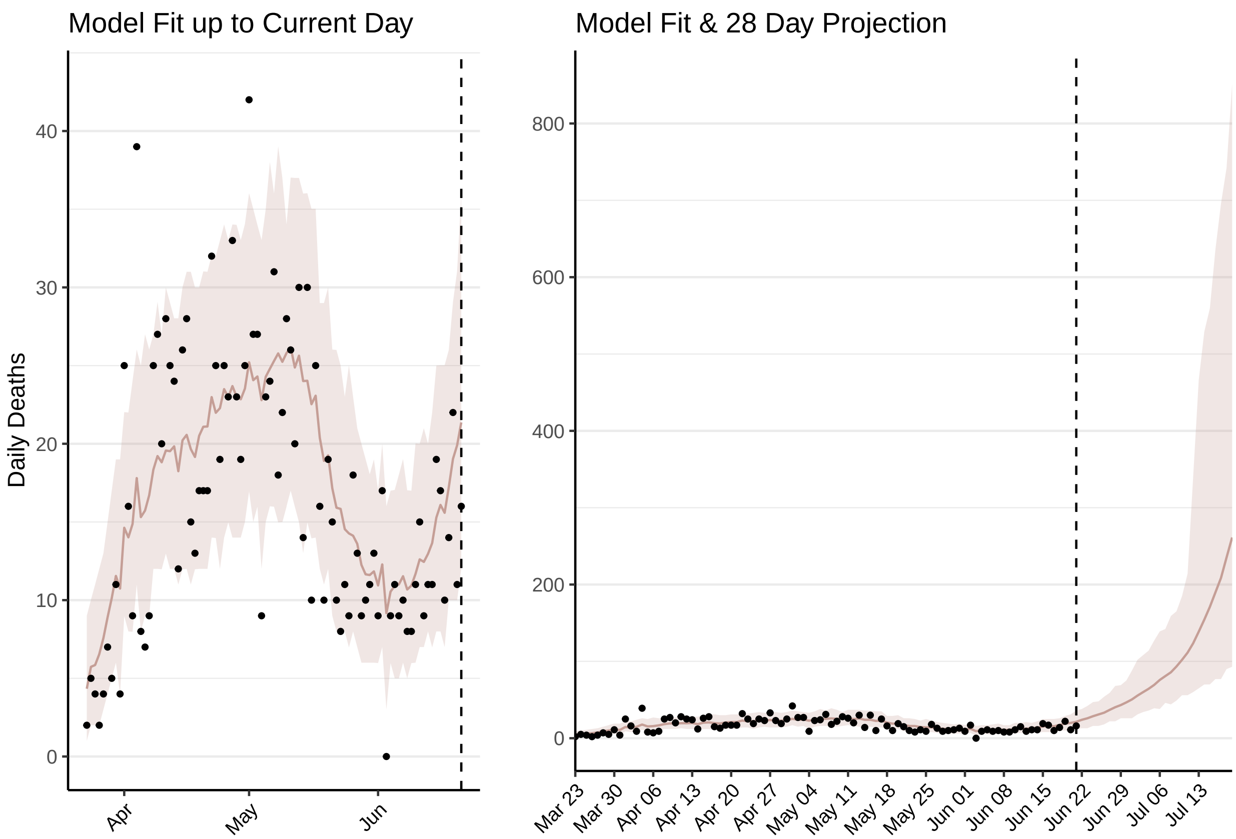


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,251 (95% CI: 1,213-1,288) patients requiring treatment with high-pressure oxygen at the current date to 10,269 (95% CI: 9,715-10,823) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 377 (95% CI: 366-388) patients requiring treatment with mechanical ventilation at the current date to 2,889 (95% CI: 2,783-2,996) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

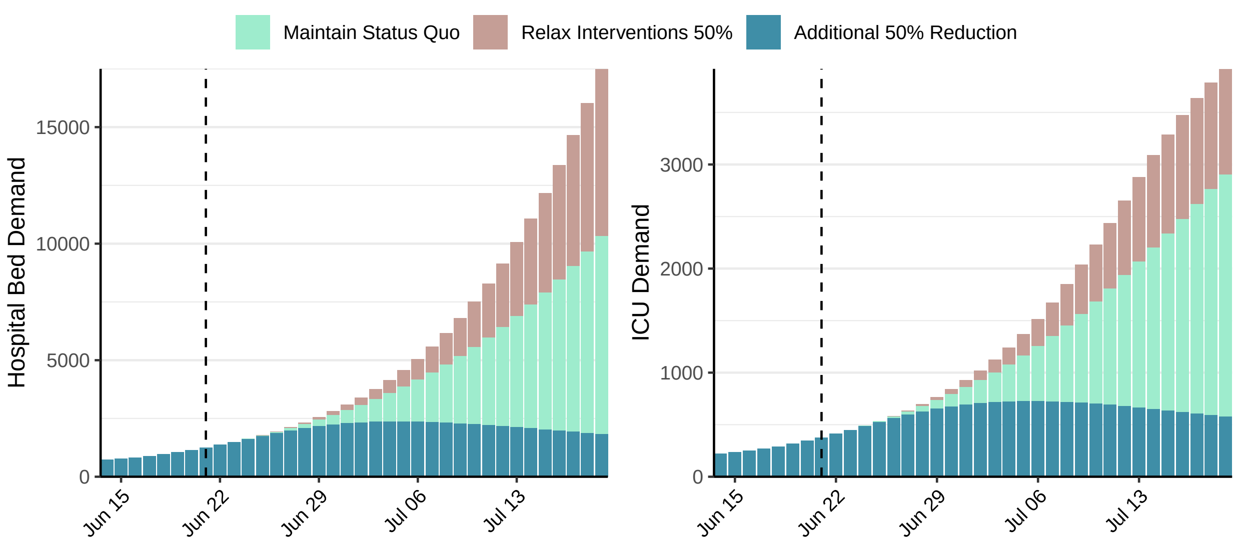


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 12,901 (95% CI: 12,417-13,384) at the current date to 5,529 (95% CI: 5,202-5,856) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 12,901 (95% CI: 12,417-13,384) at the current date to 163,286 (95% CI: 155,437-171,135) by 2020-07-19.

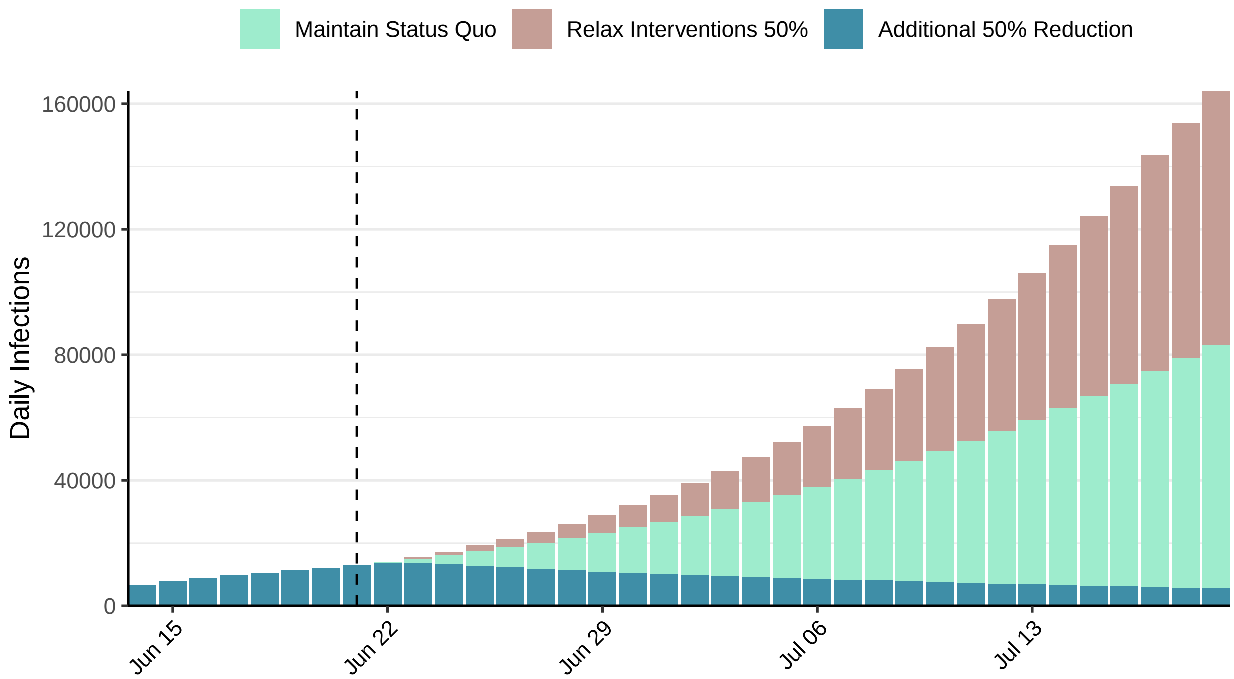


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Russia, 2020-06-21

**Download the report for Russia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 576,952 | 7,889 | 8,002 | 30 | 1.44 (95% CI: 1.32-1.6) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

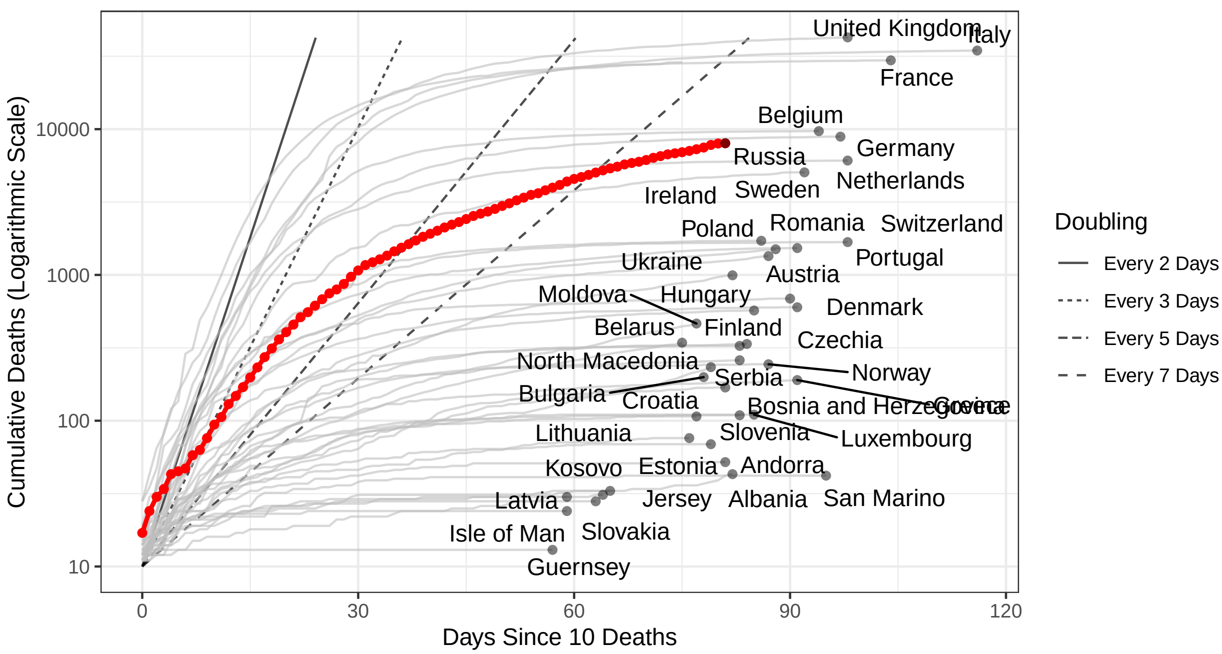


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

## COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,746,076 (95% CI: 1,690,786-1,801,365) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

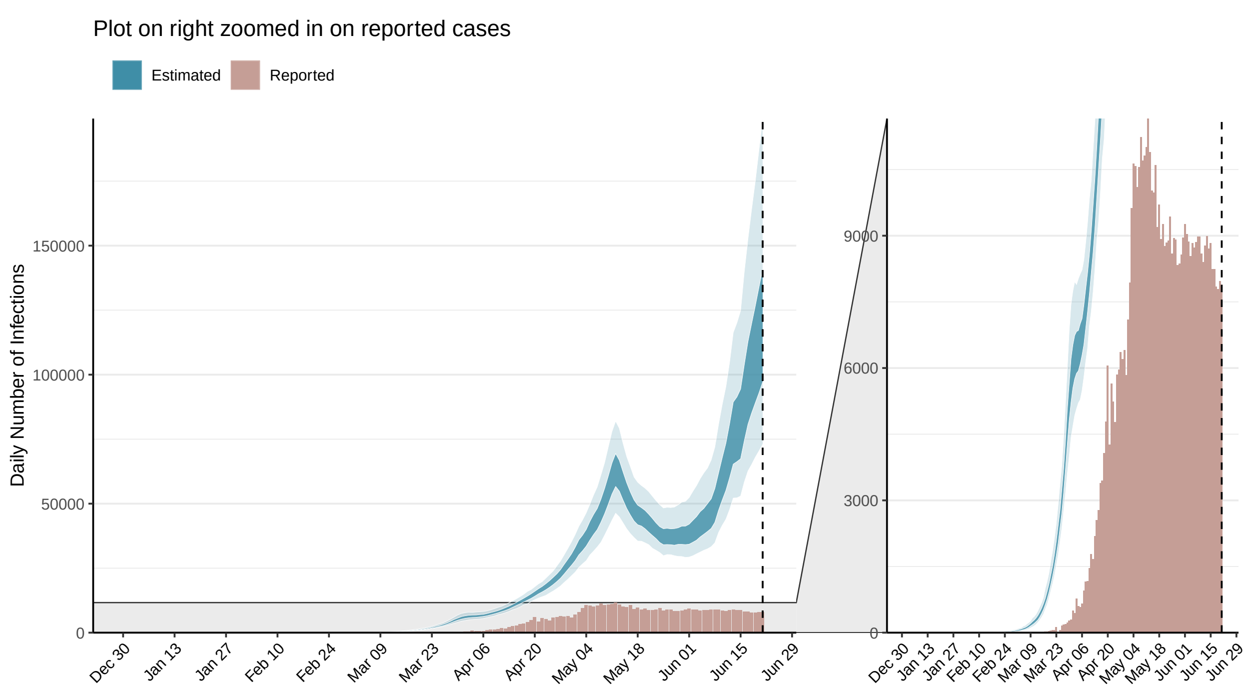


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

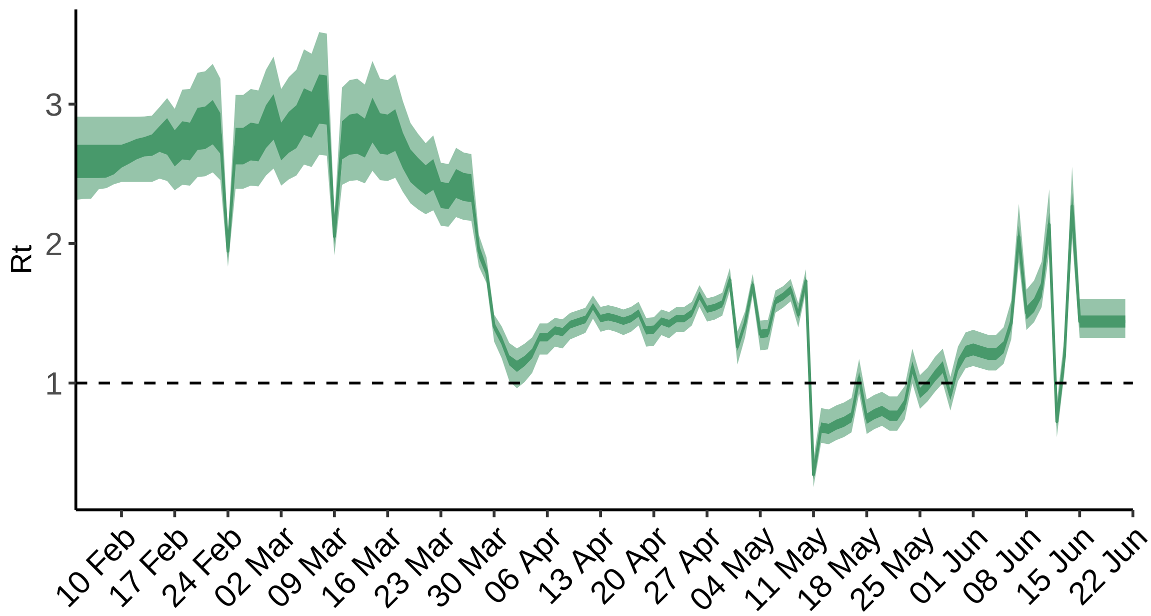


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

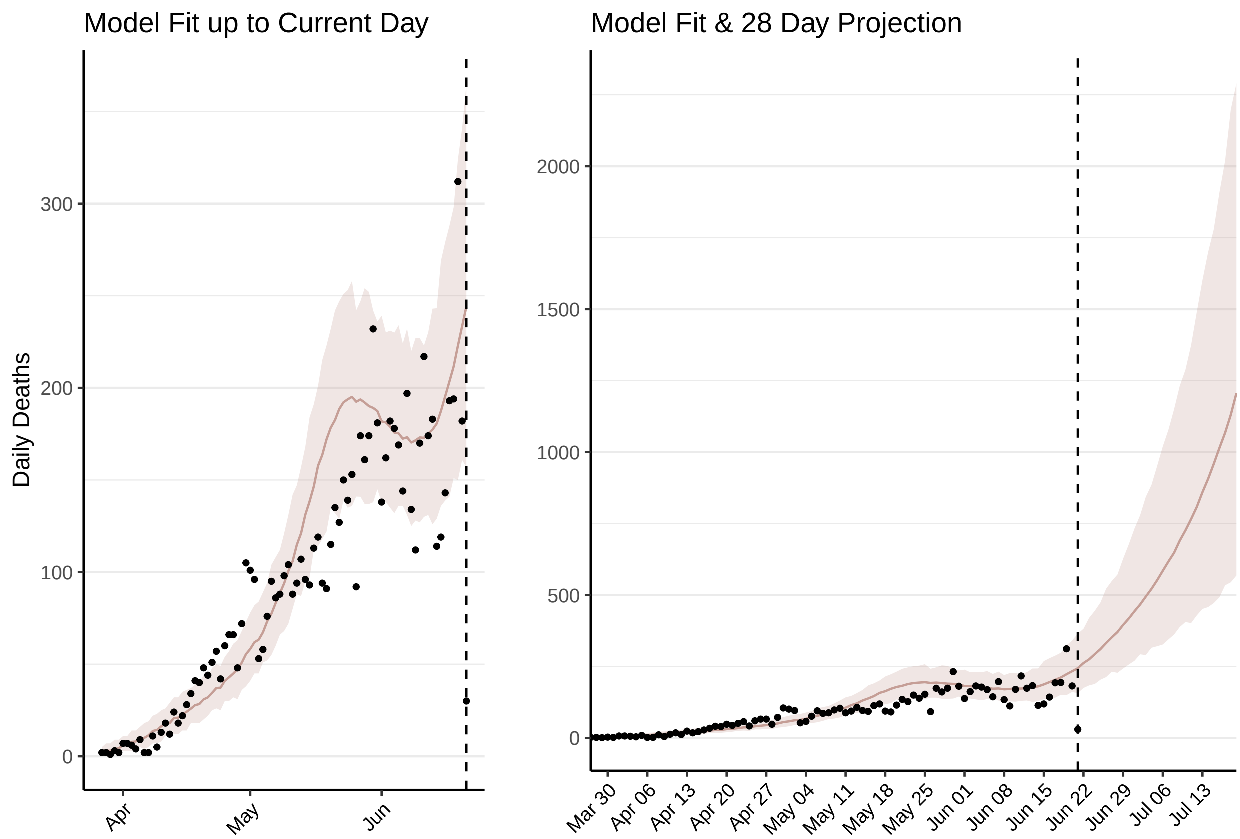


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 14,130 (95% CI: 13,670-14,591) patients requiring treatment with high-pressure oxygen at the current date to 64,119 (95% CI: 60,450-67,789) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4,017 (95% CI: 3,887-4,146) patients requiring treatment with mechanical ventilation at the current date to 18,271 (95% CI: 17,272-19,269) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

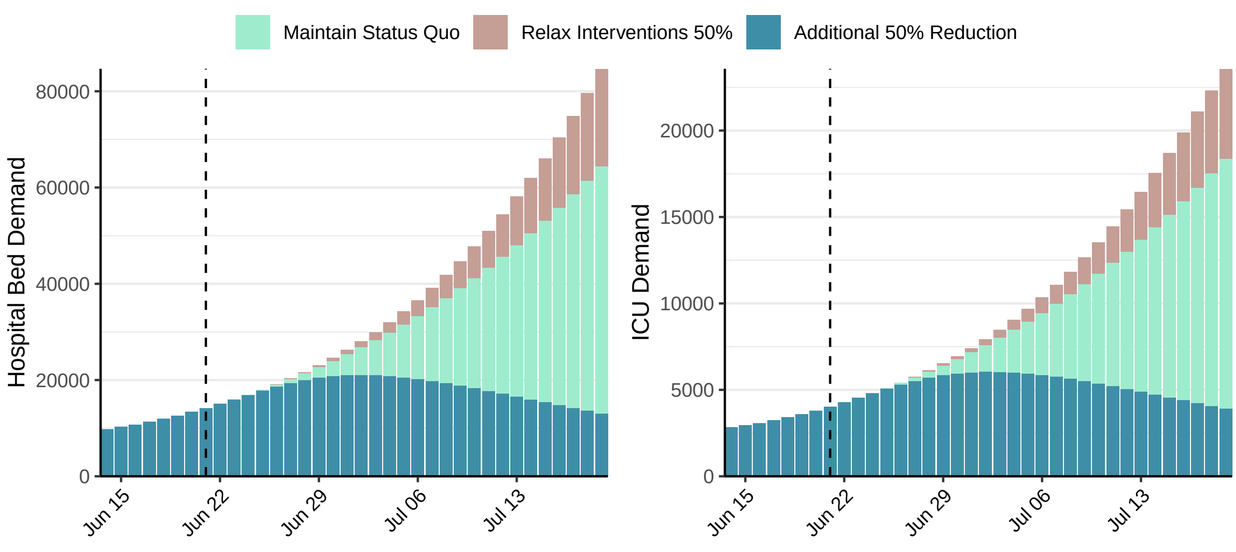


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 121,868 (95% CI: 116,877-126,858) at the current date to 33,528 (95% CI: 31,437-35,618) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 121,868 (95% CI: 116,877-126,858) at the current date to 675,538 (95% CI: 637,379-713,697) by 2020-07-19.

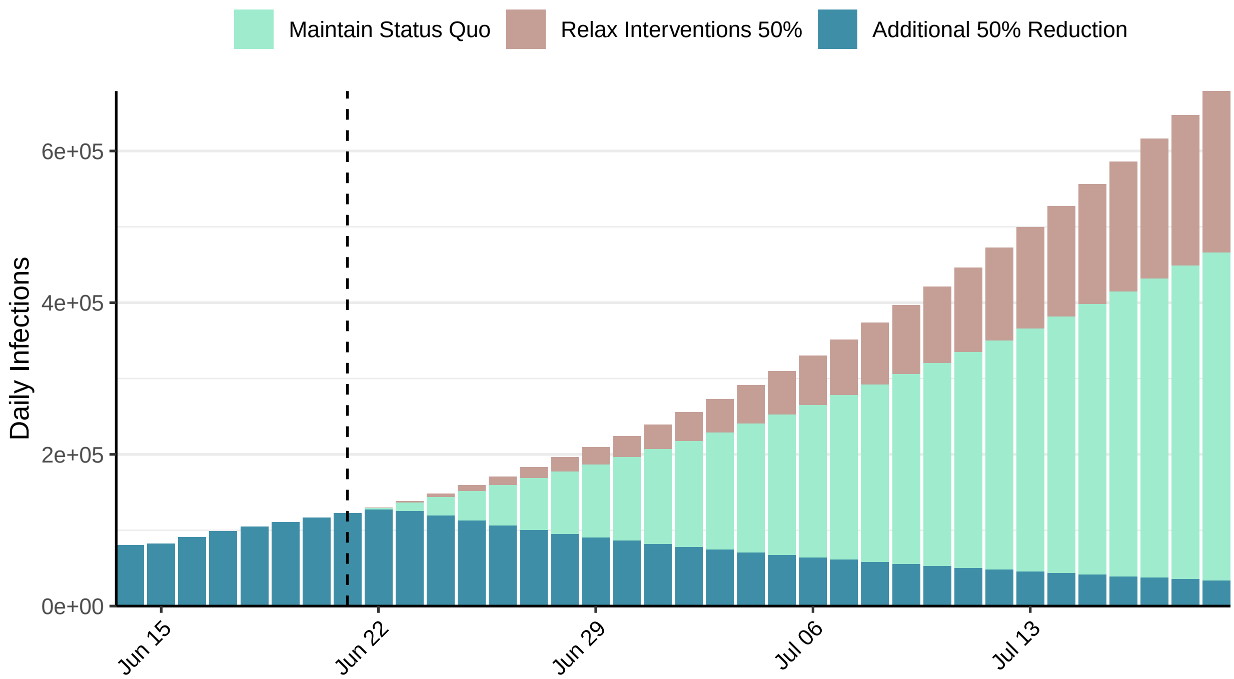


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Rwanda, 2020-06-21

**Download the report for Rwanda, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 702 | 41 | 2 | 0 | 1.31 (95% CI: 0.59-2.3) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Rwanda is not shown in the following plot as only 2 deaths have been reported to date**

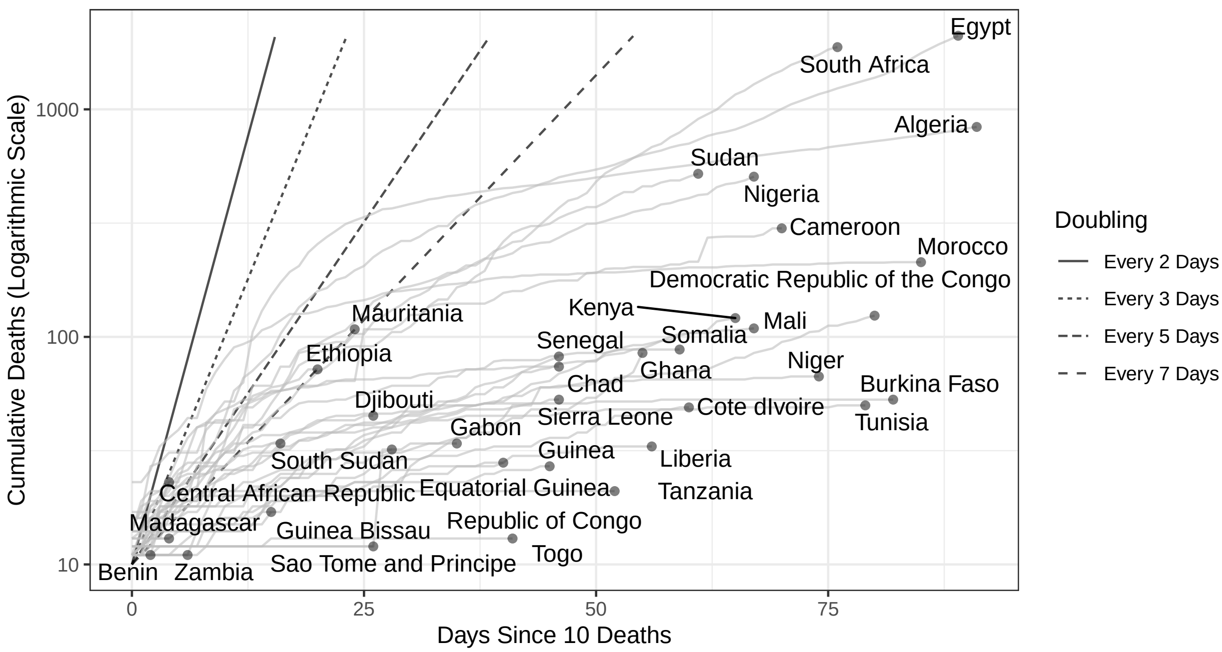


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,350 (95% CI: 1,161-1,539) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

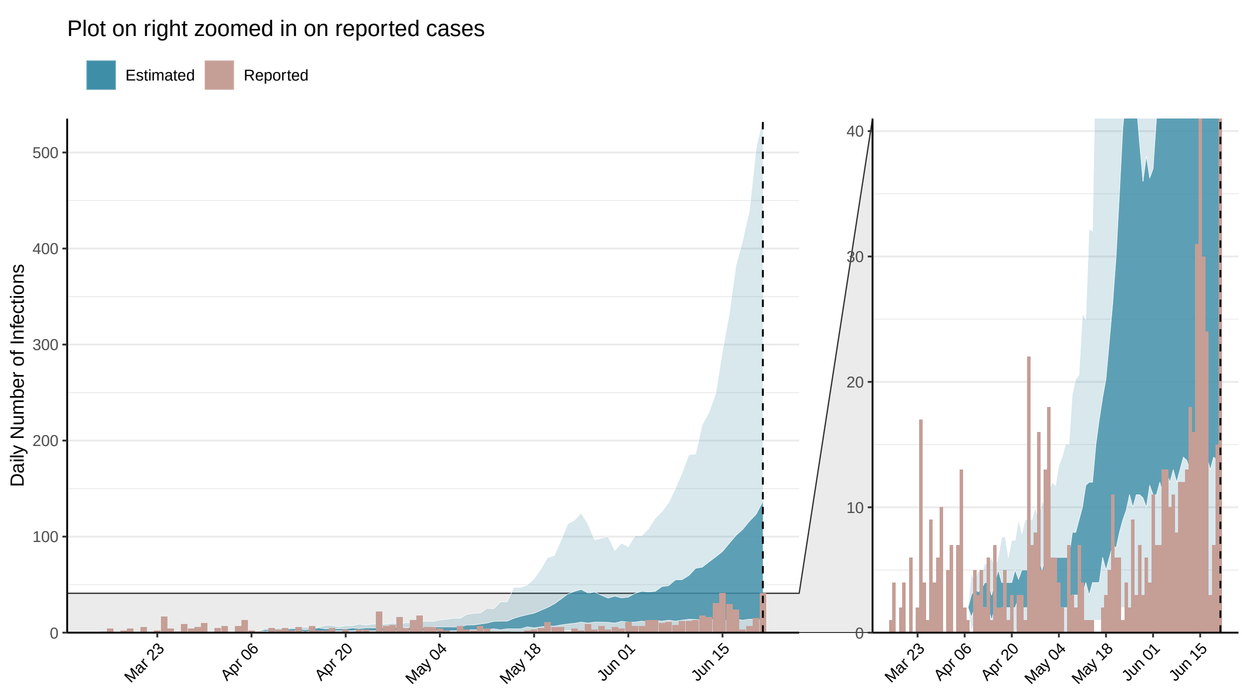


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

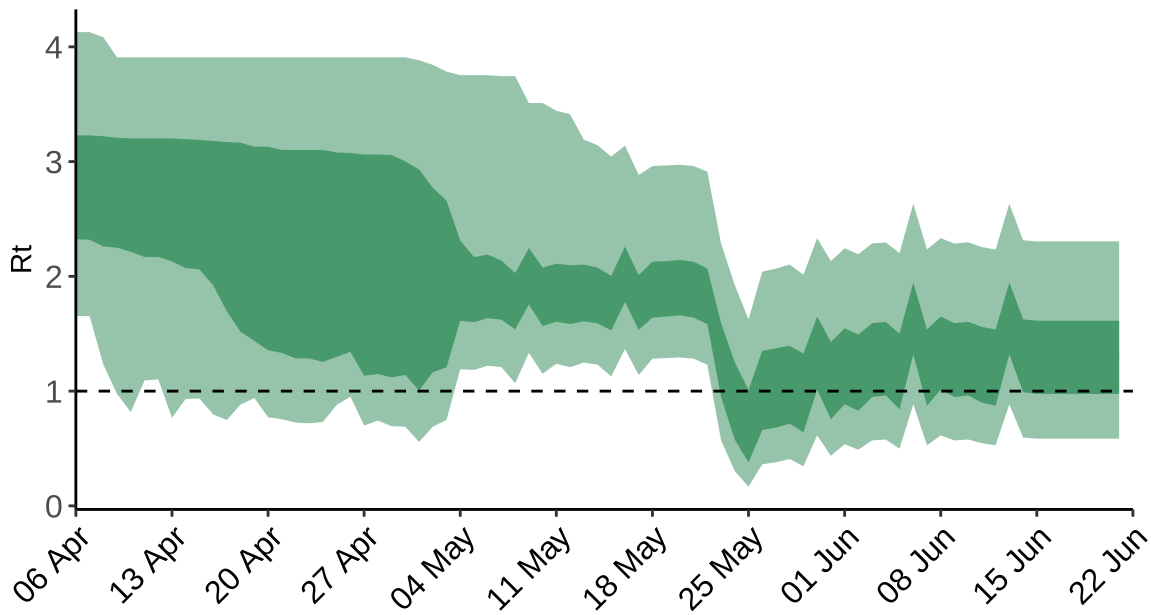


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

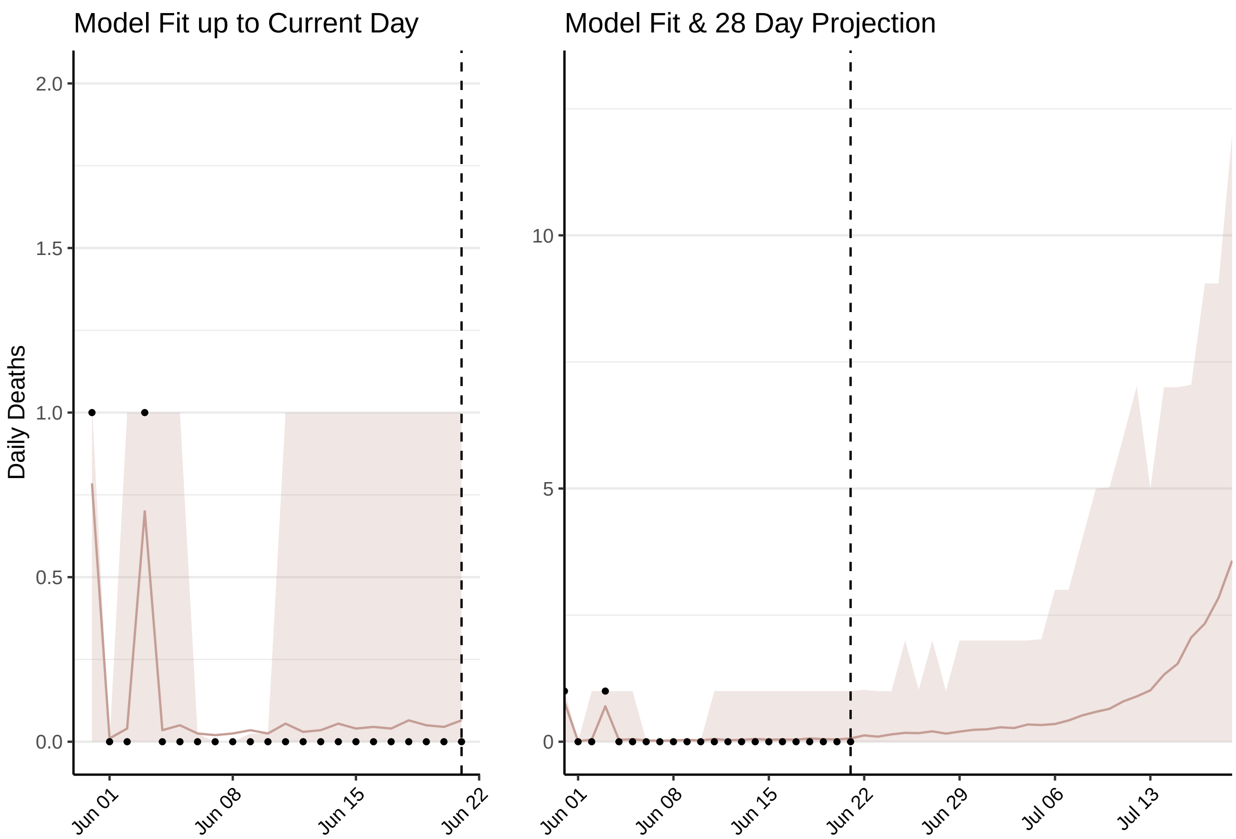


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 8 (95% CI: 6-9) patients requiring treatment with high-pressure oxygen at the current date to 128 (95% CI: 64-192) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2 (95% CI: 2-2) patients requiring treatment with mechanical ventilation at the current date to 28 (95% CI: 18-39) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

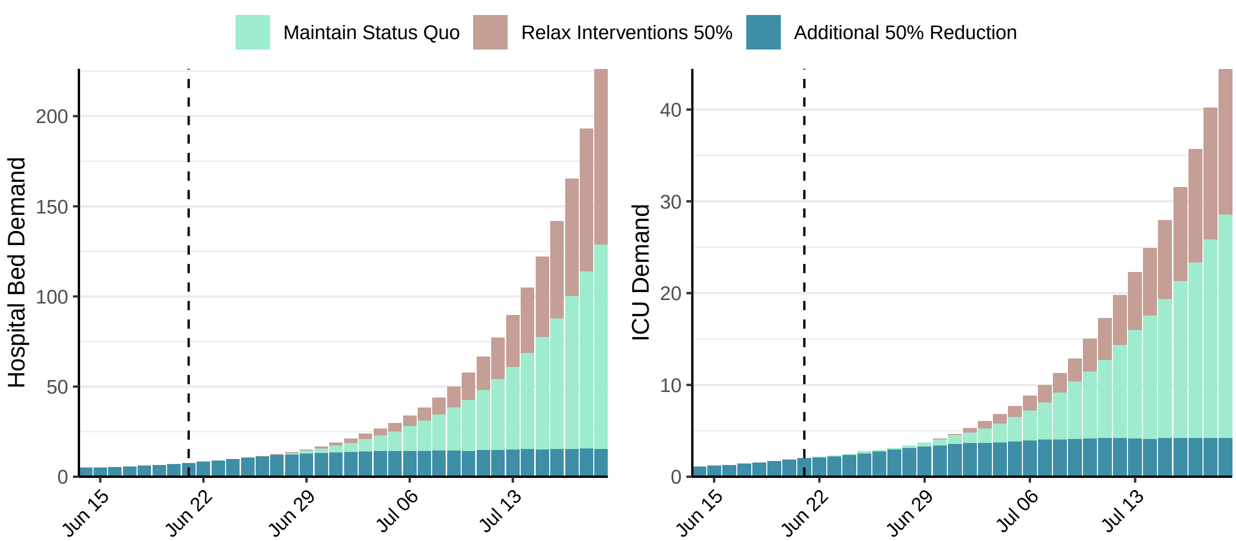


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 106 (95% CI: 85-126) at the current date to 114 (95% CI: 51-176) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 106 (95% CI: 85-126) at the current date to 5,687 (95% CI: 2,105-9,268) by 2020-07-19.

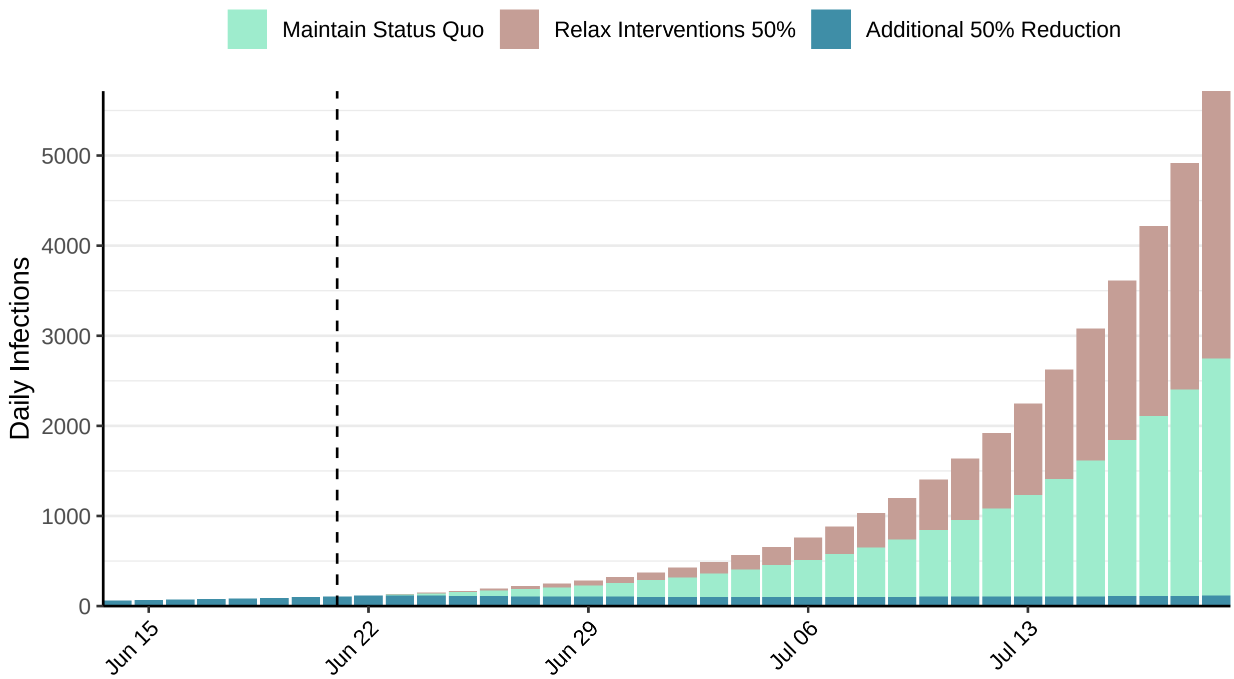


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Sudan, 2020-06-21

**Download the report for Sudan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 8,580 | 264 | 521 | 15 | 0.32 (95% CI: 0.09-0.78) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

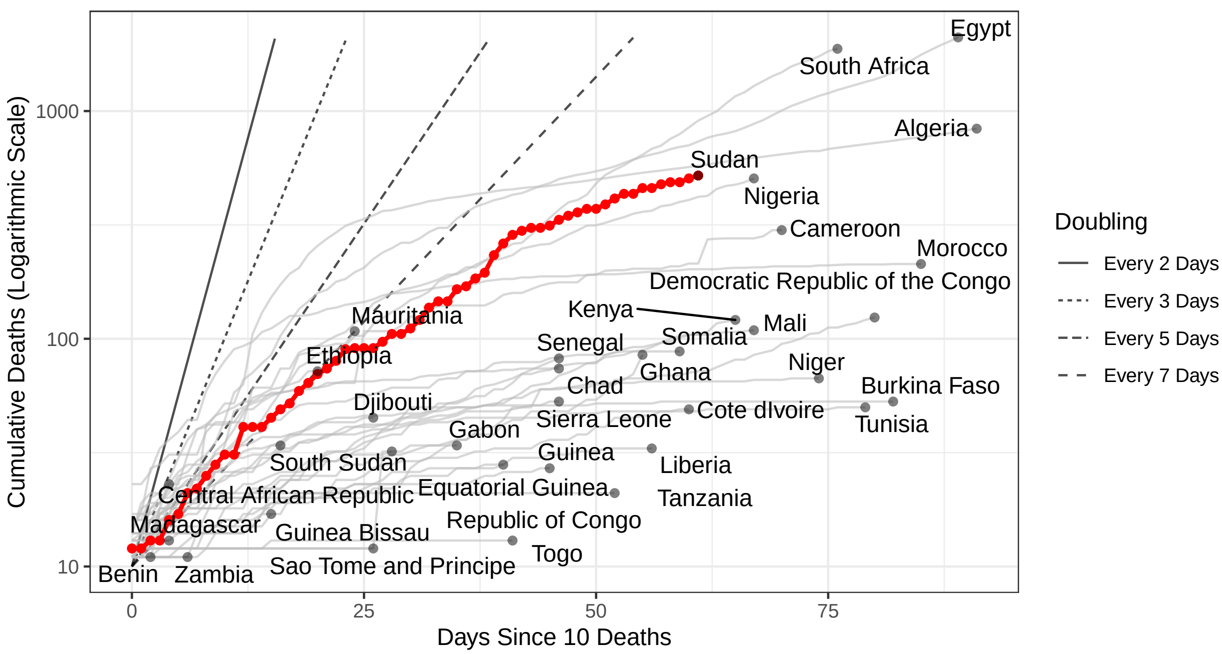


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 137,211 (95% CI: 131,878-142,544) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

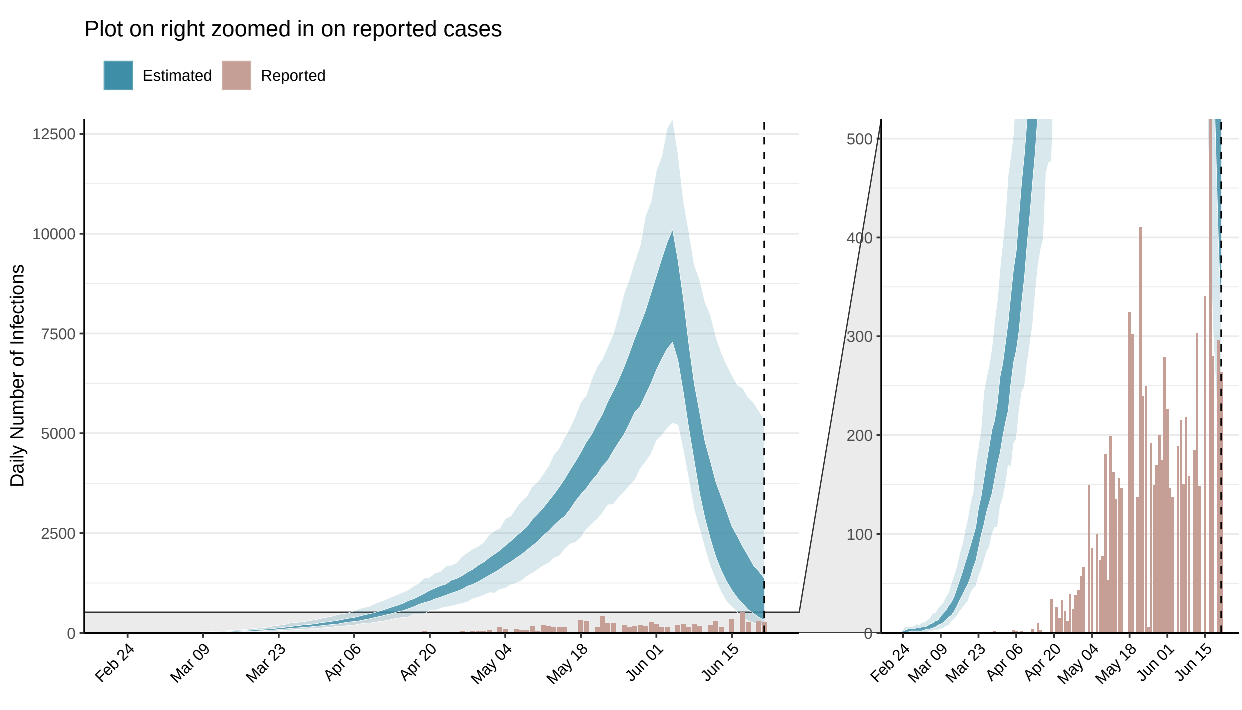


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

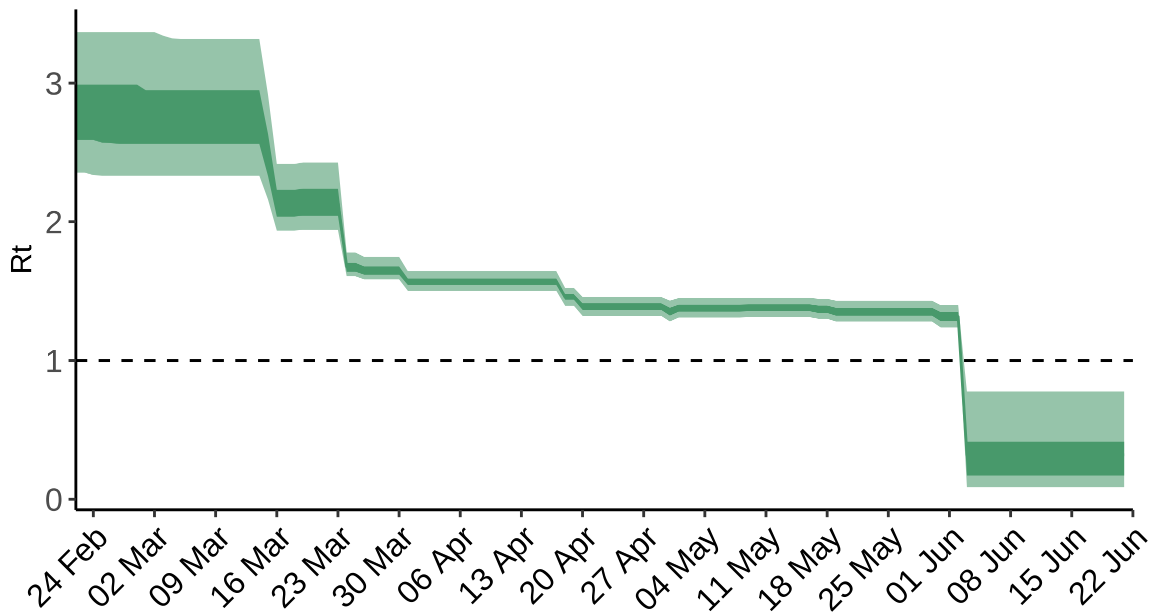


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

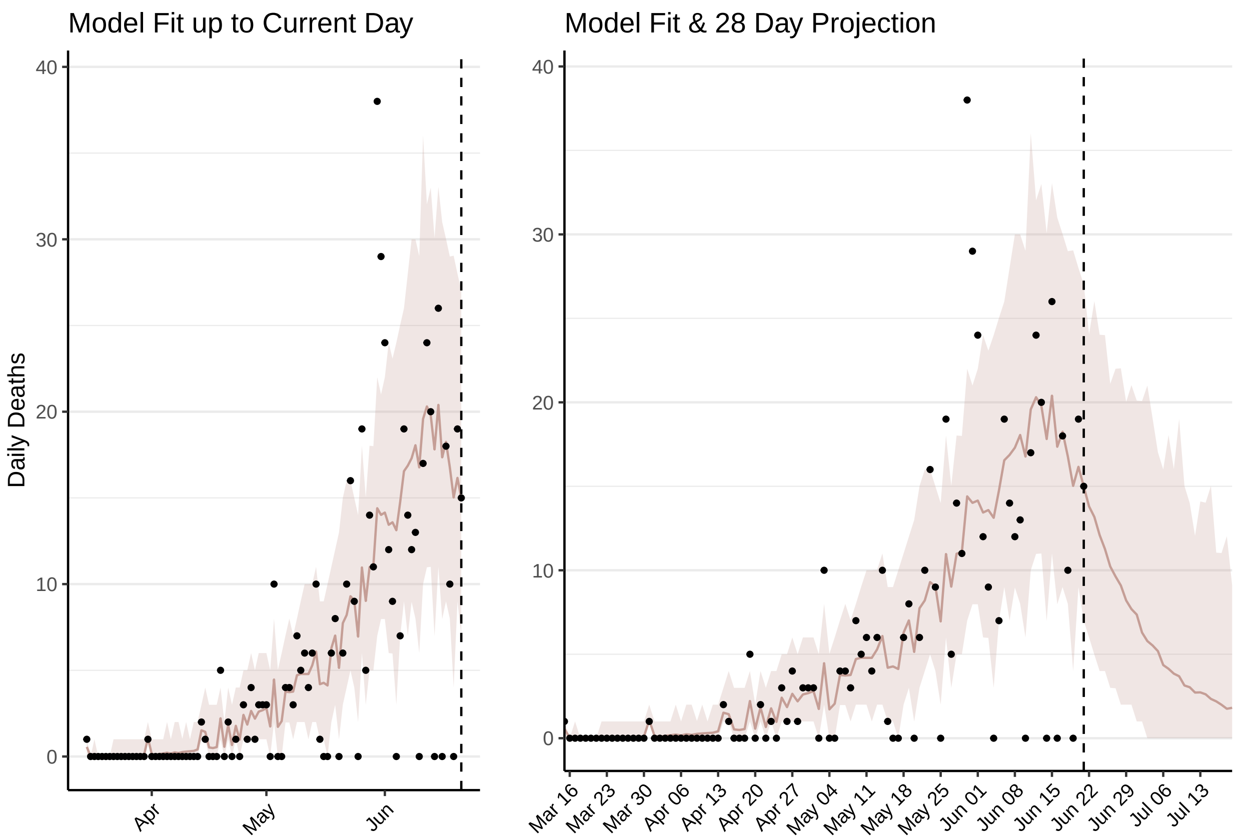


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 635 (95% CI: 605-664) patients requiring treatment with high-pressure oxygen at the current date to 71 (95% CI: 50-92) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 188 (95% CI: 179-197) patients requiring treatment with mechanical ventilation at the current date to 23 (95% CI: 17-29) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

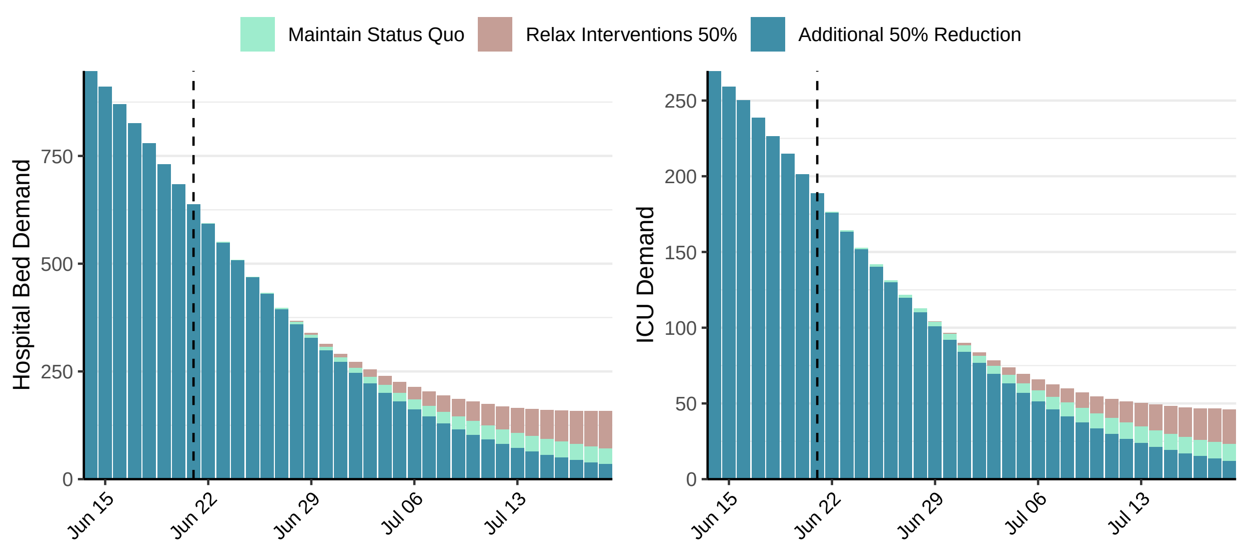


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 1,164 (95% CI: 965-1,363) at the current date to 24 (95% CI: 14-35) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 1,164 (95% CI: 965-1,363) at the current date to 1,122 (95% CI: 564-1,680) by 2020-07-19.

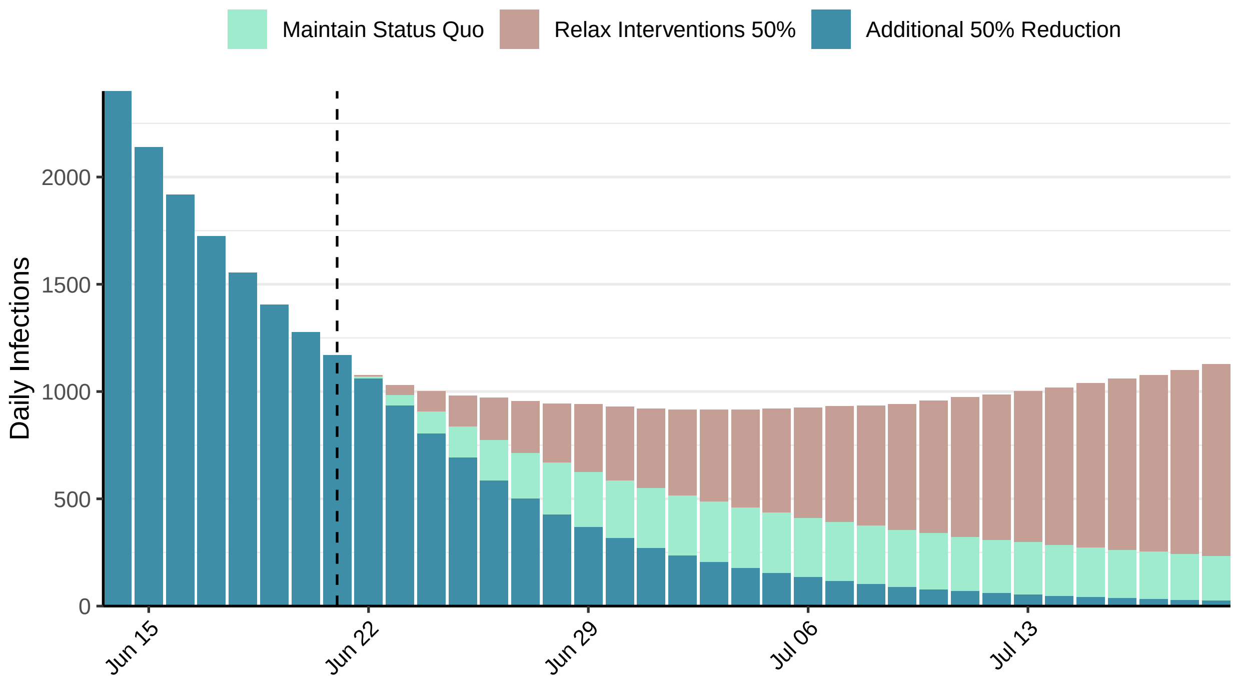


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Senegal, 2020-06-21

**Download the report for Senegal, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 5,738 | 99 | 82 | 3 | 1.6 (95% CI: 0.93-2.29) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

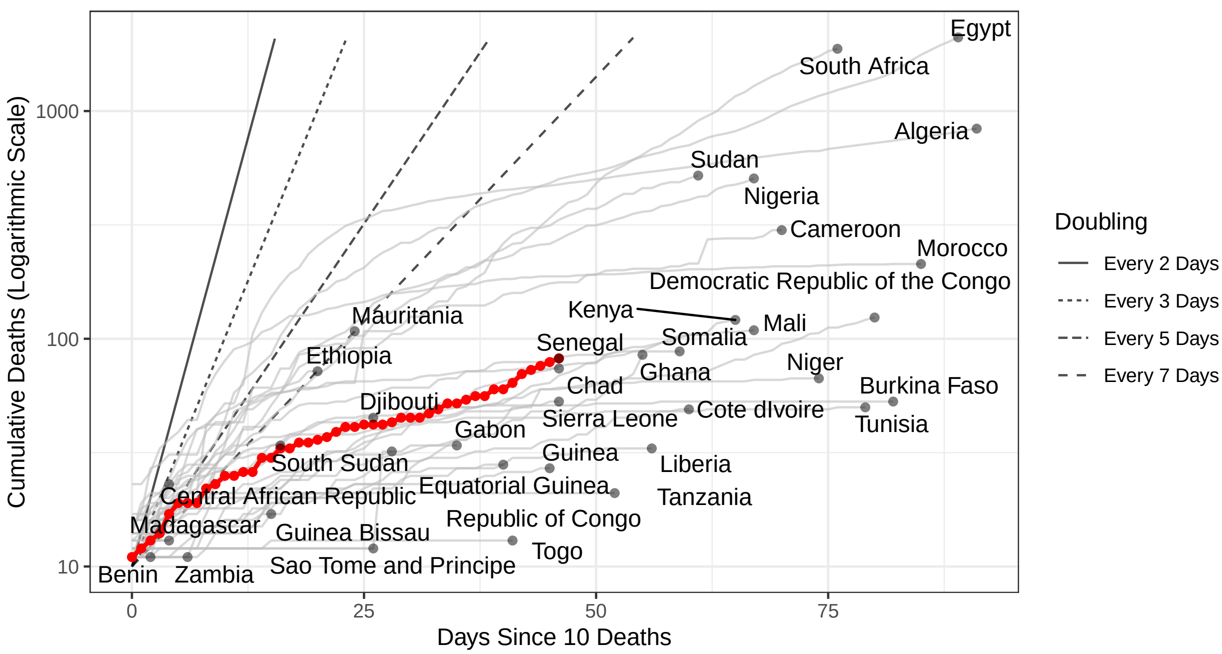


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

### COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 62,234 (95% CI: 58,483-65,985) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

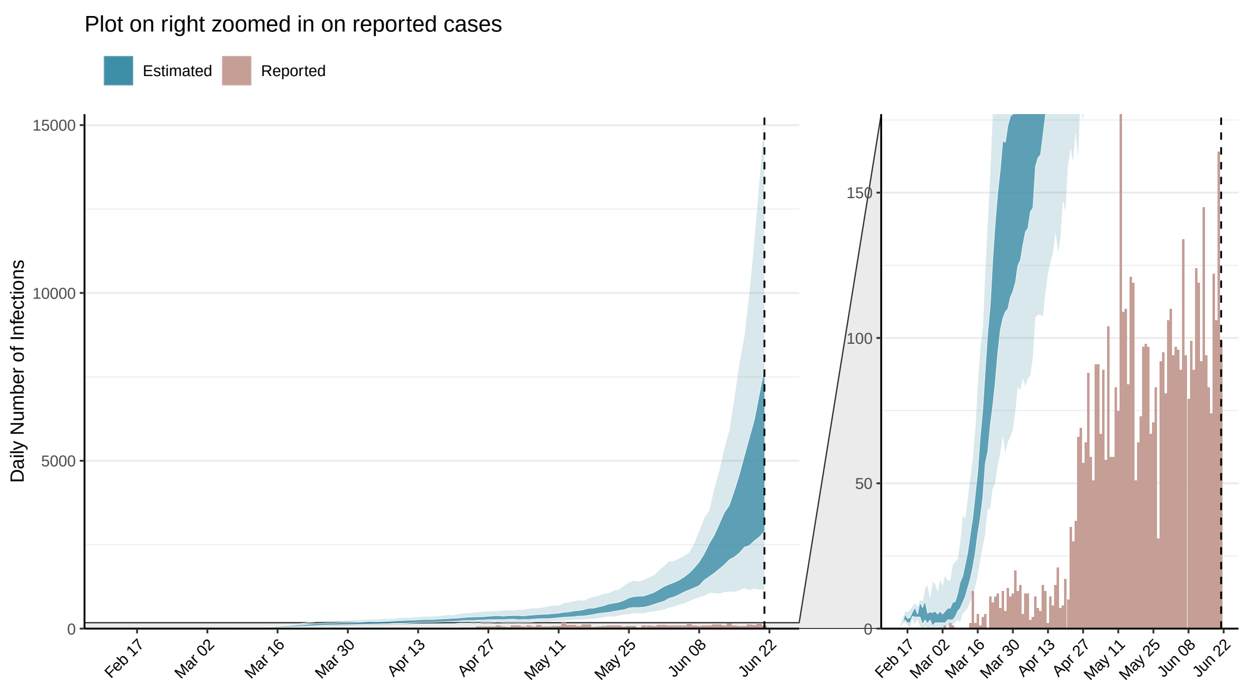


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

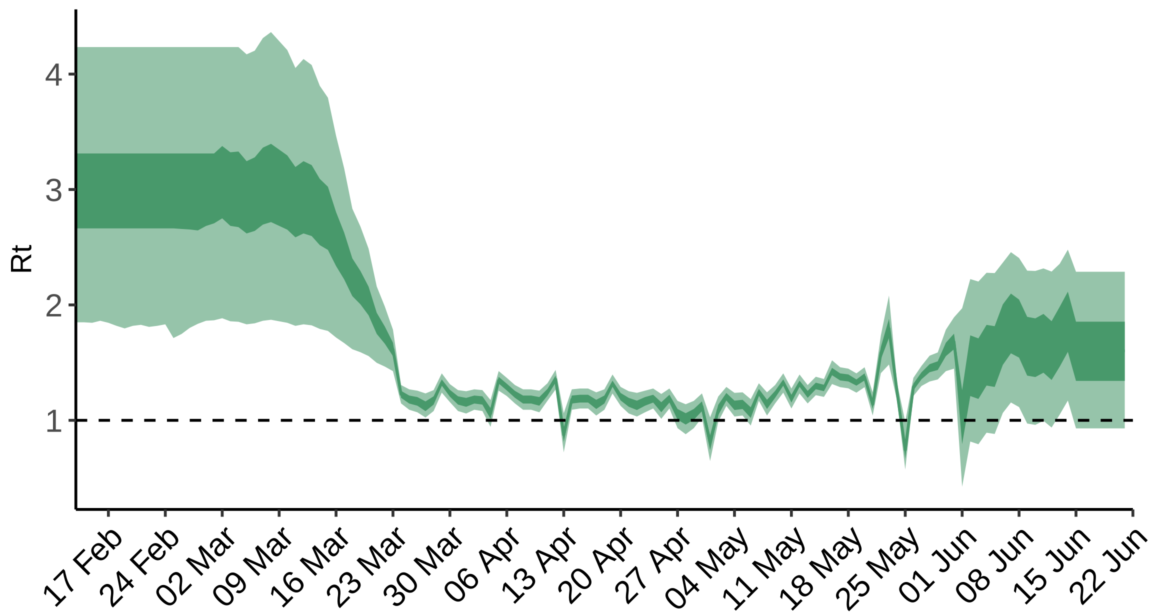


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

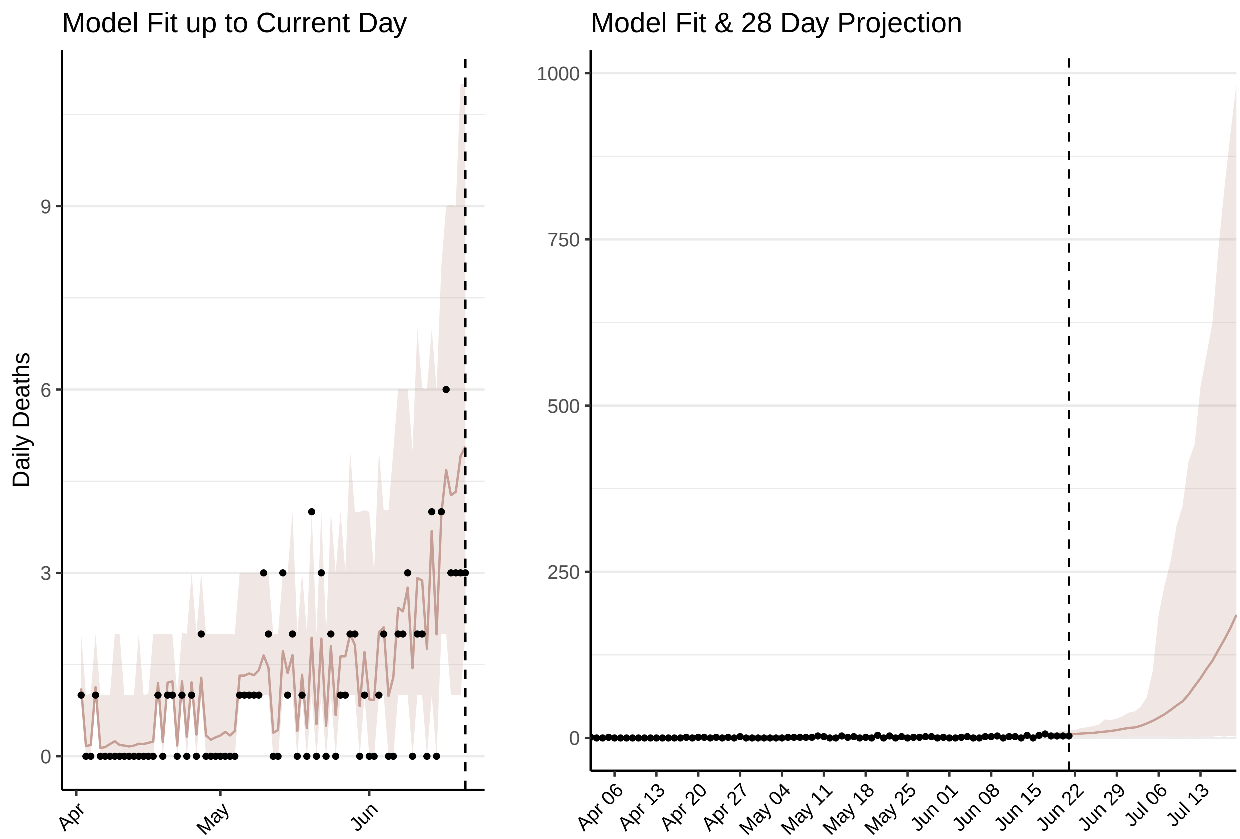


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 353 (95% CI: 332-375) patients requiring treatment with high-pressure oxygen at the current date to 5,072 (95% CI: 4,094-6,050) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 93 (95% CI: 88-99) patients requiring treatment with mechanical ventilation at the current date to 787 (95% CI: 704-869) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

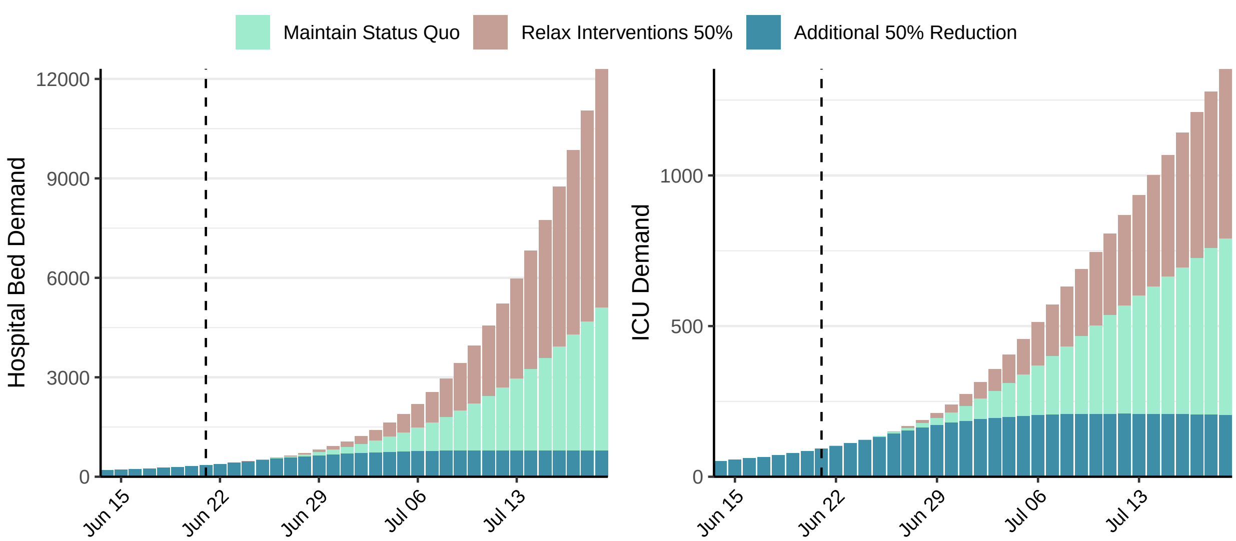


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 5,775 (95% CI: 5,187-6,363) at the current date to 5,226 (95% CI: 3,652-6,801) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 5,775 (95% CI: 5,187-6,363) at the current date to 217,638 (95% CI: 187,974-247,302) by 2020-07-19.

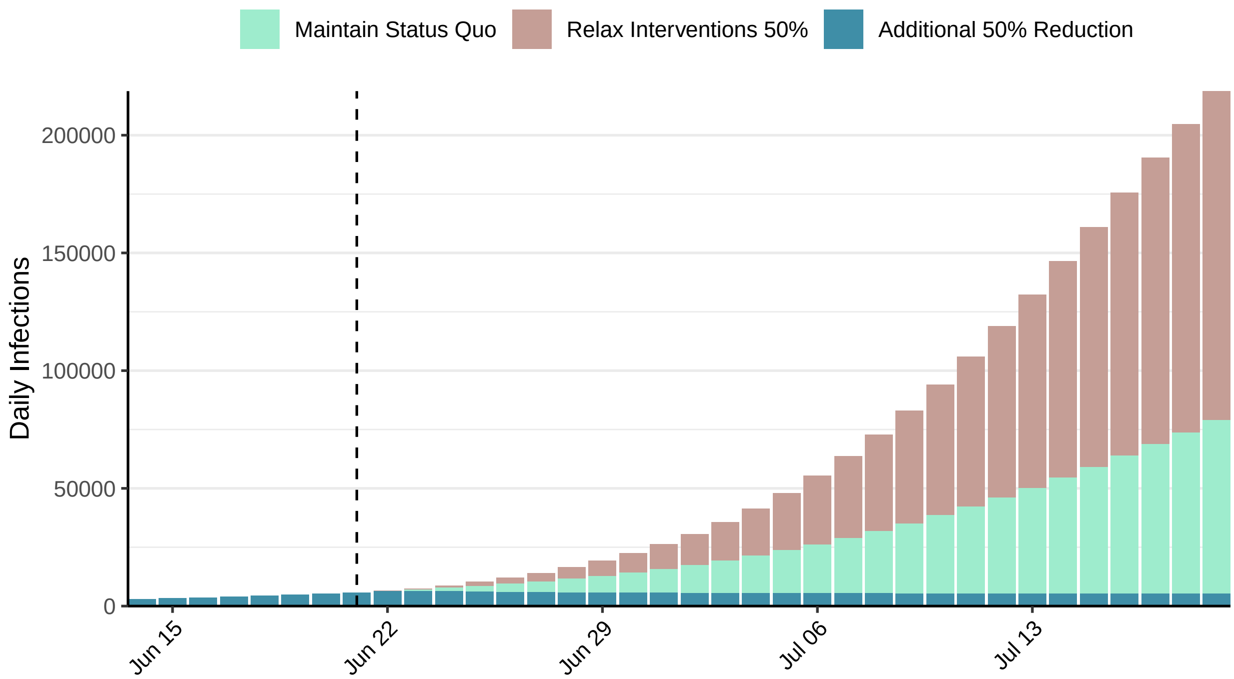


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Sierra Leone, 2020-06-21

**Download the report for Sierra Leone, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,309 | 11 | 53 | 0 | 0.94 (95% CI: 0.35-1.93) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

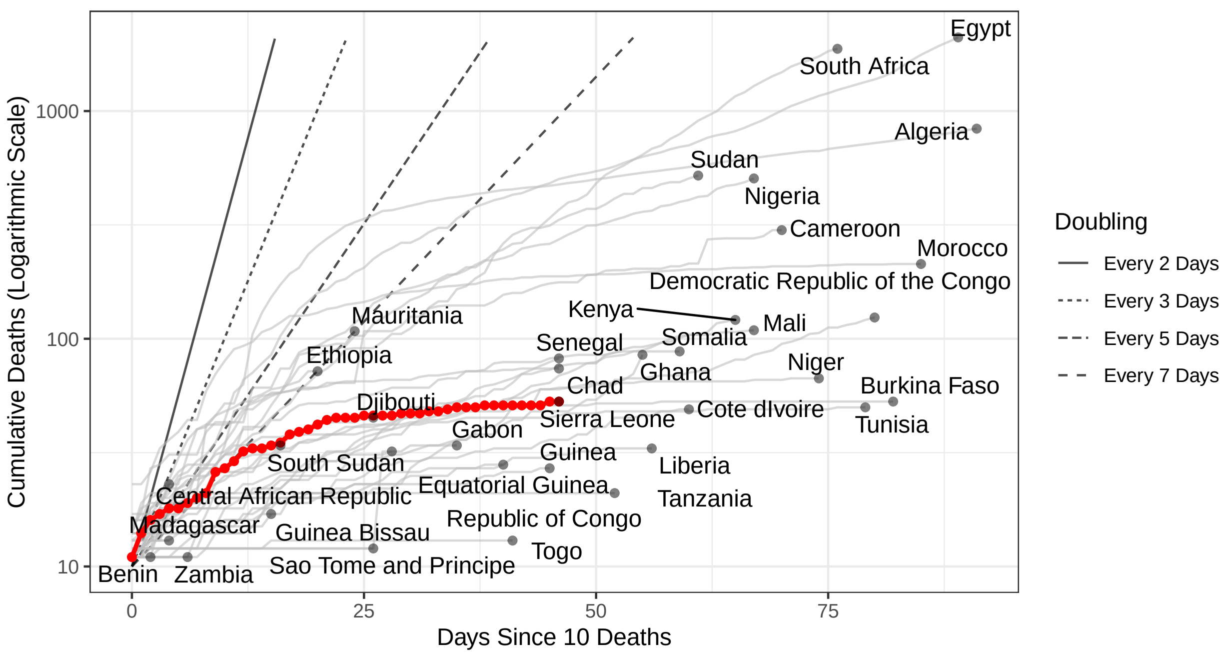


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 8,107 (95% CI: 7,584-8,631) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

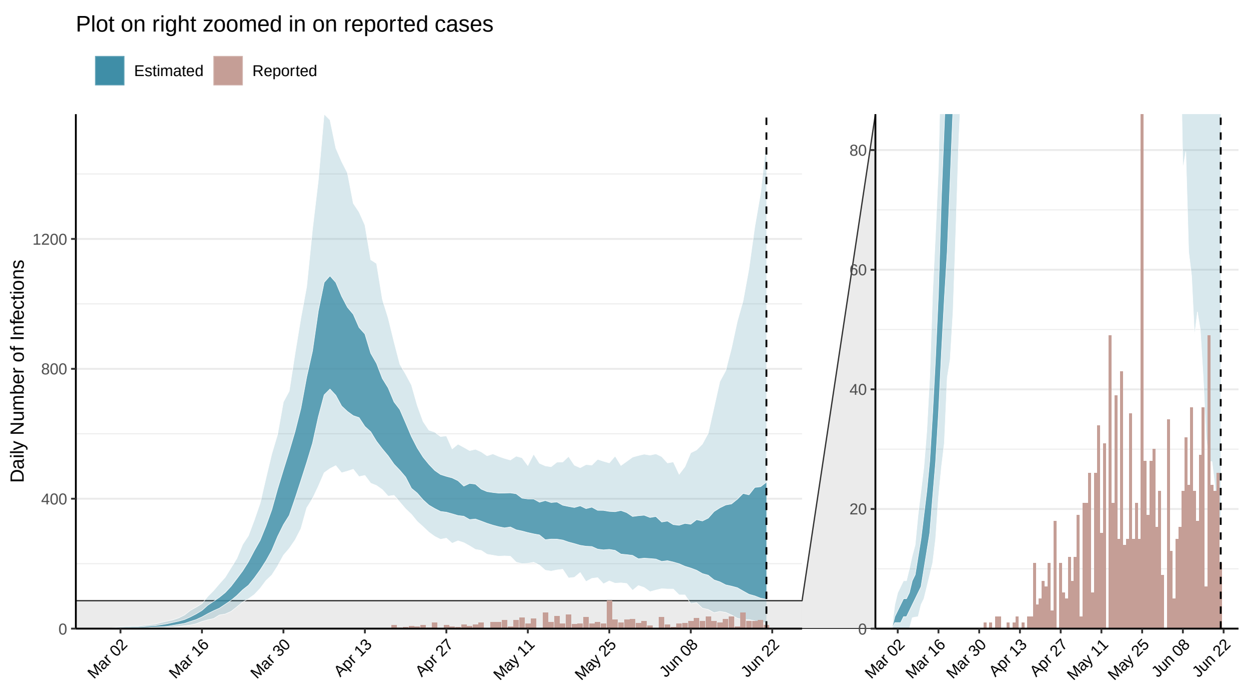


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

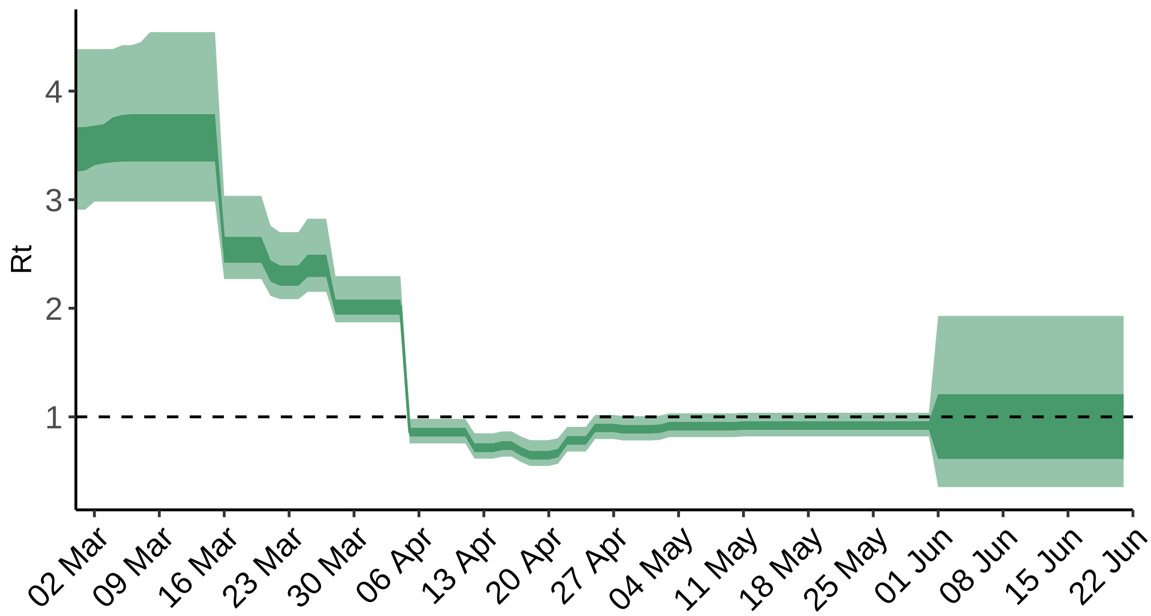


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

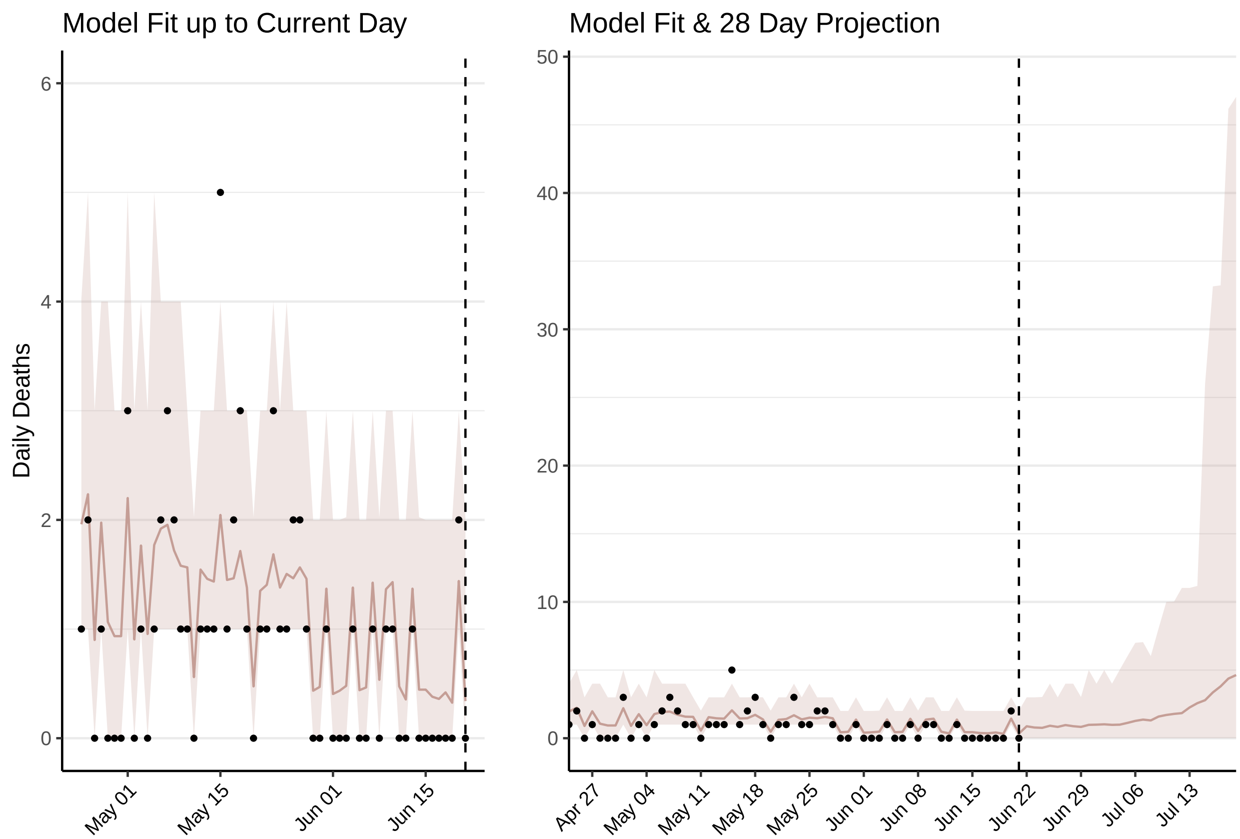


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 42 (95% CI: 39-46) patients requiring treatment with high-pressure oxygen at the current date to 167 (95% CI: 108-225) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 12 (95% CI: 11-13) patients requiring treatment with mechanical ventilation at the current date to 34 (95% CI: 25-43) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

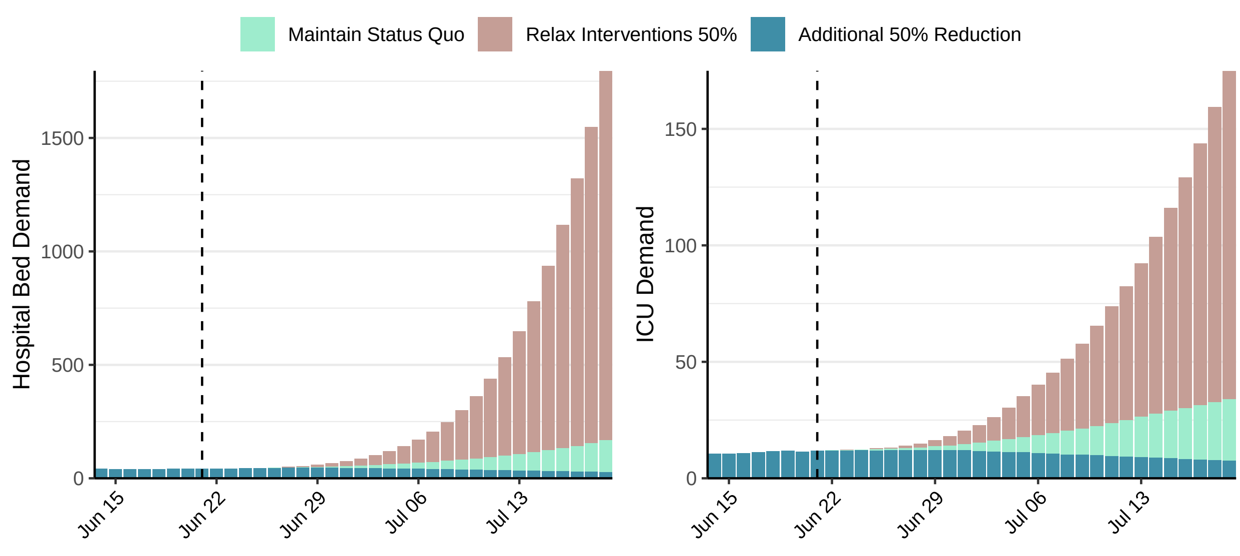


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 348 (95% CI: 293-403) at the current date to 134 (95% CI: 82-186) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 348 (95% CI: 293-403) at the current date to 44,434 (95% CI: 30,491-58,377) by 2020-07-19.

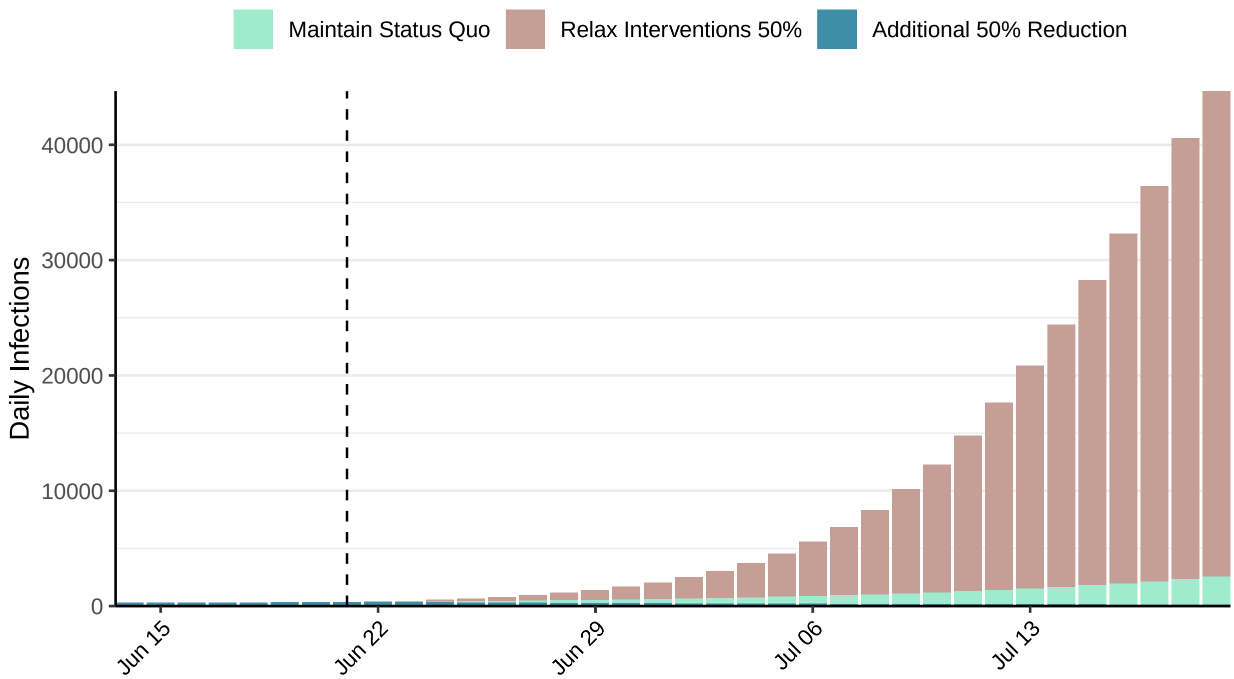


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: El Salvador, 2020-06-21

**Download the report for El Salvador, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 4,626 | 297 | 98 | 5 | 1.4 (95% CI: 1.27-1.53) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

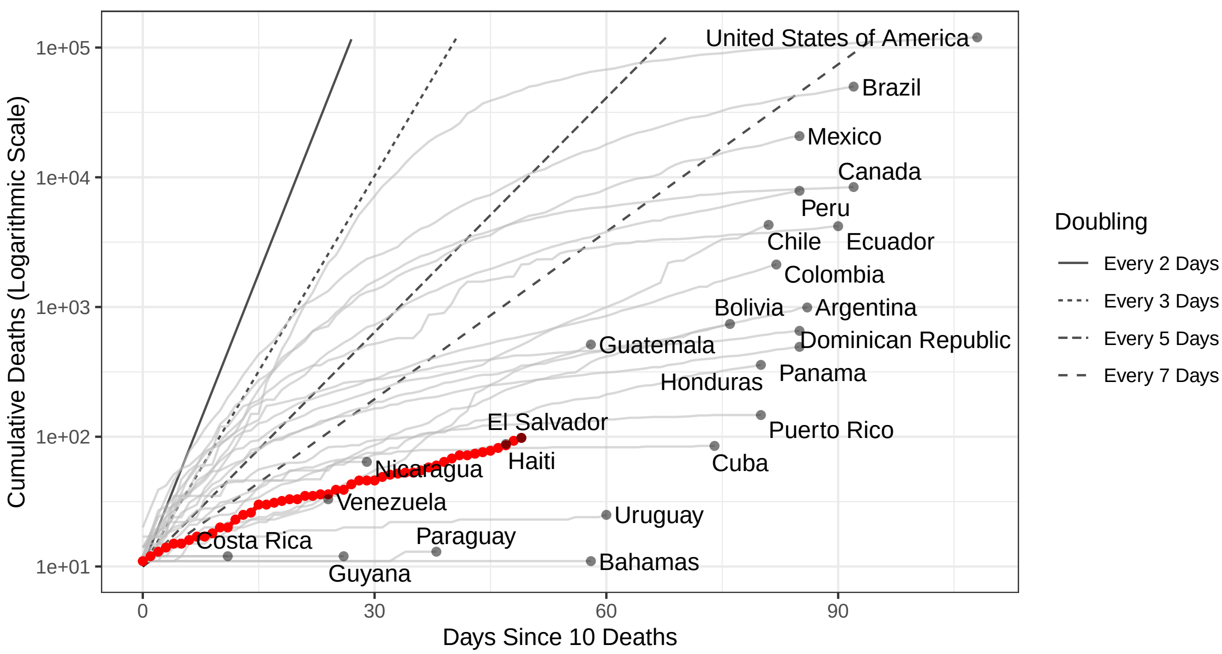


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 52,148 (95% CI: 49,815-54,482) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

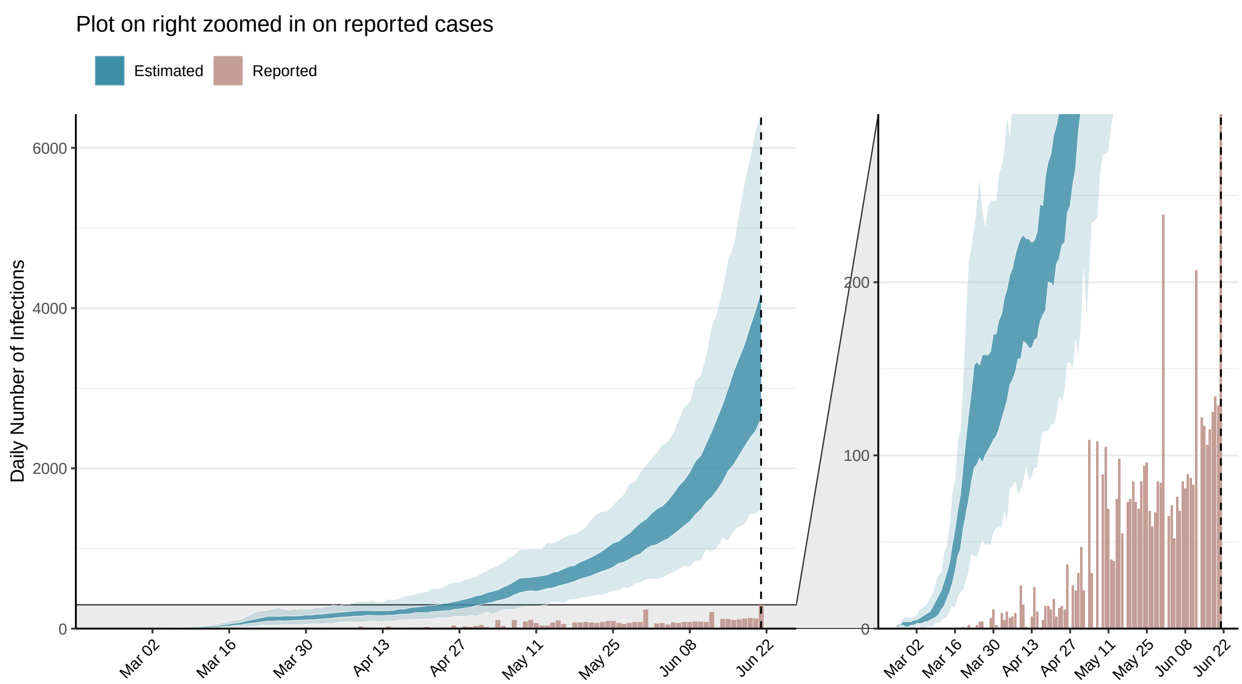


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

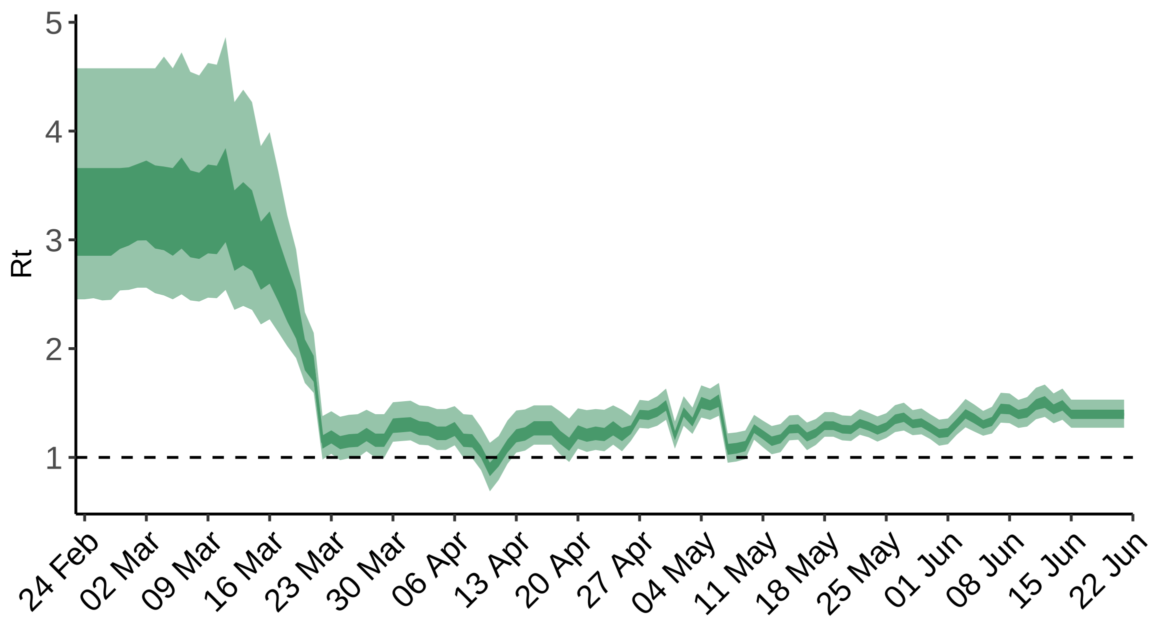


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. El Salvador is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

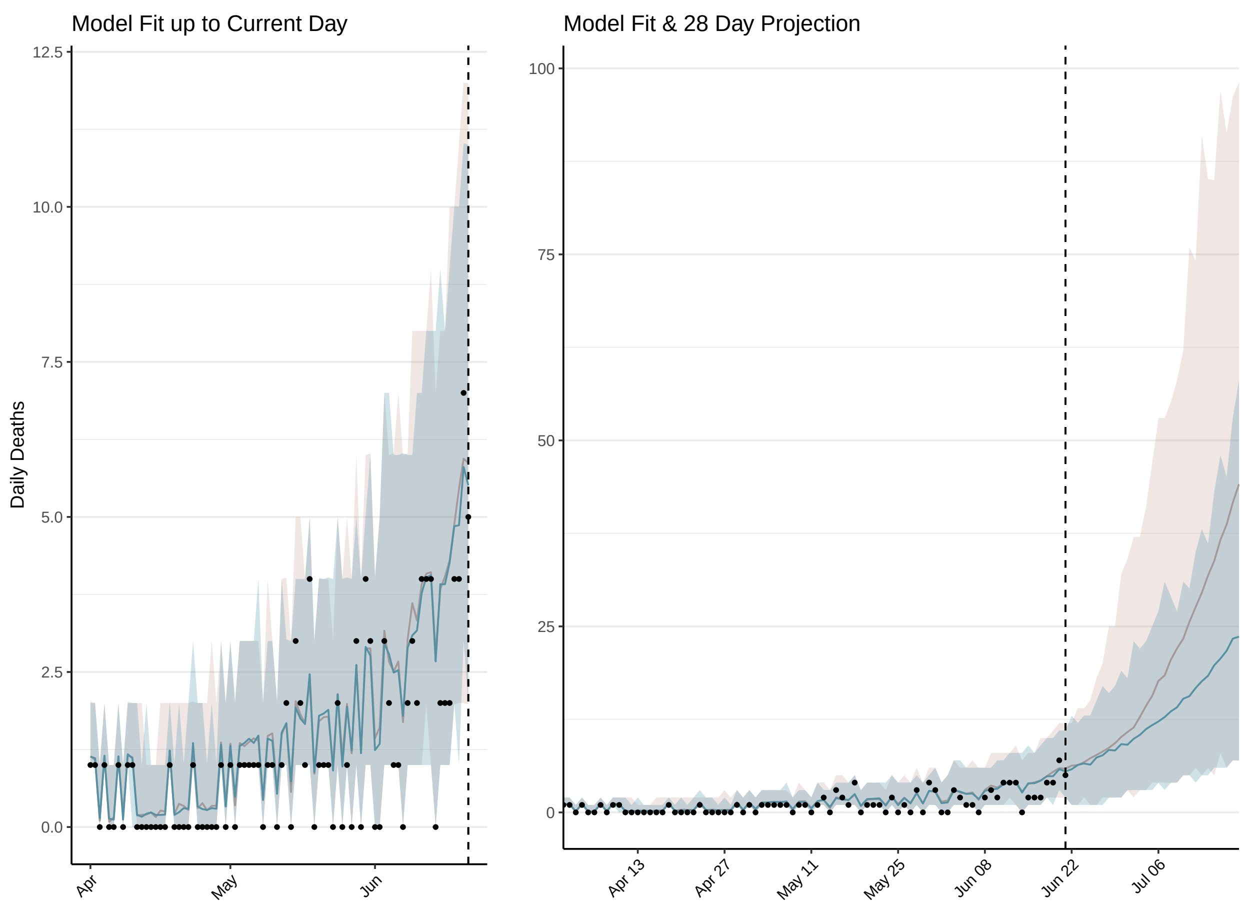


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 293 (95% CI: 280-306) patients requiring treatment with high-pressure oxygen at the current date to 1,225 (95% CI: 1,148-1,302) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 92 (95% CI: 88-97) patients requiring treatment with mechanical ventilation at the current date to 253 (95% CI: 246-260) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

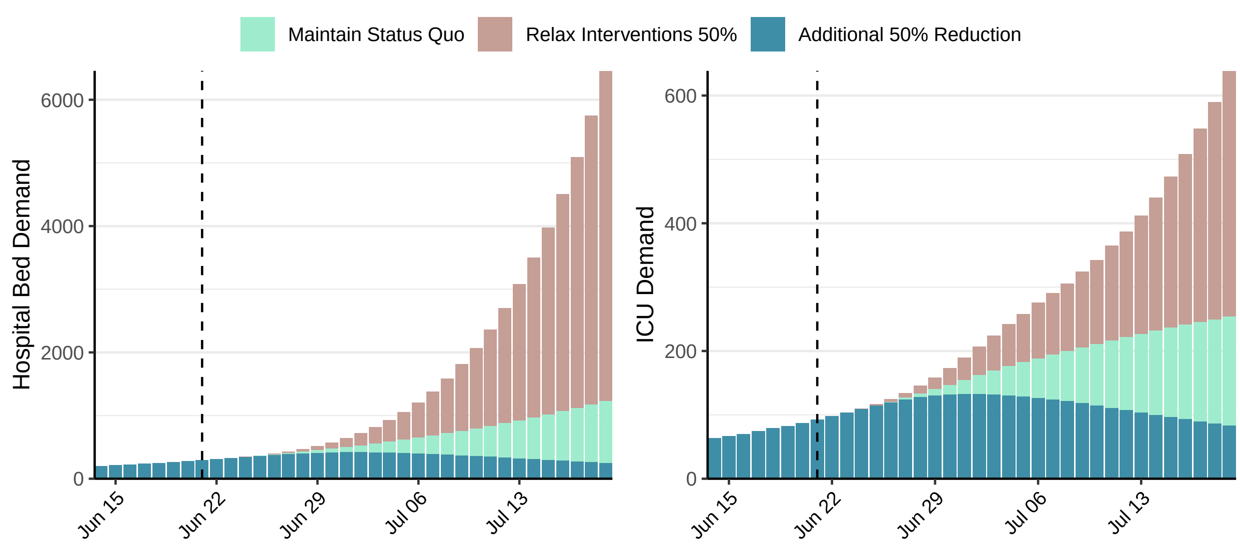


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 3,488 (95% CI: 3,310-3,665) at the current date to 928 (95% CI: 865-990) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 3,488 (95% CI: 3,310-3,665) at the current date to 107,418 (95% CI: 102,607-112,229) by 2020-07-19.

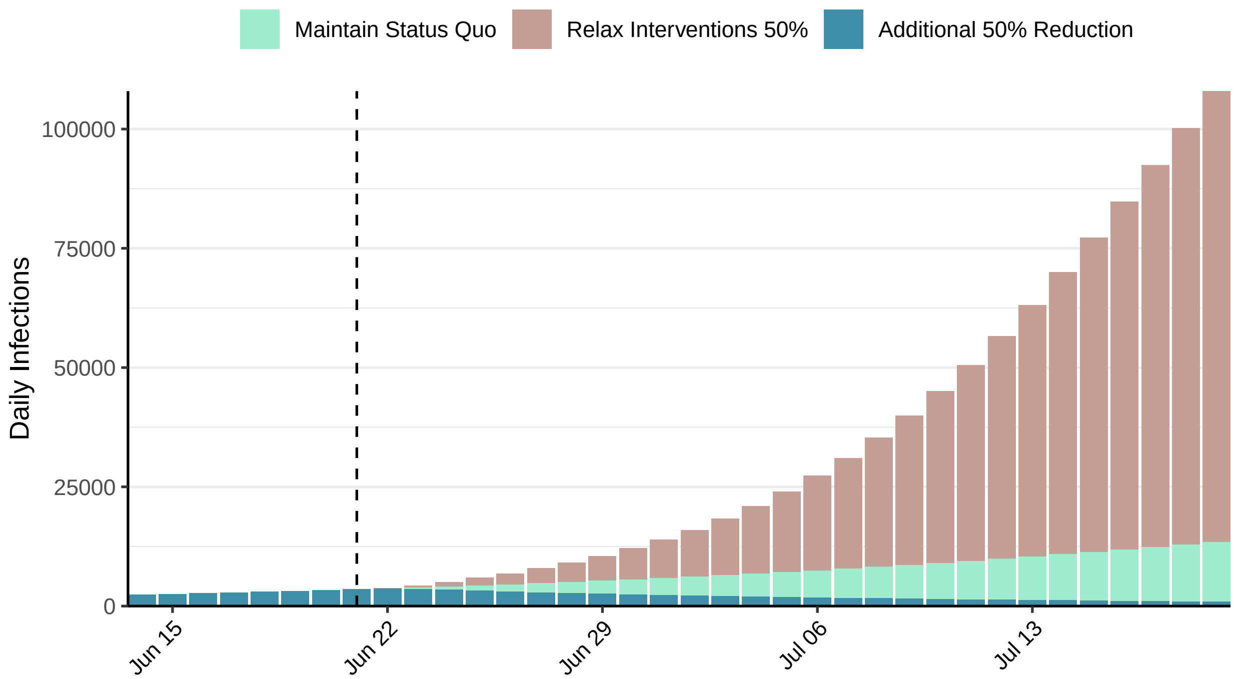


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Somalia, 2020-06-21

**Download the report for Somalia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 2,755 | 36 | 88 | 0 | 0.61 (95% CI: 0.35-0.89) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

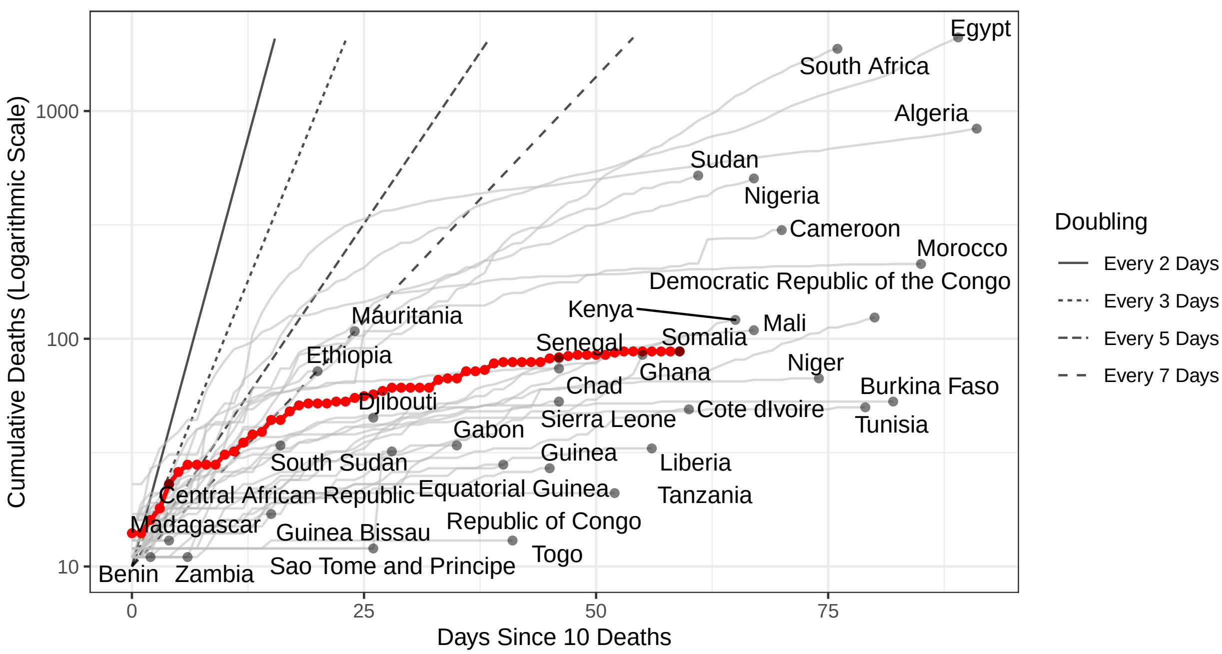


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 4,247 (95% CI: 3,987-4,506) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

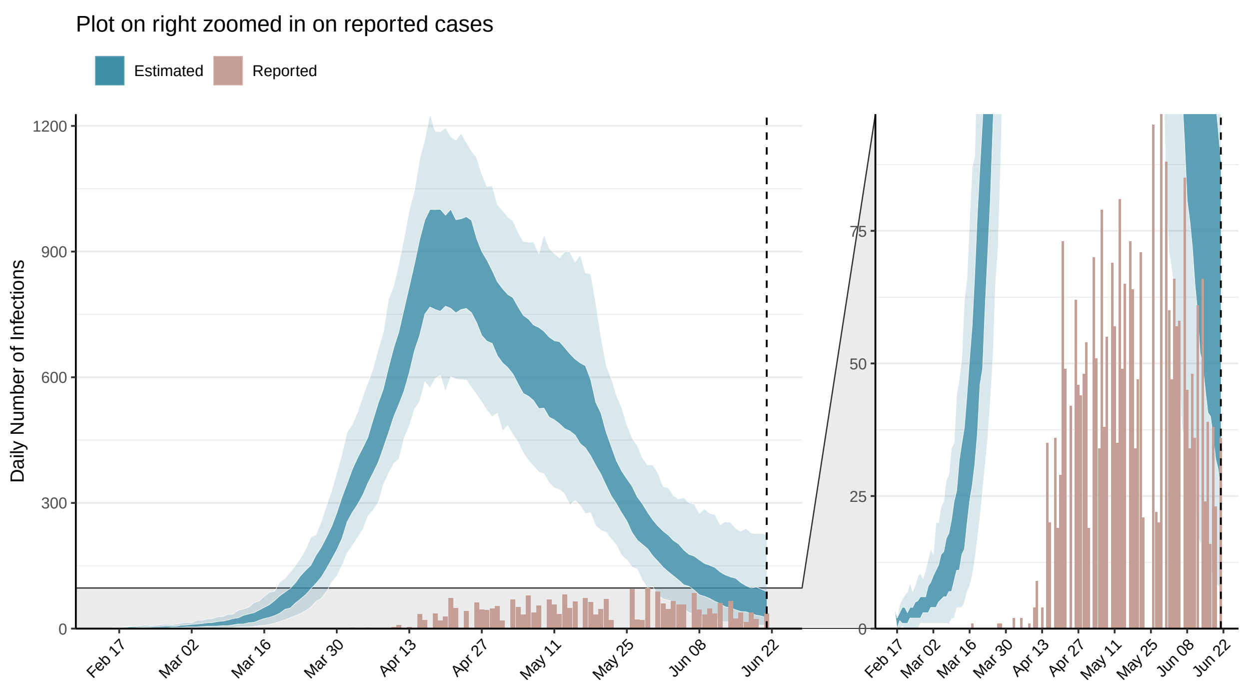


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

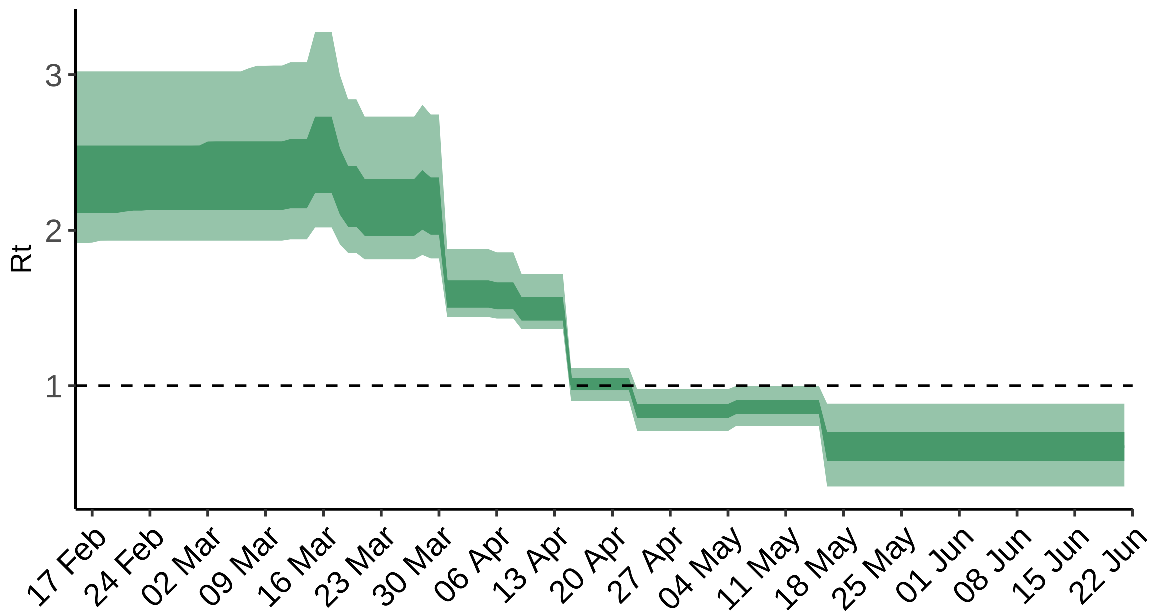


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

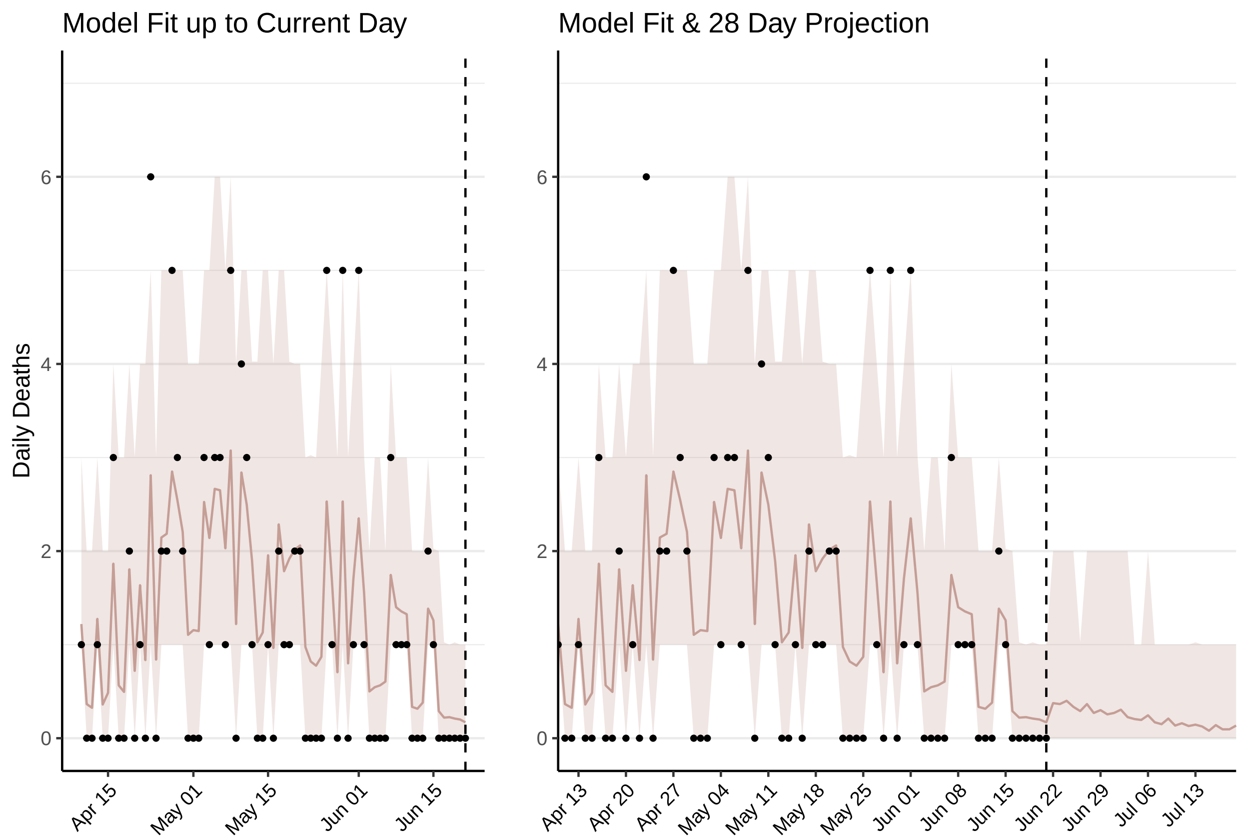


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 19 (95% CI: 17-20) patients requiring treatment with high-pressure oxygen at the current date to 5 (95% CI: 4-6) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 6 (95% CI: 5-7) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 1-2) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

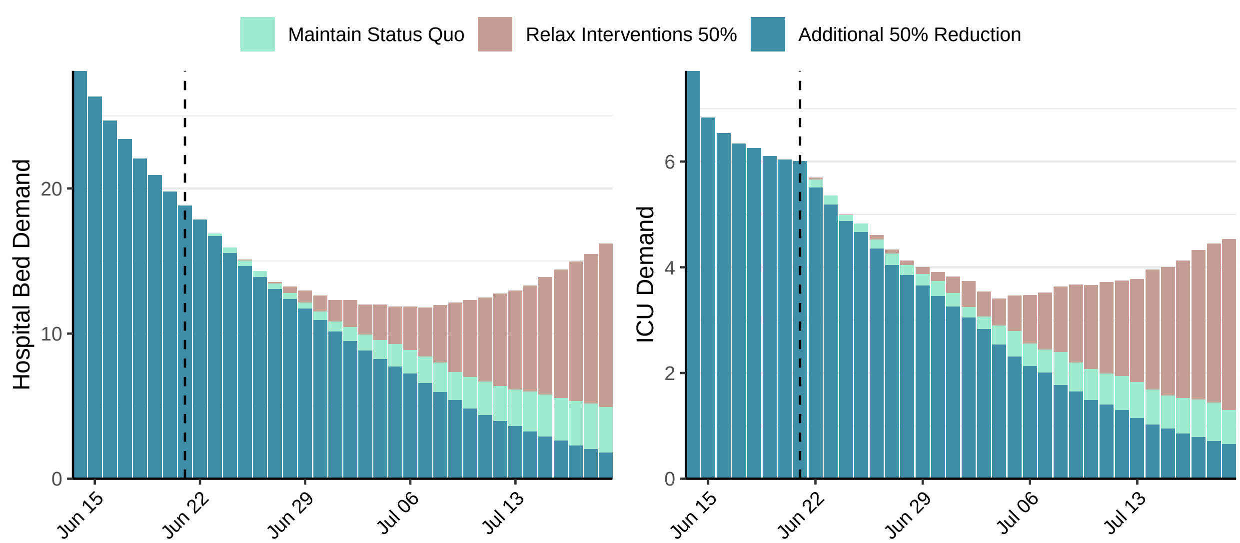


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 66 (95% CI: 58-75) at the current date to 3 (95% CI: 2-3) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 66 (95% CI: 58-75) at the current date to 182 (95% CI: 119-245) by 2020-07-19.

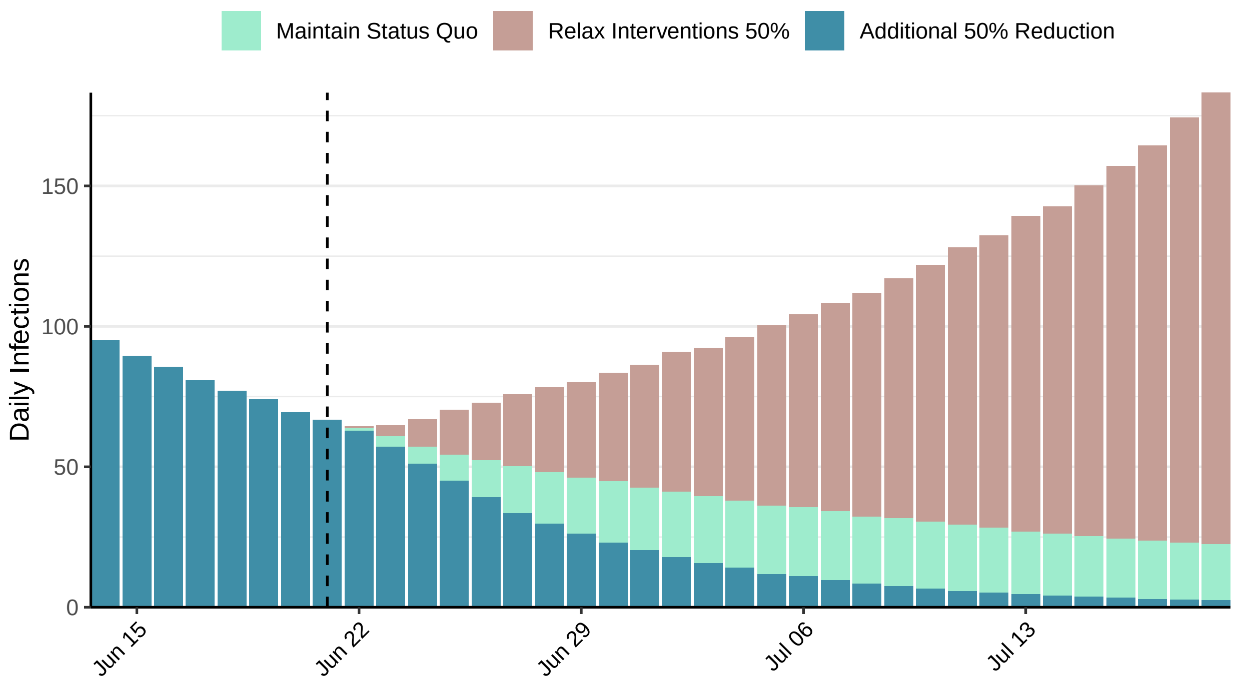


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Serbia, 2020-06-21

**Download the report for Serbia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 12,803 | 94 | 260 | 1 | 0.38 (95% CI: 0.28-0.46) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

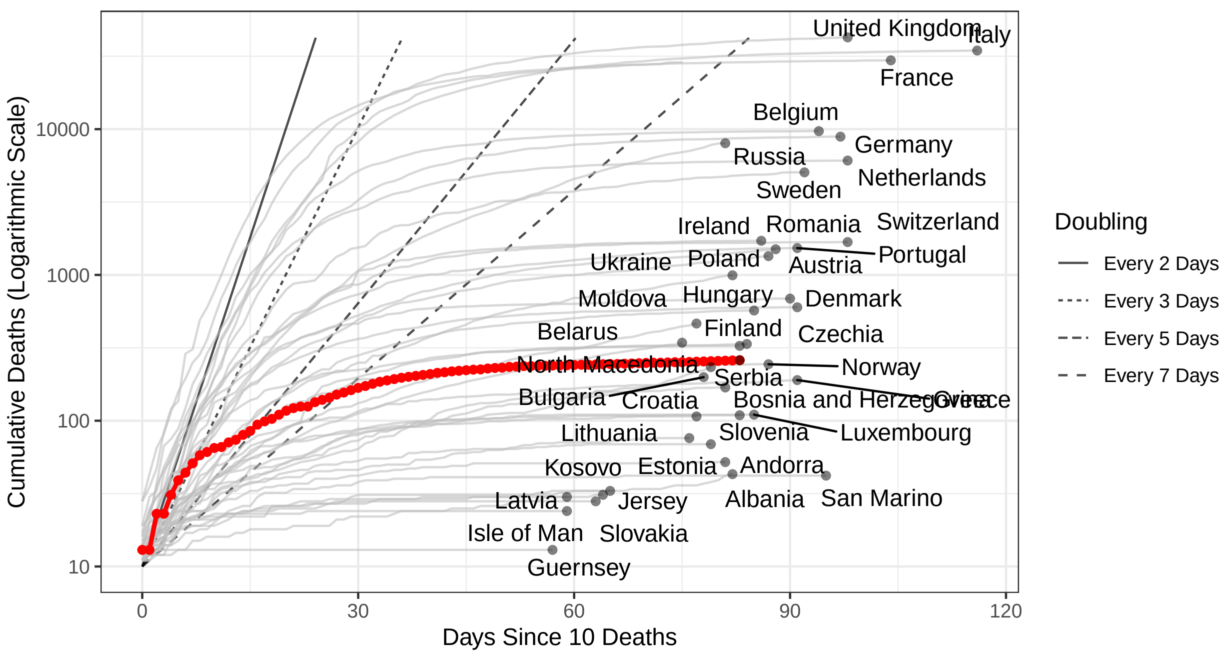


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 4,775 (95% CI: 4,585-4,965) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

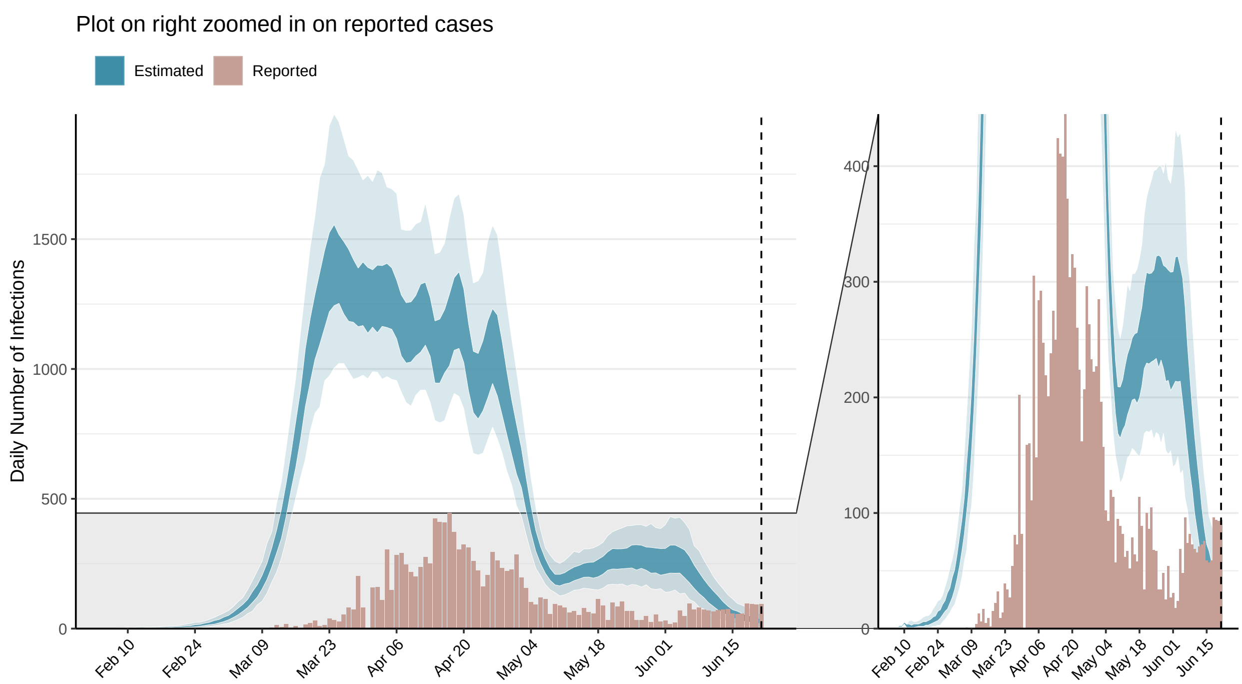


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

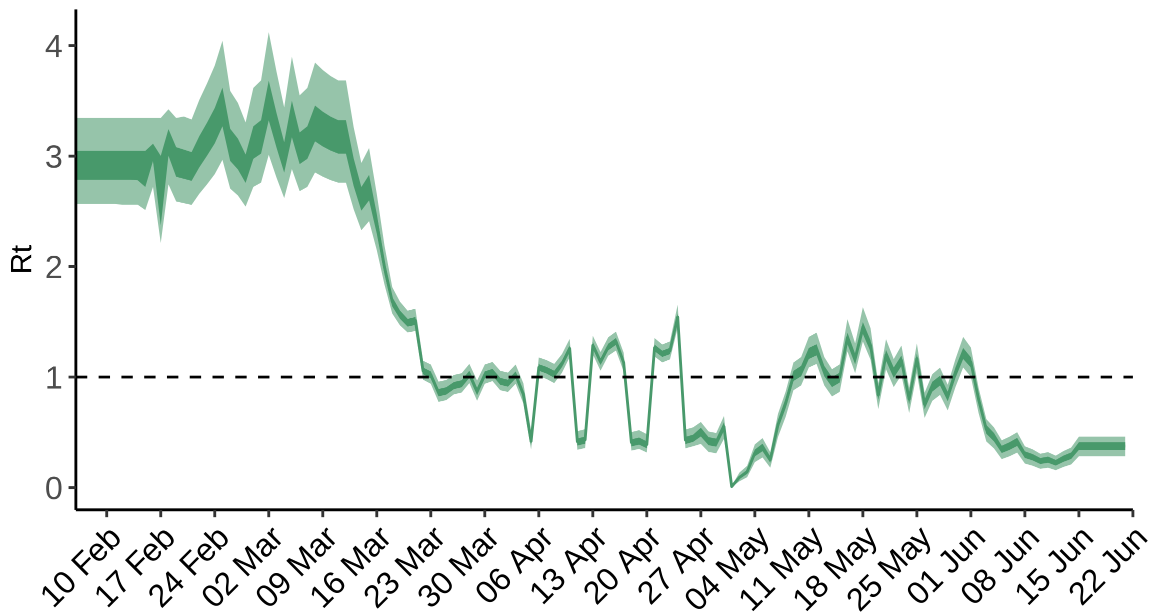


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

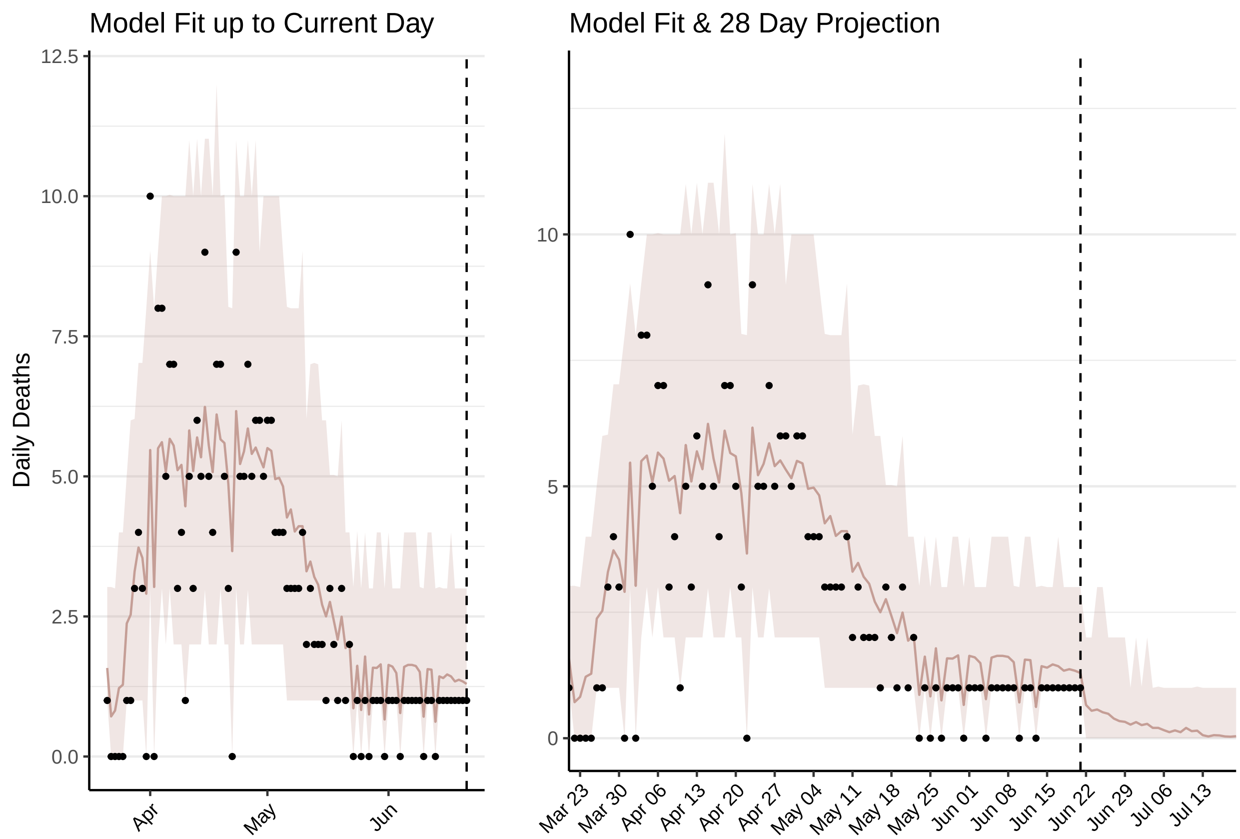


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 30 (95% CI: 28-31) patients requiring treatment with high-pressure oxygen at the current date to 2 (95% CI: 1-2) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 9 (95% CI: 9-10) patients requiring treatment with mechanical ventilation at the current date to 1 (95% CI: 0-1) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

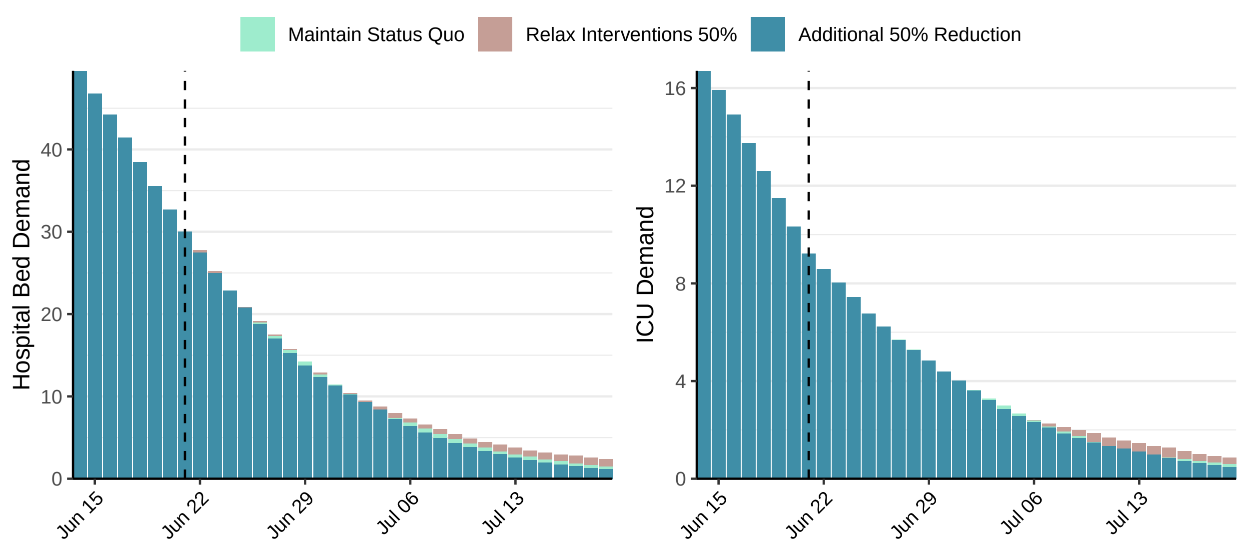


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 28 (95% CI: 26-30) at the current date to 0 (95% CI: 0-0) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 28 (95% CI: 26-30) at the current date to 4 (95% CI: 3-4) by 2020-07-19.

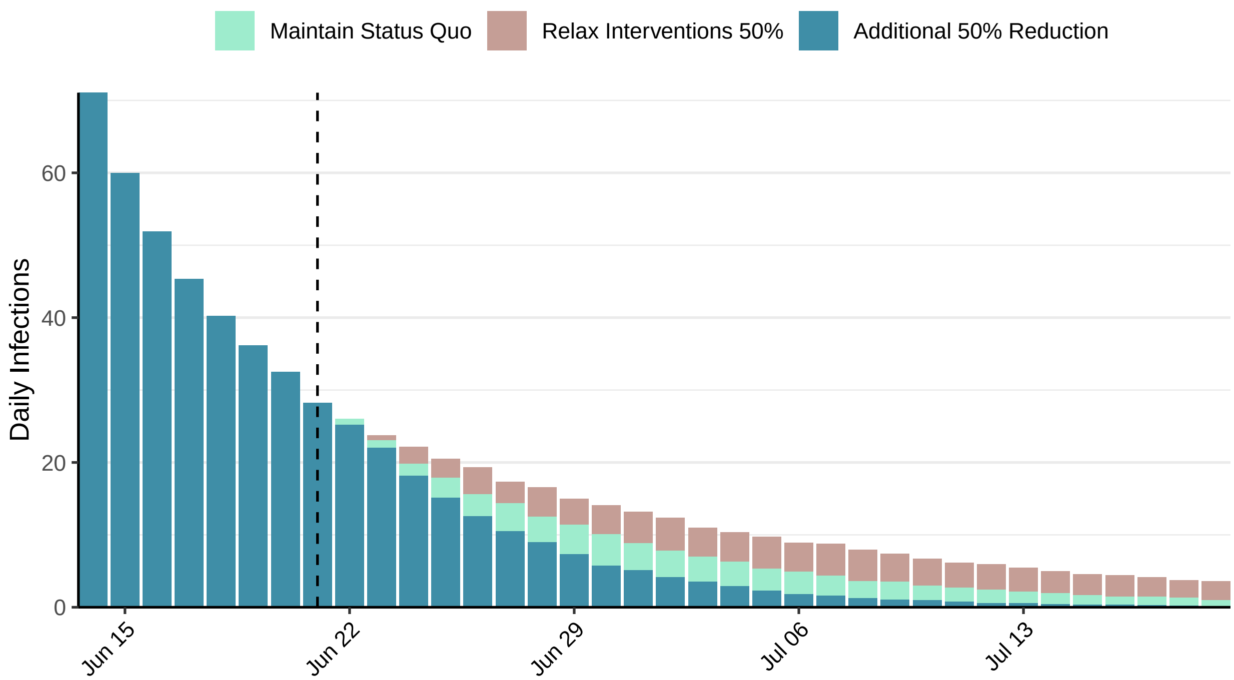


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: South Sudan, 2020-06-21

**Download the report for South Sudan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,864 | 51 | 34 | 3 | 1.27 (95% CI: 1.04-1.49) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

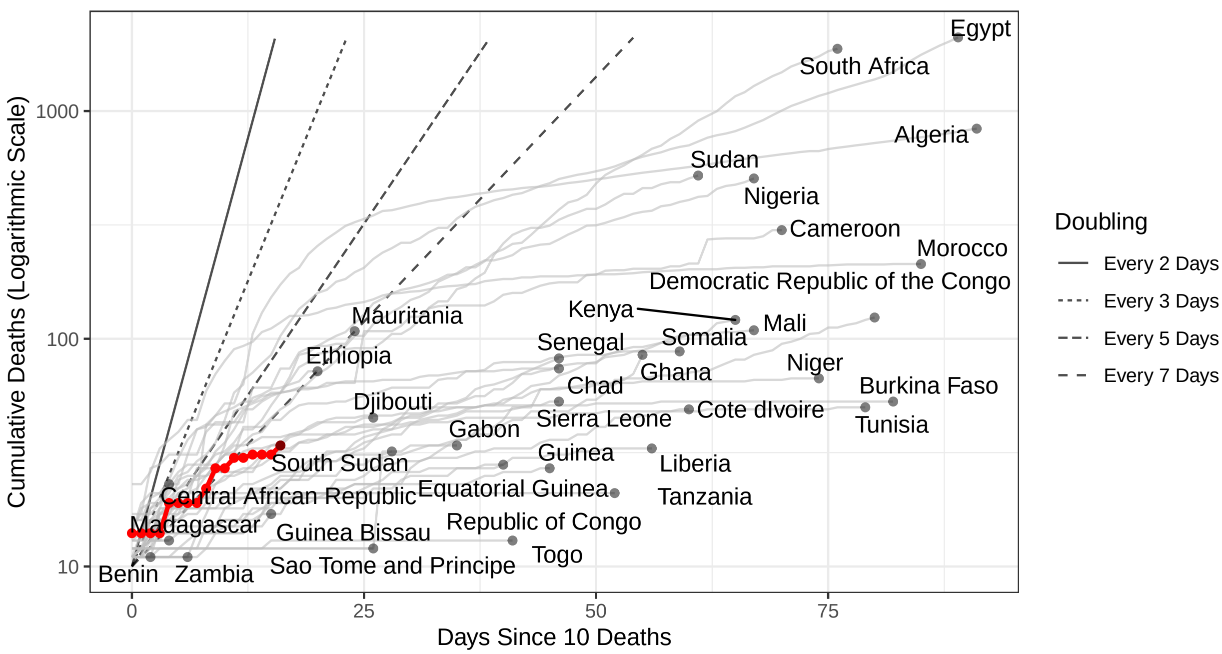


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 16,783 (95% CI: 15,878-17,687) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

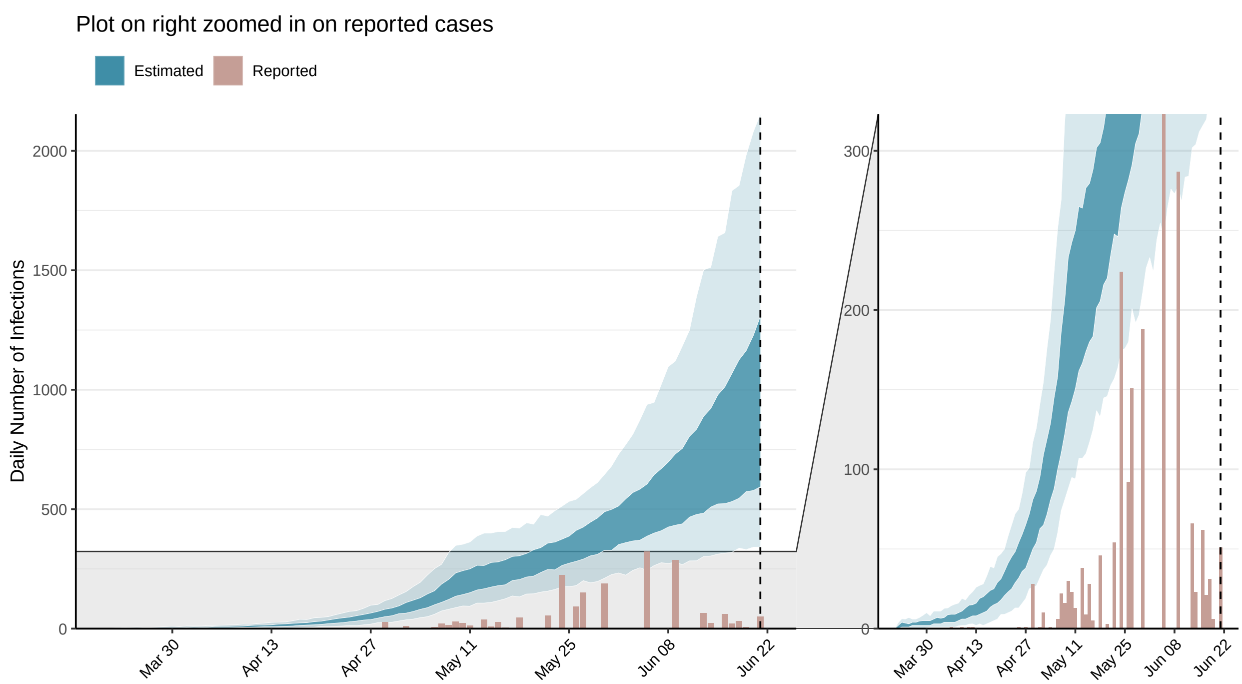


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

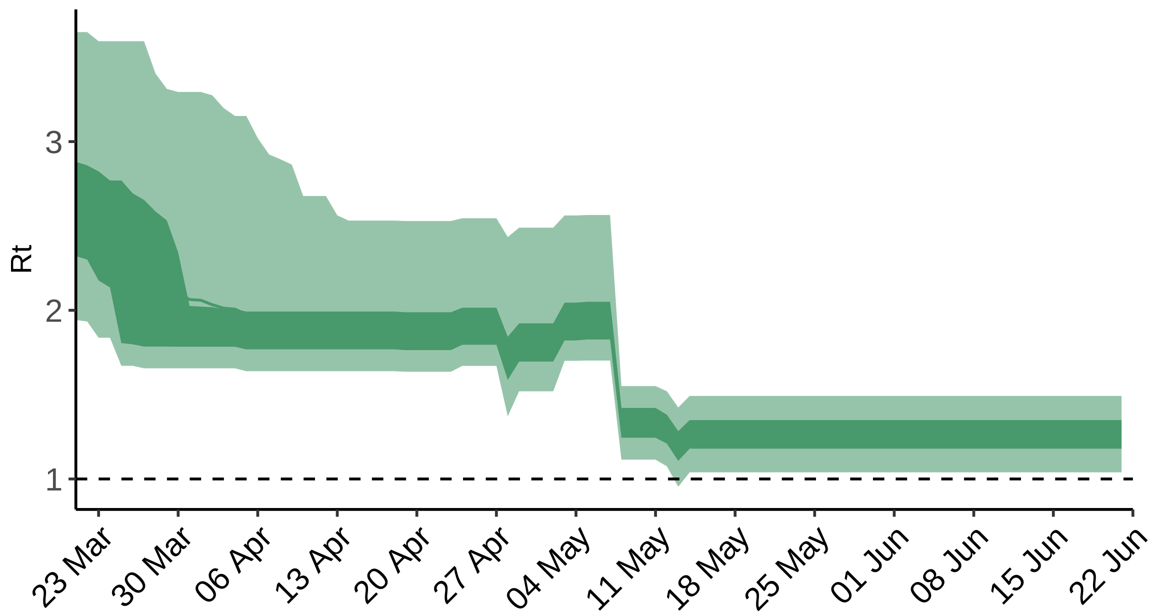


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

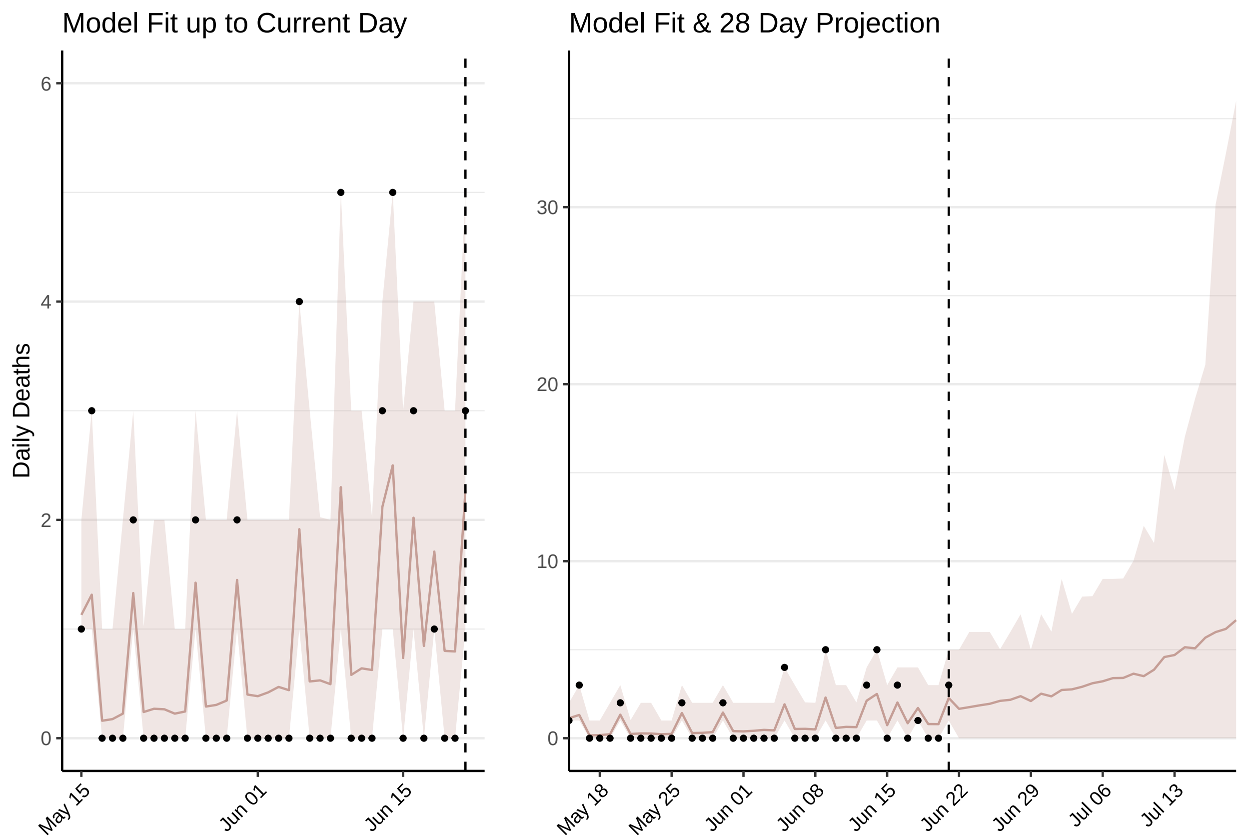


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 96 (95% CI: 90-101) patients requiring treatment with high-pressure oxygen at the current date to 325 (95% CI: 290-360) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 26 (95% CI: 25-28) patients requiring treatment with mechanical ventilation at the current date to 87 (95% CI: 79-95) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

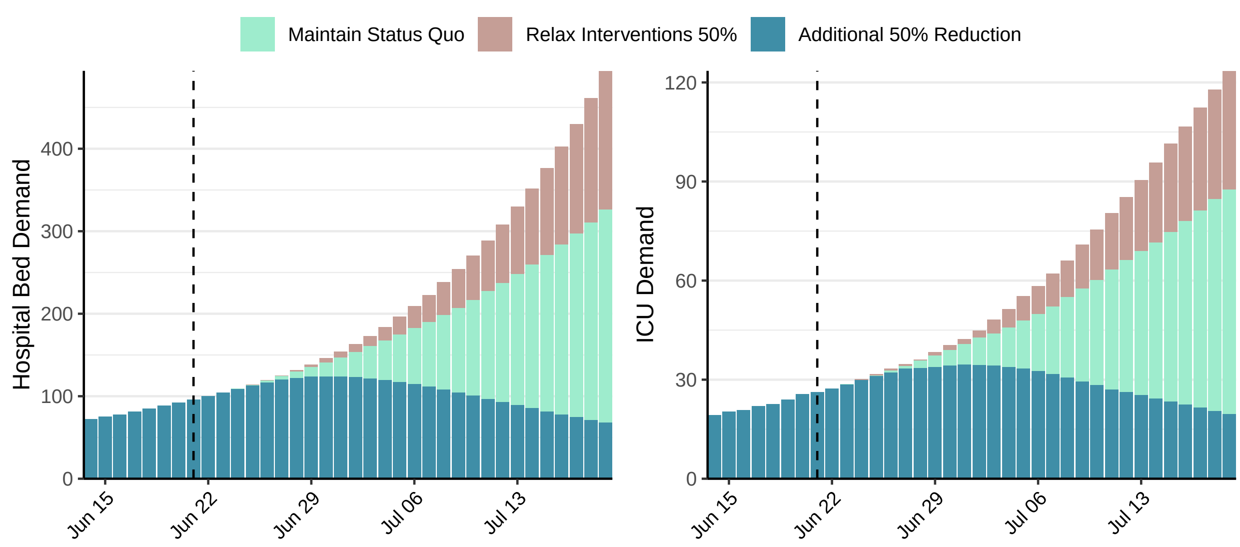


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 995 (95% CI: 923-1,068) at the current date to 233 (95% CI: 205-260) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 995 (95% CI: 923-1,068) at the current date to 6,609 (95% CI: 5,749-7,470) by 2020-07-19.

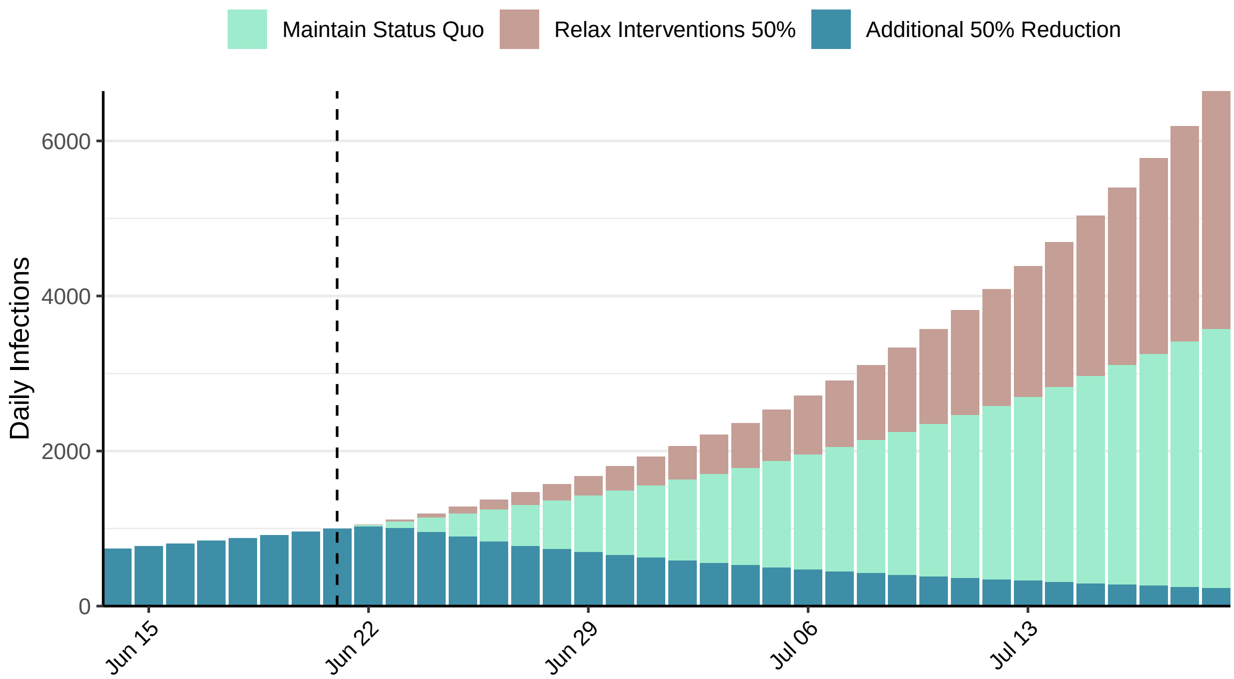


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Sao Tome and Principe, 2020-06-21

**Download the report for Sao Tome and Principe, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 698 | 5 | 12 | 0 | 0.43 (95% CI: 0.17-0.79) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

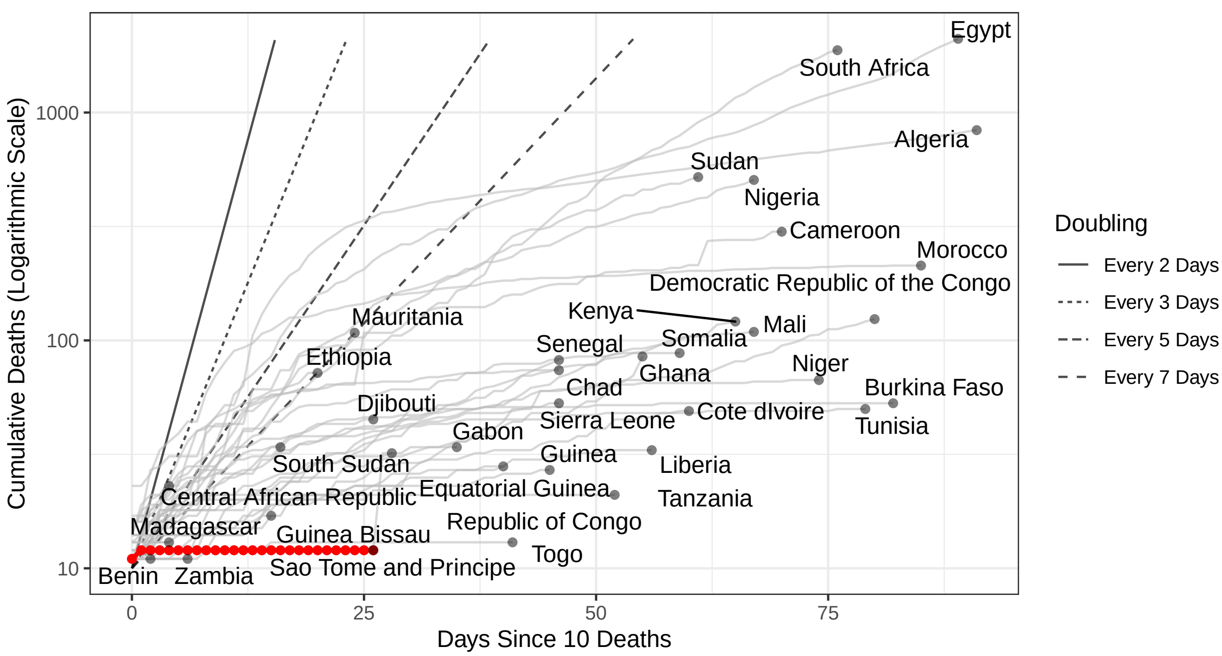


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 231 (95% CI: 203-260) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

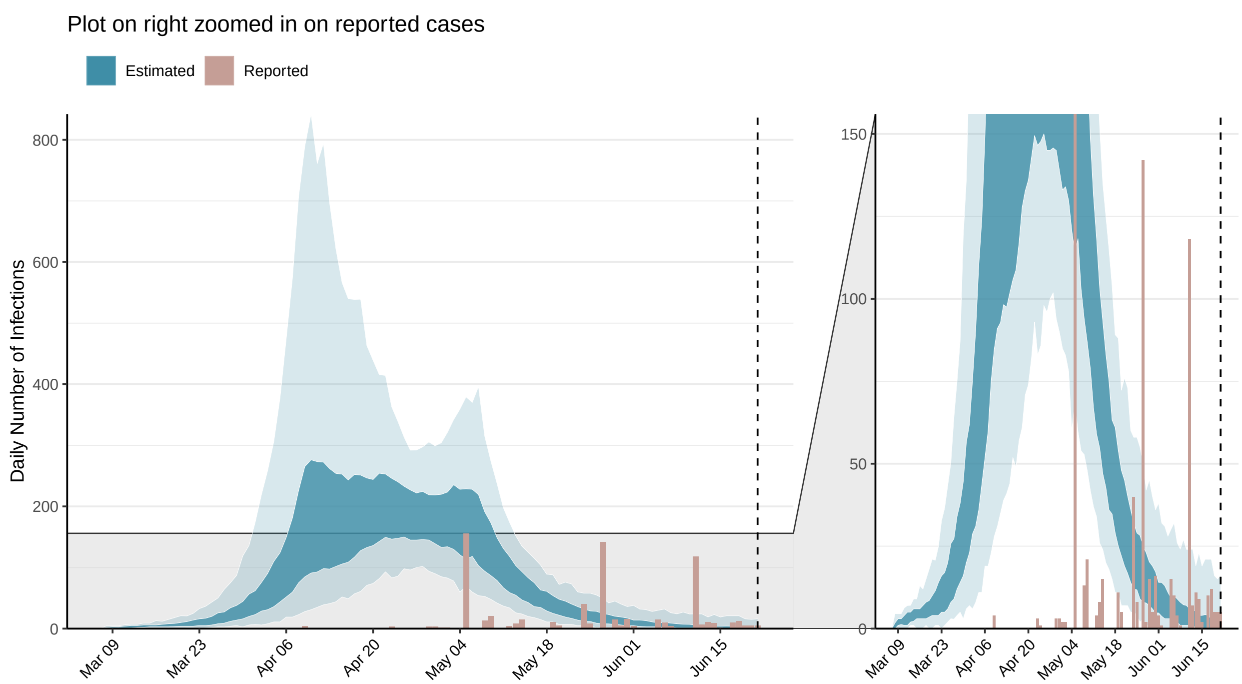


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

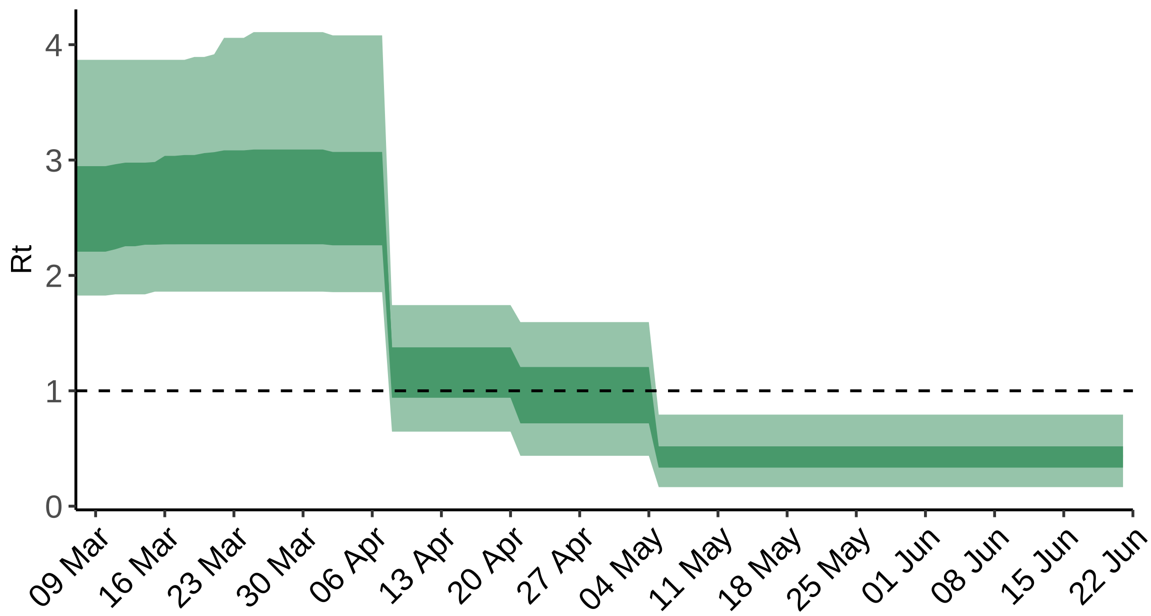


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

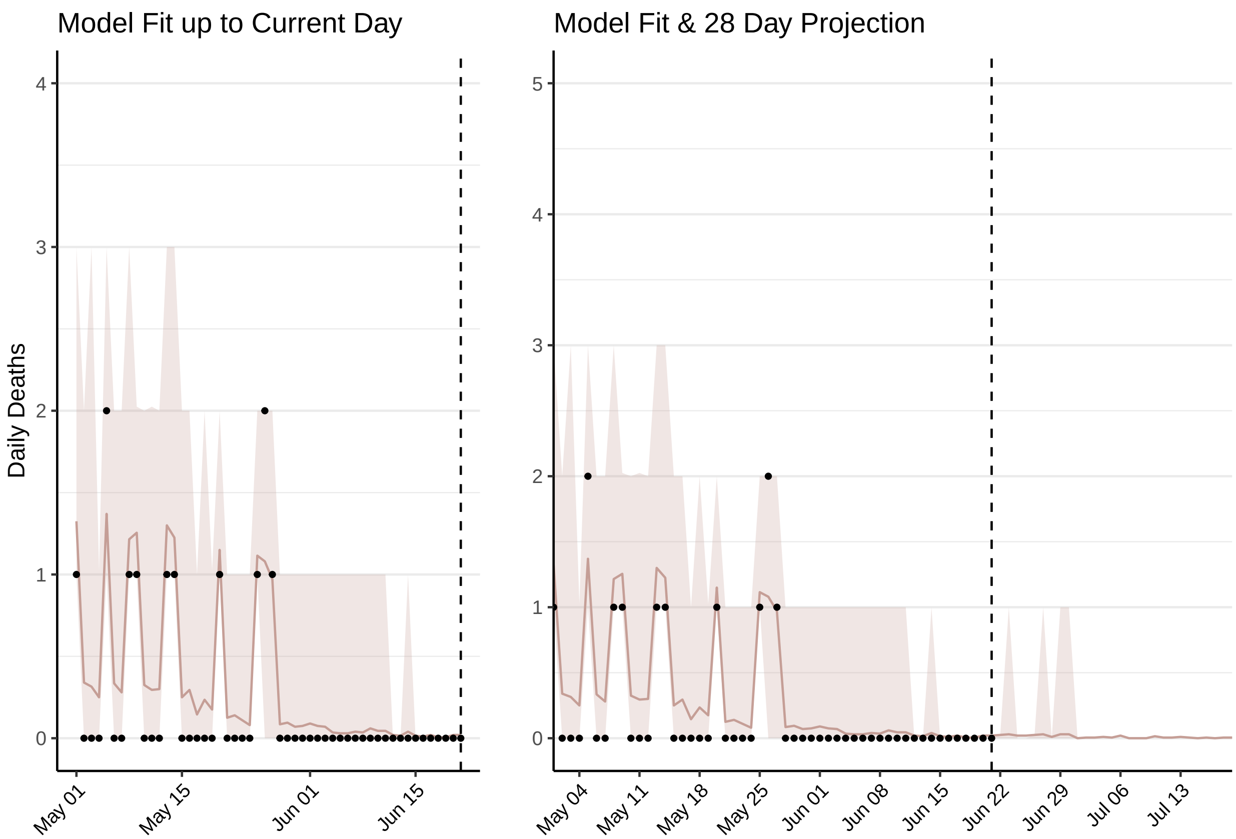


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1 (95% CI: 1-1) patients requiring treatment with high-pressure oxygen at the current date to 0 (95% CI: 0-0) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 0 (95% CI: 0-0) patients requiring treatment with mechanical ventilation at the current date to 0 (95% CI: 0-0) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

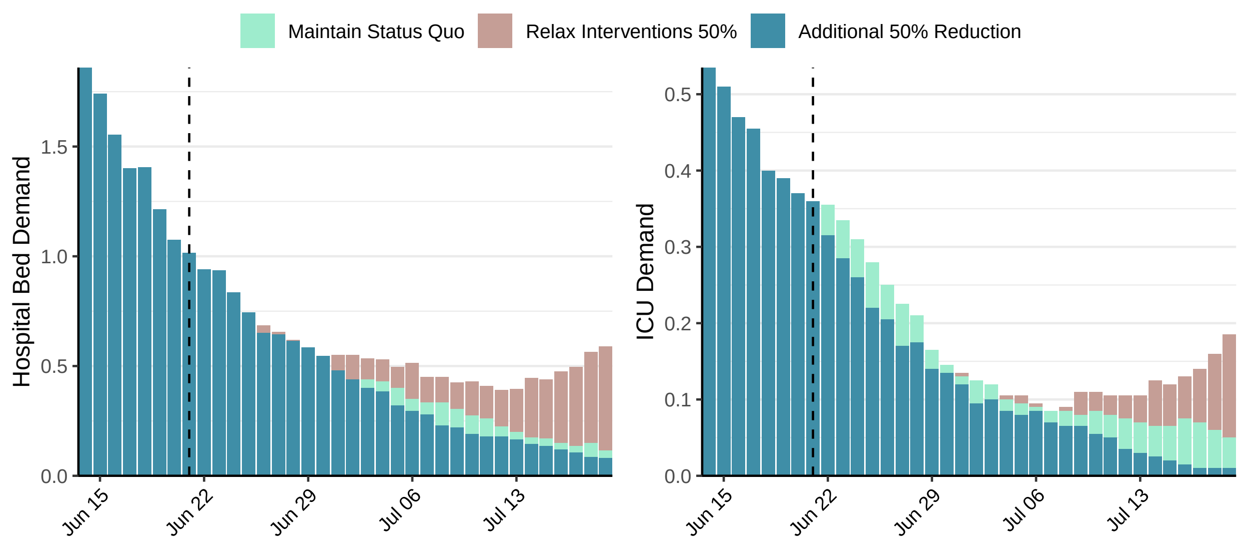


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 2 (95% CI: 2-3) at the current date to 0 (95% CI: 0-0) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 2 (95% CI: 2-3) at the current date to 6 (95% CI: 2-9) by 2020-07-19.

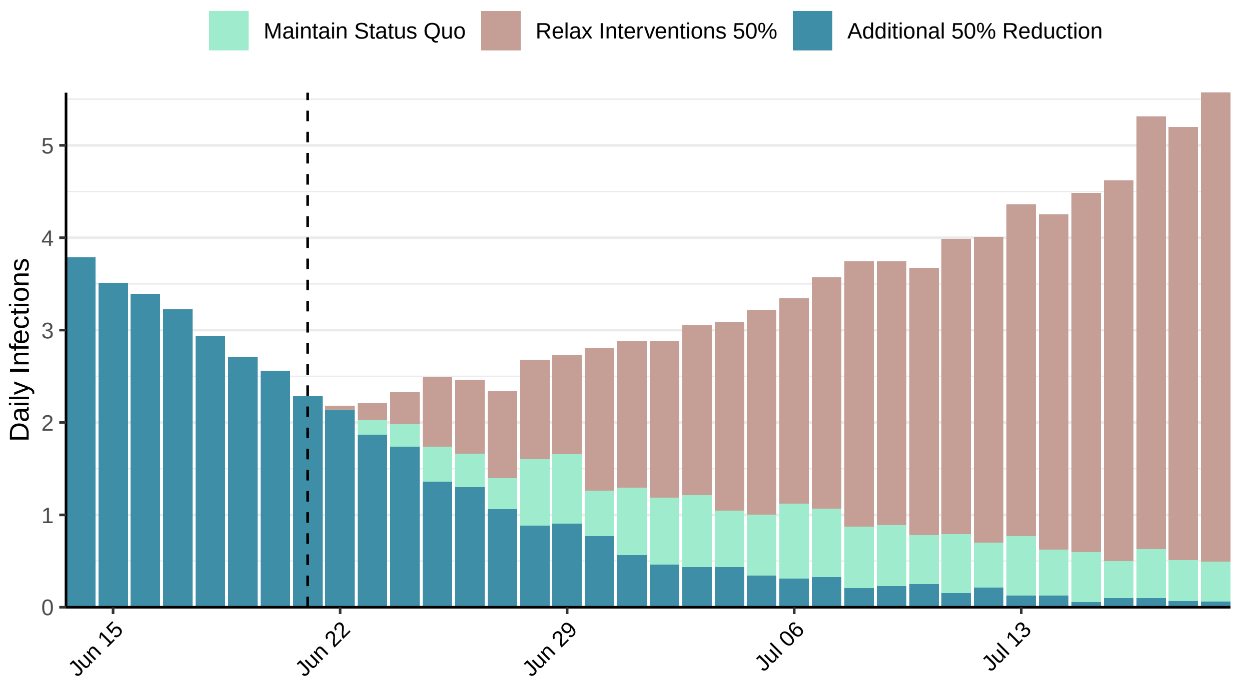


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Suriname, 2020-06-21

**Download the report for Suriname, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 302 | 9 | 8 | 0 | 2.62 (95% CI: 1.97-3.42) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Suriname is not shown in the following plot as only 8 deaths have been reported to date**

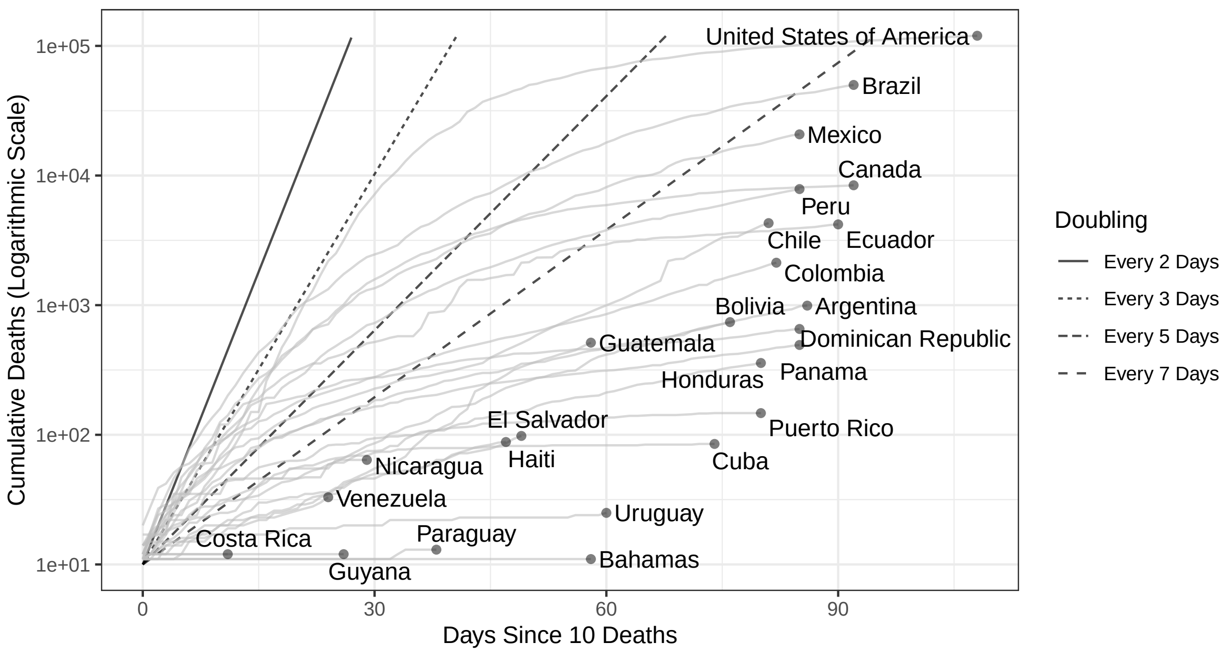


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

### COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 20,640 (95% CI: 18,732-22,549) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

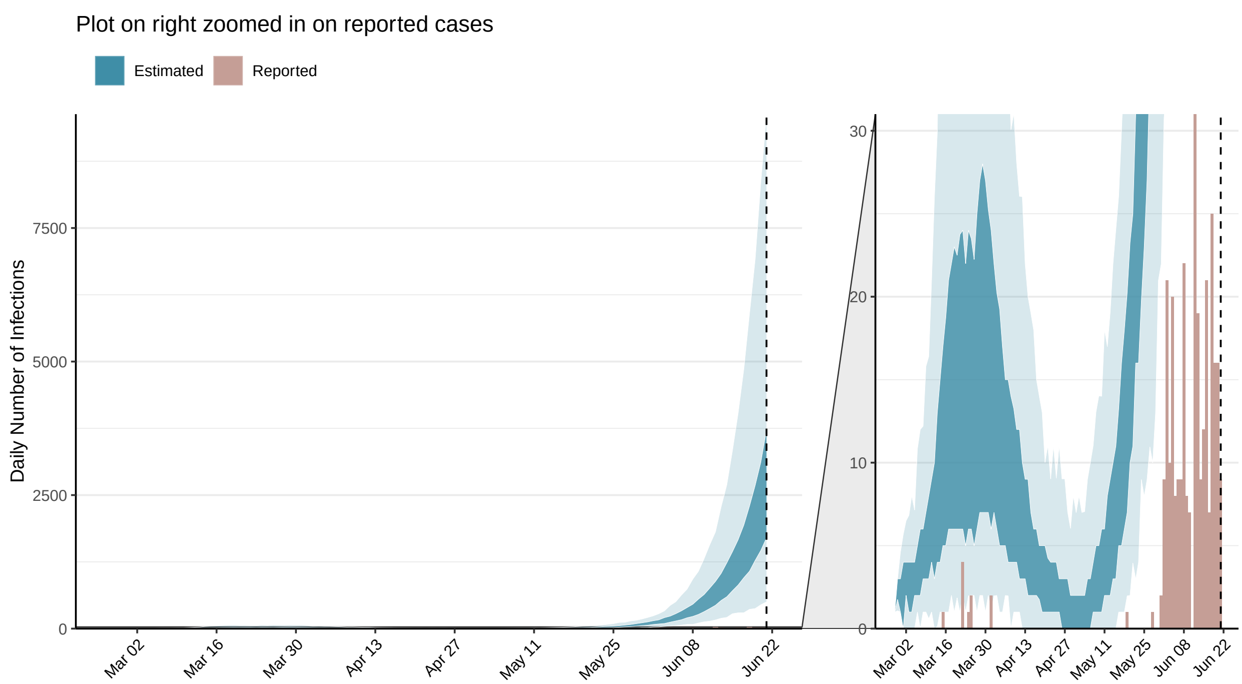


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

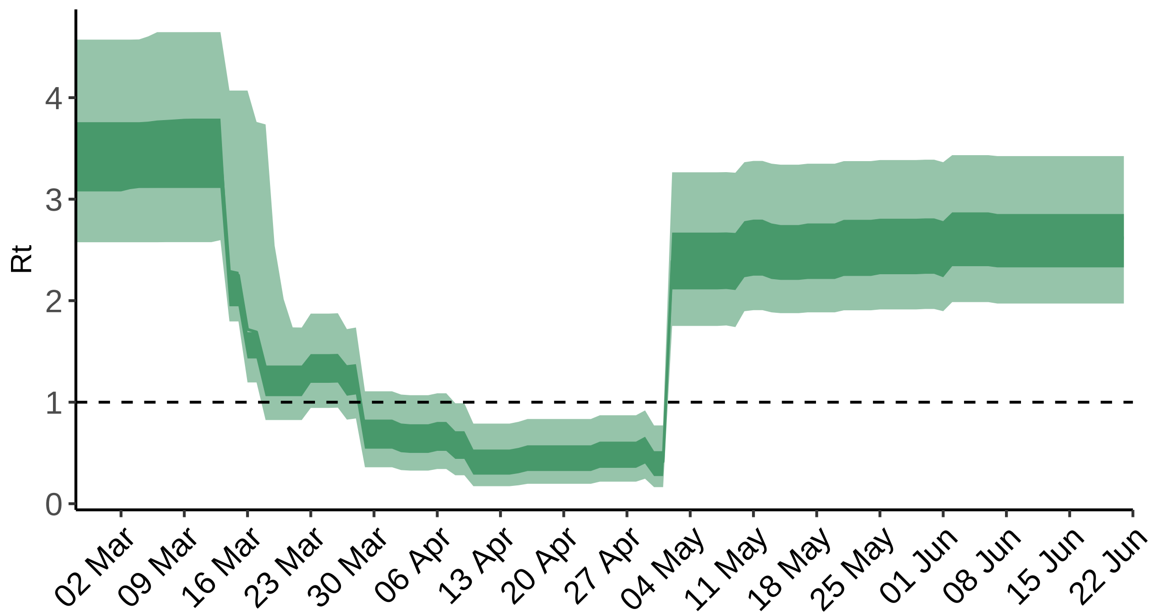


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Suriname is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

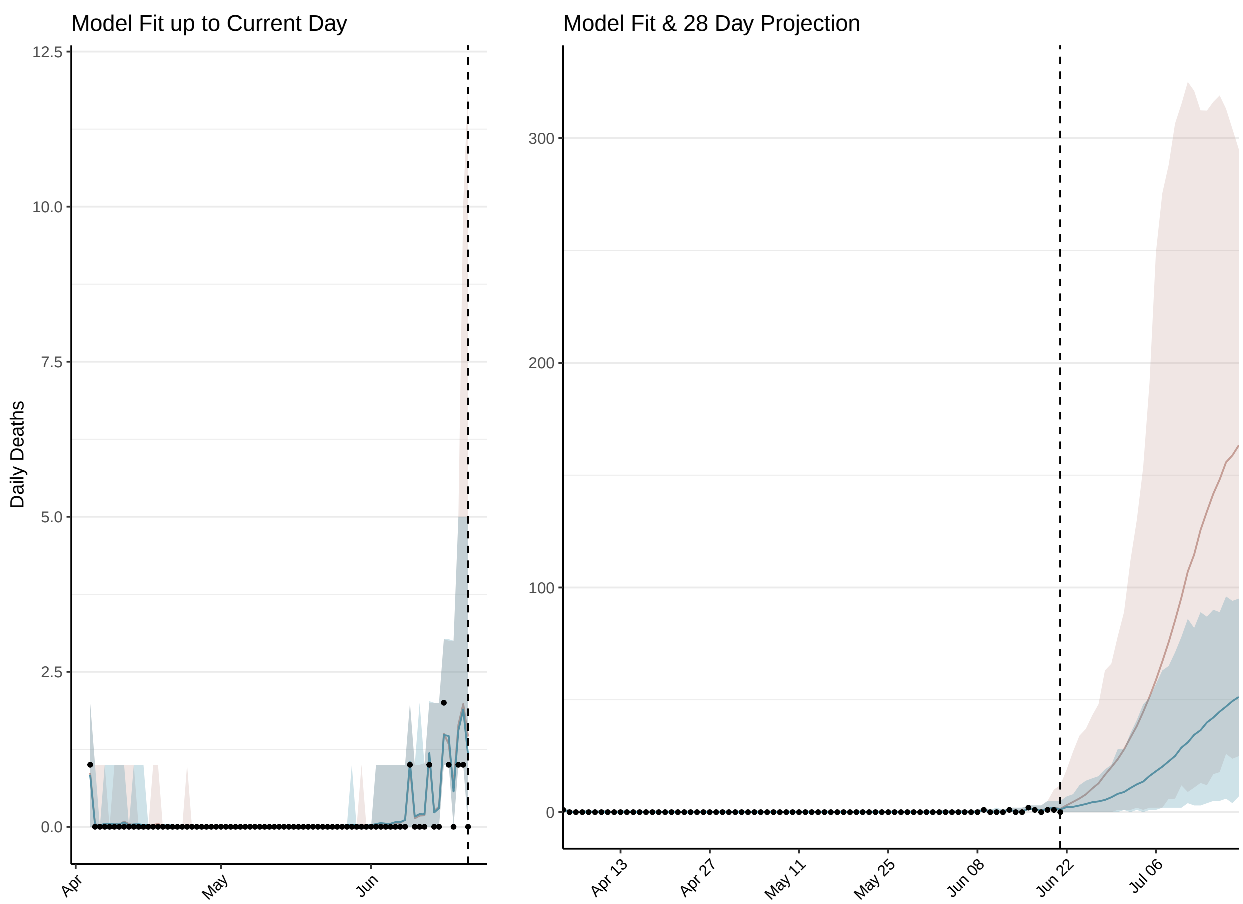


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 117 (95% CI: 106-128) patients requiring treatment with high-pressure oxygen at the current date to 2,145 (95% CI: 2,059-2,232) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 31 (95% CI: 28-33) patients requiring treatment with mechanical ventilation at the current date to 160 (95% CI: 155-166) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

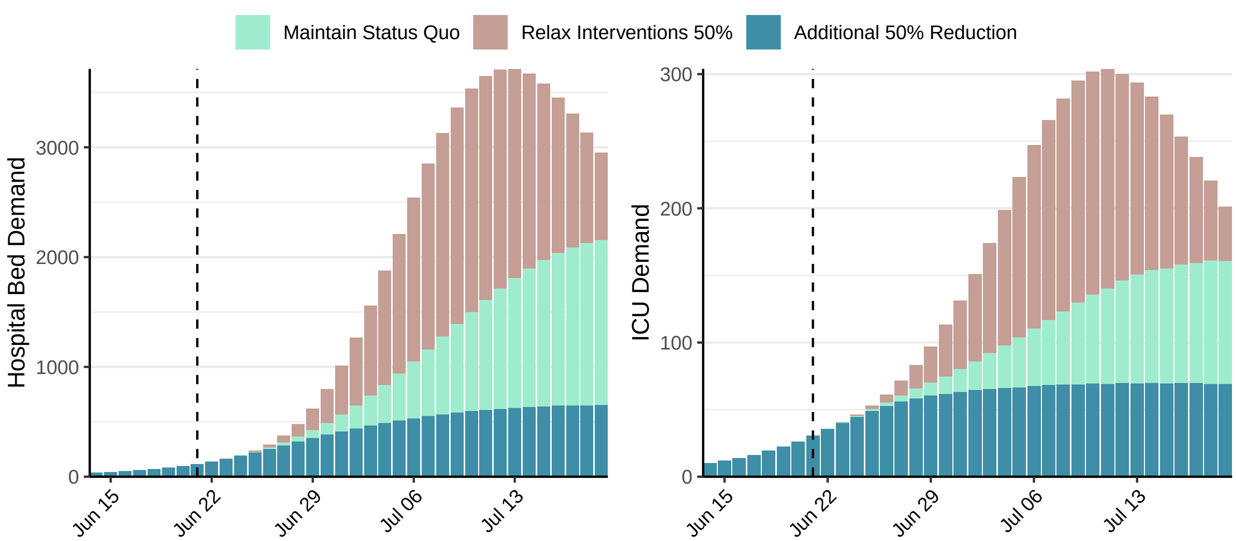


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 3,143 (95% CI: 2,816-3,470) at the current date to 3,352 (95% CI: 3,131-3,572) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 3,143 (95% CI: 2,816-3,470) at the current date to 4,697 (95% CI: 4,105-5,289) by 2020-07-19.

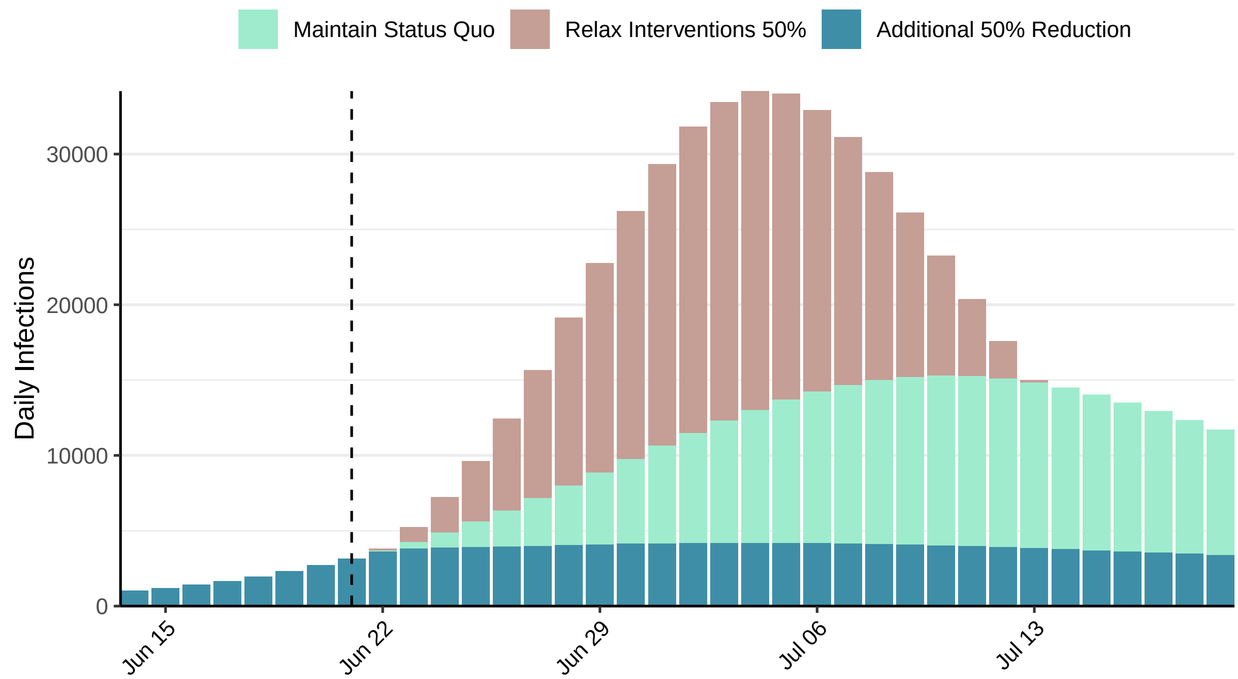


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Eswatini, 2020-06-21

**Download the report for Eswatini, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 627 | 4 | 5 | 1 | 2.06 (95% CI: 1.59-2.67) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Eswatini is not shown in the following plot as only 5 deaths have been reported to date**

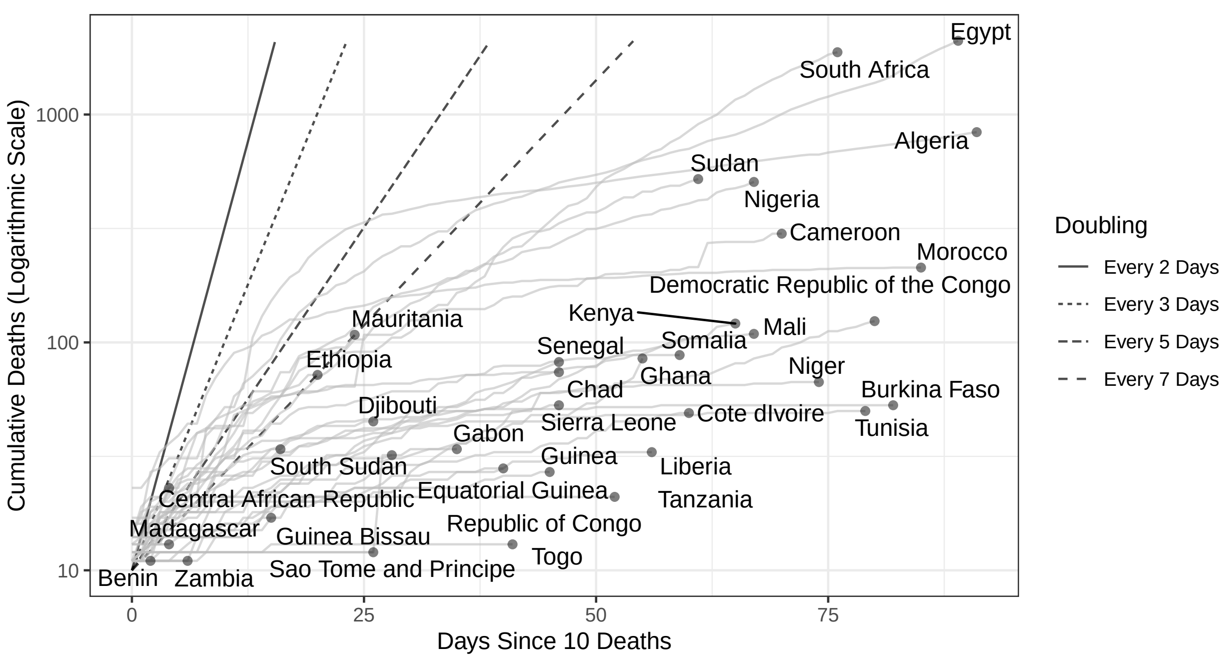


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,793 (95% CI: 3,373-4,213) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

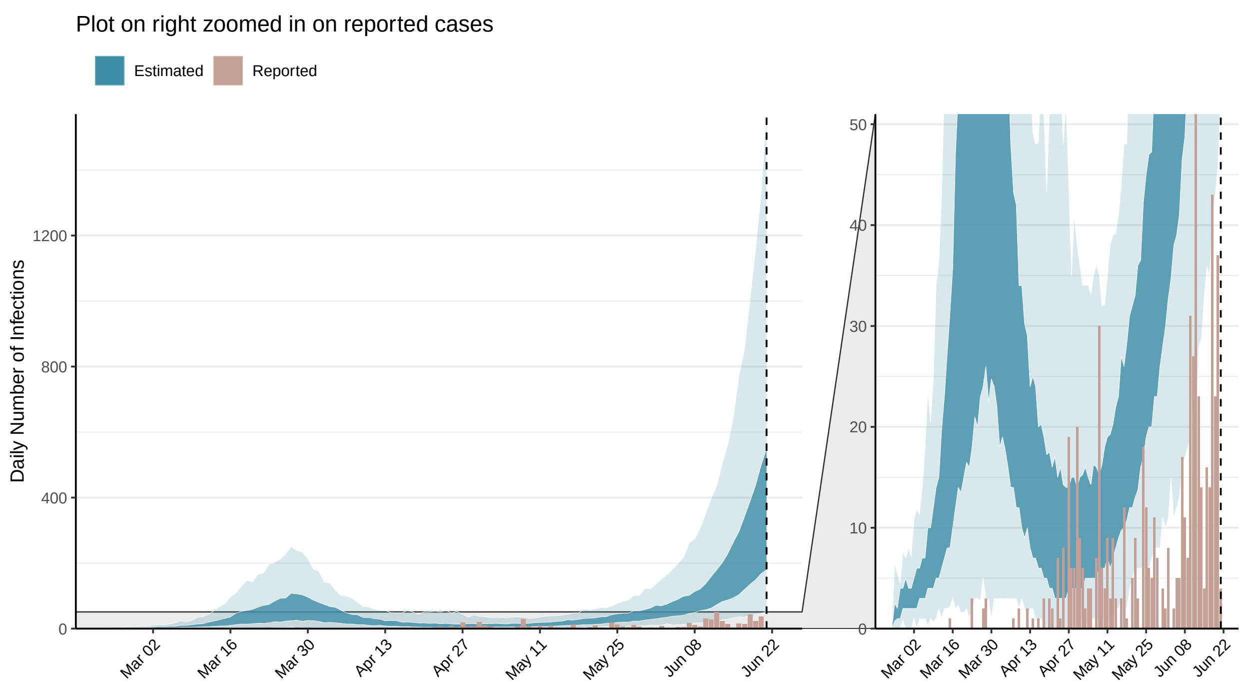


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

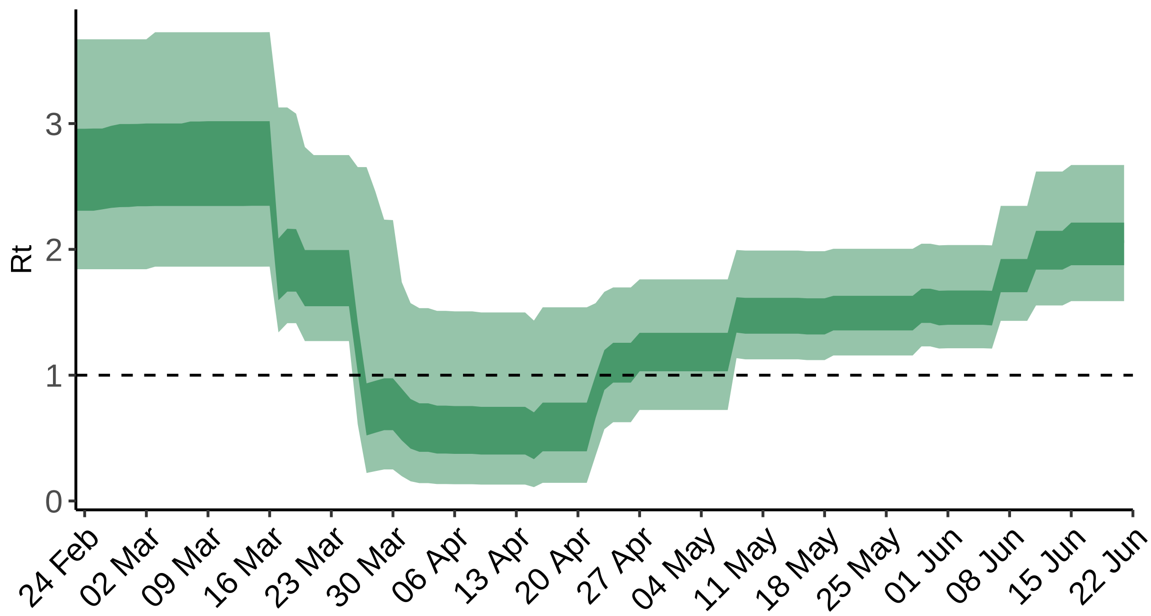


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Eswatini is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

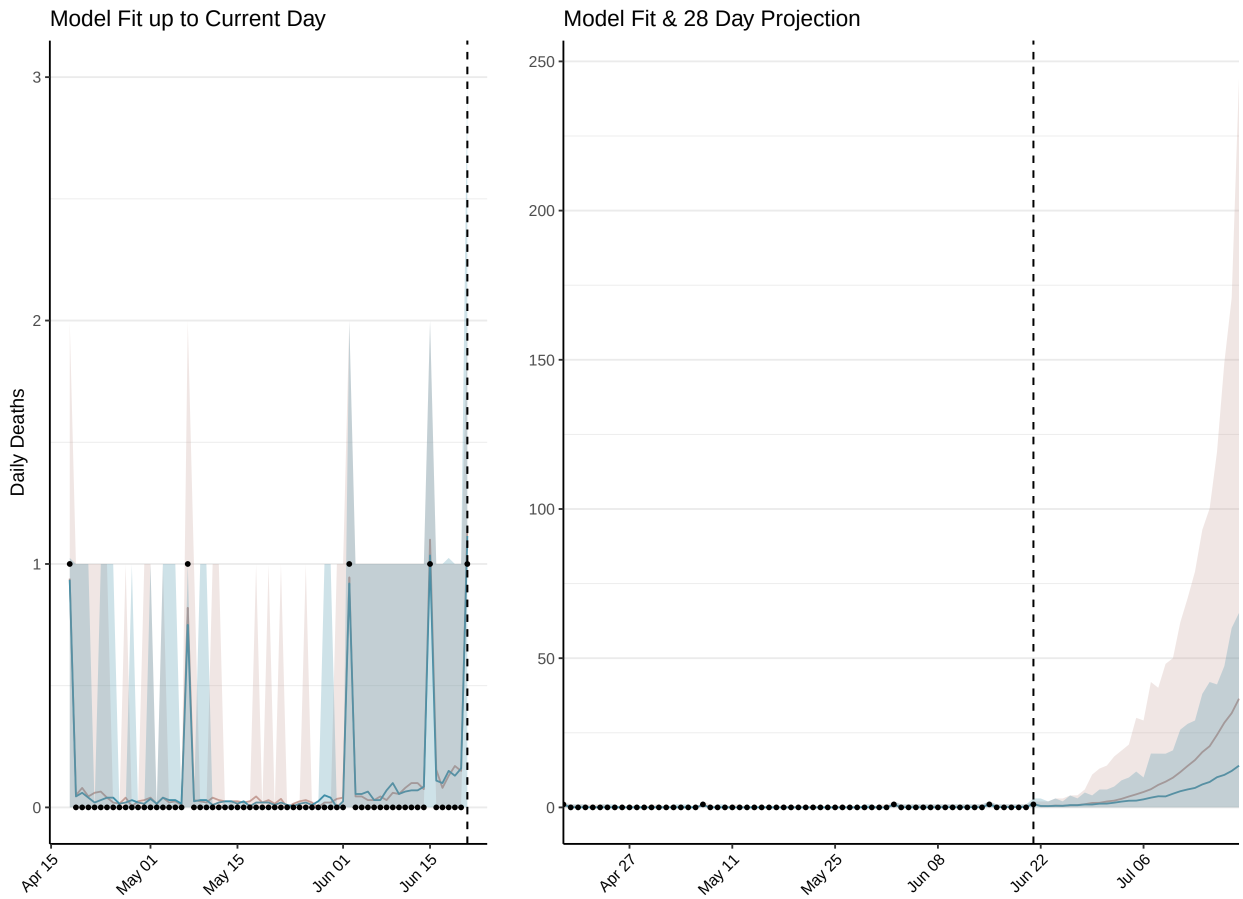


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 22 (95% CI: 19-24) patients requiring treatment with high-pressure oxygen at the current date to 664 (95% CI: 562-766) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 6 (95% CI: 5-7) patients requiring treatment with mechanical ventilation at the current date to 70 (95% CI: 64-77) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

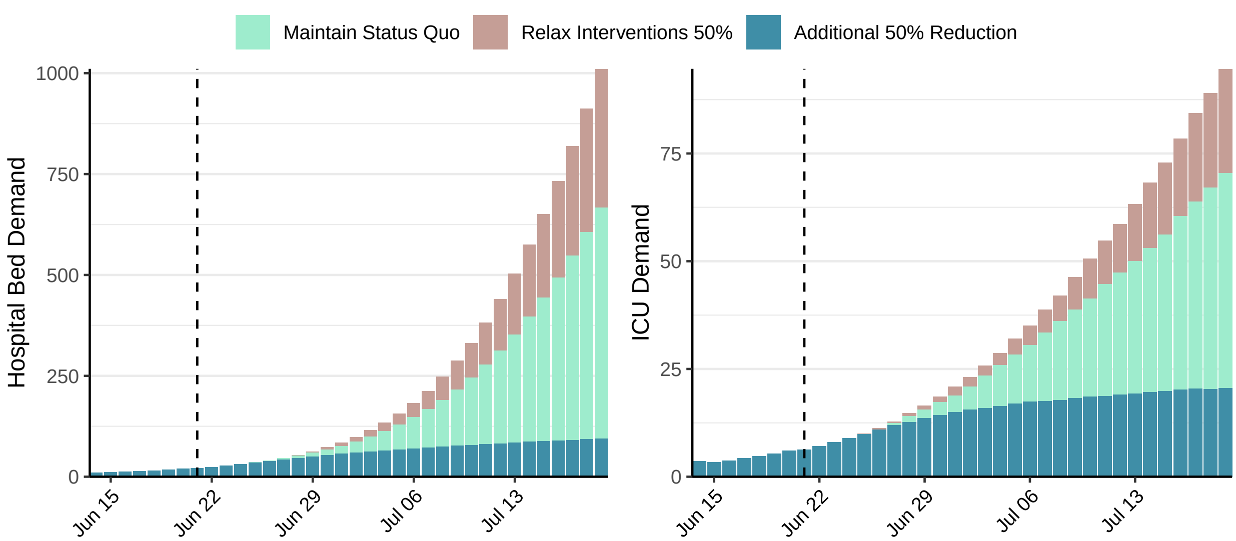


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 438 (95% CI: 379-496) at the current date to 756 (95% CI: 586-926) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 438 (95% CI: 379-496) at the current date to 17,943 (95% CI: 16,032-19,854) by 2020-07-19.

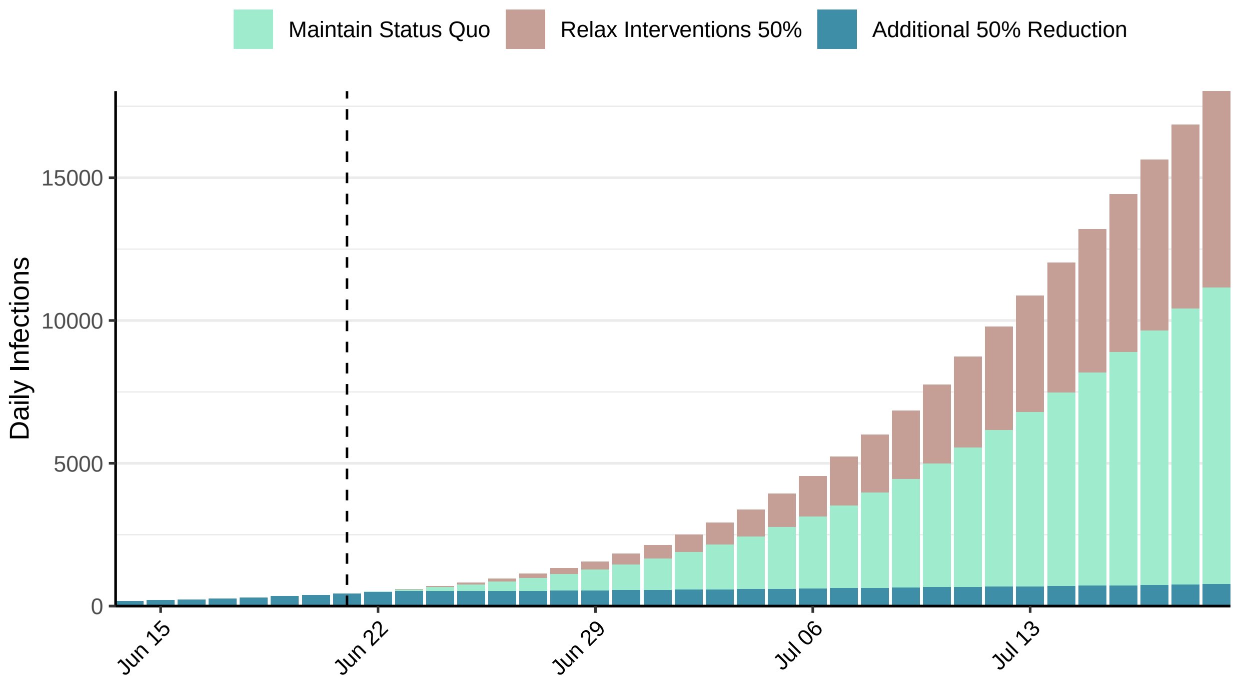


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Syria, 2020-06-21

**Download the report for Syria, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 198 | 11 | 7 | 0 | 1.37 (95% CI: 0.97-1.82) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Syria is not shown in the following plot as only 7 deaths have been reported to date**

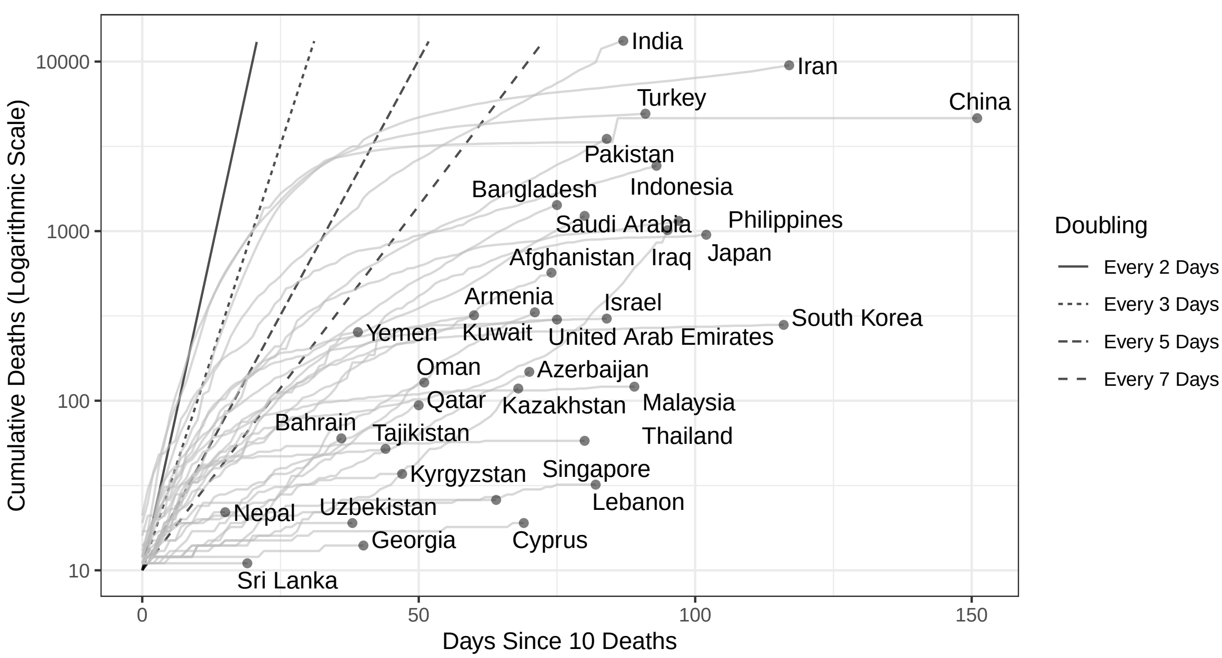


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 2,299 (95% CI: 2,029-2,568) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

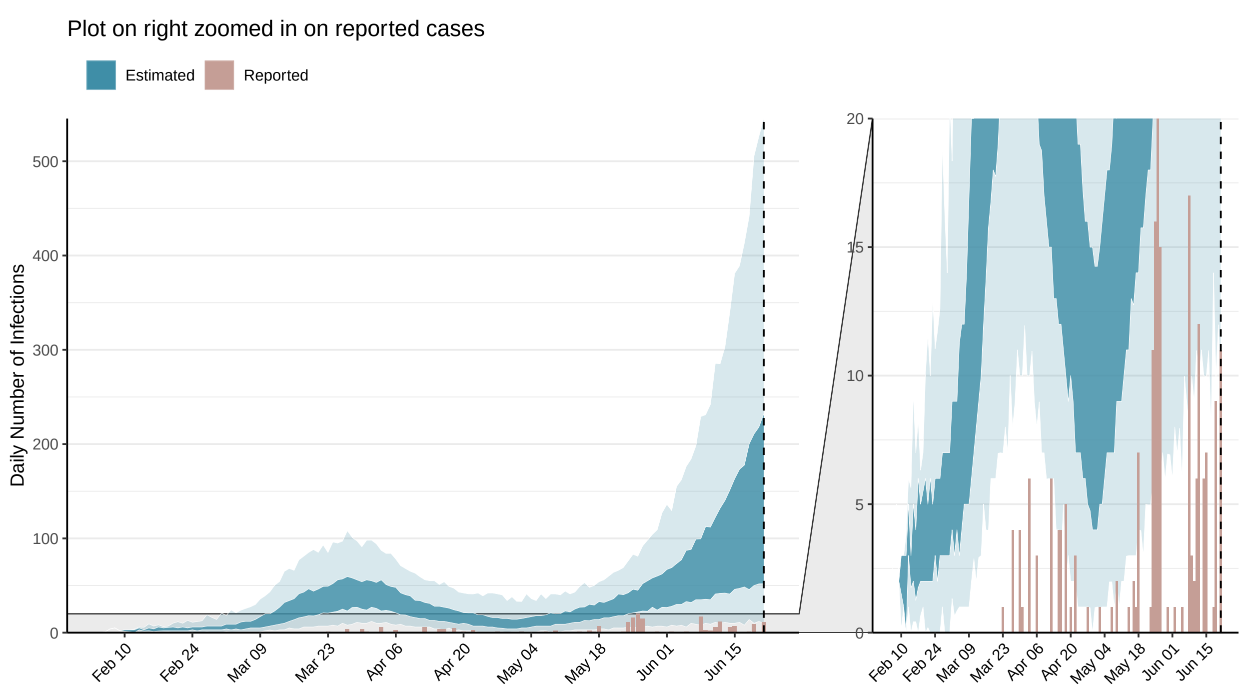


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

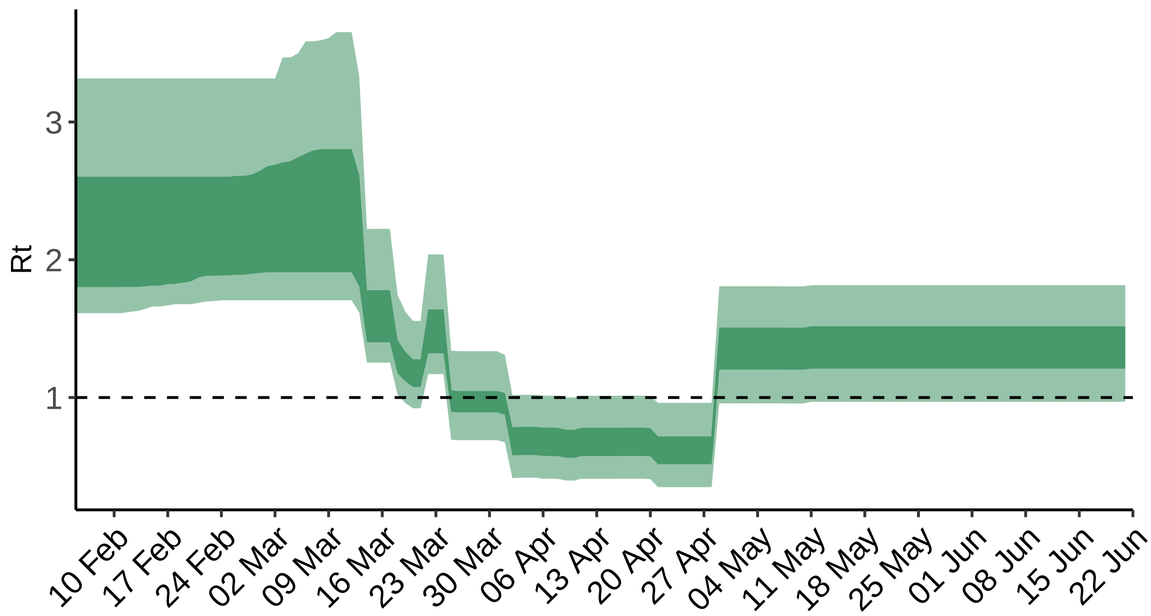


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

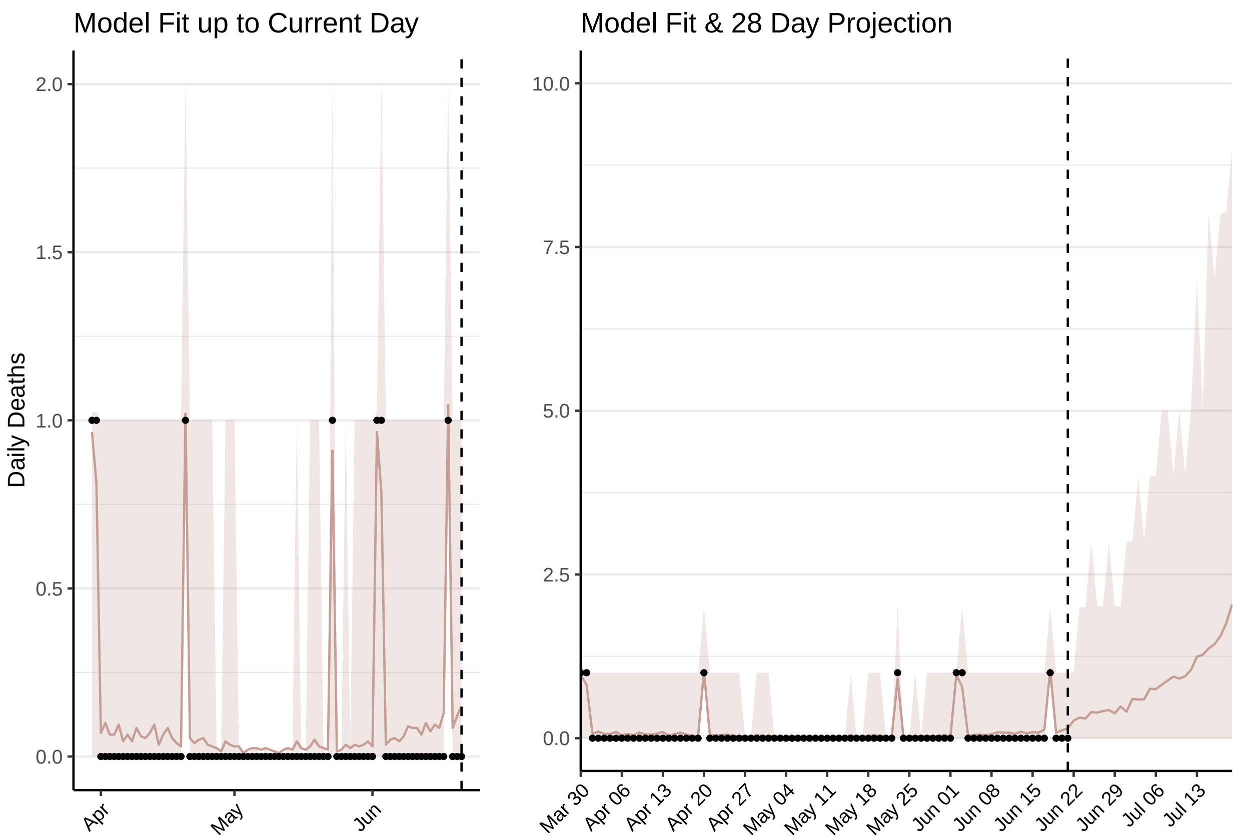


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 15 (95% CI: 13-17) patients requiring treatment with high-pressure oxygen at the current date to 106 (95% CI: 80-132) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4 (95% CI: 4-5) patients requiring treatment with mechanical ventilation at the current date to 30 (95% CI: 23-37) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

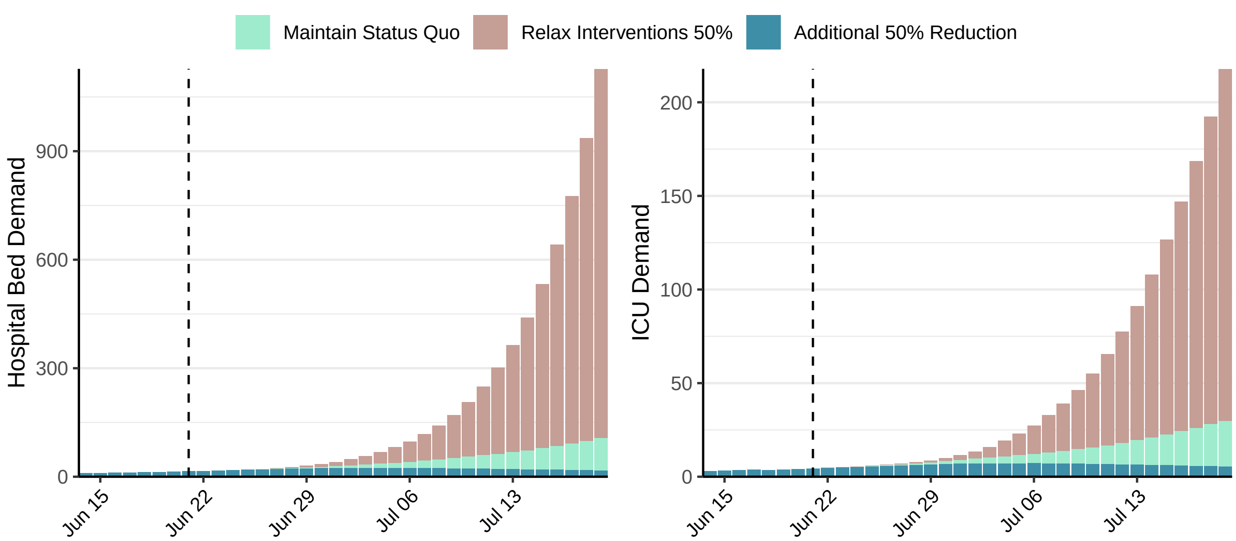


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 169 (95% CI: 143-195) at the current date to 71 (95% CI: 52-90) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 169 (95% CI: 143-195) at the current date to 30,155 (95% CI: 21,780-38,530) by 2020-07-19.

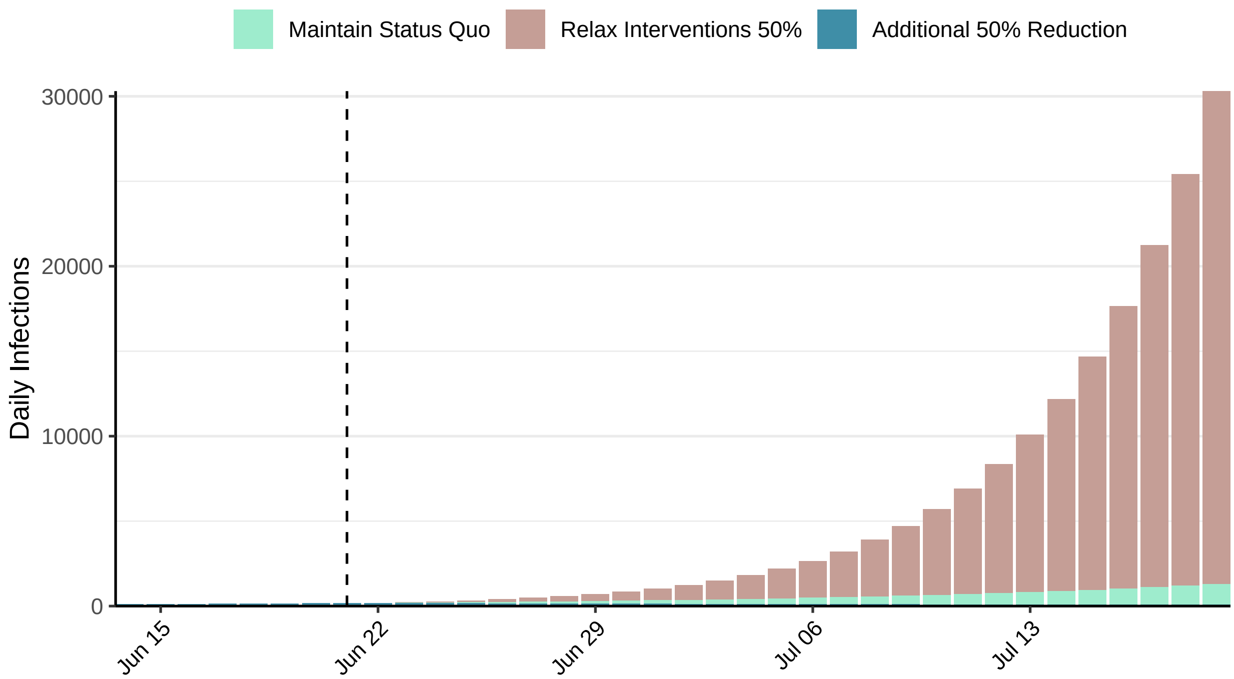


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Chad, 2020-06-21

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### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 858 | 0 | 74 | 0 | 0.91 (95% CI: 0.61-1.29) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

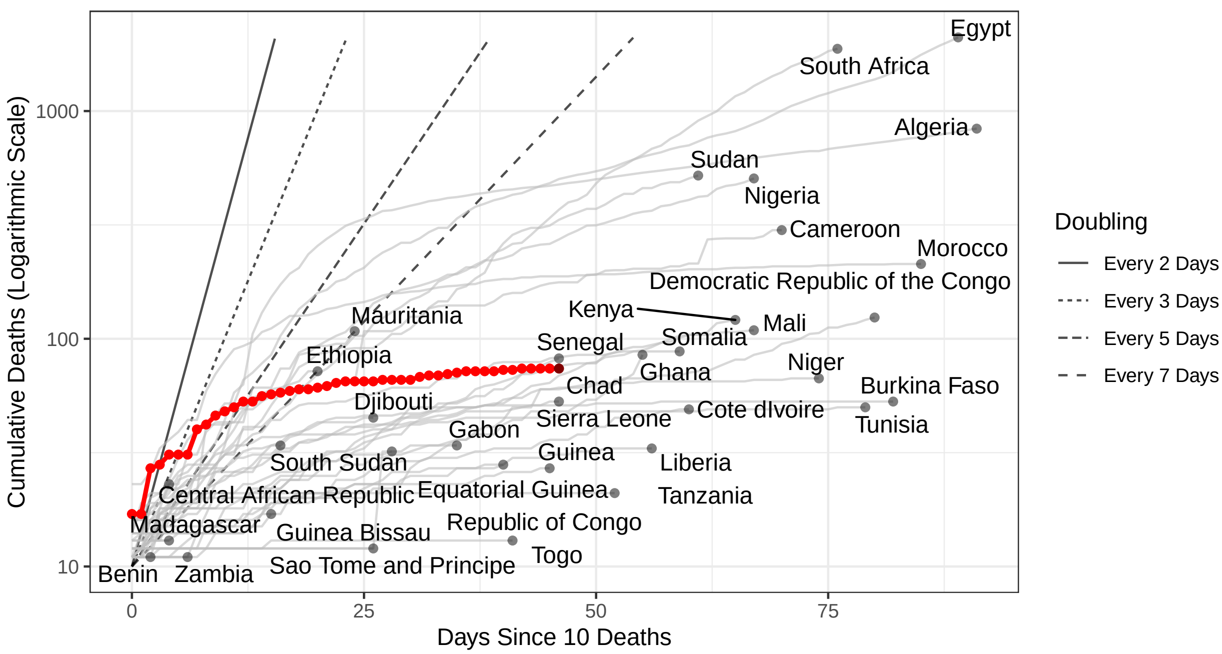


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 29,622 (95% CI: 28,283-30,962) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

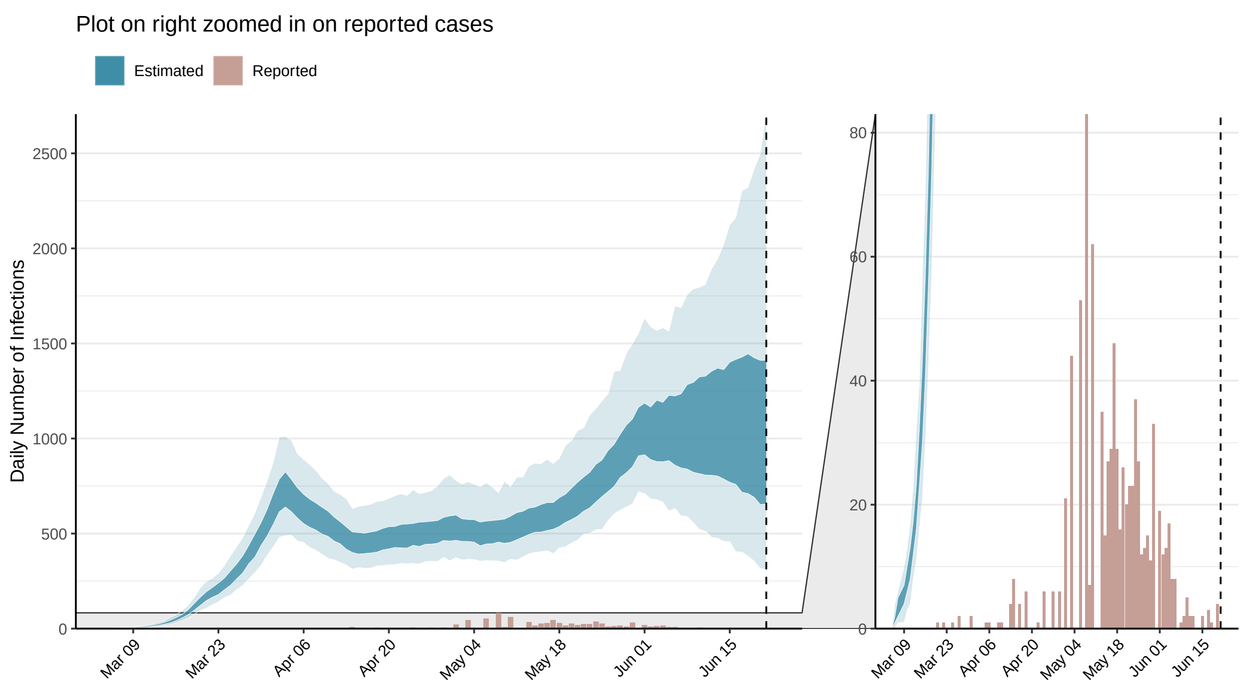


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

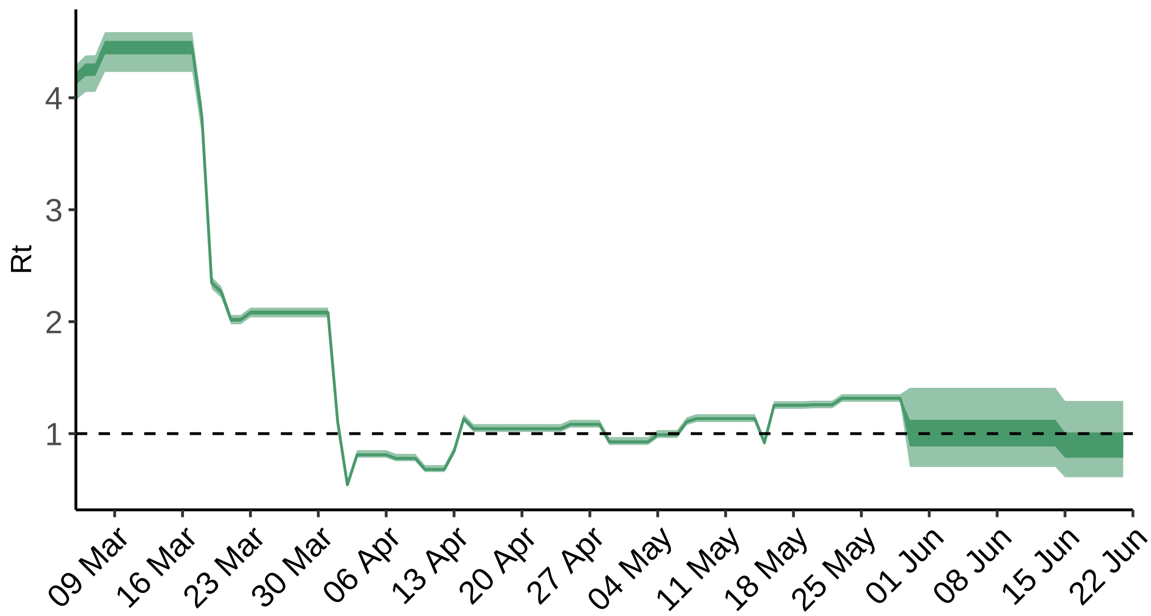


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

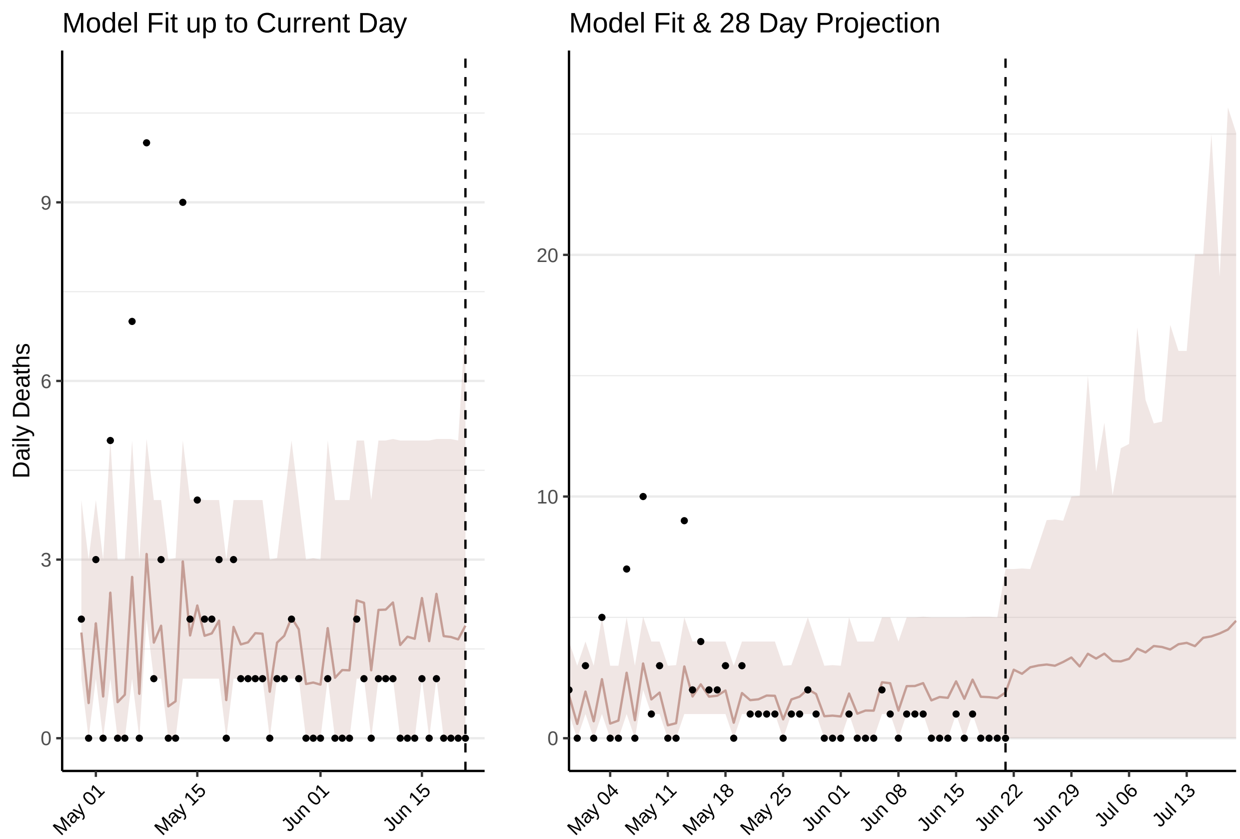


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 149 (95% CI: 141-157) patients requiring treatment with high-pressure oxygen at the current date to 184 (95% CI: 146-223) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 40 (95% CI: 38-42) patients requiring treatment with mechanical ventilation at the current date to 40 (95% CI: 35-44) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

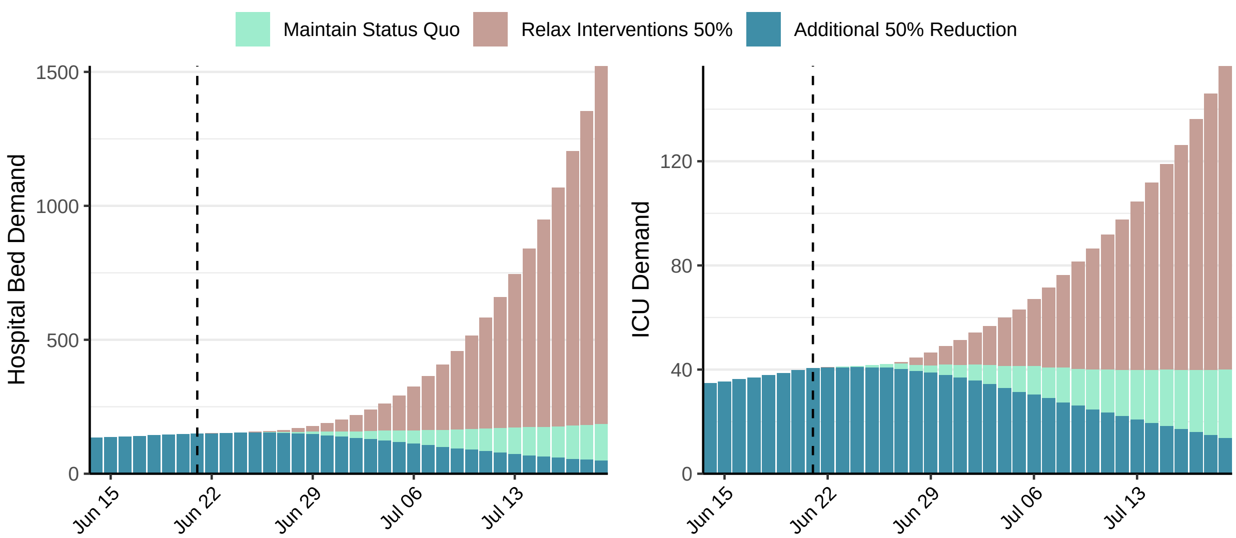


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 1,158 (95% CI: 1,050-1,267) at the current date to 127 (95% CI: 94-160) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 1,158 (95% CI: 1,050-1,267) at the current date to 36,296 (95% CI: 25,797-46,795) by 2020-07-19.

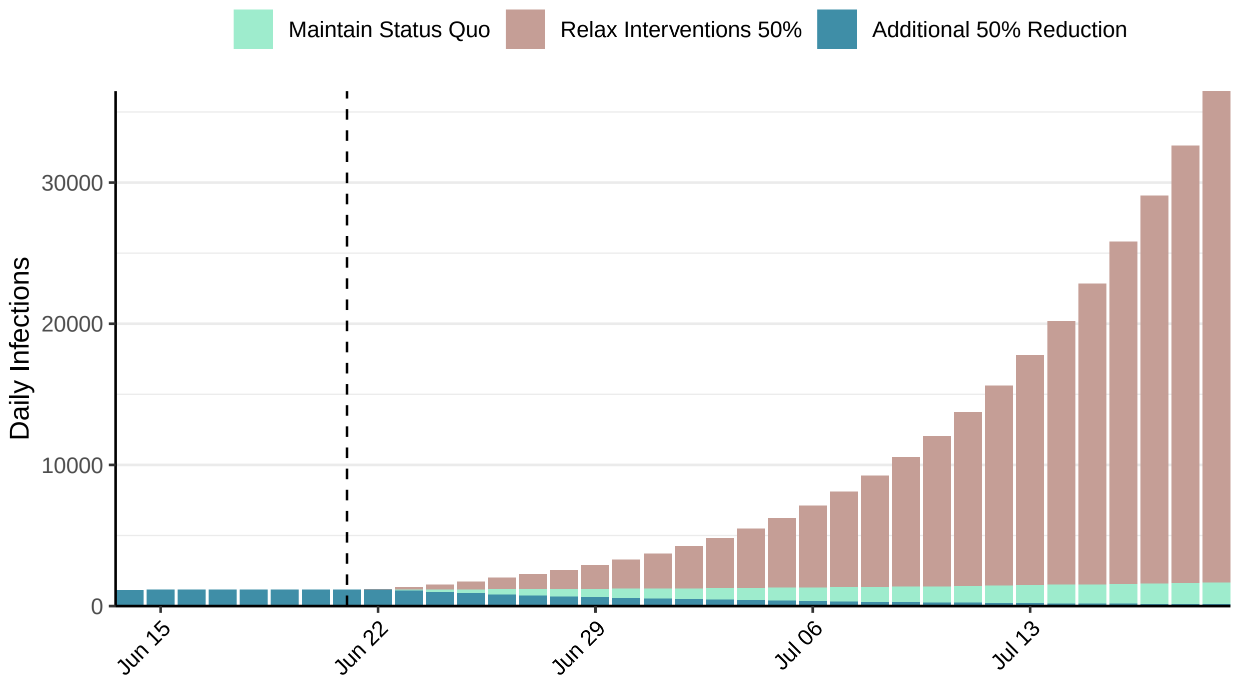


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Togo, 2020-06-21

**Download the report for Togo, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 561 | 6 | 13 | 0 | 1.54 (95% CI: 1-2.39) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

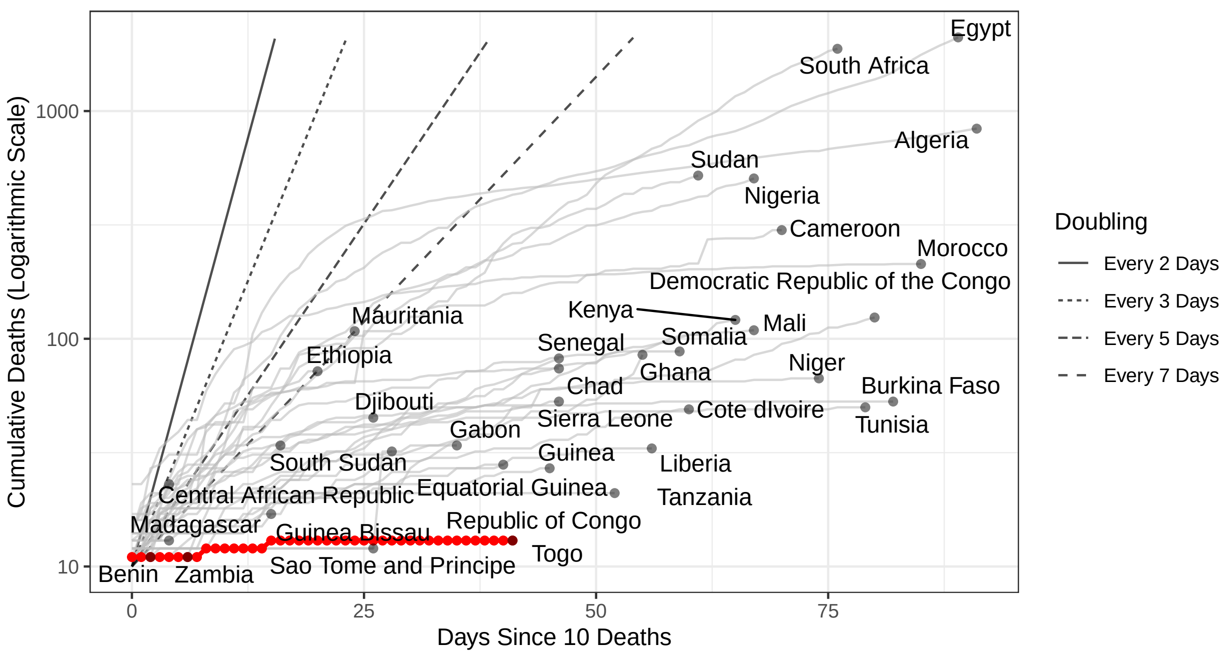


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,849 (95% CI: 1,660-2,039) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

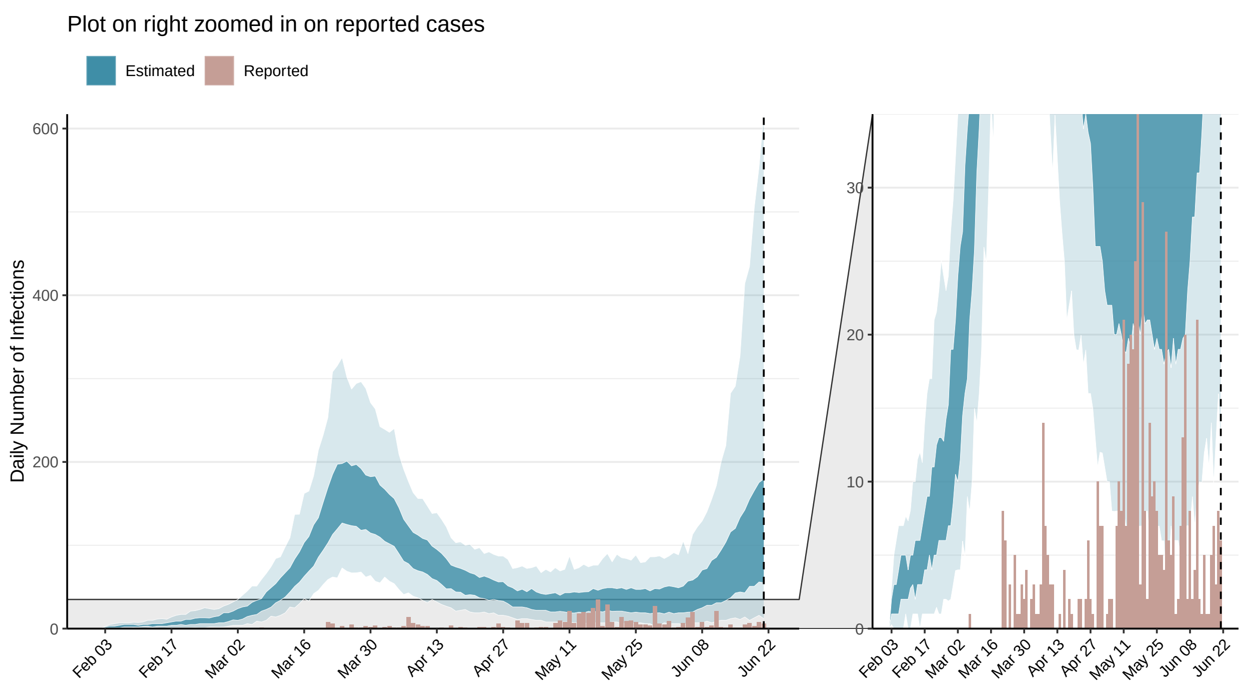


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

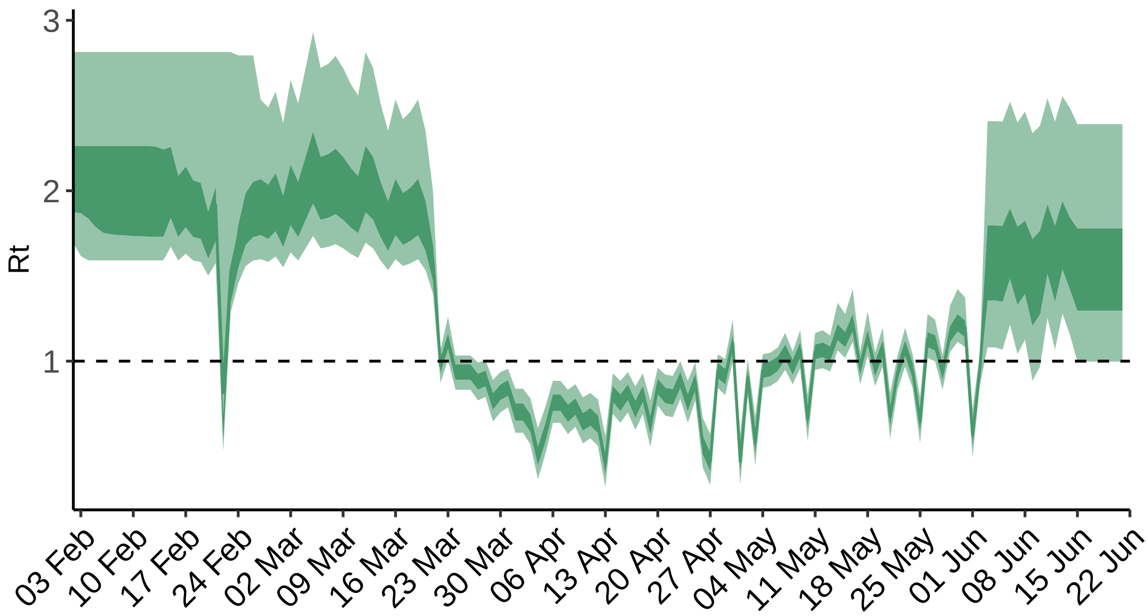


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

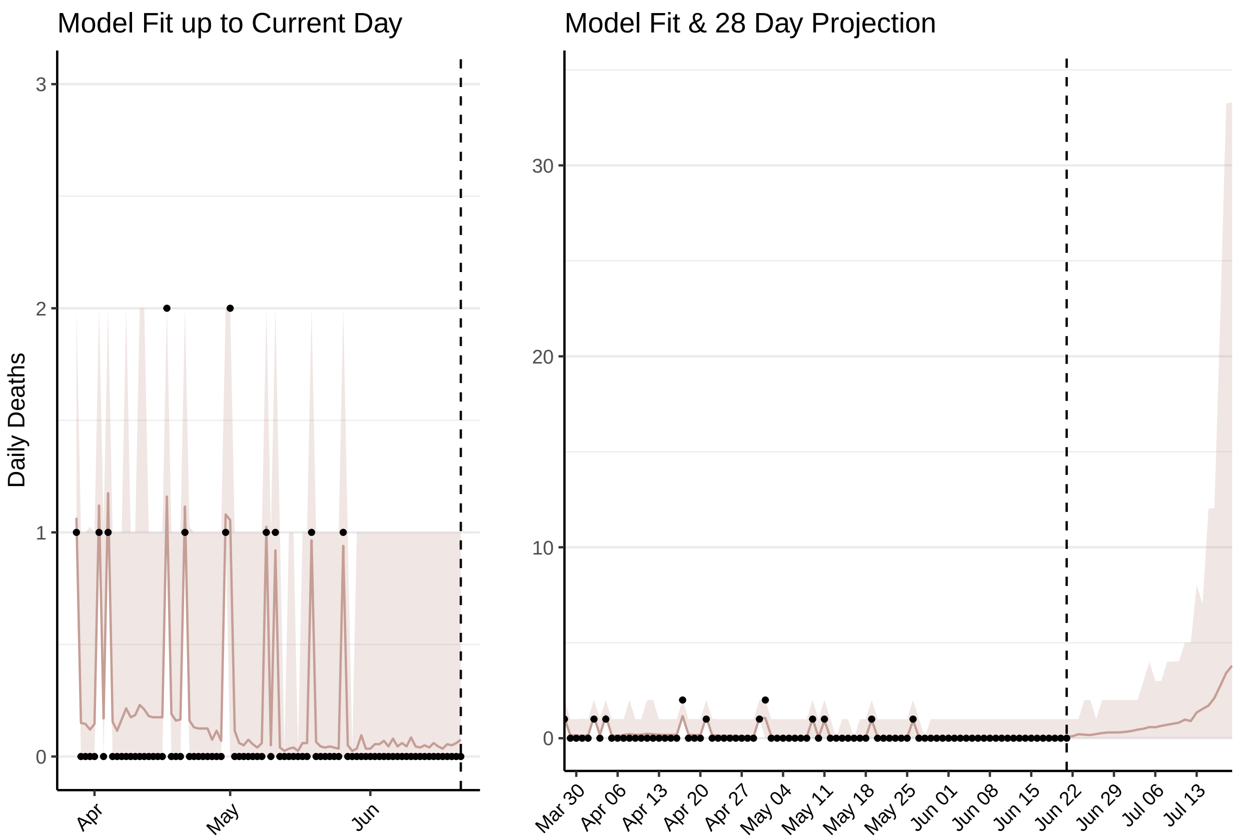


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 11 (95% CI: 9-12) patients requiring treatment with high-pressure oxygen at the current date to 156 (95% CI: 117-195) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 3 (95% CI: 2-3) patients requiring treatment with mechanical ventilation at the current date to 35 (95% CI: 28-42) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

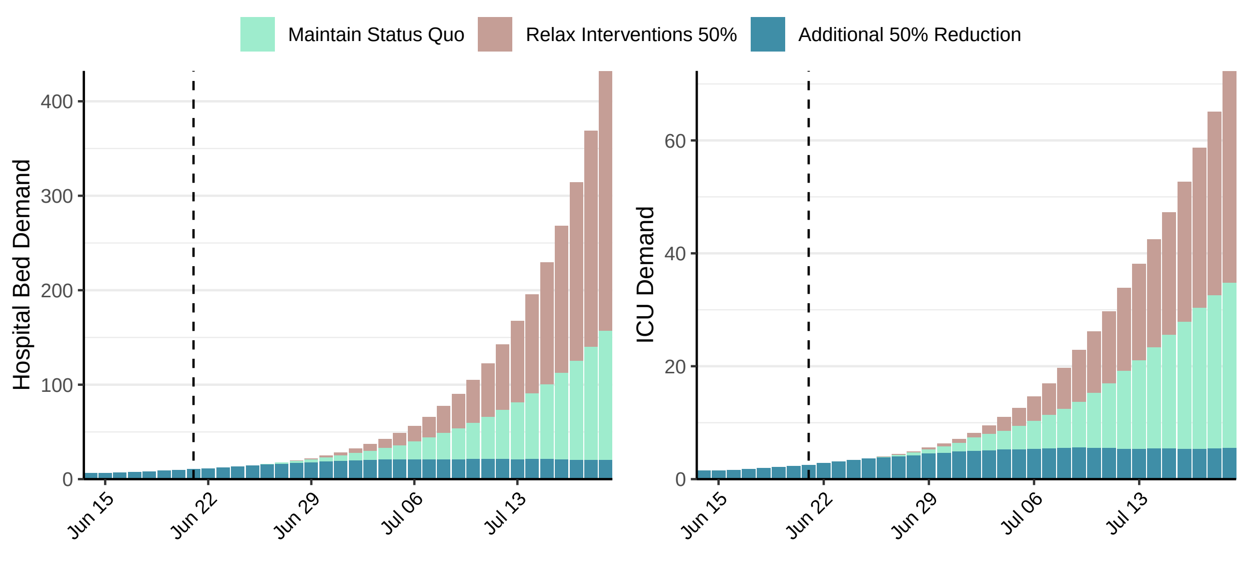


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 156 (95% CI: 134-177) at the current date to 135 (95% CI: 99-170) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 156 (95% CI: 134-177) at the current date to 11,453 (95% CI: 7,958-14,948) by 2020-07-19.

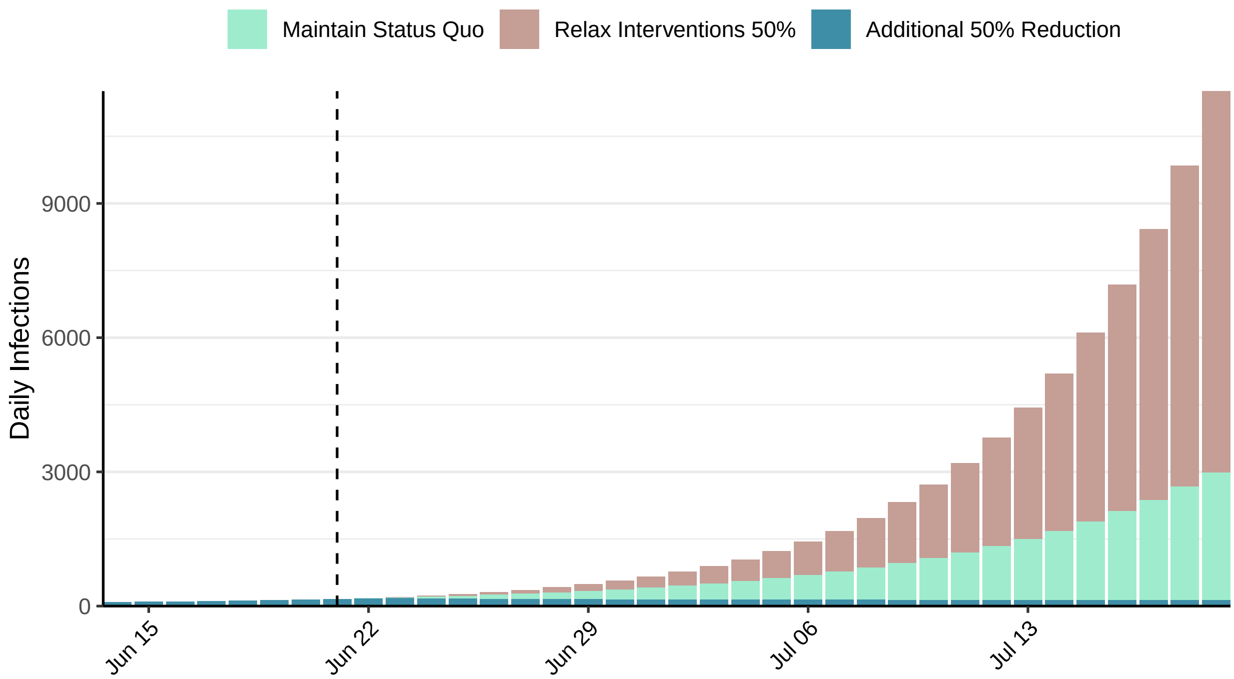


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Thailand, 2020-06-21

**Download the report for Thailand, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 3,147 | 1 | 58 | 0 | 1.29 (95% CI: 0.91-1.68) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

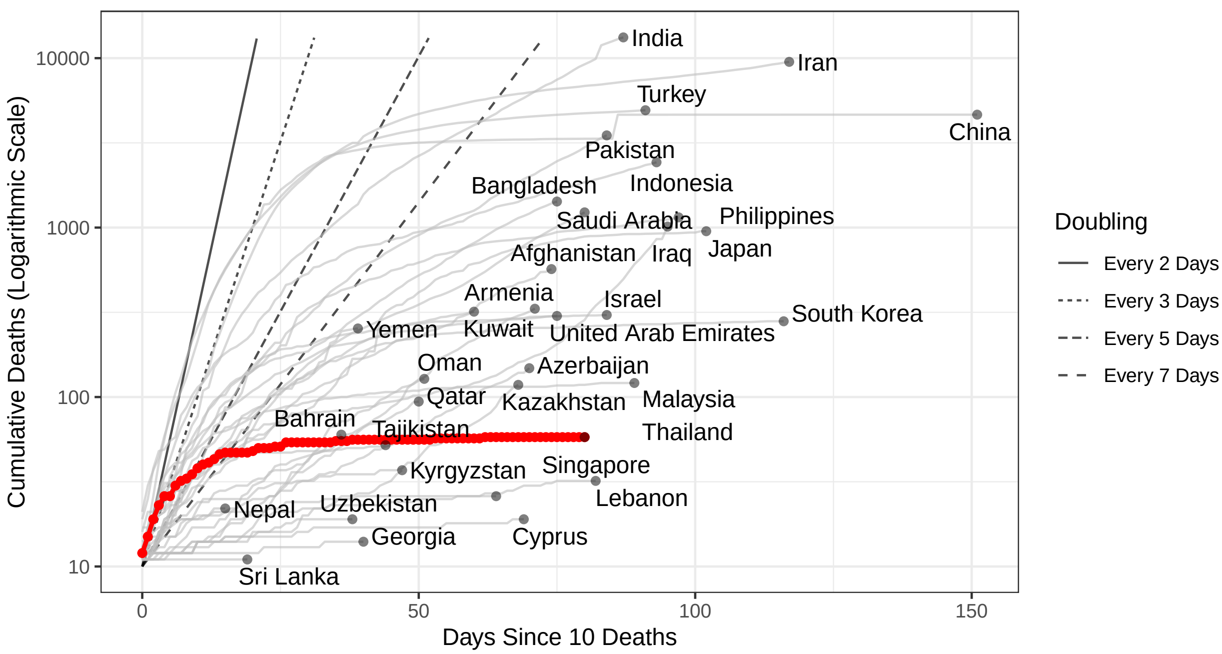


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 450 (95% CI: 393-506) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

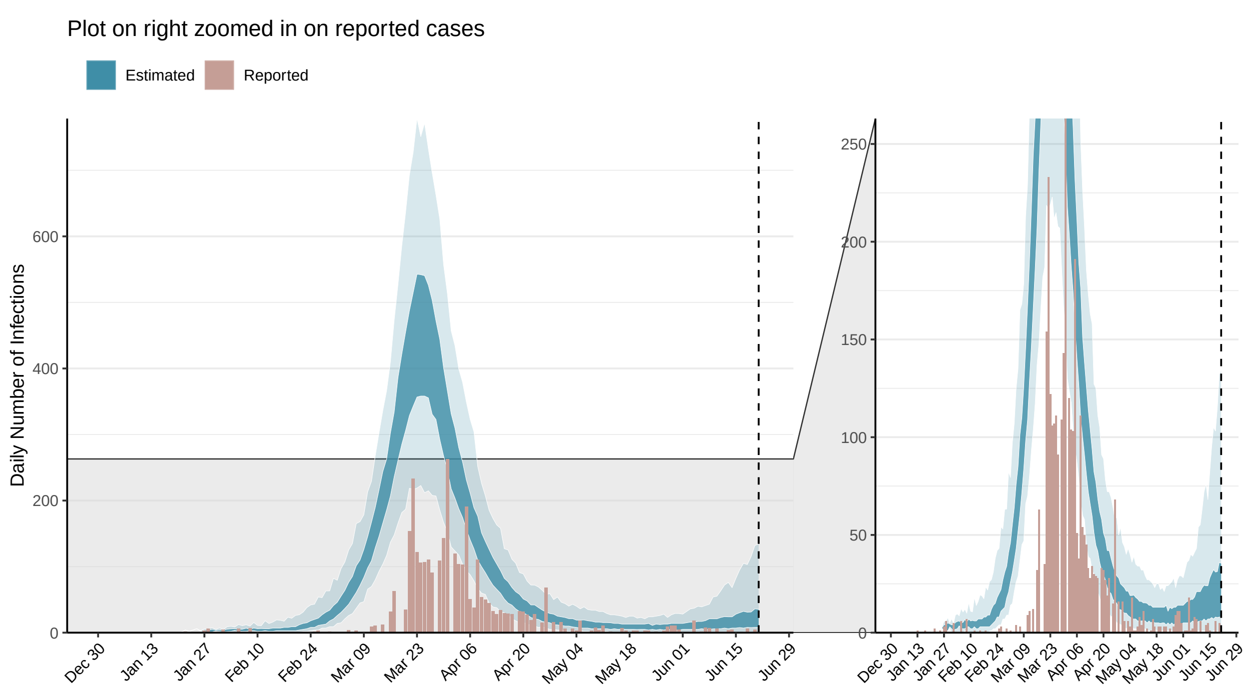


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

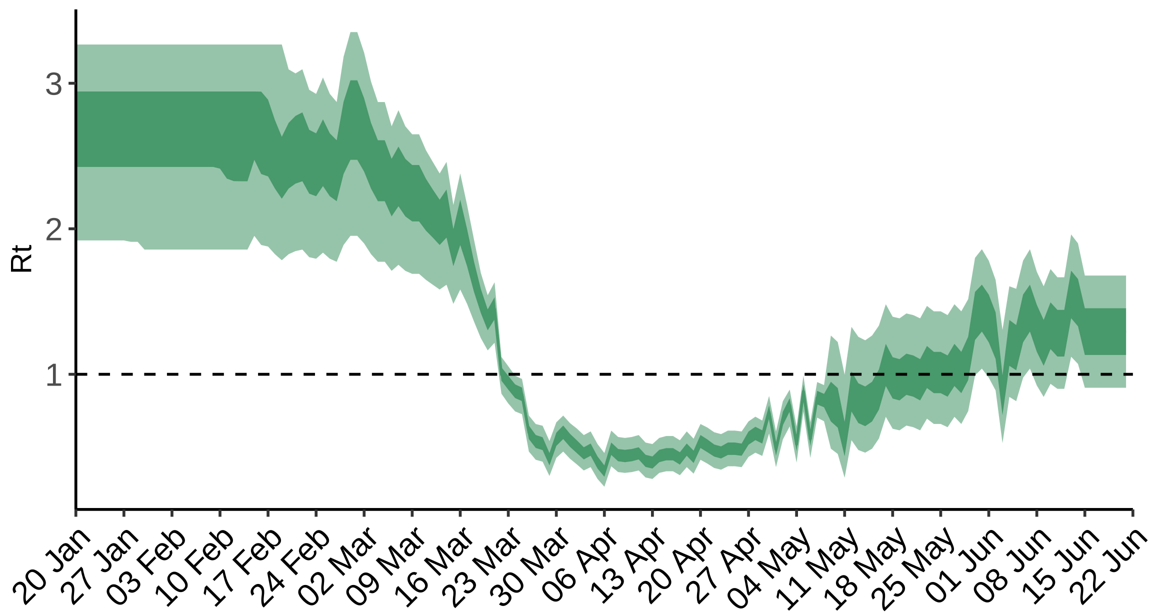


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

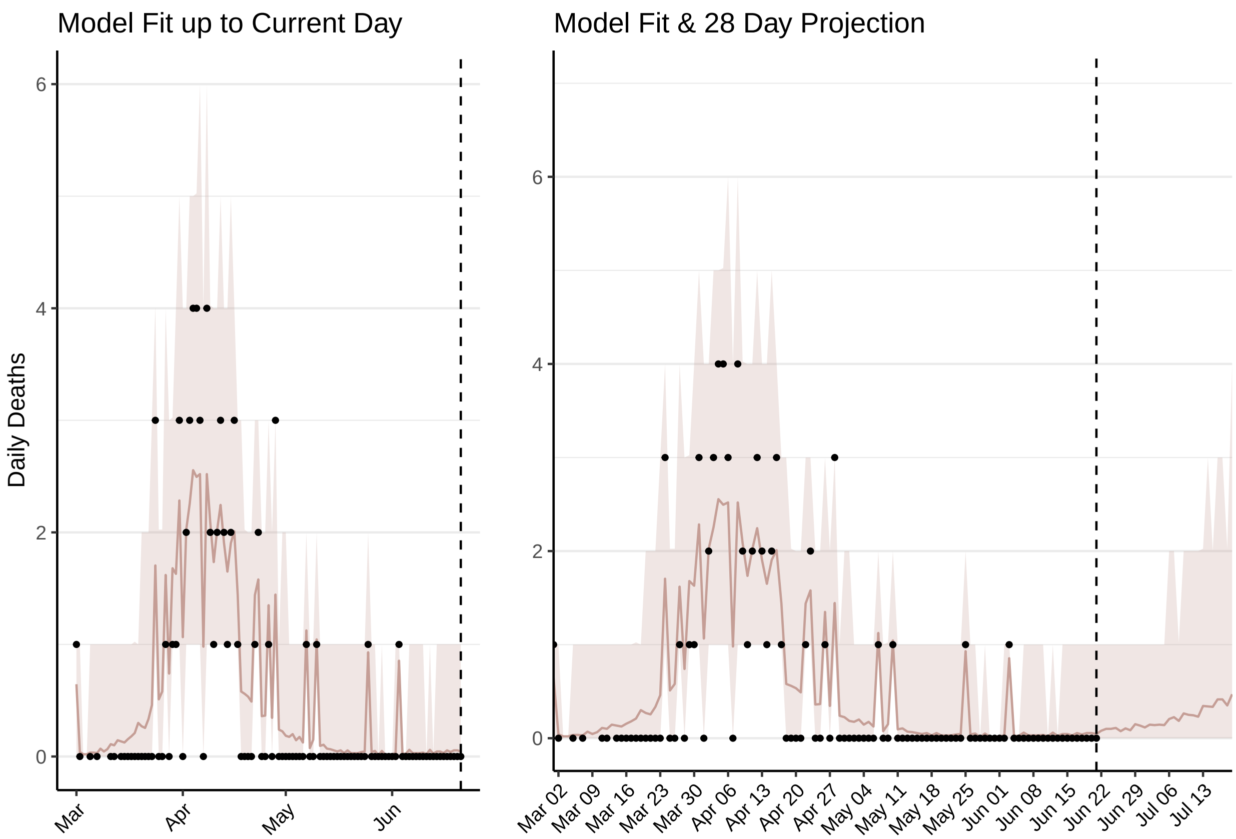


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 4 (95% CI: 4-5) patients requiring treatment with high-pressure oxygen at the current date to 25 (95% CI: 20-31) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 1 (95% CI: 1-2) patients requiring treatment with mechanical ventilation at the current date to 8 (95% CI: 6-9) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

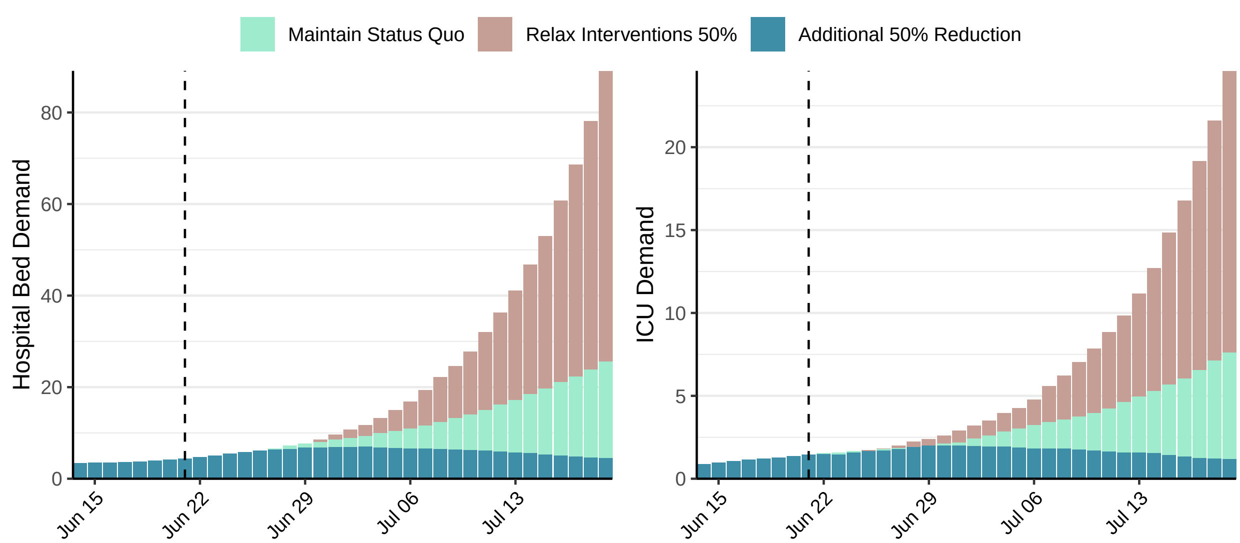


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 31 (95% CI: 26-35) at the current date to 11 (95% CI: 9-14) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 31 (95% CI: 26-35) at the current date to 1,097 (95% CI: 798-1,396) by 2020-07-19.

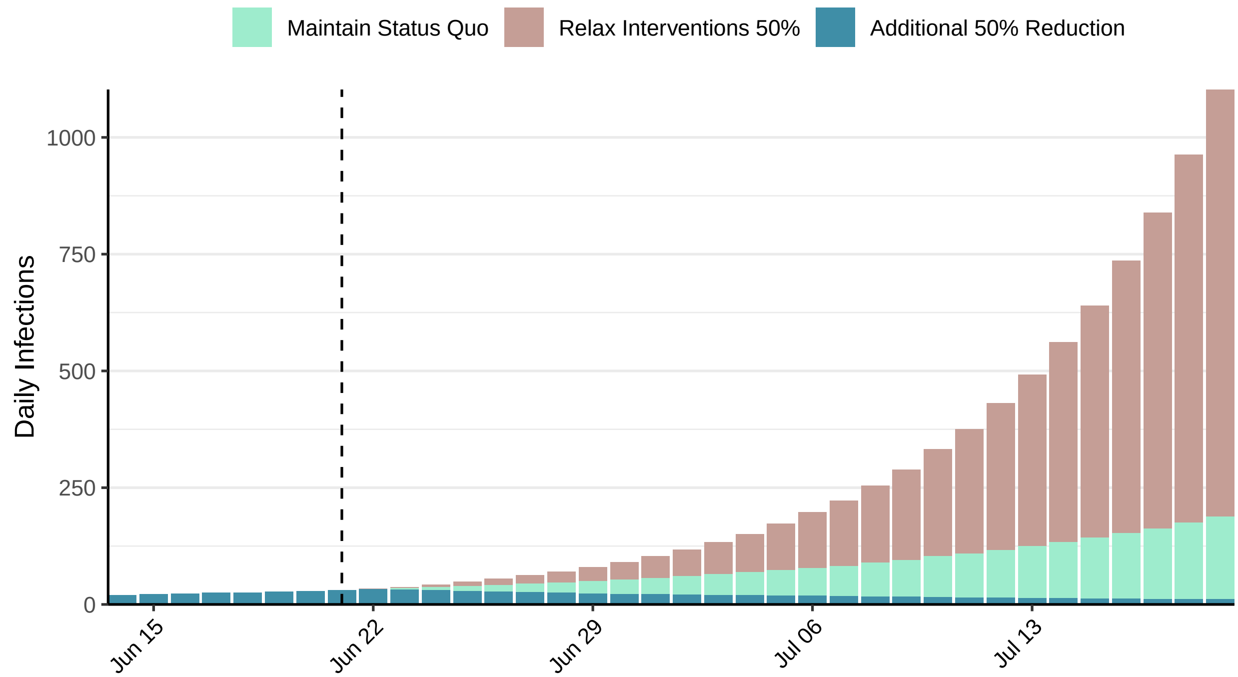


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Tajikistan, 2020-06-21

**Download the report for Tajikistan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 5,399 | 61 | 52 | 1 | 2.42 (95% CI: 1.27-3.73) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

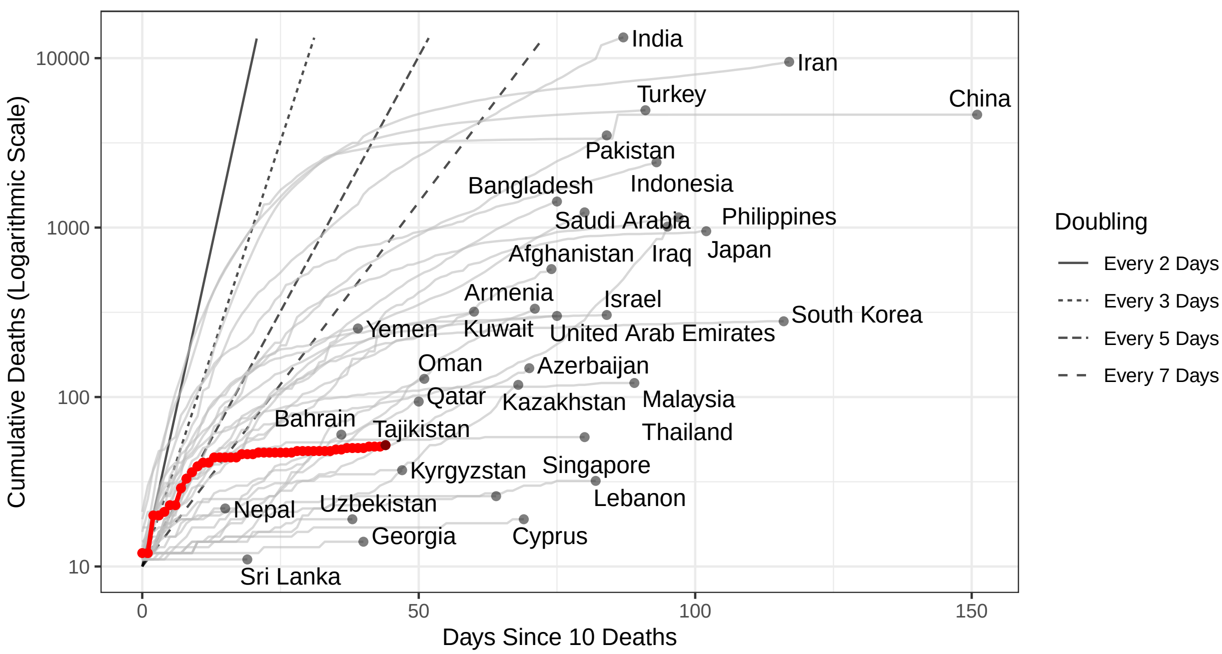


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

## COVID-19 Transmission Modelling

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 5,887 (95% CI: 5,319-6,456) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

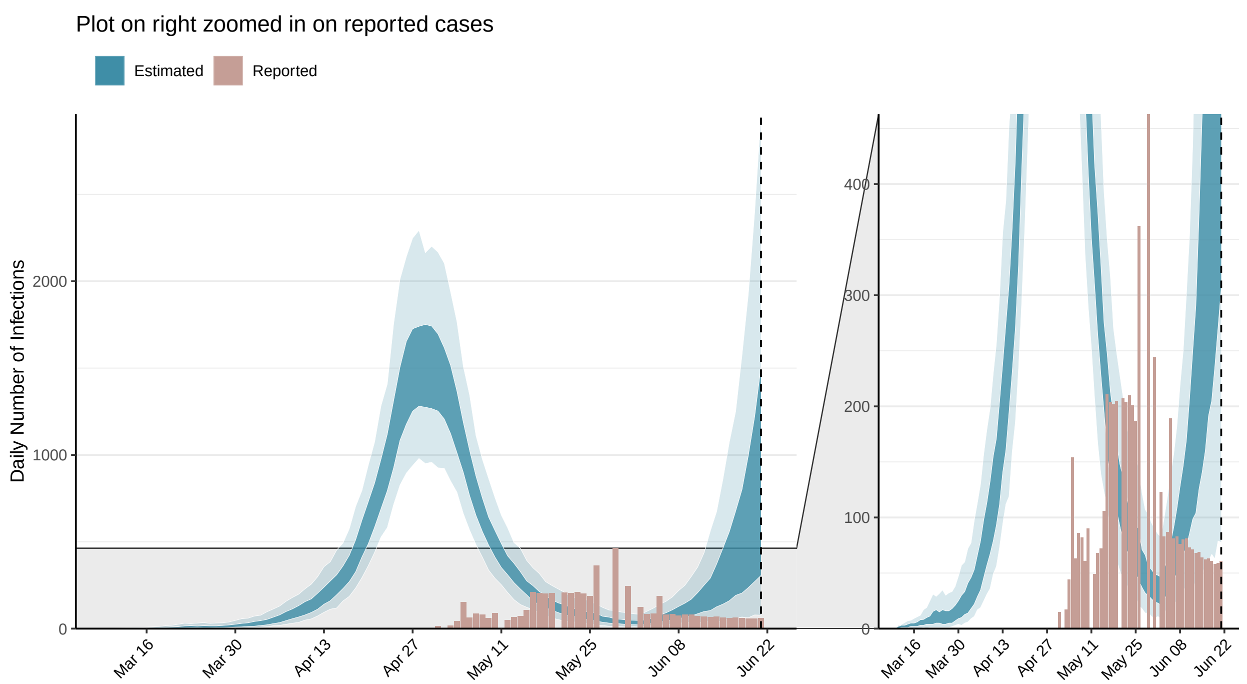


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

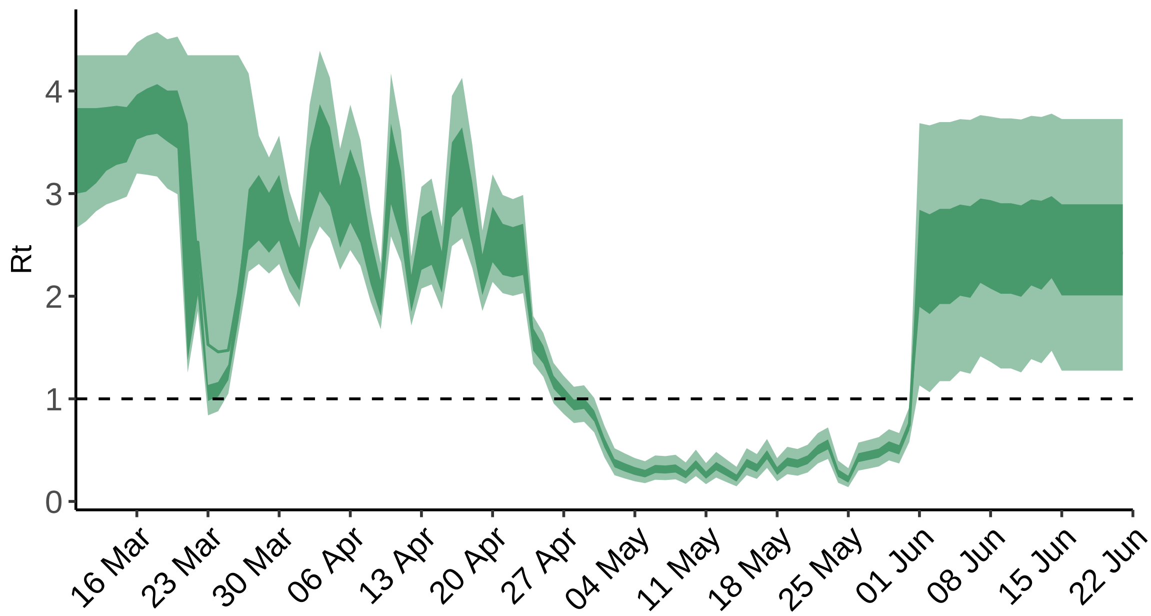


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

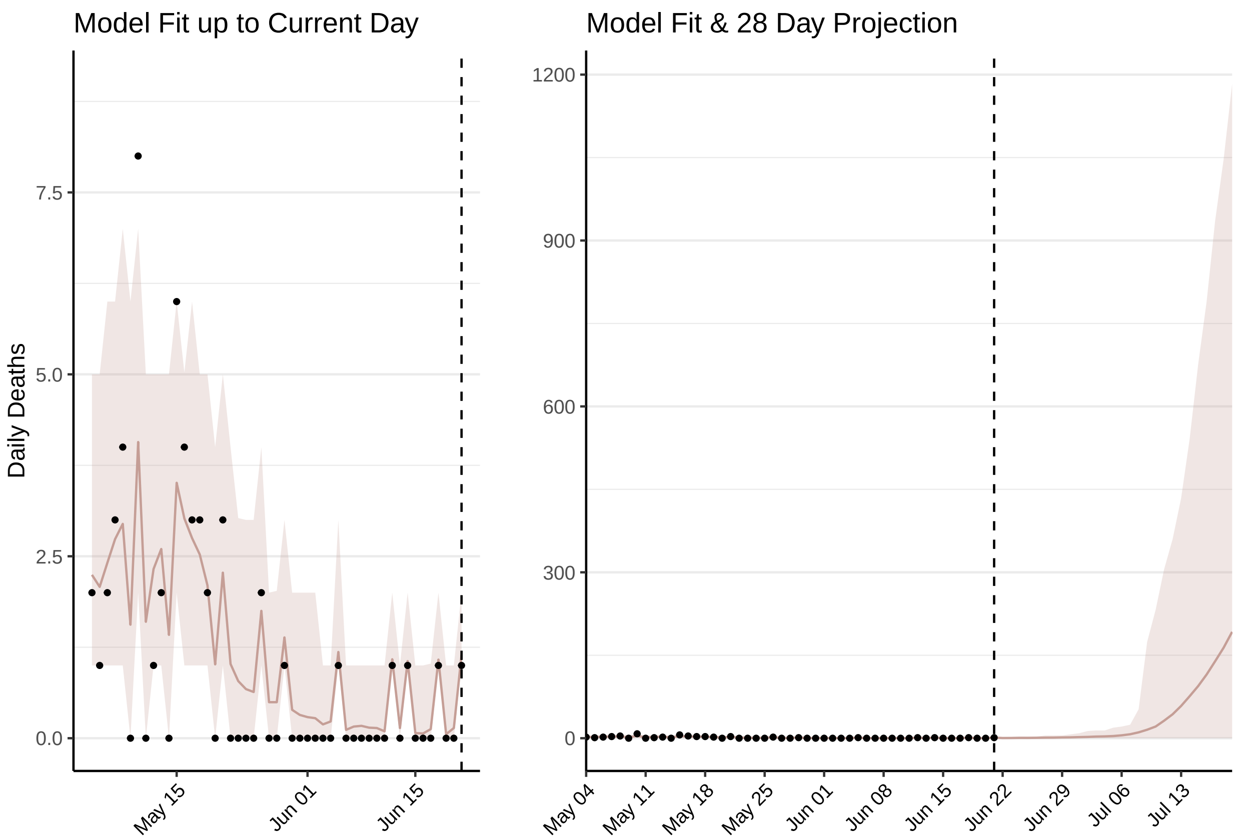


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 32 (95% CI: 29-35) patients requiring treatment with high-pressure oxygen at the current date to 5,388 (95% CI: 4,209-6,567) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 7 (95% CI: 6-8) patients requiring treatment with mechanical ventilation at the current date to 572 (95% CI: 486-658) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

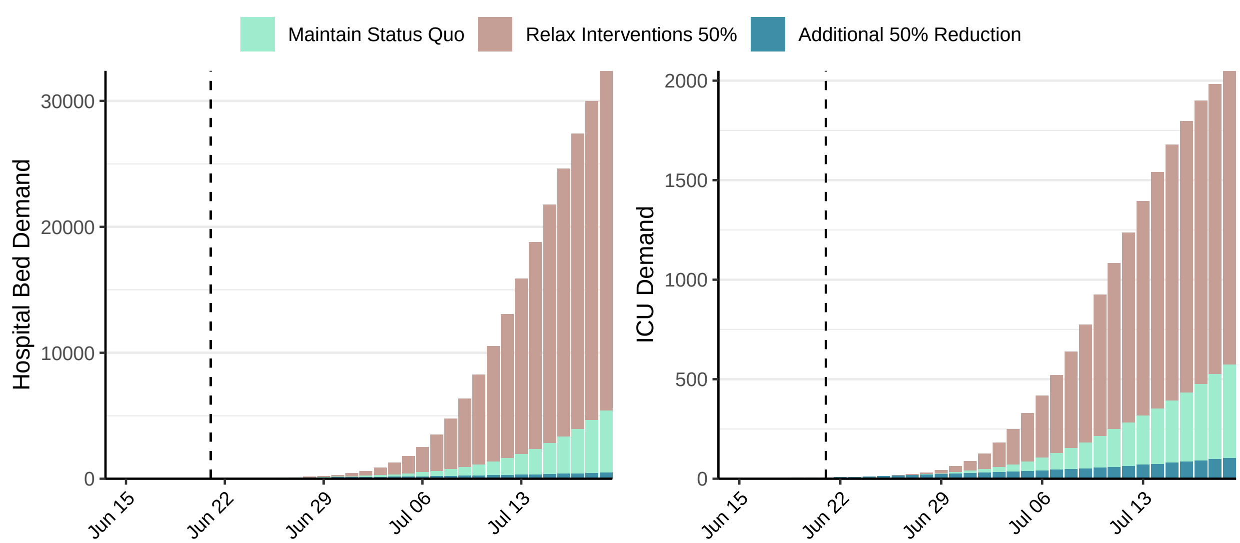


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 913 (95% CI: 794-1,032) at the current date to 6,833 (95% CI: 4,945-8,720) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 913 (95% CI: 794-1,032) at the current date to 360,252 (95% CI: 330,304-390,200) by 2020-07-19.

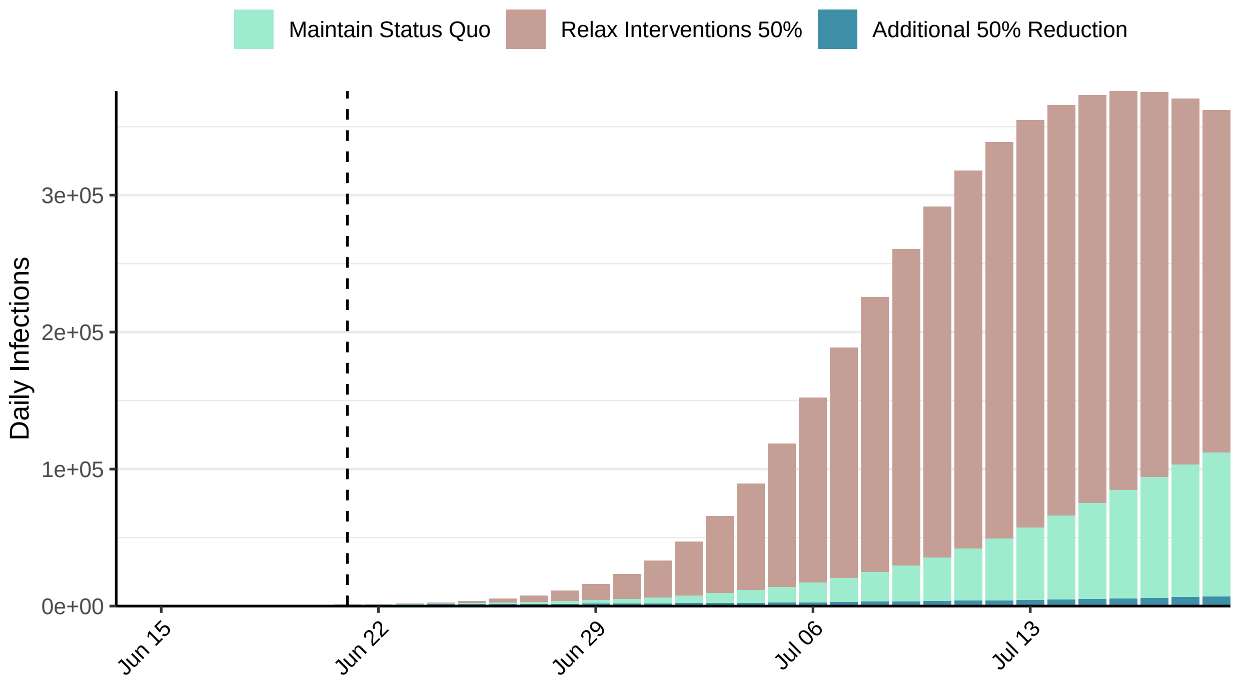


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Tunisia, 2020-06-21

**Download the report for Tunisia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,156 | 10 | 50 | 0 | 1.57 (95% CI: 1.31-1.94) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

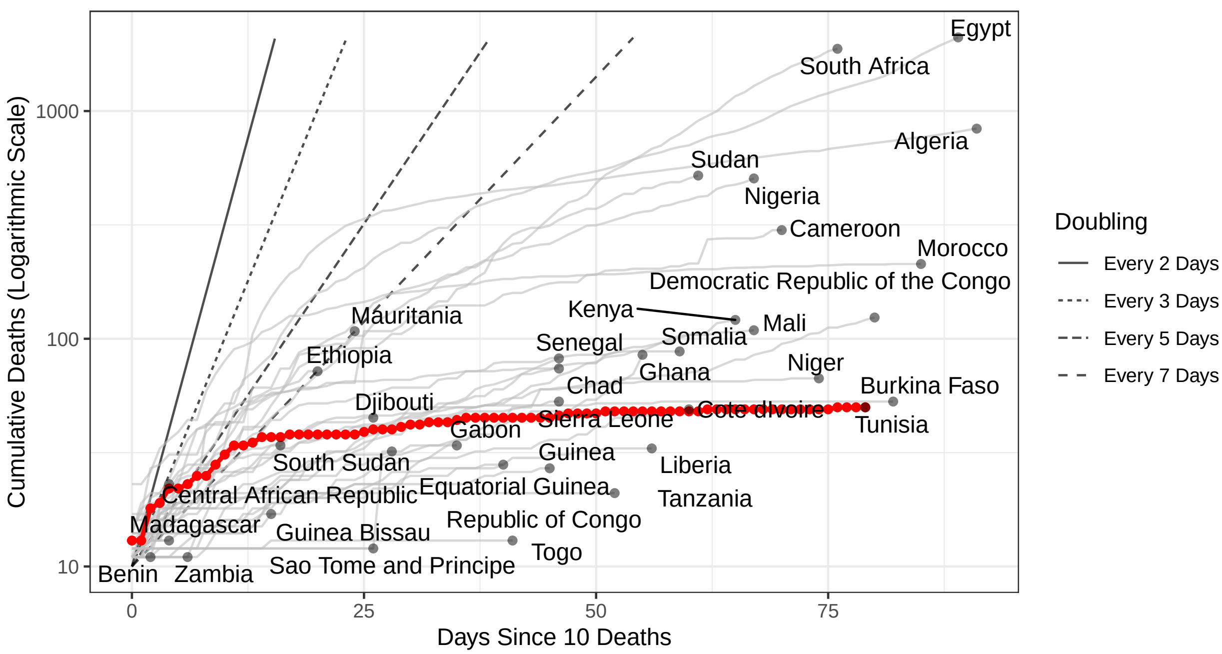


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 672 (95% CI: 612-732) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

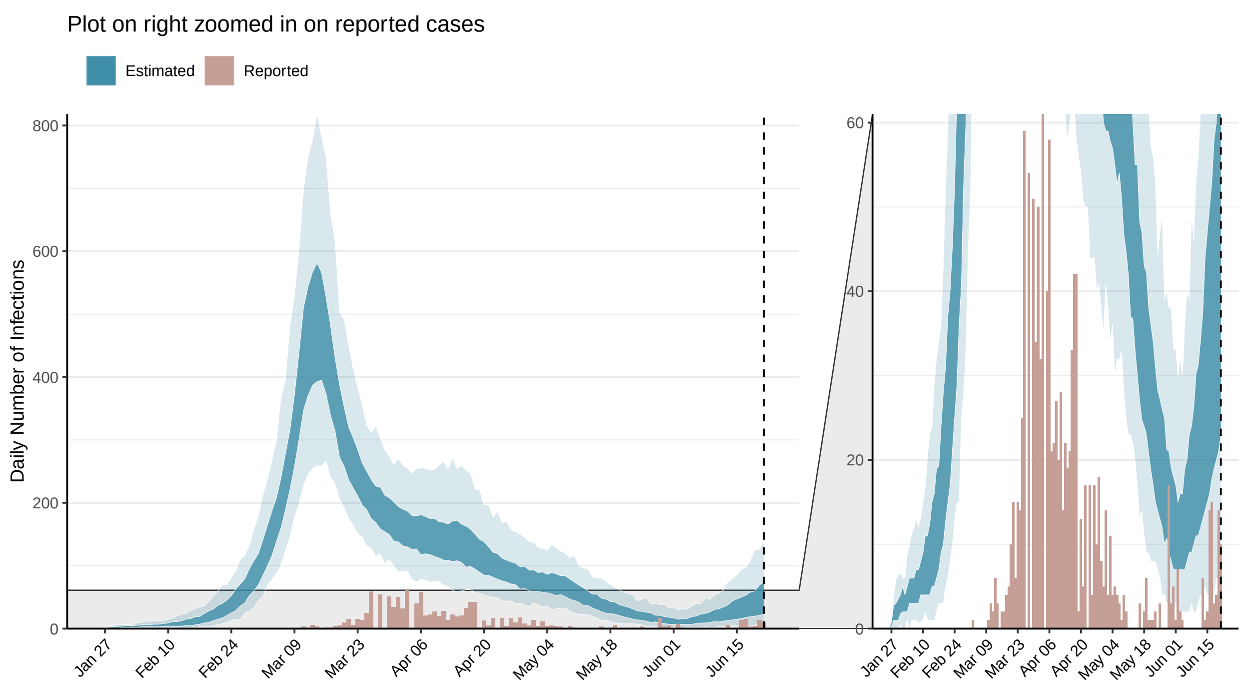


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

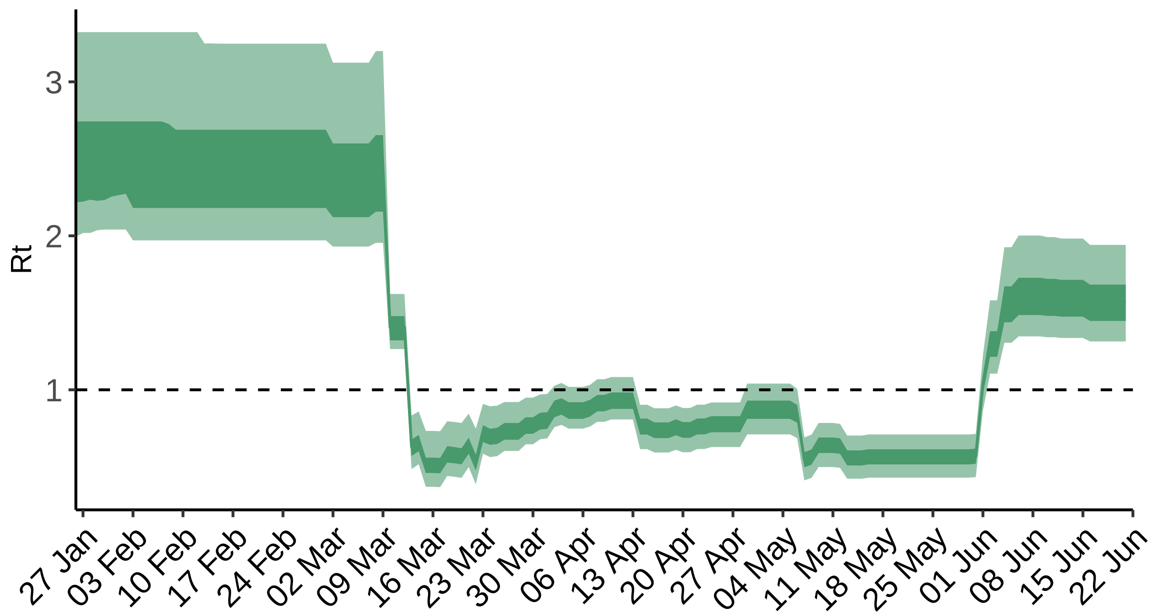


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

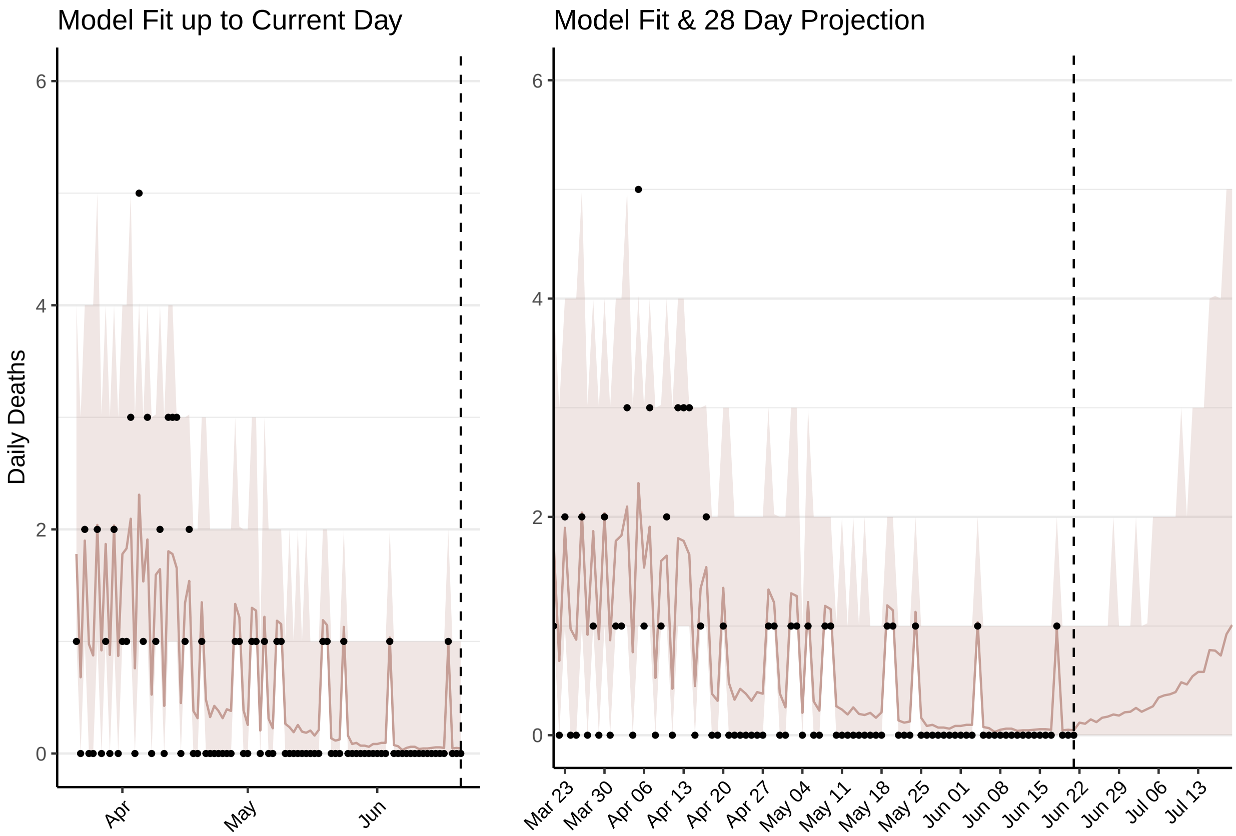


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 5 (95% CI: 5-6) patients requiring treatment with high-pressure oxygen at the current date to 52 (95% CI: 44-60) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2 (95% CI: 1-2) patients requiring treatment with mechanical ventilation at the current date to 16 (95% CI: 14-19) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

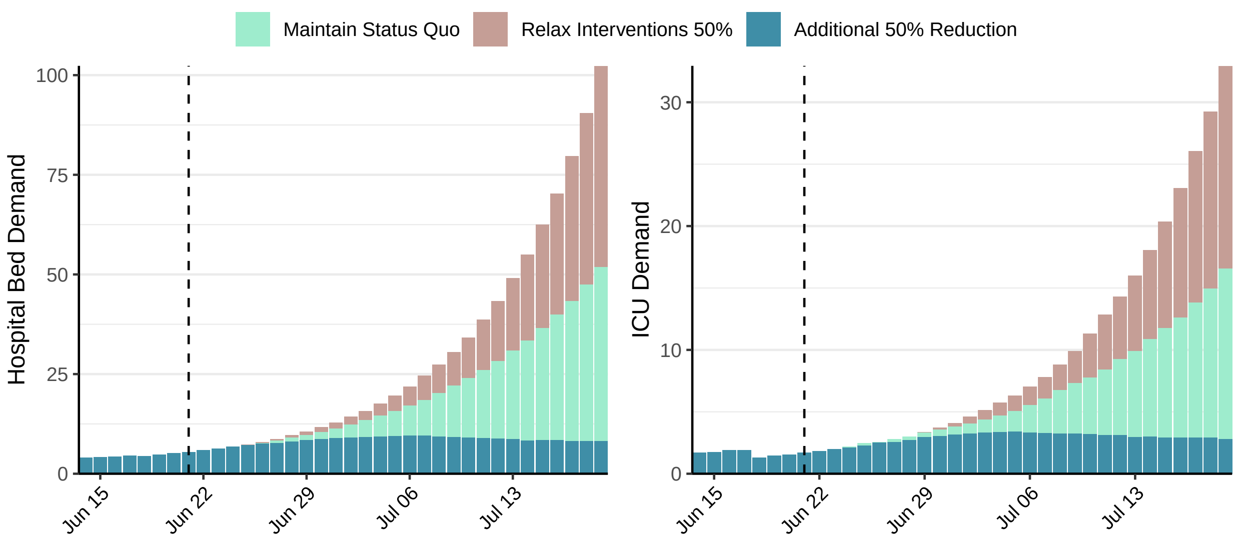


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 52 (95% CI: 47-58) at the current date to 30 (95% CI: 25-35) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 52 (95% CI: 47-58) at the current date to 1,454 (95% CI: 1,178-1,731) by 2020-07-19.

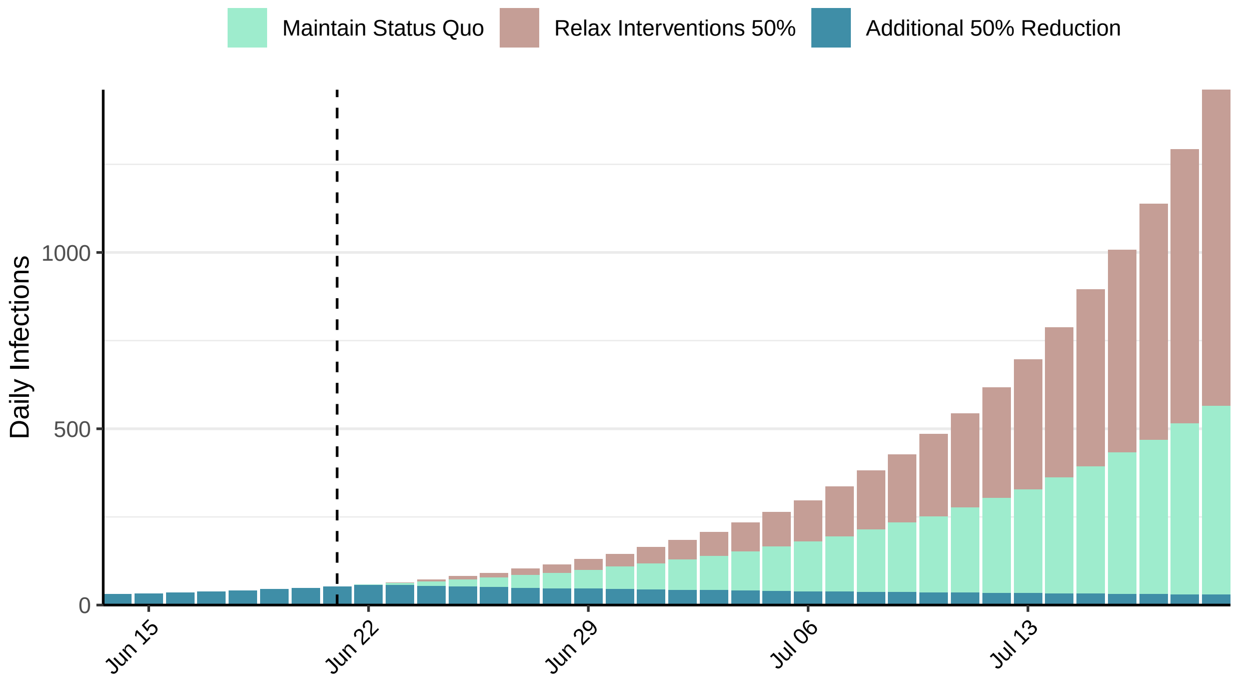


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Turkey, 2020-06-21

**Download the report for Turkey, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 186,493 | 1,248 | 4,927 | 22 | 2 (95% CI: 1.82-2.22) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

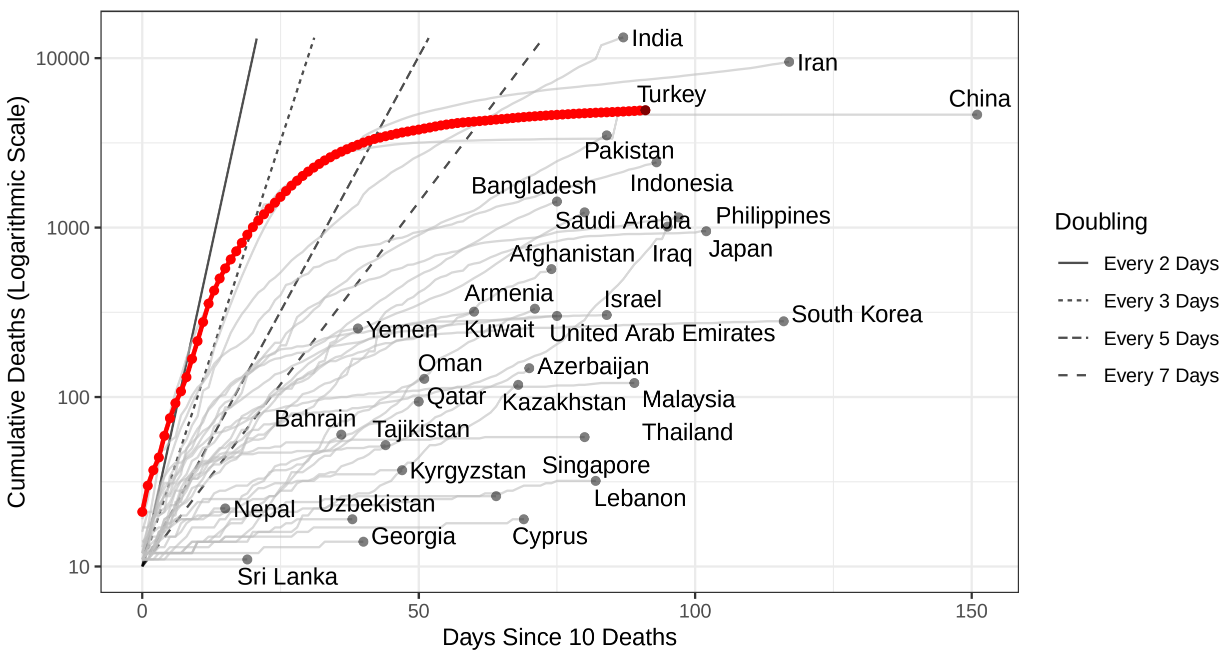


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 307,851 (95% CI: 298,535-317,166) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

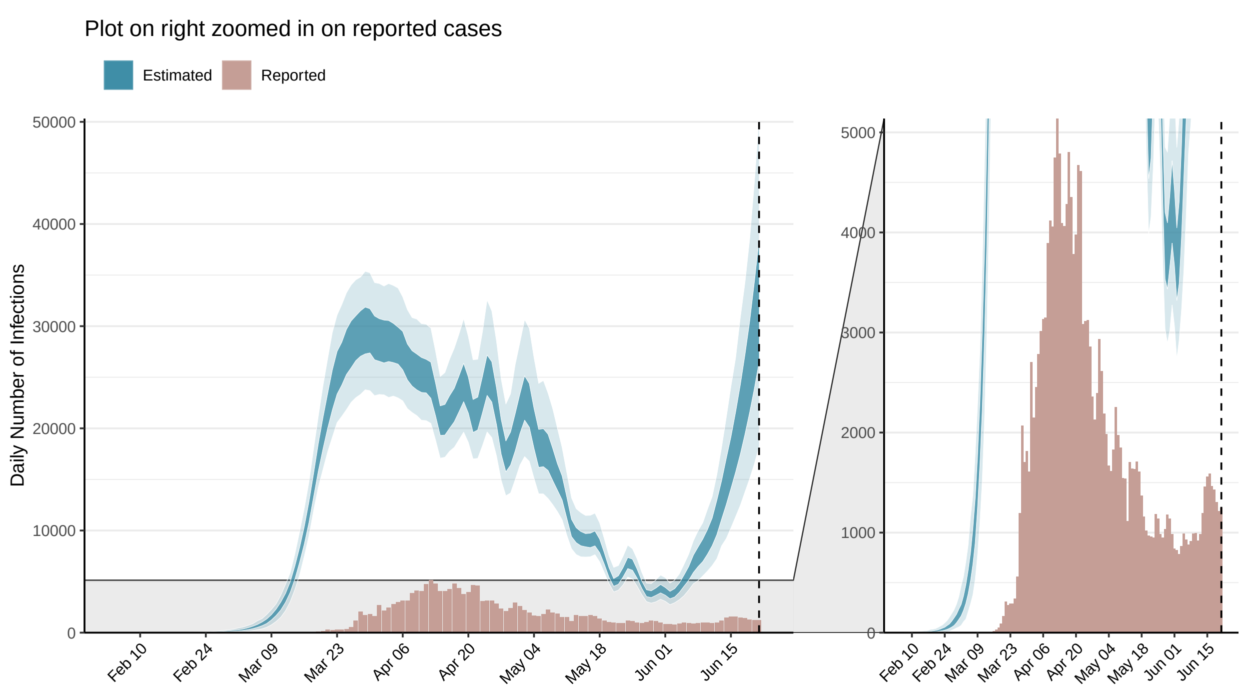


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

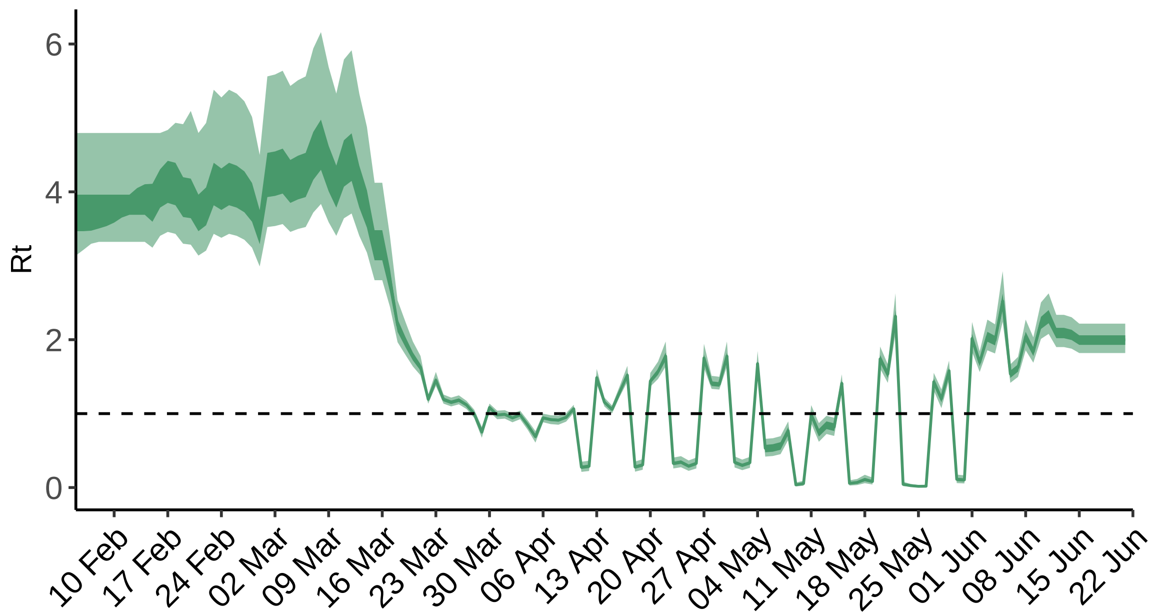


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Turkey is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

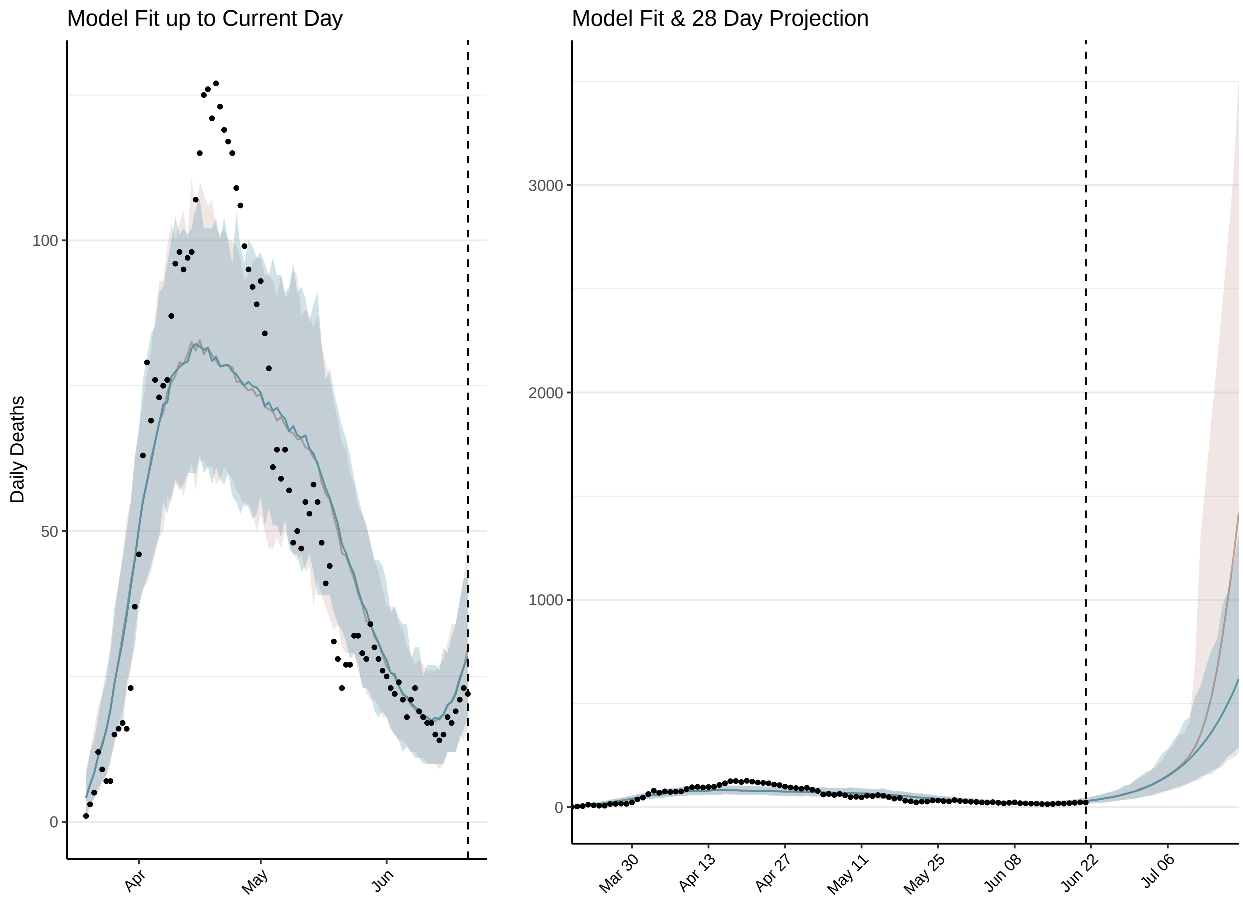


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 2,121 (95% CI: 2,057-2,185) patients requiring treatment with high-pressure oxygen at the current date to 45,636 (95% CI: 42,865-48,407) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 523 (95% CI: 507-539) patients requiring treatment with mechanical ventilation at the current date to 8,596 (95% CI: 8,336-8,855) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

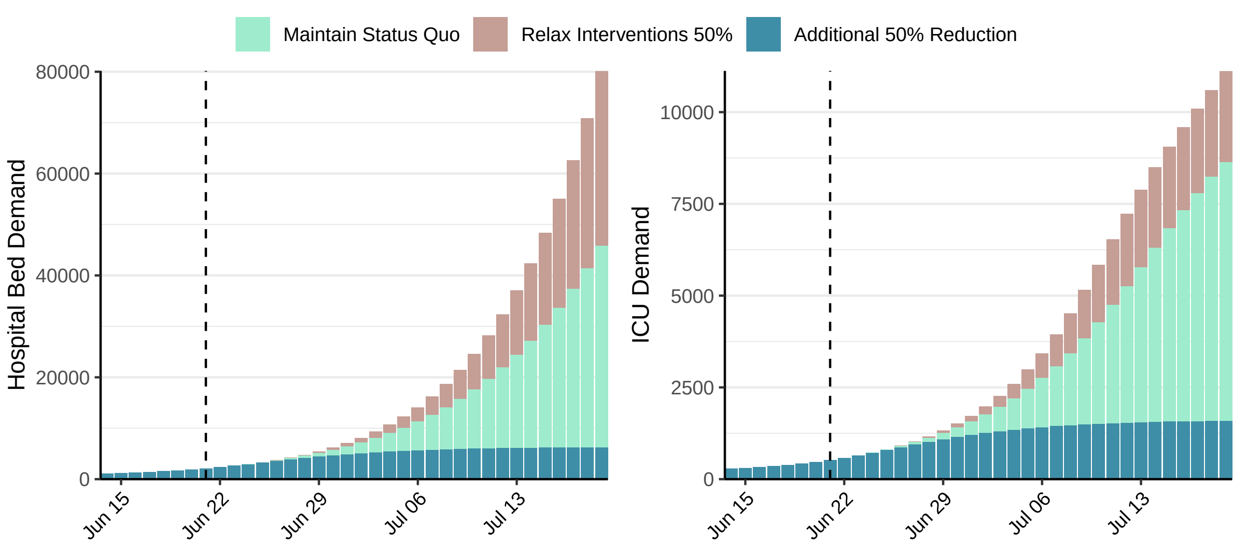


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 32,779 (95% CI: 31,503-34,055) at the current date to 34,039 (95% CI: 31,739-36,338) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 32,779 (95% CI: 31,503-34,055) at the current date to 1,201,190 (95% CI: 1,138,109-1,264,272) by 2020-07-19.

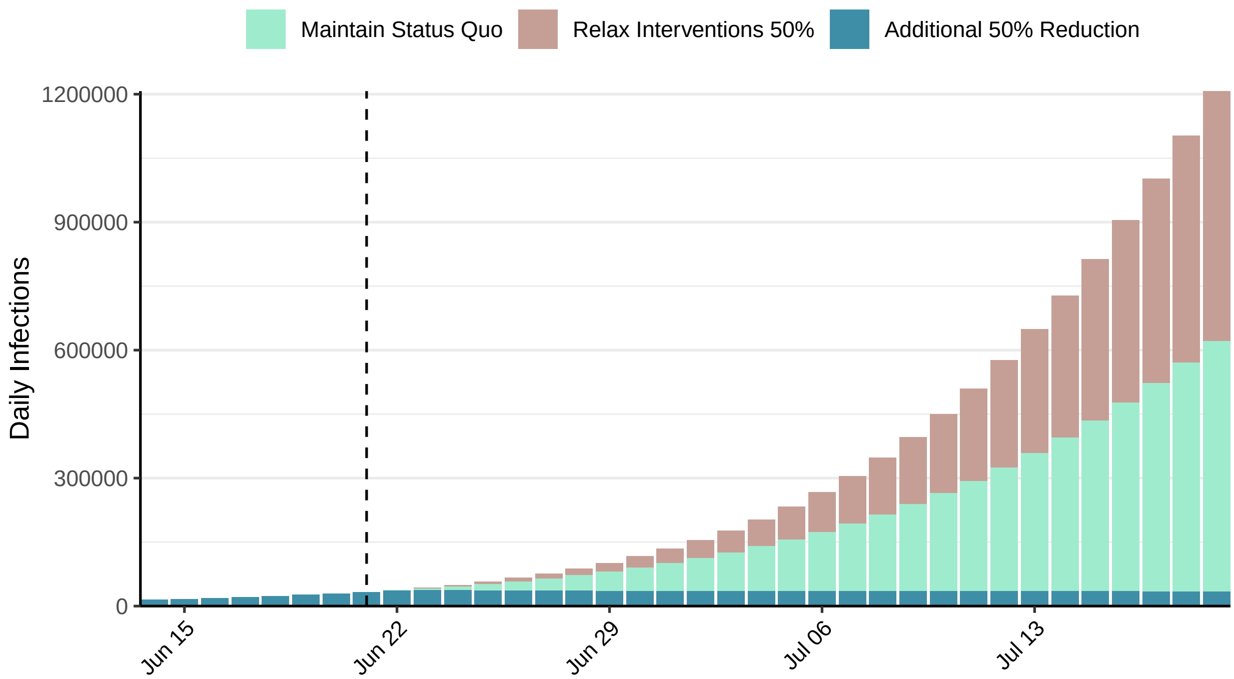


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Tanzania, 2020-06-21

**Download the report for Tanzania, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 509 | 0 | 21 | 0 | 1.93 (95% CI: 1.57-2.38) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

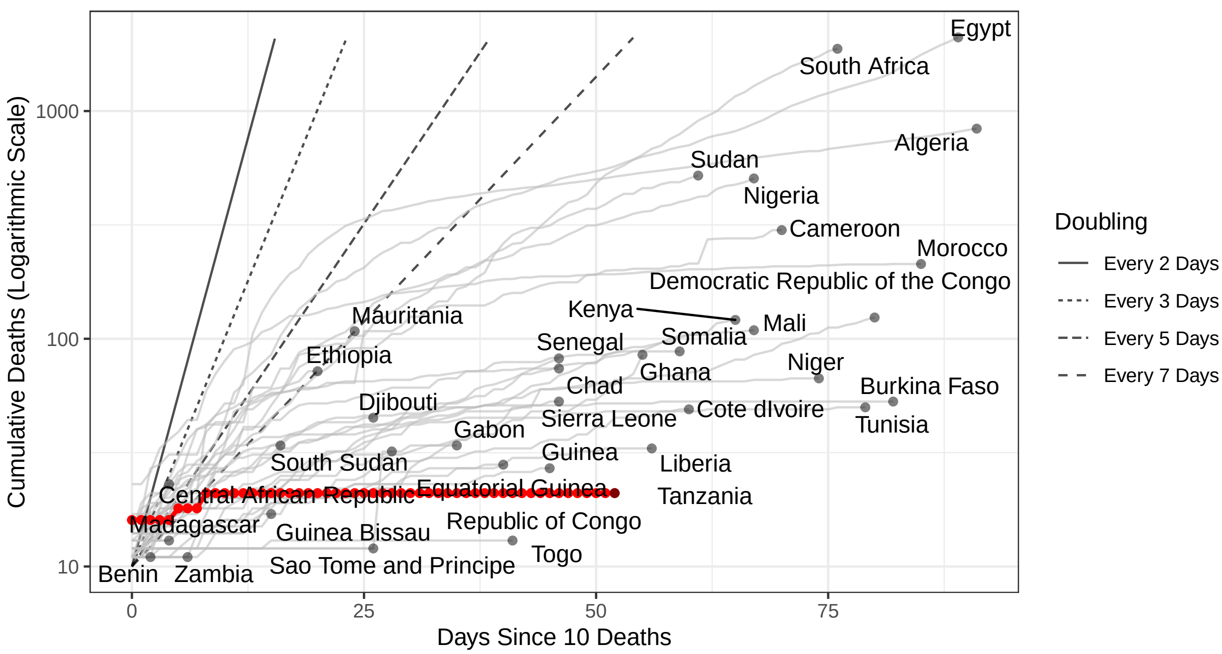


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,297 (95% CI: 1,148-1,447) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

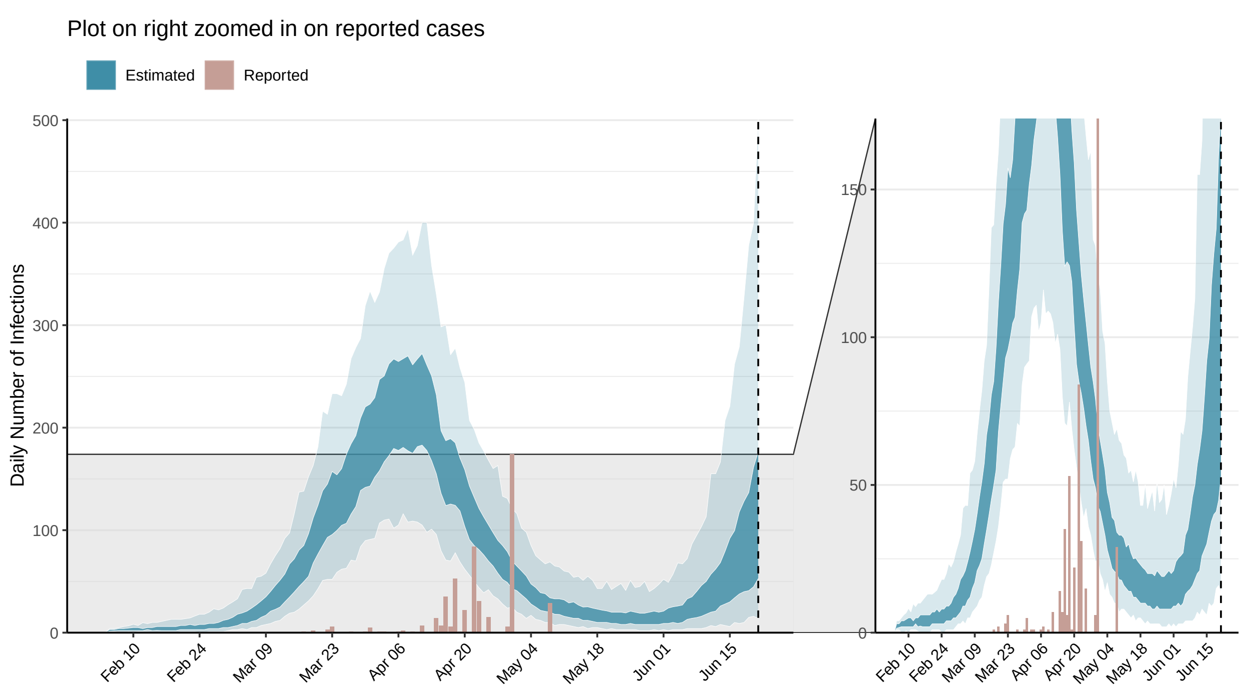


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

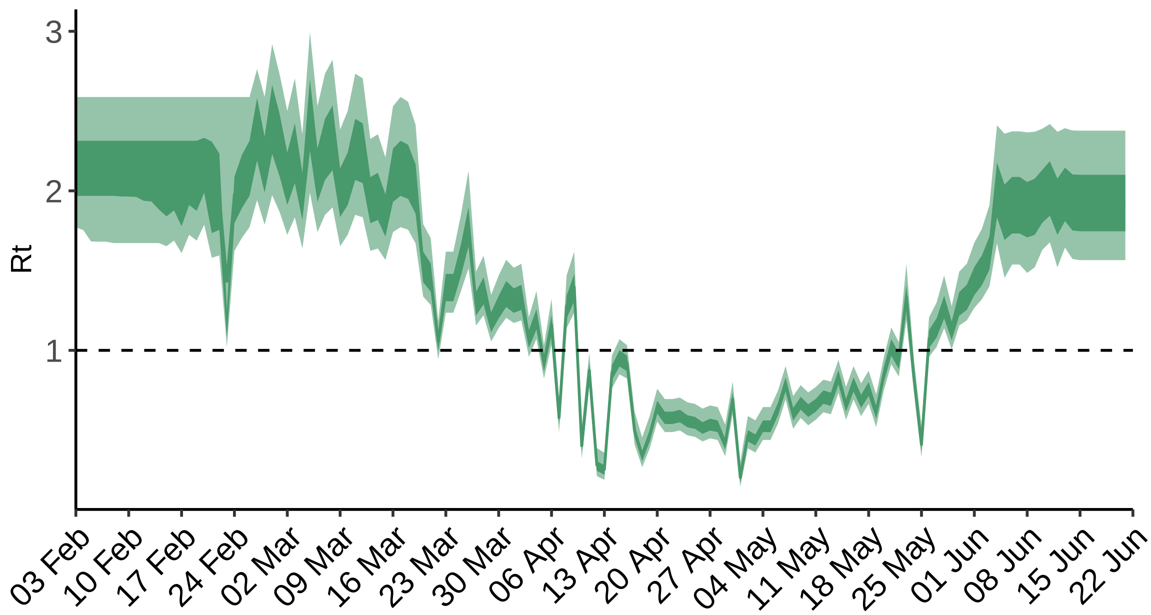


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

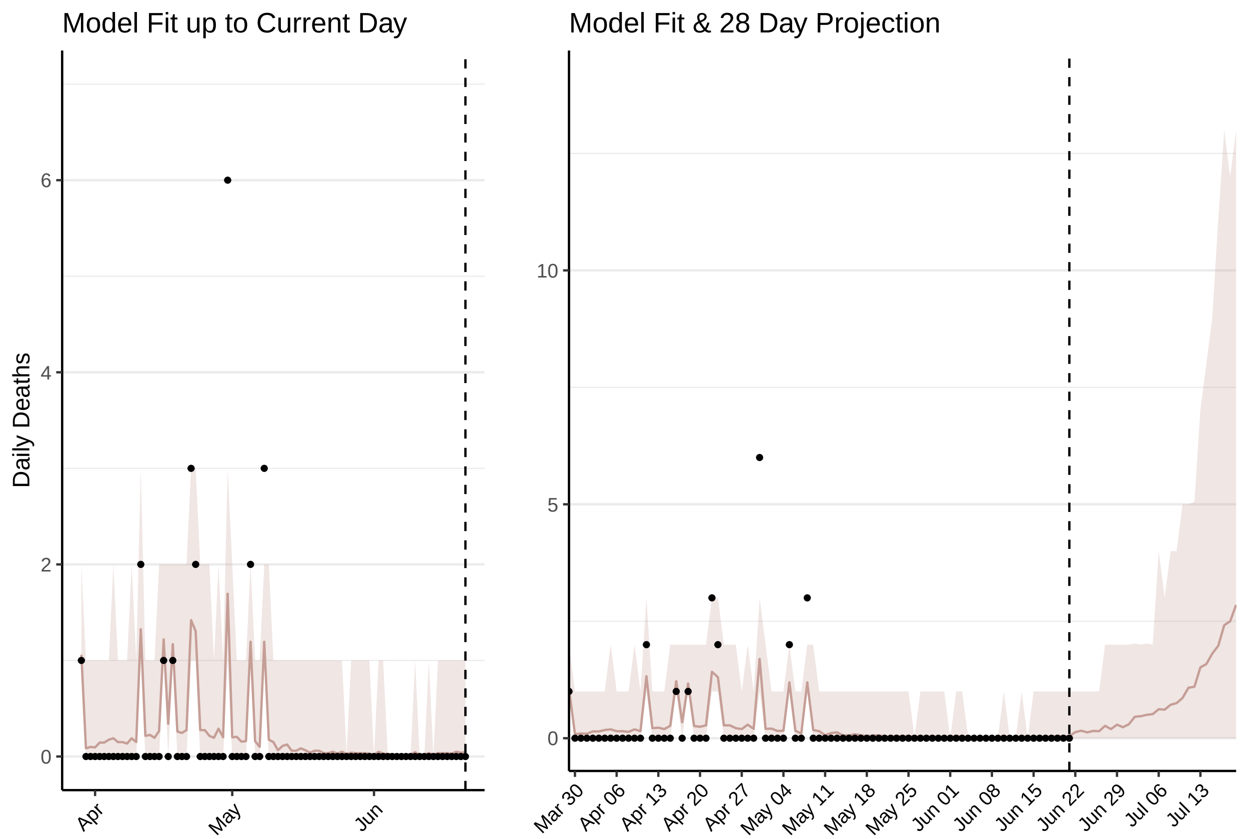


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 7 (95% CI: 6-8) patients requiring treatment with high-pressure oxygen at the current date to 212 (95% CI: 173-250) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2 (95% CI: 2-2) patients requiring treatment with mechanical ventilation at the current date to 53 (95% CI: 44-63) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

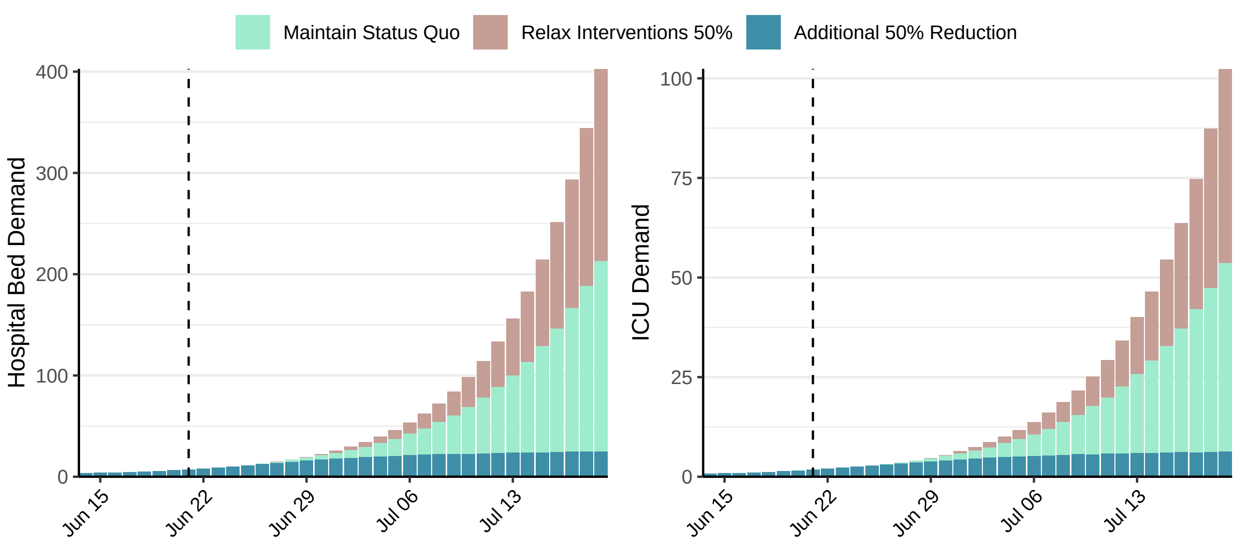


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 144 (95% CI: 125-163) at the current date to 194 (95% CI: 157-230) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 144 (95% CI: 125-163) at the current date to 10,939 (95% CI: 8,655-13,222) by 2020-07-19.

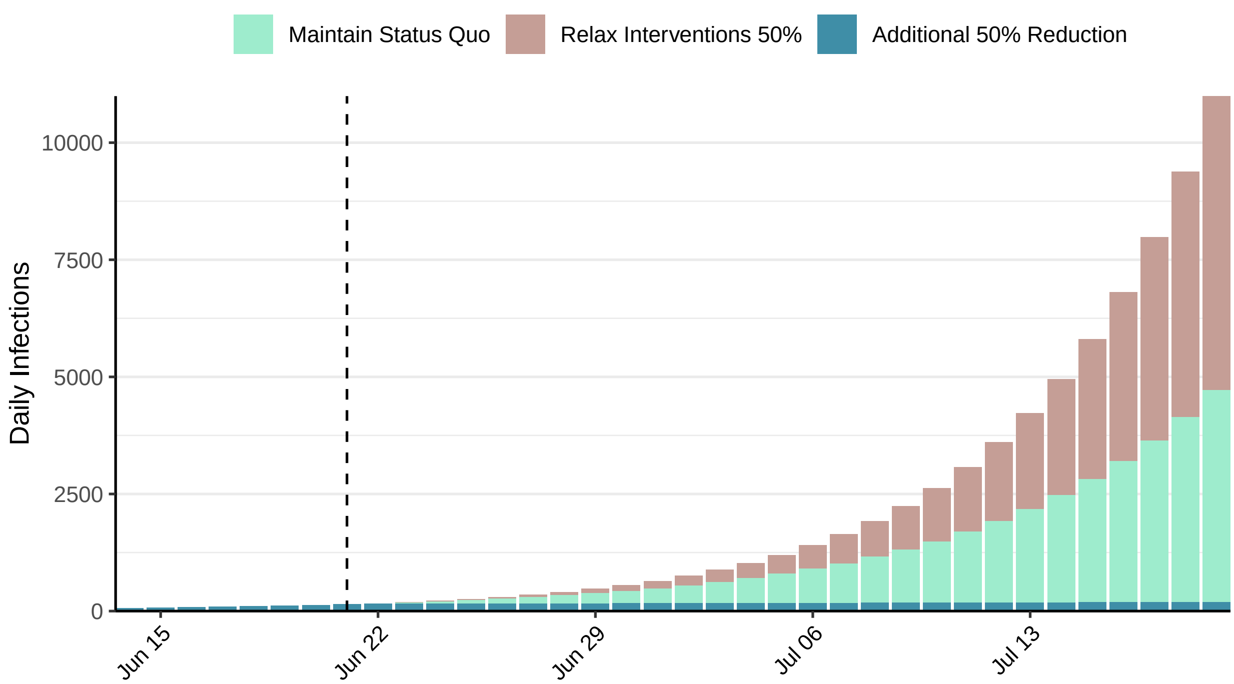


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Ukraine, 2020-06-21

**Download the report for Ukraine, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 35,825 | 841 | 994 | 9 | 1.85 (95% CI: 1.68-2.12) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

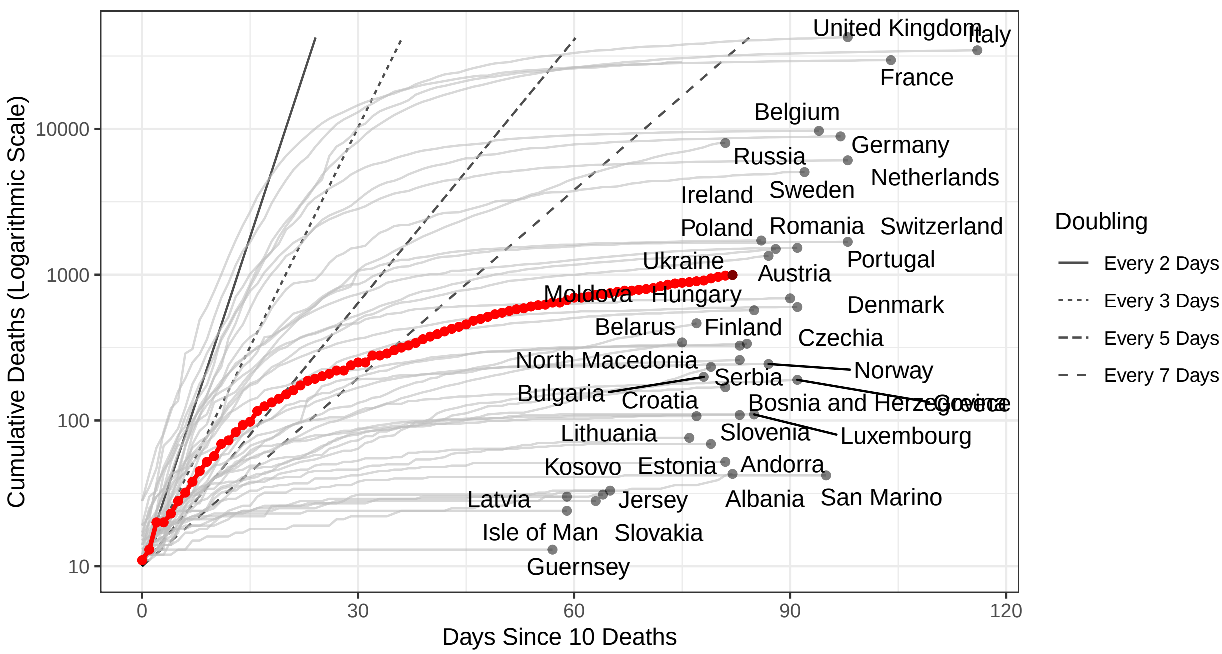


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 234,308 (95% CI: 227,236-241,380) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

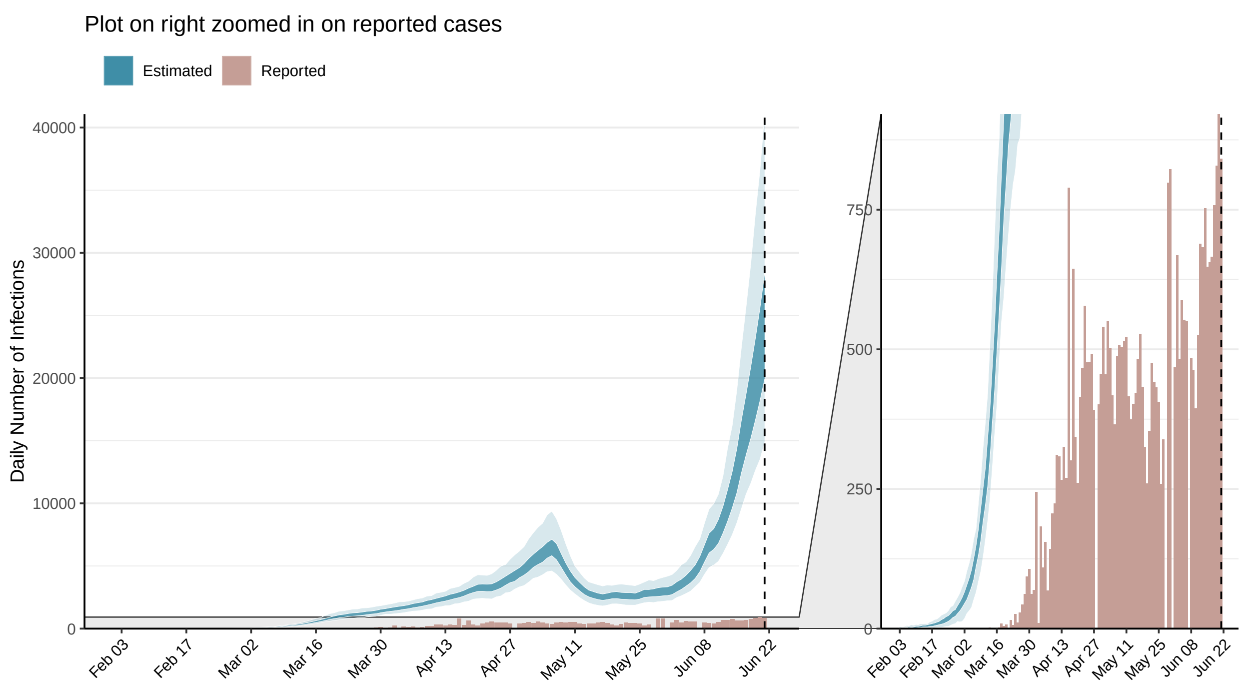


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

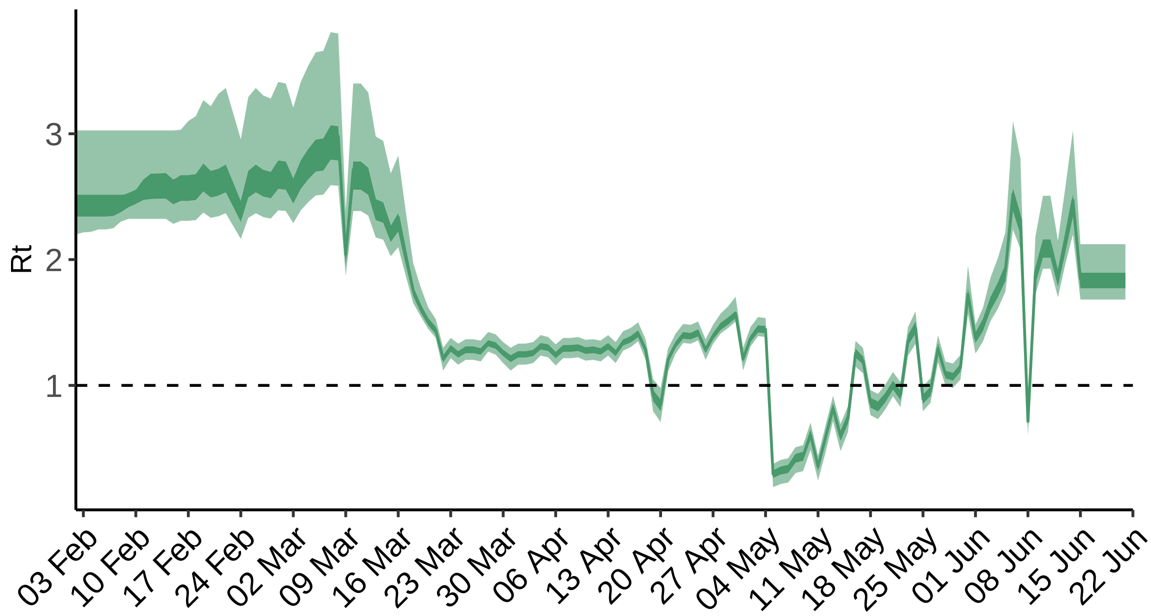


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

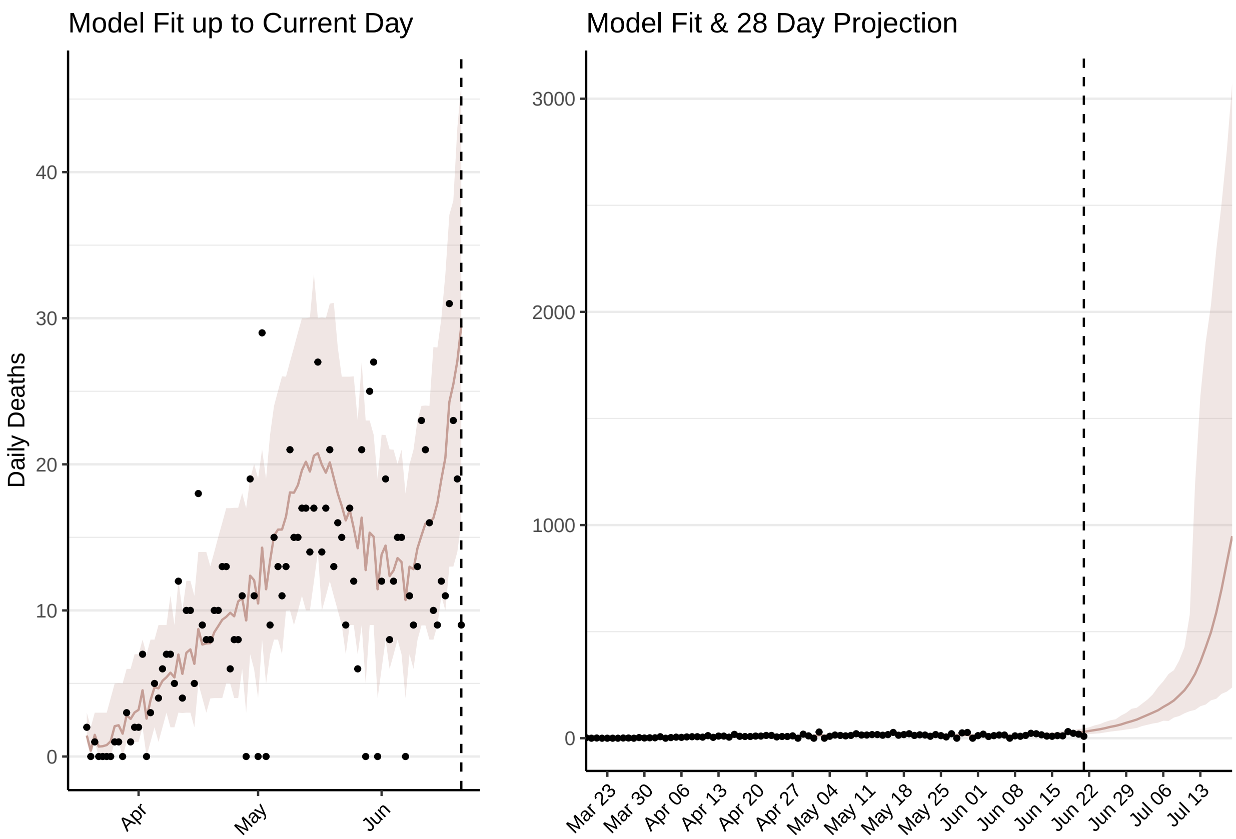


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,941 (95% CI: 1,882-1,999) patients requiring treatment with high-pressure oxygen at the current date to 31,410 (95% CI: 29,419-33,401) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 548 (95% CI: 531-564) patients requiring treatment with mechanical ventilation at the current date to 7,572 (95% CI: 7,316-7,829) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

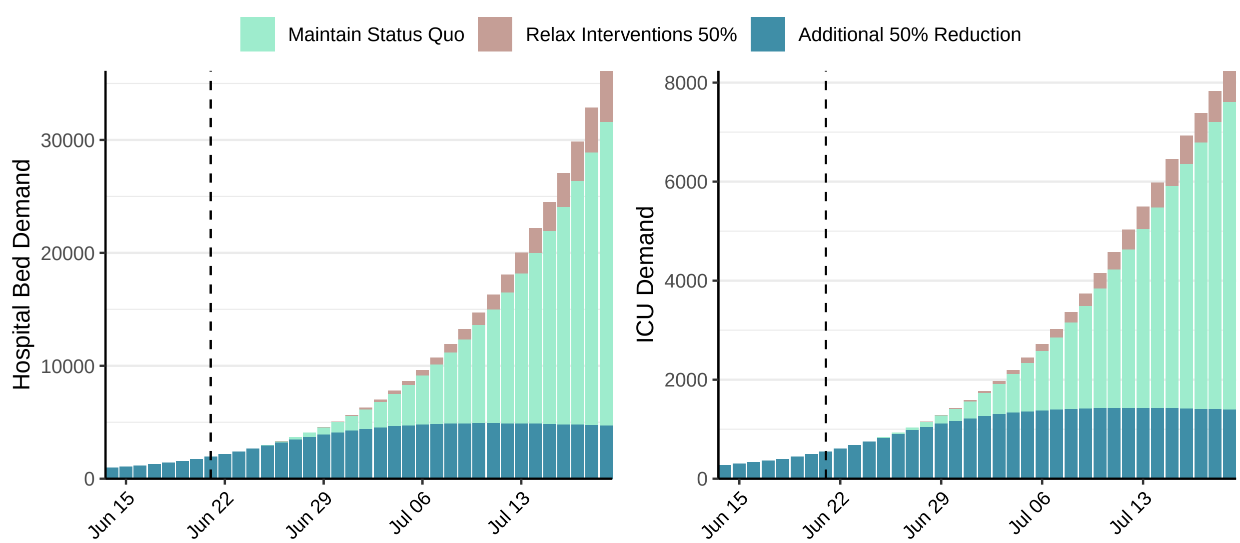


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 24,371 (95% CI: 23,439-25,303) at the current date to 19,134 (95% CI: 17,746-20,522) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 24,371 (95% CI: 23,439-25,303) at the current date to 365,702 (95% CI: 343,497-387,908) by 2020-07-19.

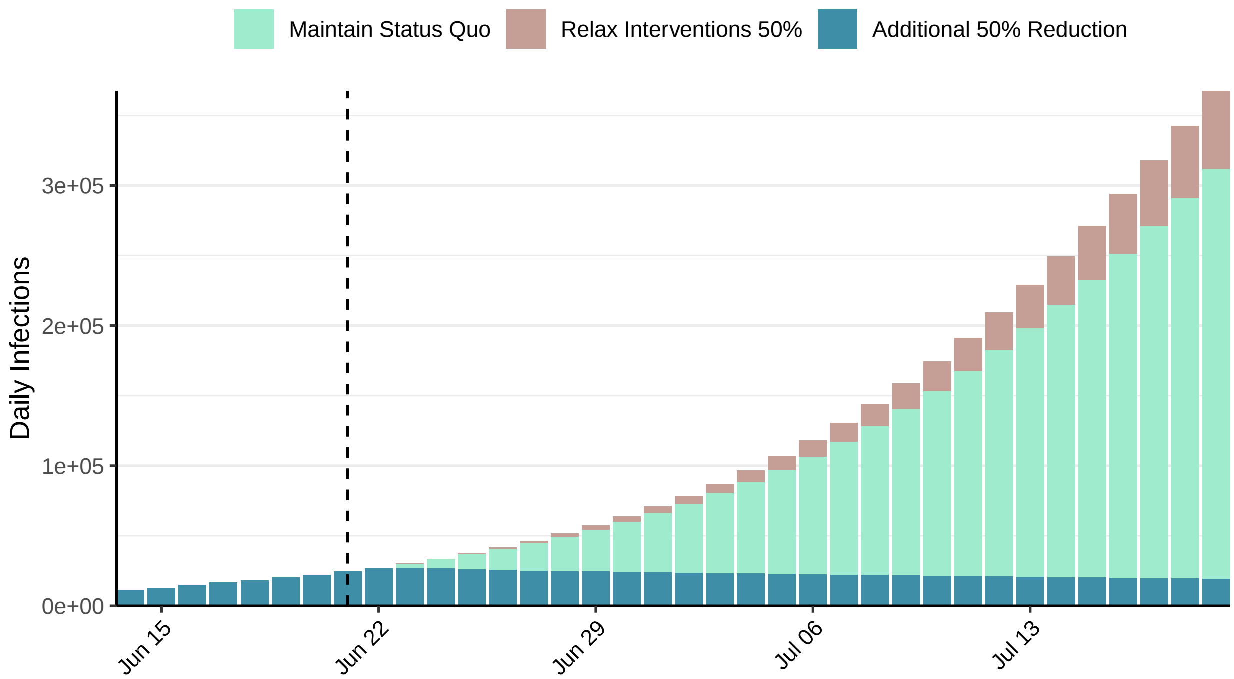


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Uruguay, 2020-06-21

**Download the report for Uruguay, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 859 | 6 | 25 | 1 | 1.24 (95% CI: 0.96-1.51) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

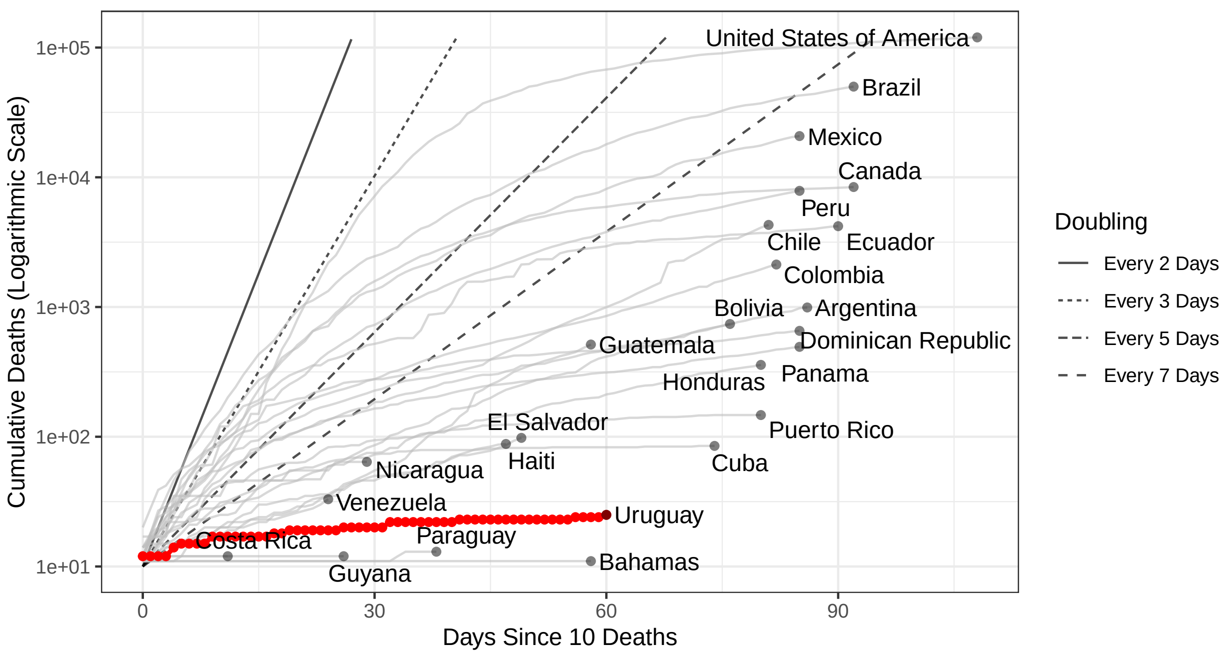


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,695 (95% CI: 1,551-1,840) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

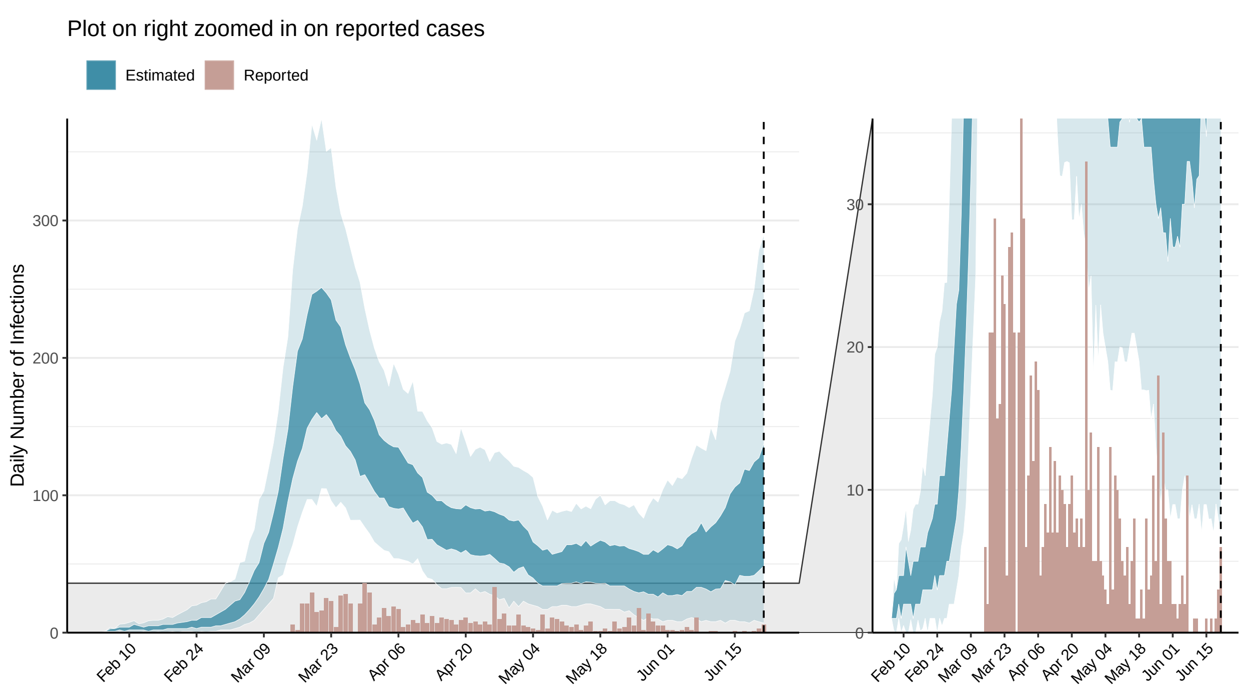


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

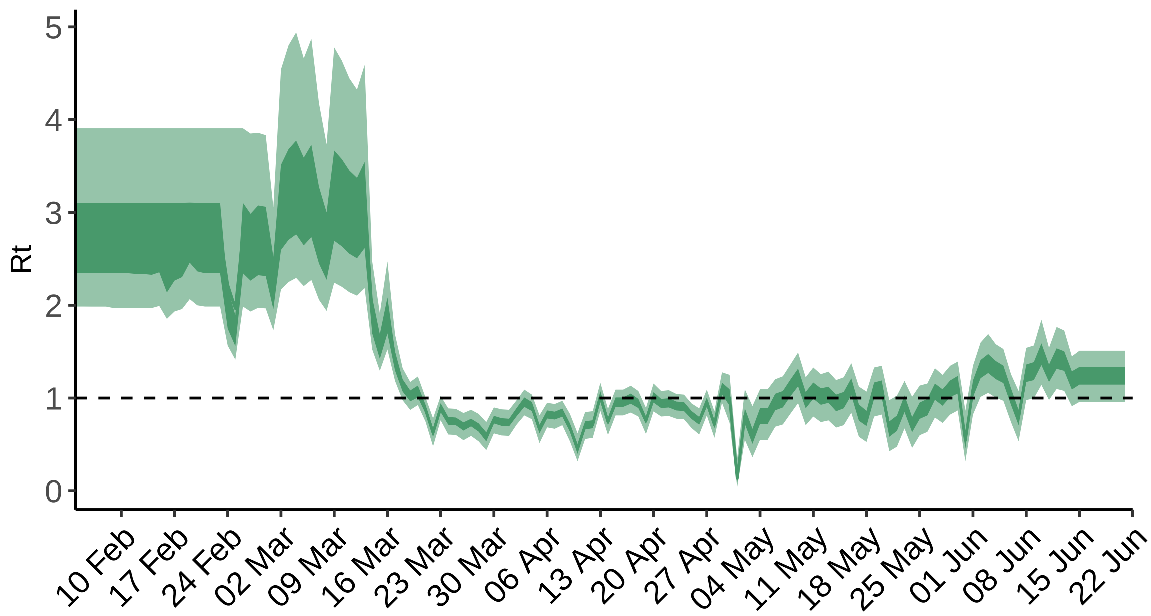


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

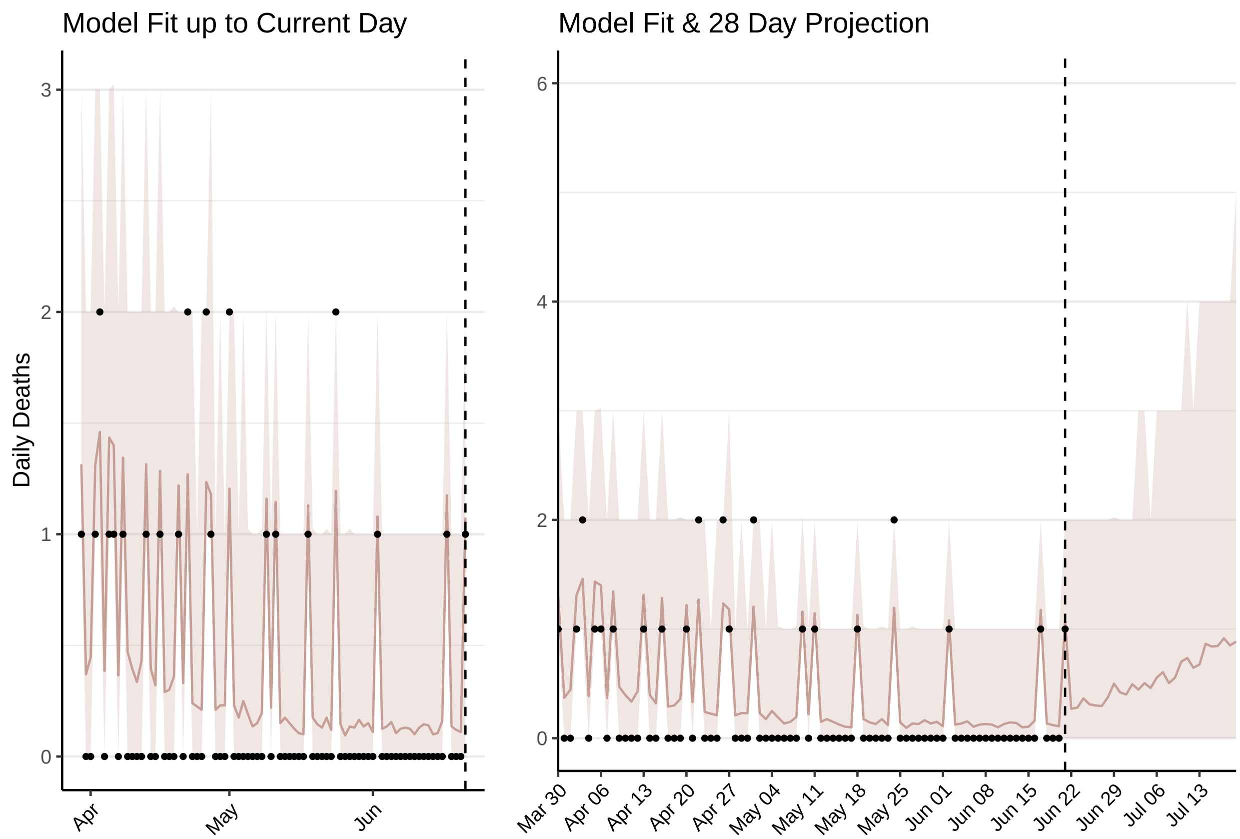


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 12 (95% CI: 11-13) patients requiring treatment with high-pressure oxygen at the current date to 40 (95% CI: 33-46) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 4 (95% CI: 4-5) patients requiring treatment with mechanical ventilation at the current date to 15 (95% CI: 13-17) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

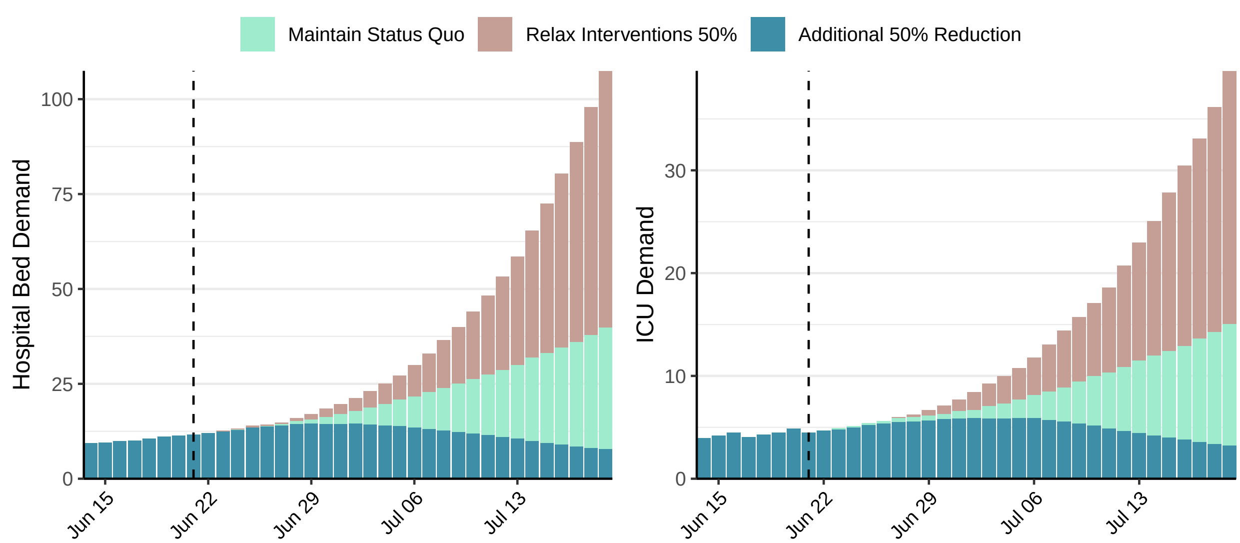


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 99 (95% CI: 88-110) at the current date to 23 (95% CI: 19-26) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 99 (95% CI: 88-110) at the current date to 1,542 (95% CI: 1,268-1,816) by 2020-07-19.

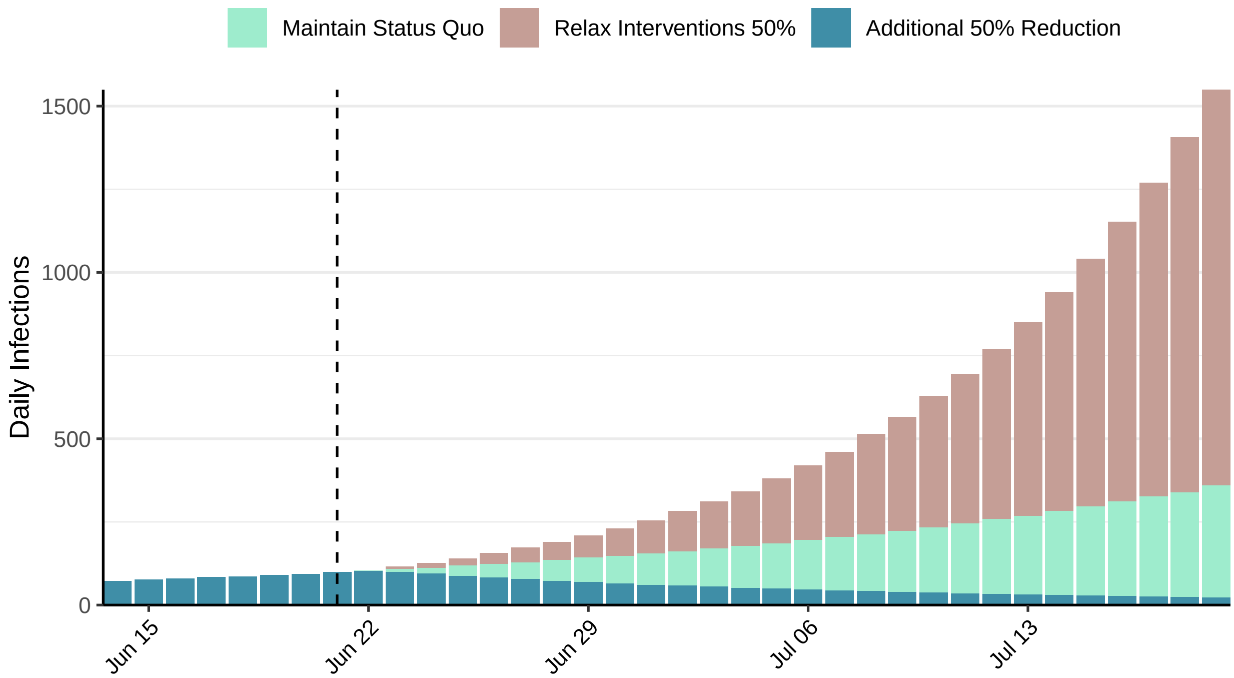


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Uzbekistan, 2020-06-21

**Download the report for Uzbekistan, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 6,216 | 191 | 19 | 0 | 1.24 (95% CI: 1.16-1.33) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

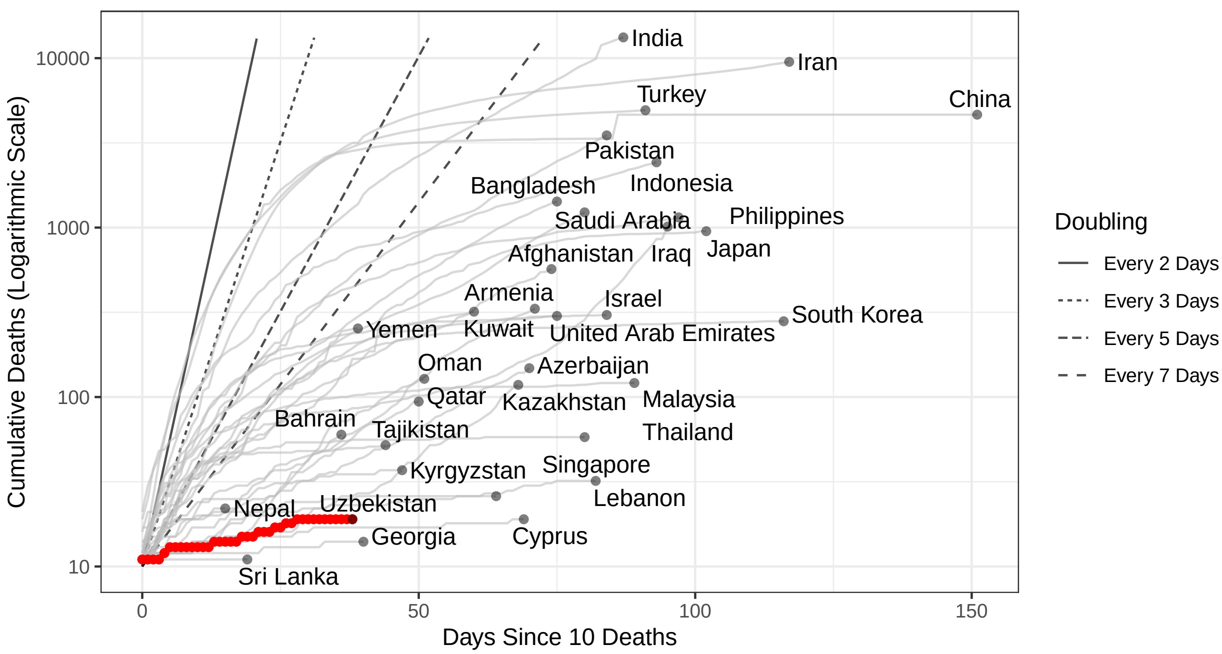


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 9,463 (95% CI: 8,814-10,112) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

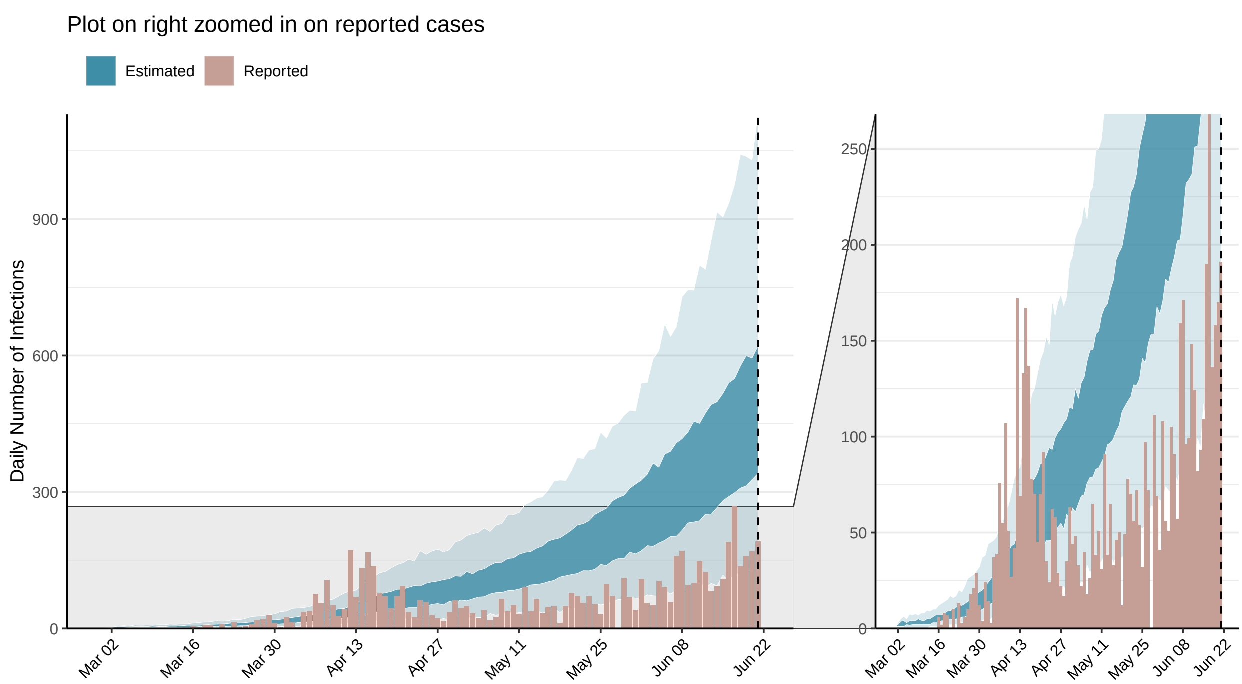


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

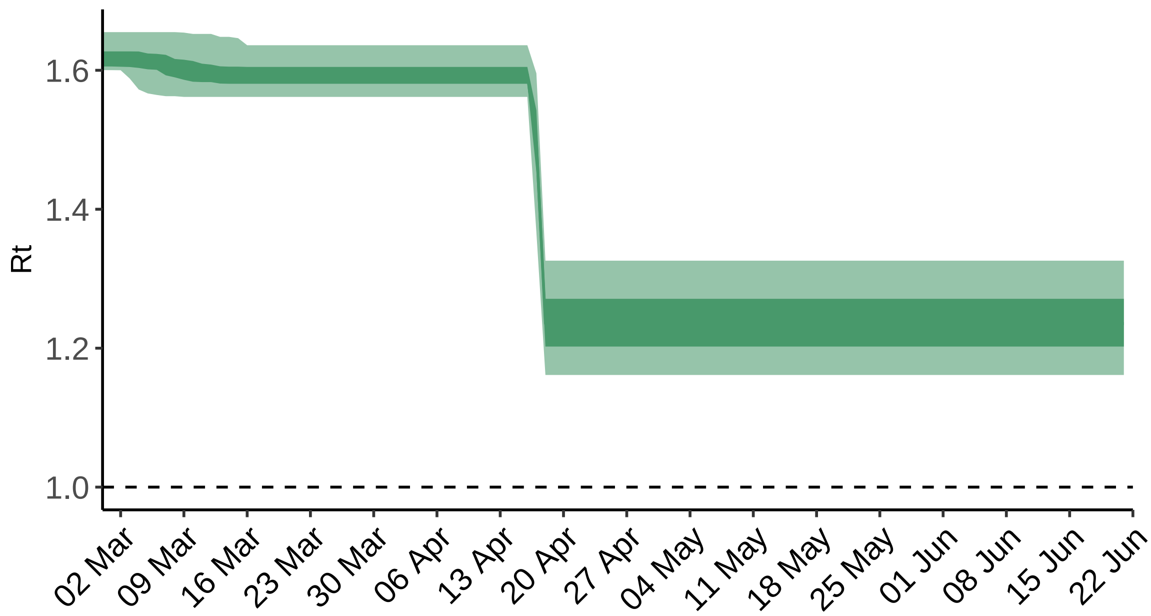


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

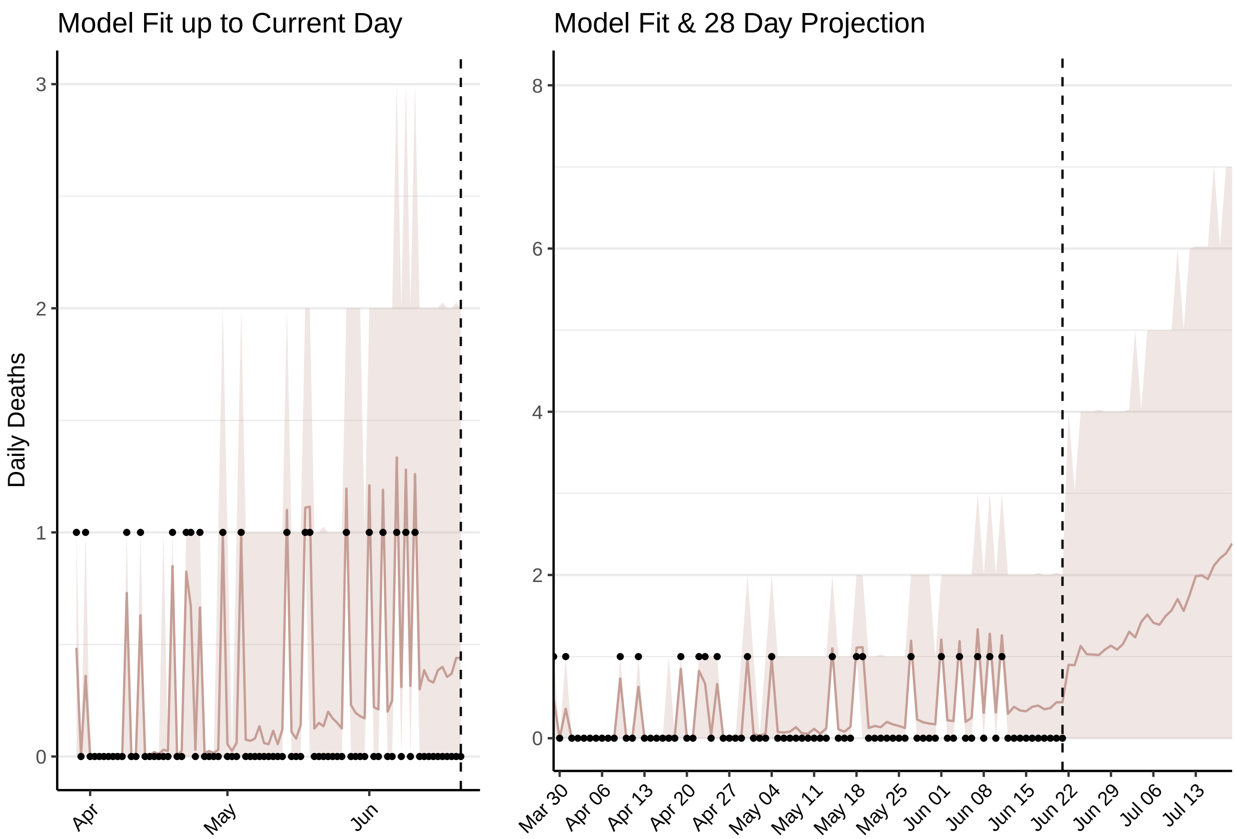


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 59 (95% CI: 55-64) patients requiring treatment with high-pressure oxygen at the current date to 159 (95% CI: 144-174) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 14 (95% CI: 13-15) patients requiring treatment with mechanical ventilation at the current date to 35 (95% CI: 32-38) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

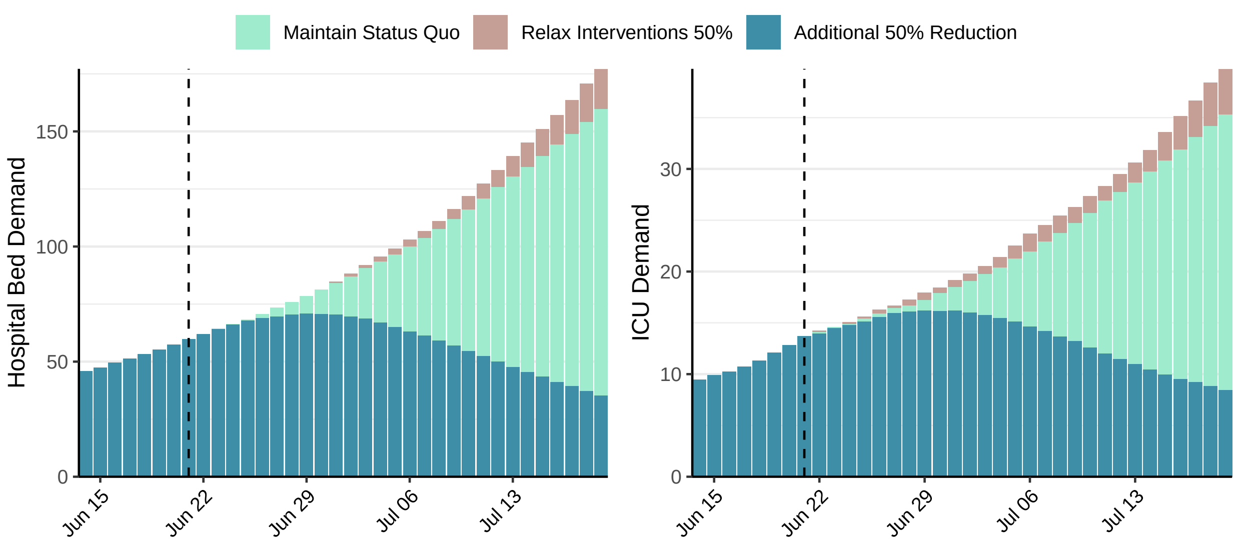


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 521 (95% CI: 482-560) at the current date to 97 (95% CI: 88-107) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 521 (95% CI: 482-560) at the current date to 1,673 (95% CI: 1,509-1,836) by 2020-07-19.

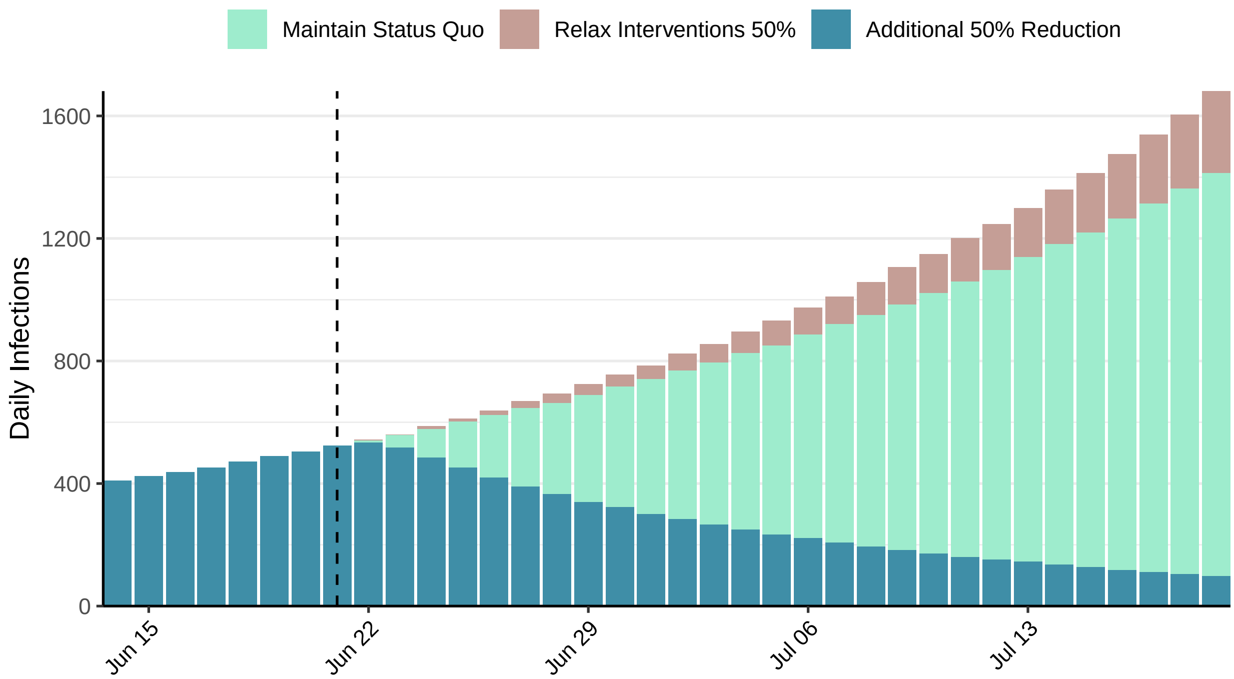


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Venezuela, 2020-06-21

**Download the report for Venezuela, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 3,790 | 199 | 33 | 3 | 1.96 (95% CI: 1.7-2.31) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

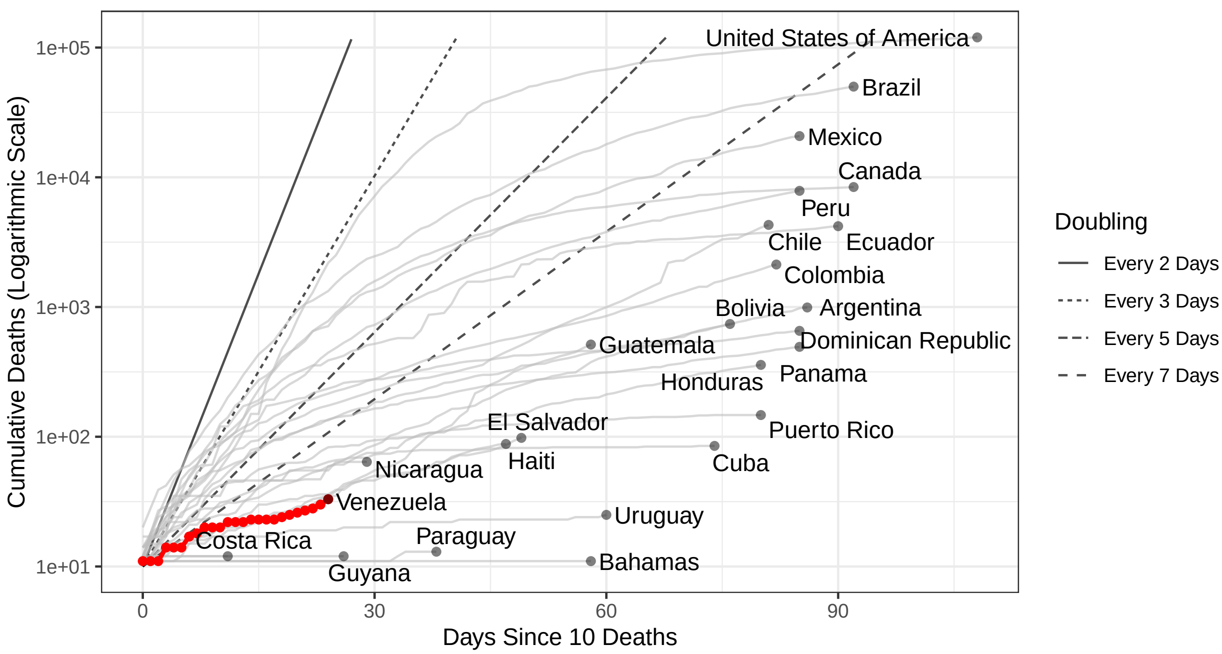


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 36,043 (95% CI: 33,952-38,134) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

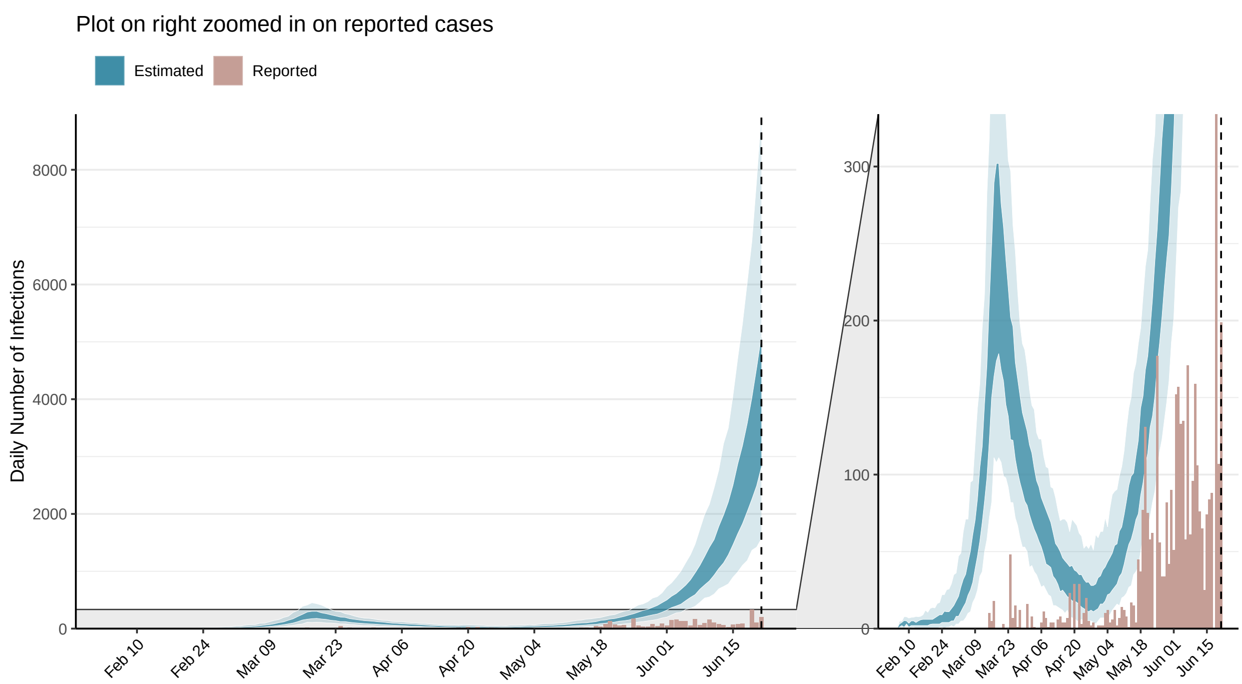


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

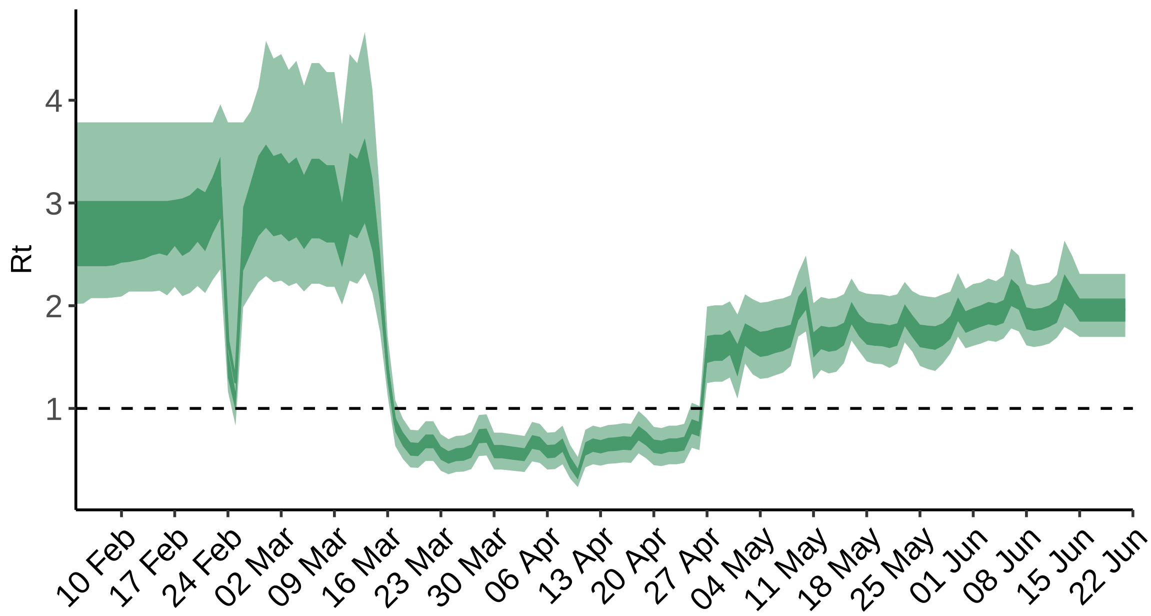


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

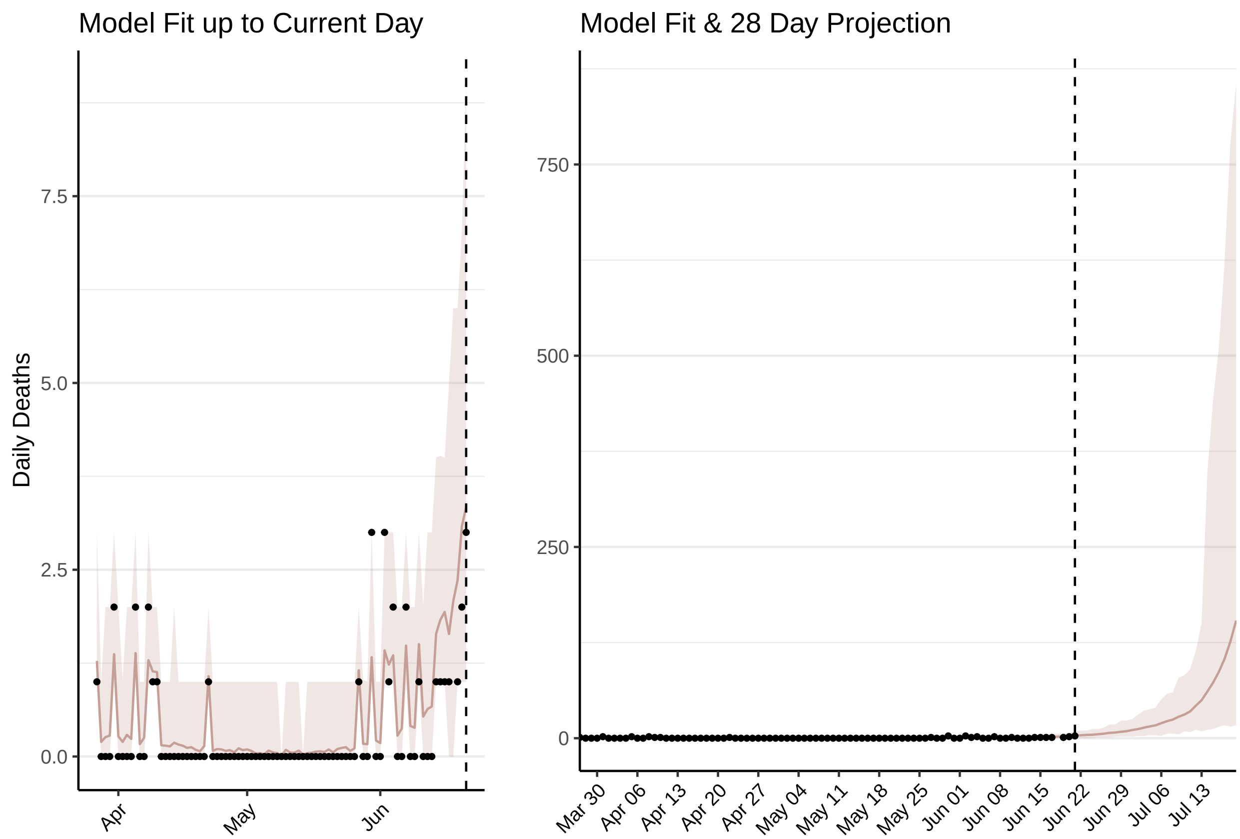


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 208 (95% CI: 195-220) patients requiring treatment with high-pressure oxygen at the current date to 5,542 (95% CI: 4,947-6,138) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 61 (95% CI: 57-65) patients requiring treatment with mechanical ventilation at the current date to 1,423 (95% CI: 1,314-1,533) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

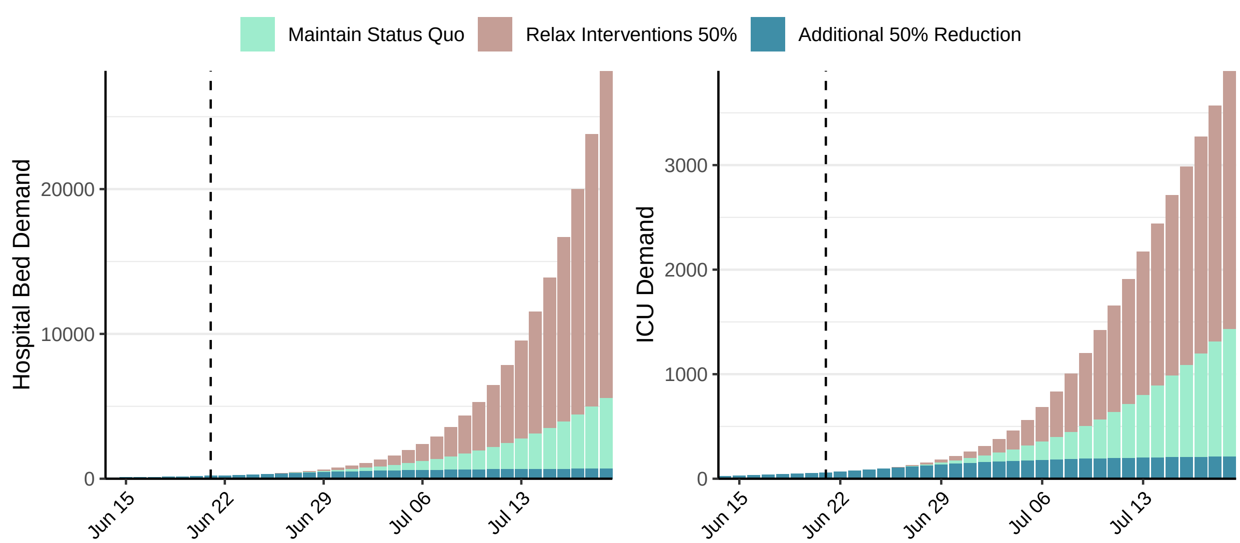


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 4,115 (95% CI: 3,829-4,400) at the current date to 4,951 (95% CI: 4,378-5,524) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 4,115 (95% CI: 3,829-4,400) at the current date to 620,382 (95% CI: 576,314-664,451) by 2020-07-19.

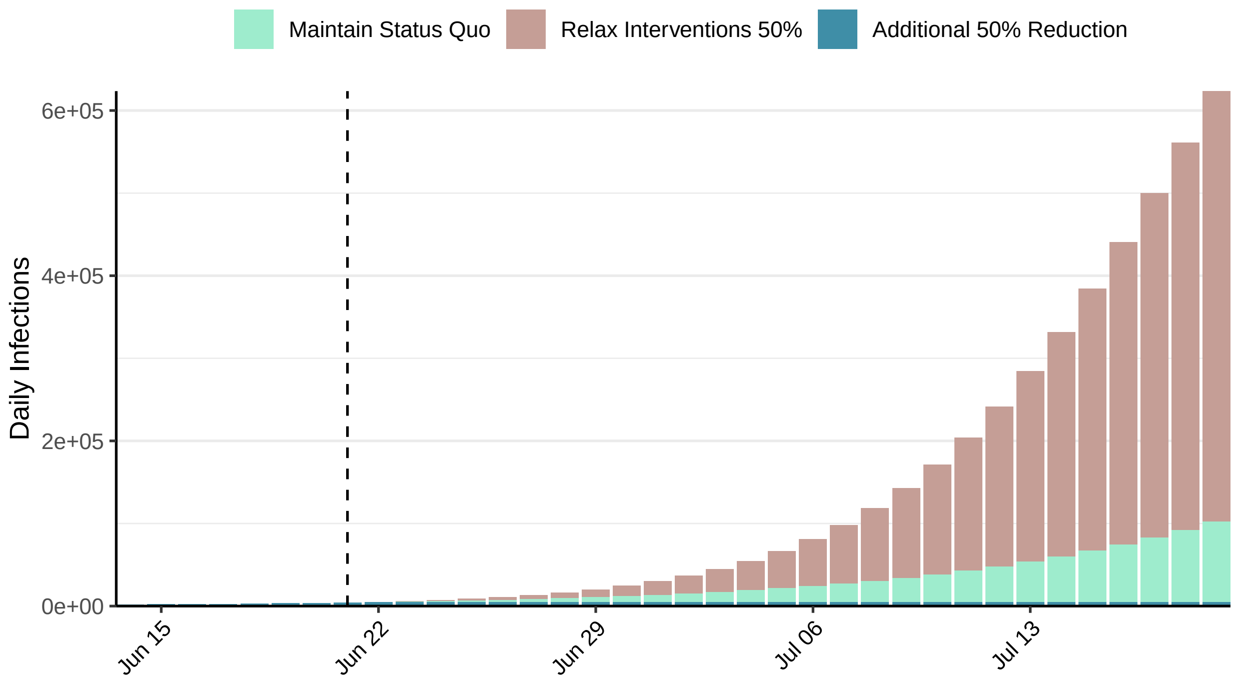


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Yemen, 2020-06-21

**Download the report for Yemen, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 923 | 4 | 254 | 3 | 1.73 (95% CI: 1.4-2.15) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

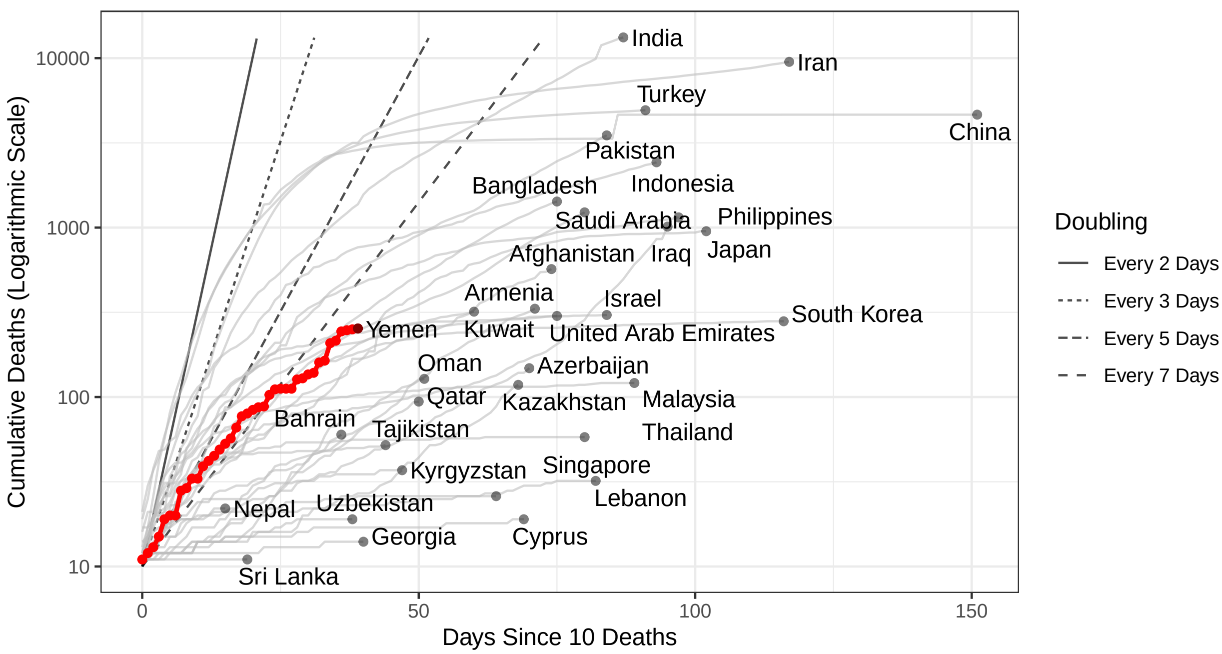


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 288,595 (95% CI: 278,963-298,226) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

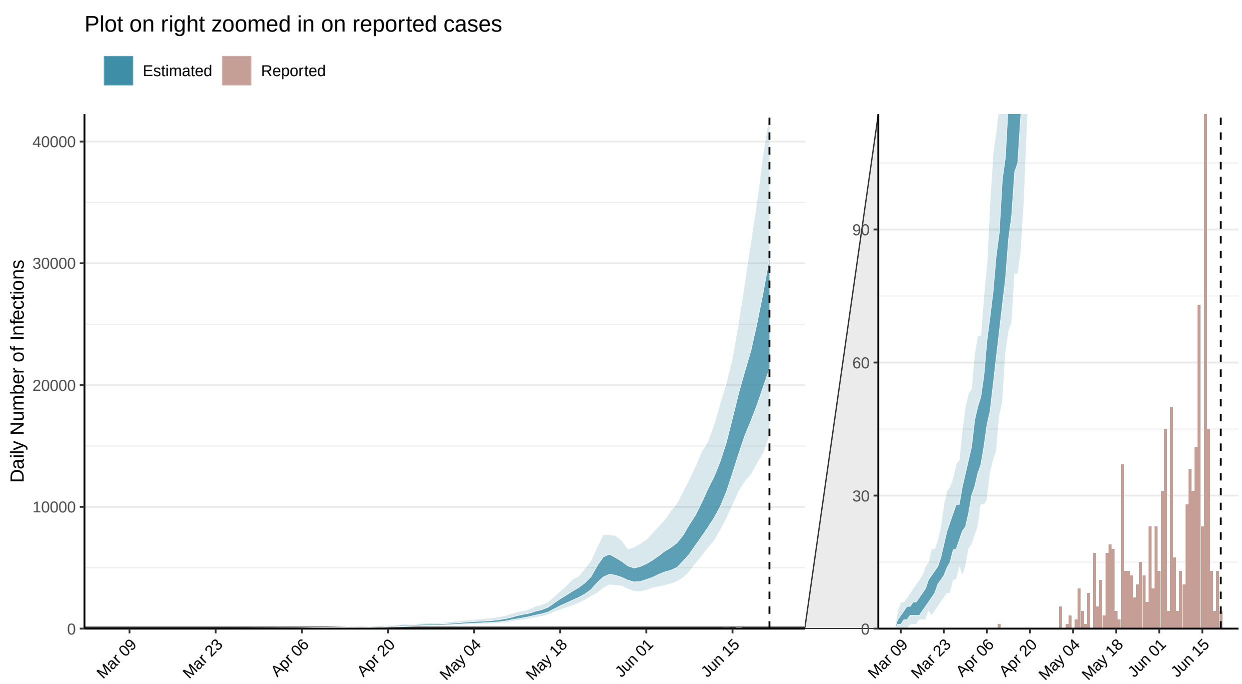


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

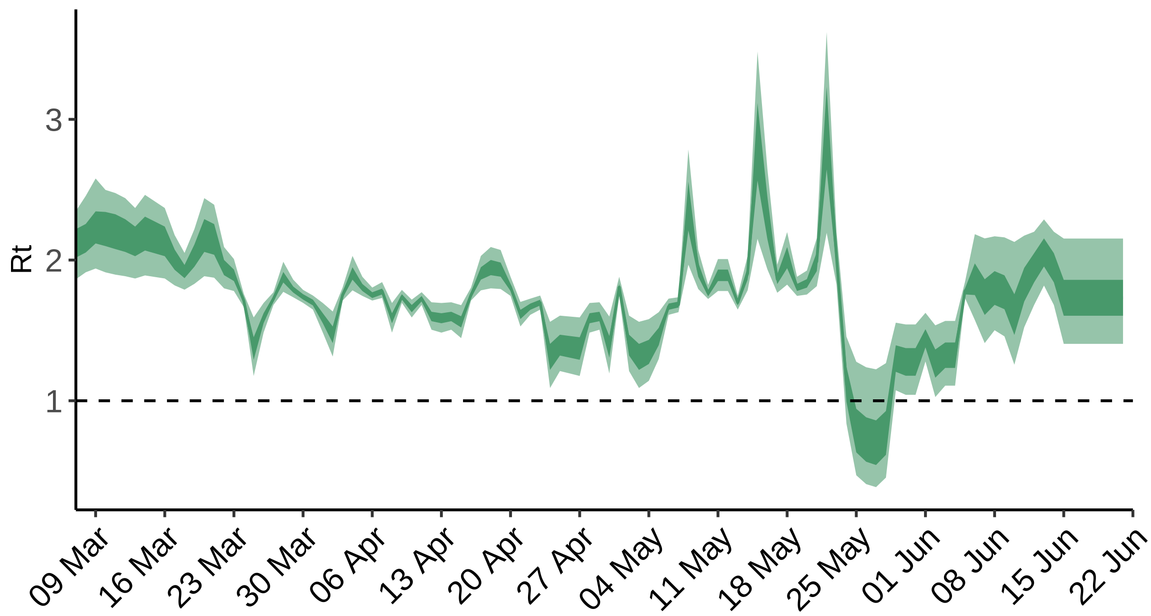


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. Yemen is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

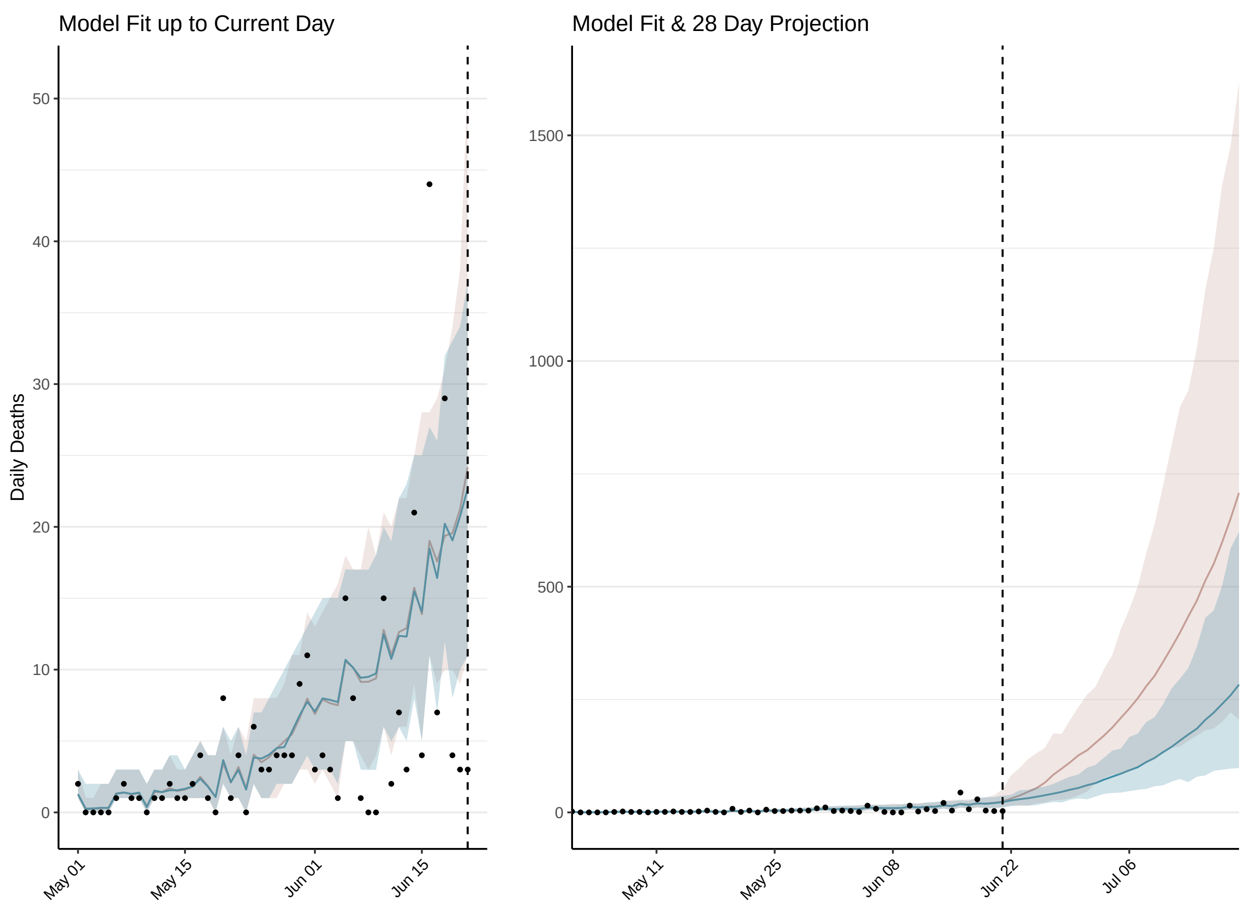


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 1,610 (95% CI: 1,555-1,665) patients requiring treatment with high-pressure oxygen at the current date to 17,873 (95% CI: 16,629-19,117) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 420 (95% CI: 407-434) patients requiring treatment with mechanical ventilation at the current date to 1,331 (95% CI: 1,268-1,394) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

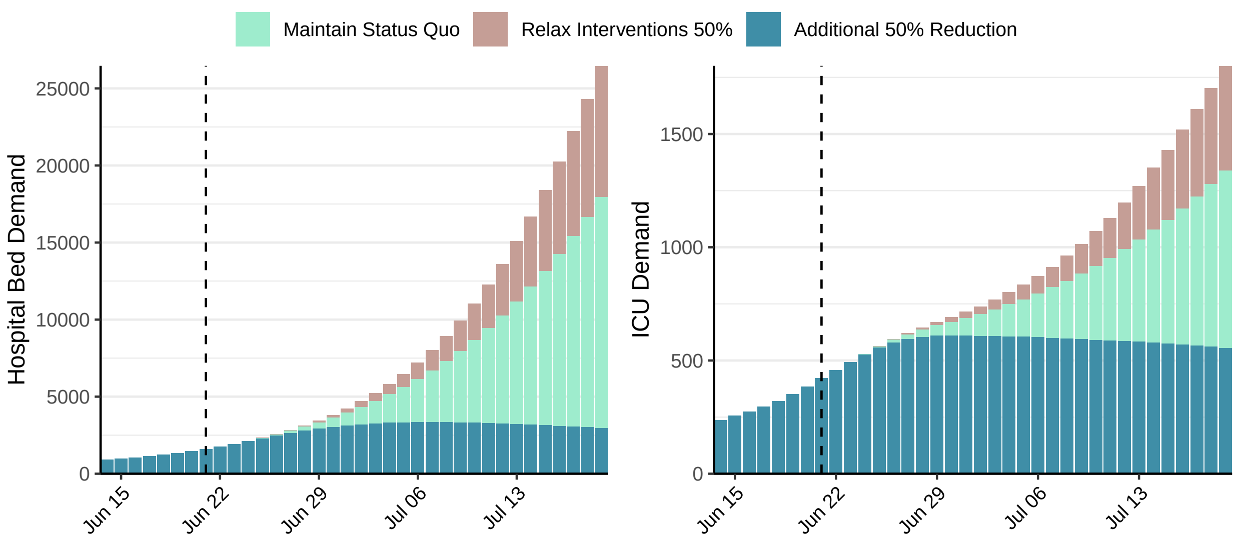


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 26,231 (95% CI: 25,239-27,223) at the current date to 16,764 (95% CI: 15,342-18,186) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 26,231 (95% CI: 25,239-27,223) at the current date to 414,093 (95% CI: 385,898-442,288) by 2020-07-19.

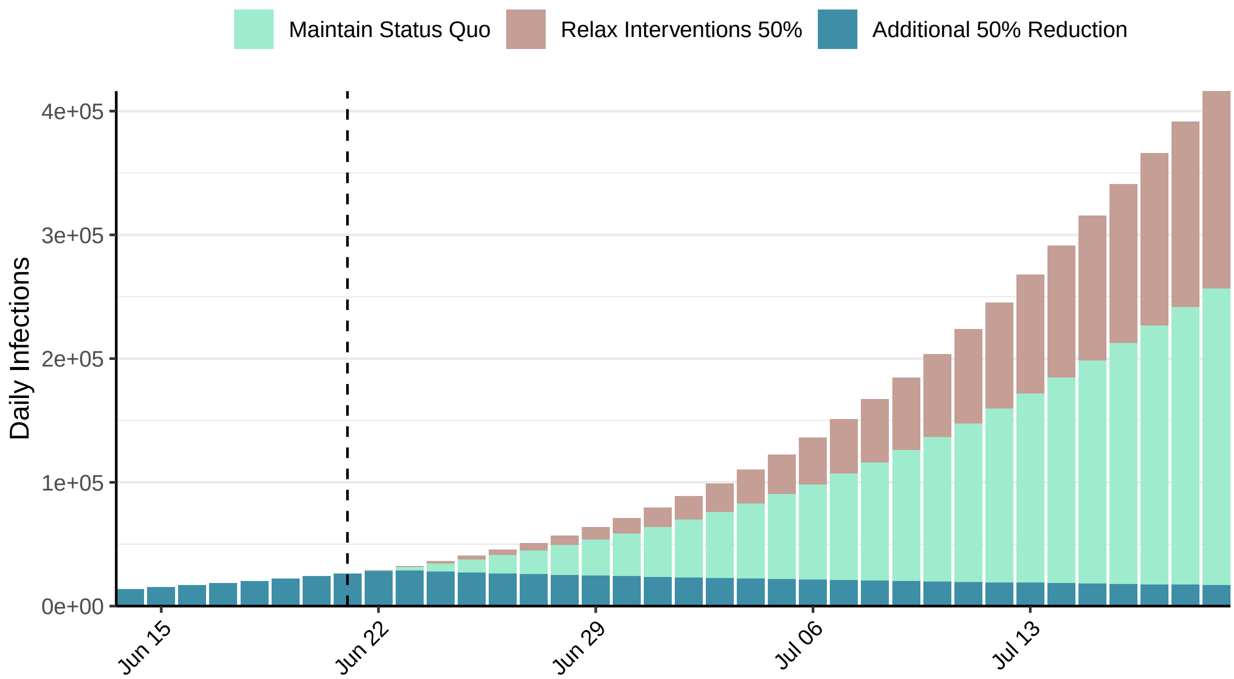


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: South Africa, 2020-06-21

**Download the report for South Africa, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 92,681 | 4,966 | 1,877 | 46 | 1.68 (95% CI: 1.57-1.84) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

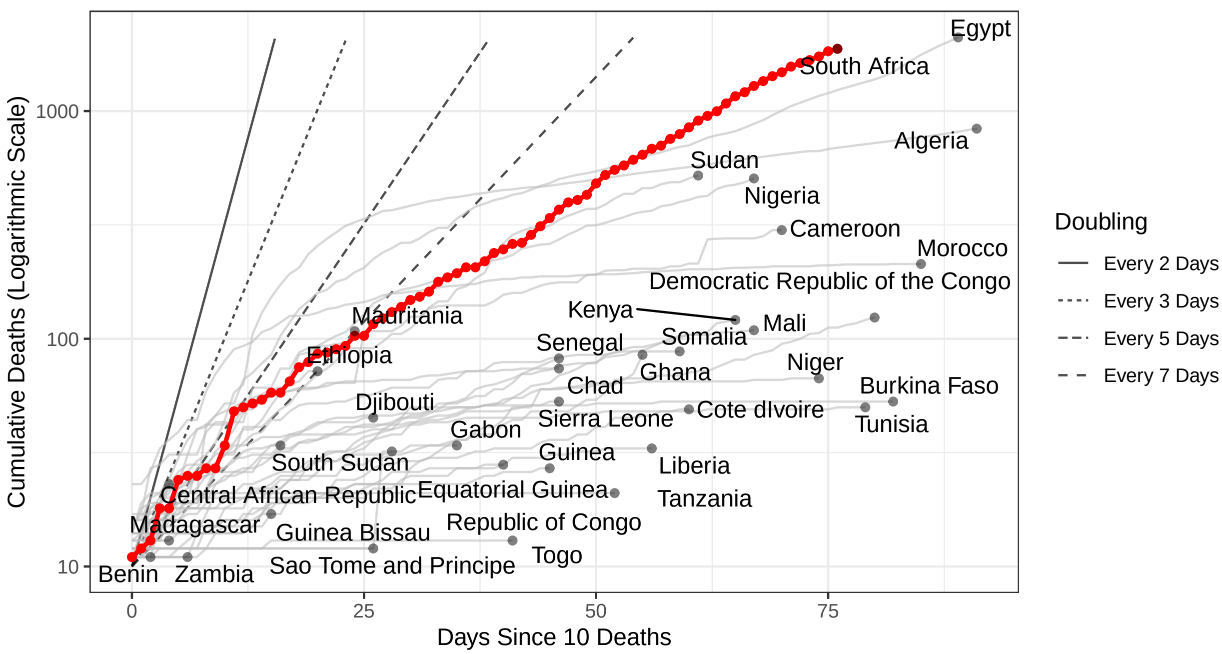


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 1,182,013 (95% CI: 1,149,473-1,214,554) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

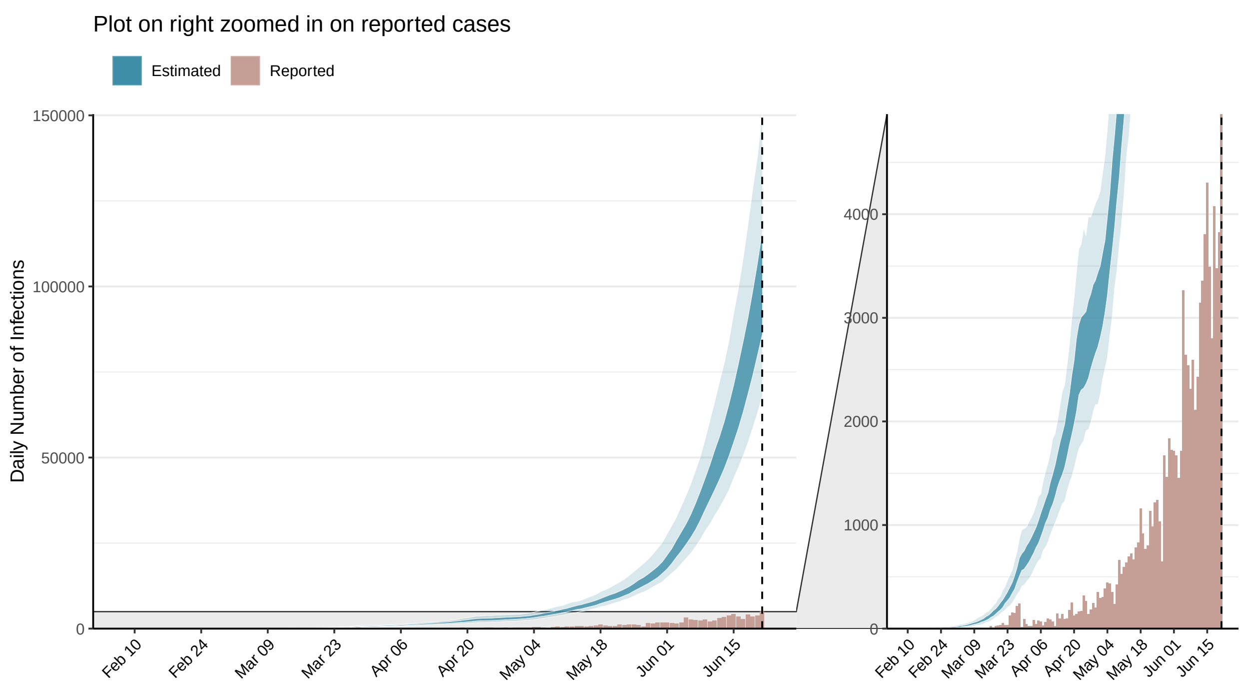


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

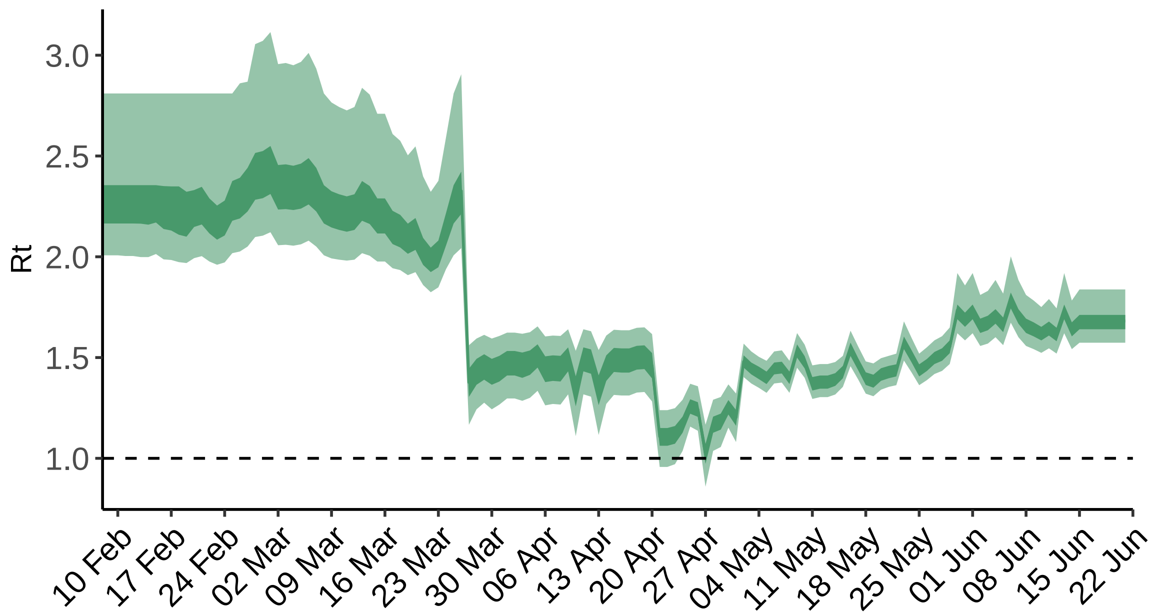


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value. **N.B. South Africa is forecast to be close to or surpassing our best estimates for healthcare capacity in the next 28 days.** Estimates of deaths in the next 28 days may be inaccurate due to our working assumptions for mortality in individuals who do not receive appropriate treatment. See our methods for more information.

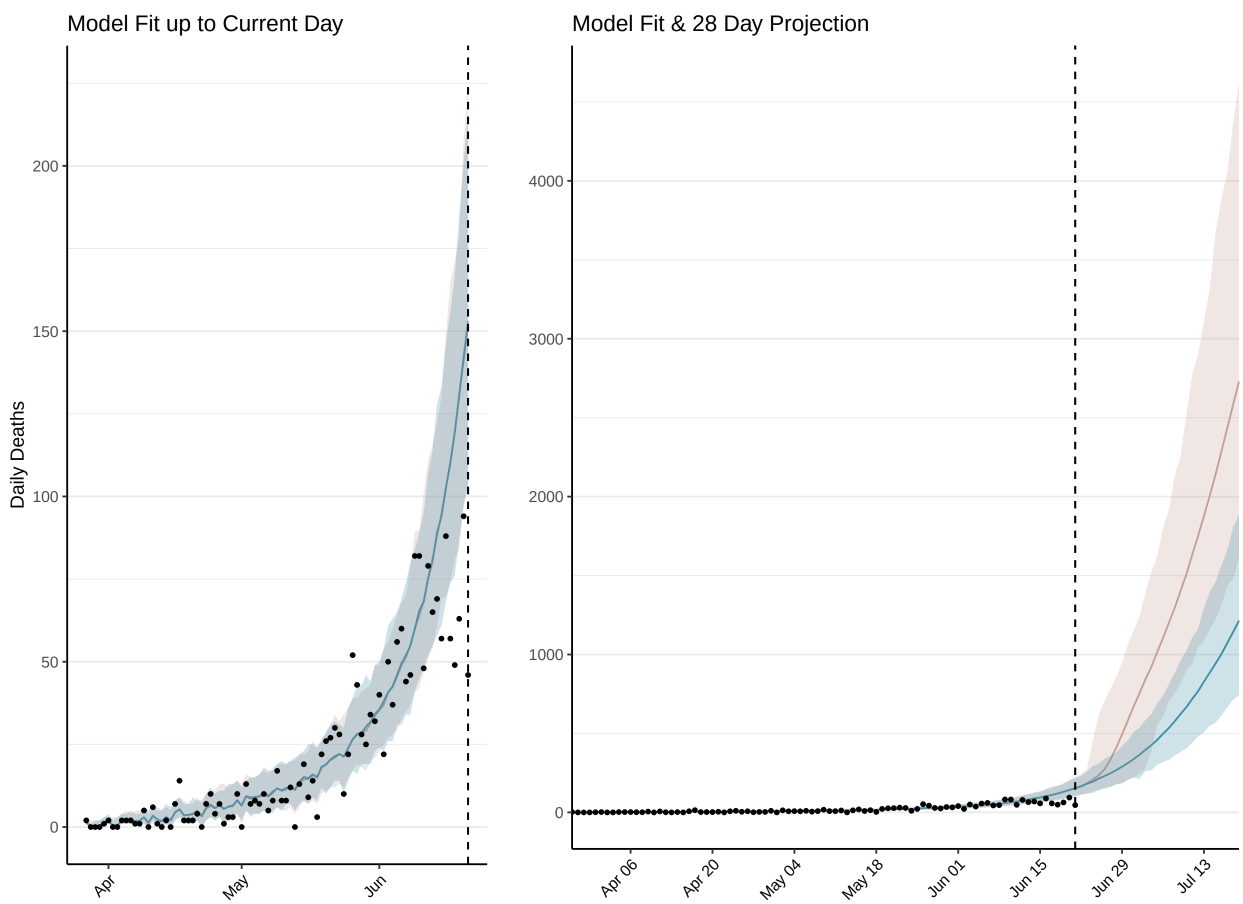


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days. The forecasted deaths in blue assumes healthcare capacity has been surged to ensure sufficient supply of ICU and hospital beds. The red curve assumes no surging in healthcare capacity and subsequently projects increased deaths.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 10,344 (95% CI: 10,059-10,629) patients requiring treatment with high-pressure oxygen at the current date to 77,491 (95% CI: 74,640-80,343) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 2,605 (95% CI: 2,533-2,677) patients requiring treatment with mechanical ventilation at the current date to 7,085 (95% CI: 6,947-7,222) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

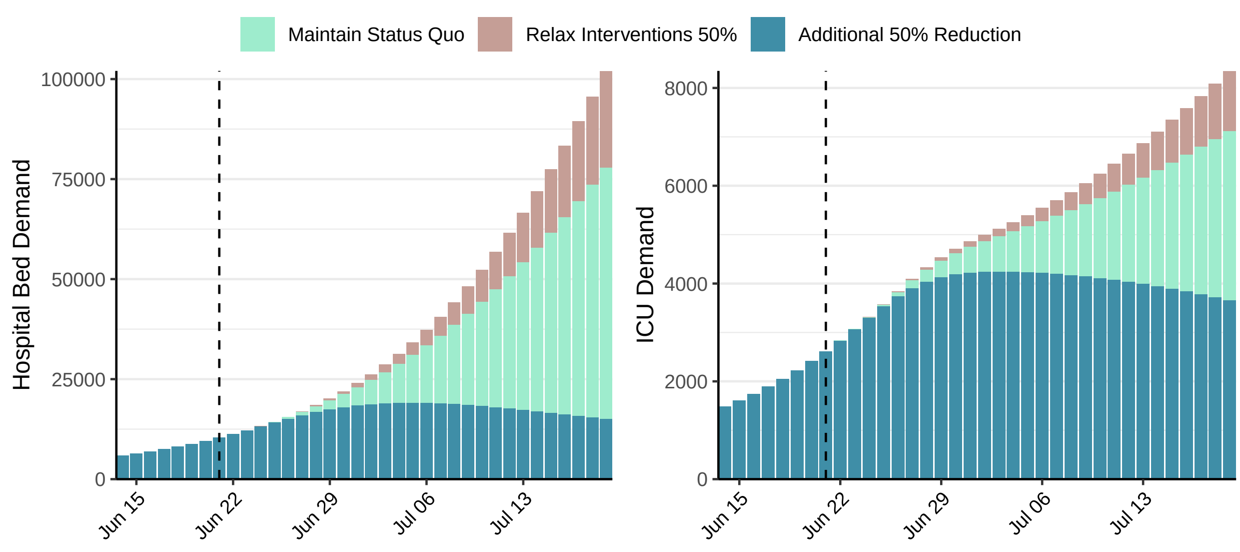


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 102,309 (95% CI: 99,015-105,602) at the current date to 47,531 (95% CI: 45,415-49,648) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 102,309 (95% CI: 99,015-105,602) at the current date to 845,027 (95% CI: 820,648-869,405) by 2020-07-19.

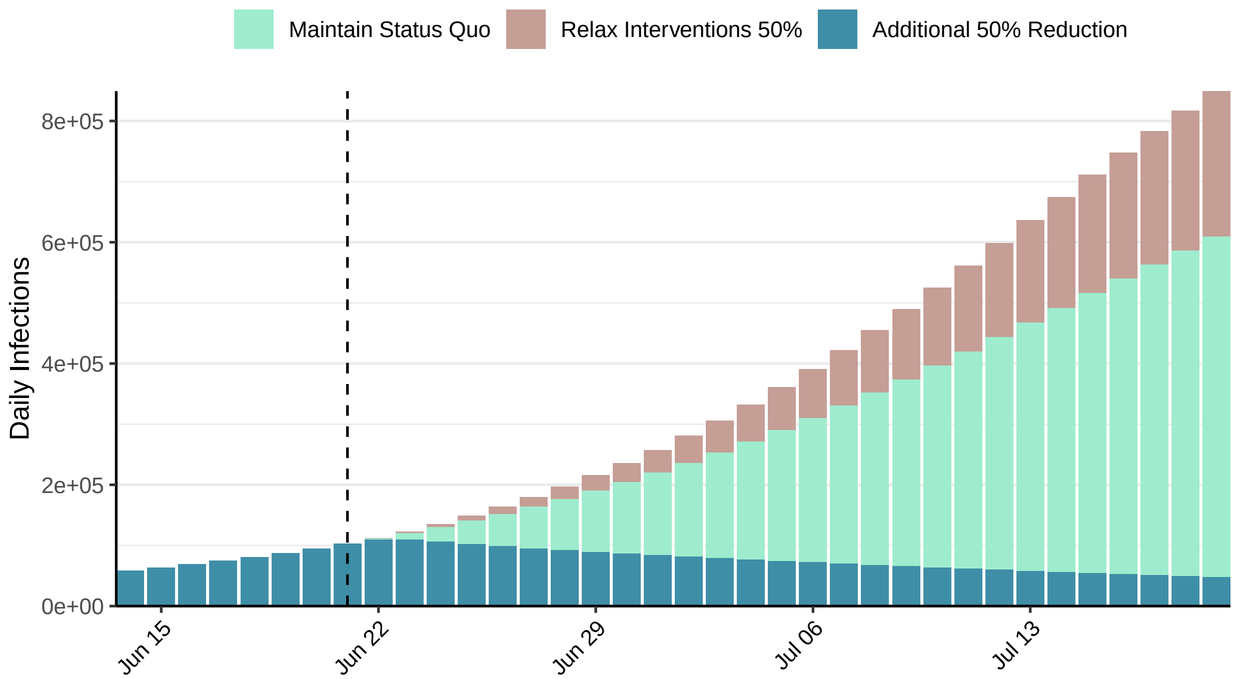


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Zambia, 2020-06-21

**Download the report for Zambia, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 1,430 | 0 | 11 | 0 | 1.66 (95% CI: 1.51-1.91) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease.

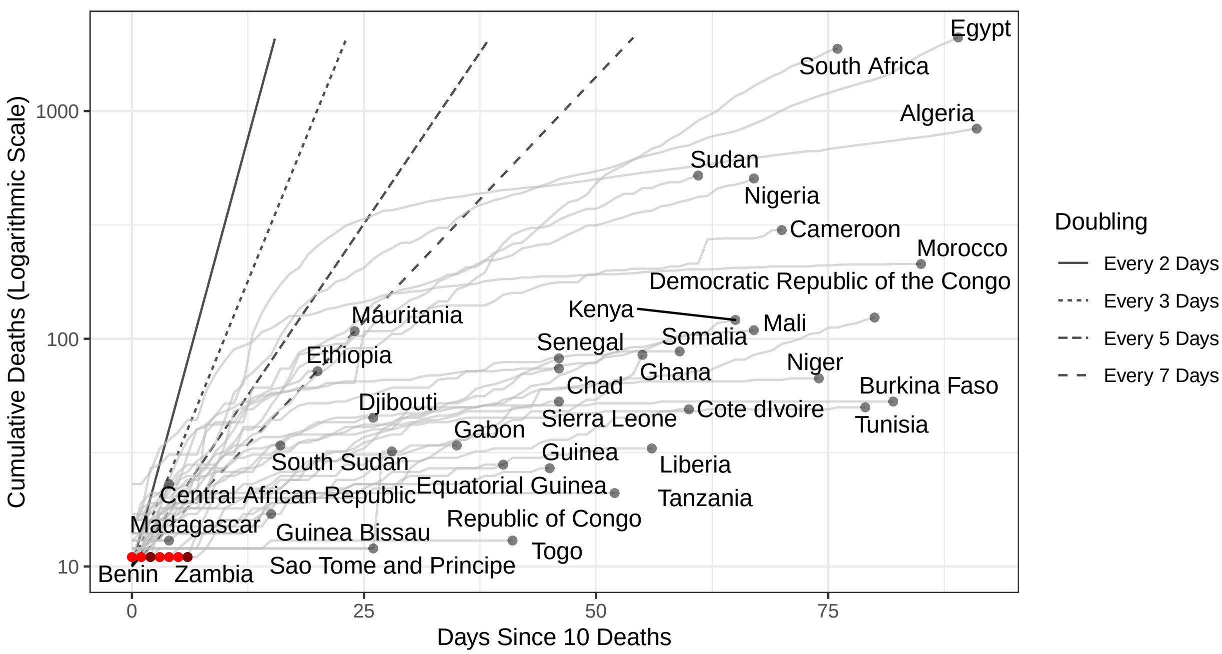


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 6,656 (95% CI: 6,183-7,129) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

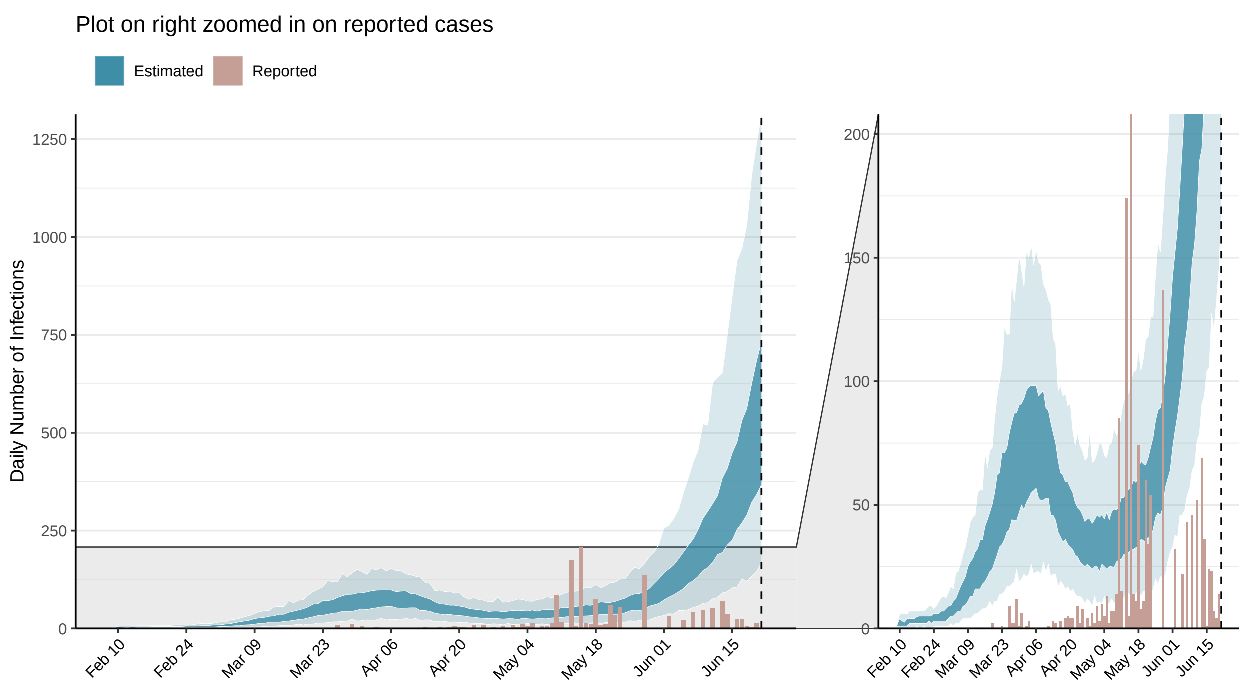


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

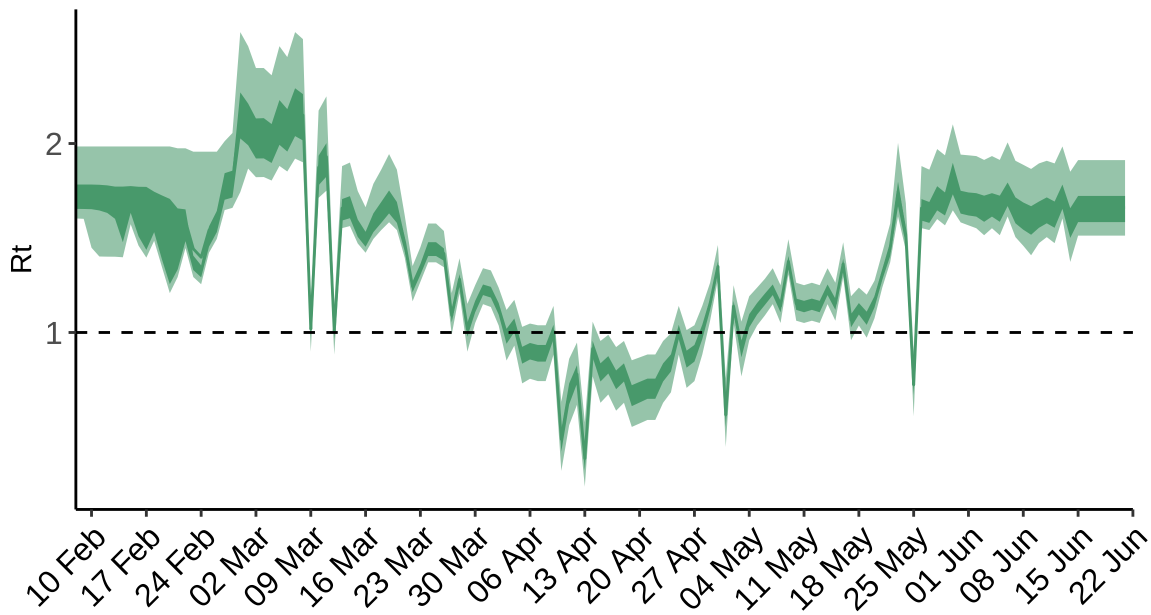


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

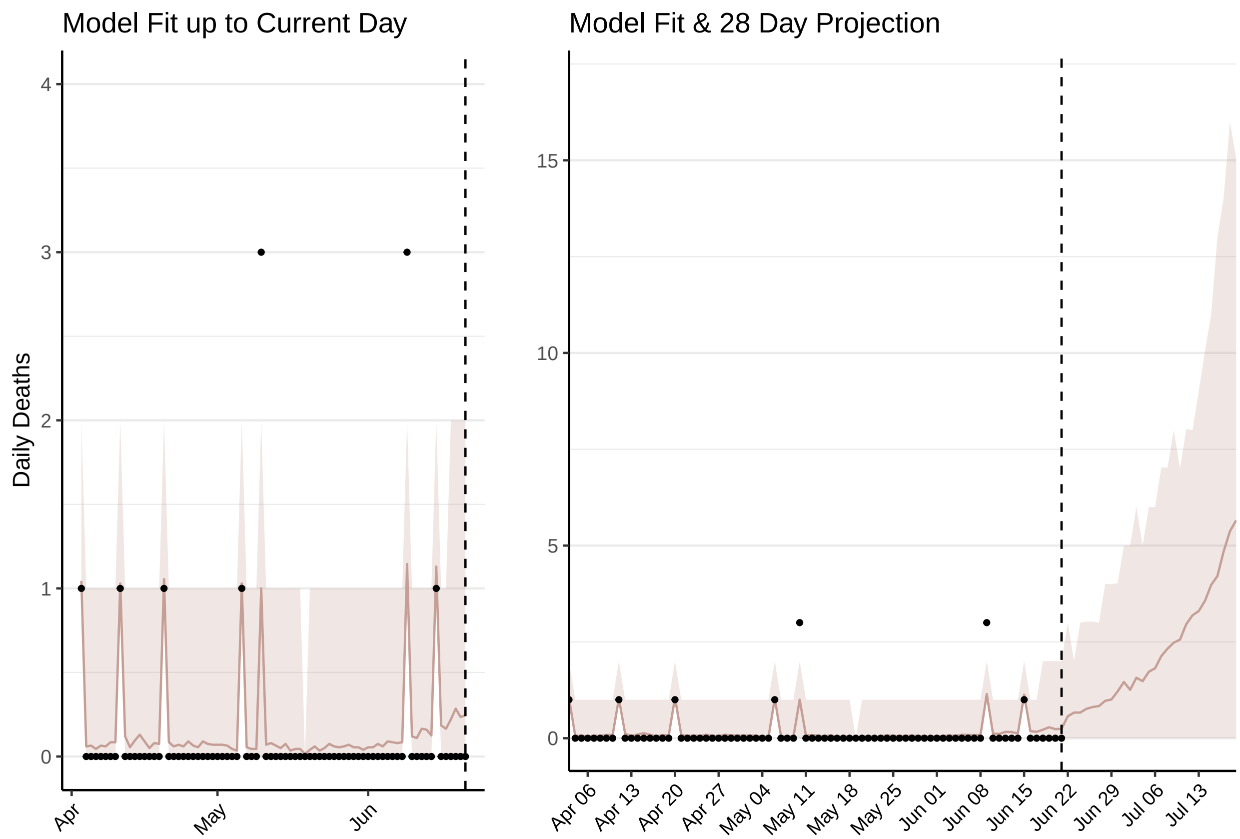


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 36 (95% CI: 33-39) patients requiring treatment with high-pressure oxygen at the current date to 383 (95% CI: 347-418) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 9 (95% CI: 9-10) patients requiring treatment with mechanical ventilation at the current date to 97 (95% CI: 88-106) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

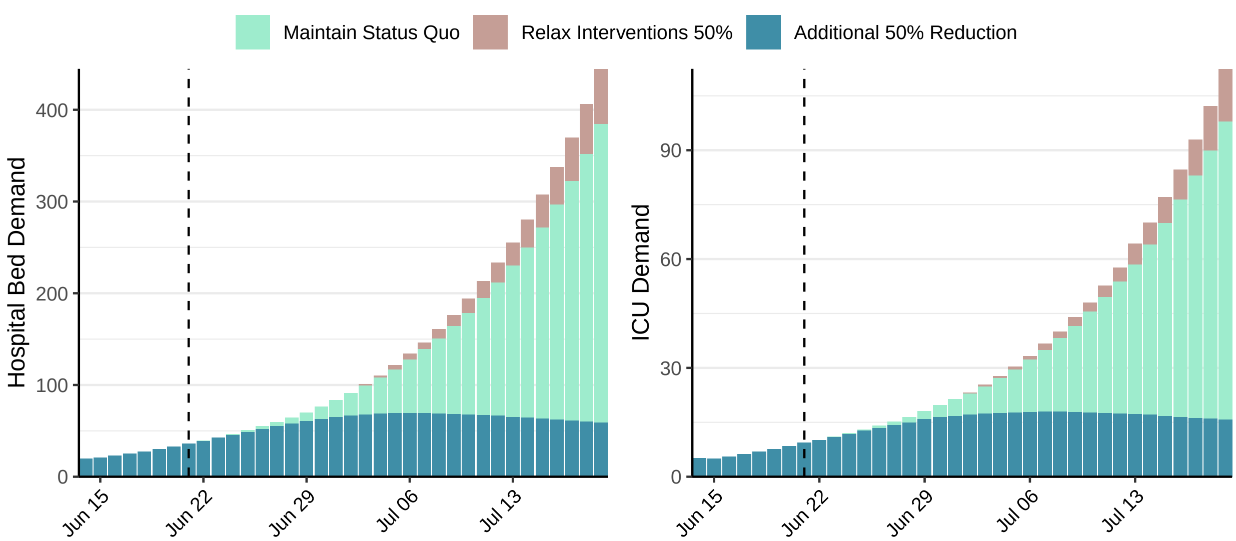


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 588 (95% CI: 544-632) at the current date to 337 (95% CI: 305-370) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 588 (95% CI: 544-632) at the current date to 7,818 (95% CI: 7,021-8,615) by 2020-07-19.

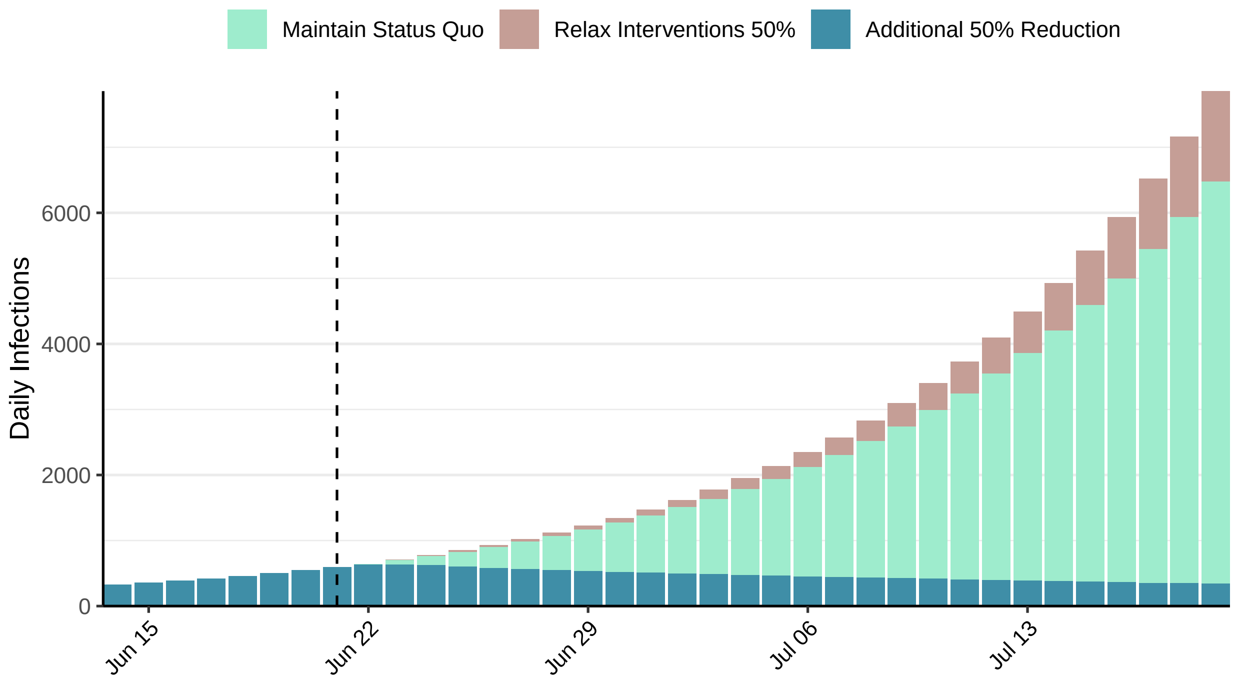


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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## Situation Report for COVID-19: Zimbabwe, 2020-06-21

**Download the report for Zimbabwe, 2020-06-21 here.** This report uses data from the European Centre for Disease Control. These data are updated daily and whilst there may be a short delay, they are generally consistent with Ministry reports. These data are then used to back-calculate an 'inferred number of COVID-19 infections' using mathematical modelling techniques (see Report 12 for further details) to estimate the number of people that have been infected and to make short-term projections for future healthcare needs.

### Epidemiological Situation

| Total Reported Cases | New Reported Cases | Total Reported Deaths | New Reported Deaths | Estimated $R_t$ |
|---|---|---|---|---|
| 486 | 7 | 6 | 2 | 1.93 (95% CI: 1.44-2.4) |

The figure below shows the cumulative reported deaths as a function of the time since the 10th death was reported. Dashed lines show the expected trajectory for different doubling times of the epidemic. For example, with a doubling time of 3 days, if there are currently a total of 20 deaths reported, we would expect there to be 40 deaths in total reported in 3 days-time, 80 deaths in 6 days-time, 160 deaths in 9 days-time etc. For most epidemics, in the absence of interventions, we expect a doubling time of 3-4 days for this disease. **N.B. Zimbabwe is not shown in the following plot as only 6 deaths have been reported to date**

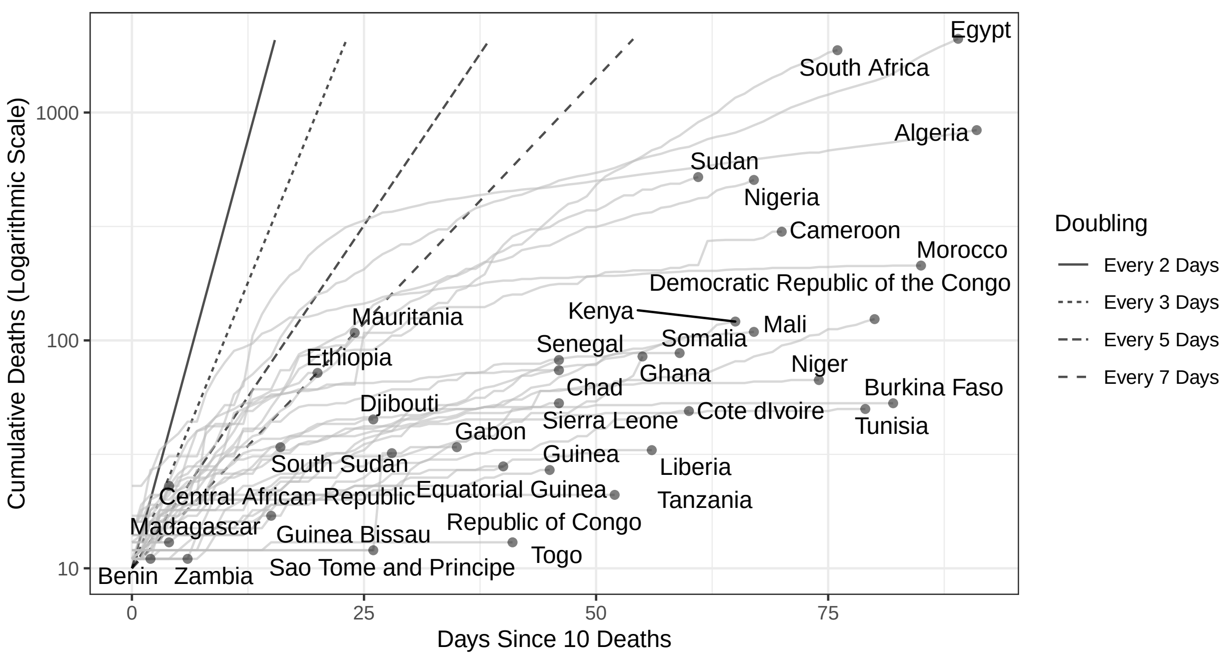


Figure 1: **Cumulative Deaths since 10 deaths.** Country not shown if fewer than 10 deaths.

**COVID-19 Transmission Modelling**

We assume that the deaths reported to date provide the best indication of the stage of the epidemic, as deaths are more consistently and accurately reported. Our current working estimate is that 1 death indicates that approximately 100 people will have been infected with the other 99 recovering (based on an infection fatality ratio of ~1%). These infections will have happened approximately 21 days previously – capturing a 5-day period from infection to onset of symptoms (the incubation period), 4 days from onset of symptoms to hospitalisation, and 12 days in hospital before death. With a 3-day doubling time, 100 infections that occurred 15 days ago will have generated 200 infections 12 days ago, 400 infections 9 days ago, 800 infections 6 days ago and 1,600 infections 3 days ago resulting in approximately 3,200 infections at the time the first death is observed.

To explore this, we fit our age-structured SEIR model (see Methods) to the time series of deaths in a country, in order to estimate the start date of the epidemic and the baseline R0. We assume that 100% of COVID-19 related deaths have been reported. We have also included the impact of interventions that have been put in place and their effect on human mobility and transmission based on the Google COVID-19 Community Mobility Reports. Using our mathematical model that formalises this approach, we estimate that there has been a total of 3,033 (95% CI: 2,661-3,406) infections over the past 4 weeks.

The figure below shows the estimated number of people infected over the past 4 weeks. The bar charts show, for comparison, the number of reported cases. The right-hand plot shows these data on a different scale as the estimated infections are likely to be much larger than the reported cases. **Importantly**, the estimated infections includes both asymptomatic and mild cases that would not necessarily be identified through surveillance. Consequently, the estimated infections are likely to be significantly higher than the reported cases (see our FAQ for further explanation of these differences and why the reported cases and estimated infections are unlikely to match).

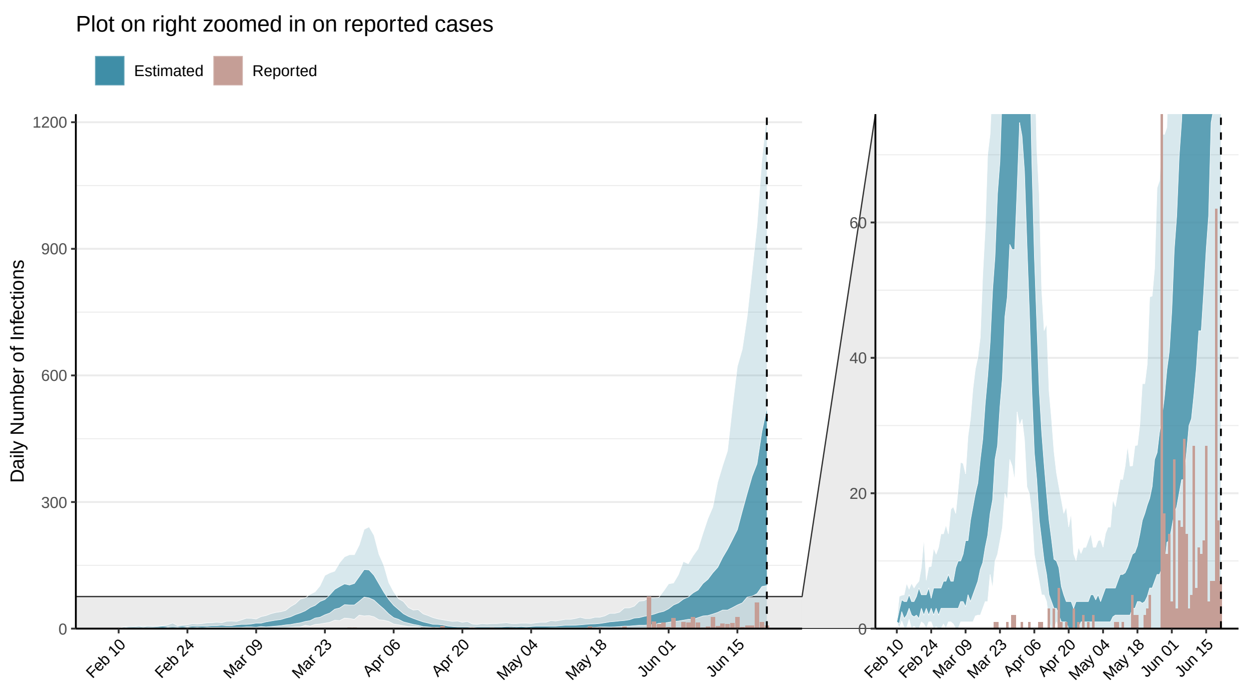


Figure 2: **Daily number of infections estimated by fitting to the current total of deaths.** Reported cases are shown in red. Model estimated infections are shown in blue (dark blue 50% interquartile range, light blue 95% quantile). The dashed line shows the current day.

By fitting to the time series of deaths, we are able to estimate a time-varying reproduction number, $R_t$. $R_t$ is the the average number of secondary infections caused by a single infected person at a given time. If $R_t$ is above 1, the rate of transmission is increasing and the number of new infections is increasing. $R_t$ is assumed to change in relation to mobility fall in proportion. When fitting our model we assume that 100% of COVID-19 related deaths have been reported (please see our FAQ section for more information about this assumption). We also assume a fixed date at which the impact of mobility on transmission changes from pre-lockdown levels to post-lockdown levels, which may cause large changes in Rt. We are working to refine how this switch occurs and to formally calculate its shape.

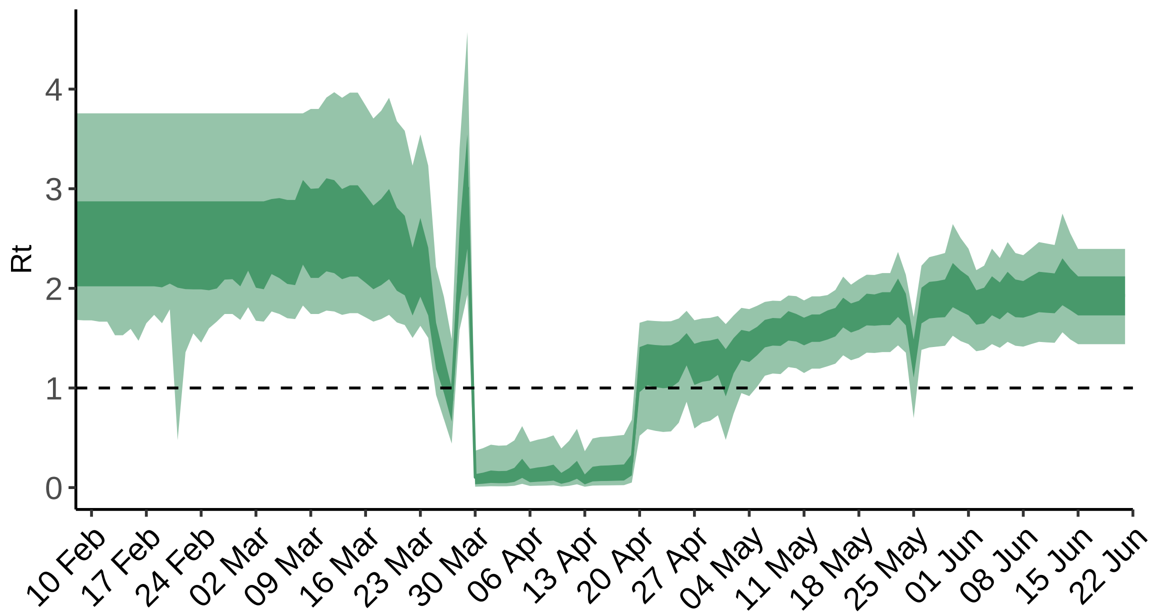


Figure 3: **Time-varying reproduction number, $R_t$.** $R_t$ is the average number of secondary infections caused by a single infected person at time equal to $t$. $R_t < 1$ indicates a slowing epidemic in which new infections are not increasing. $R_t > 1$ indicates a growing epidemic in which new infections are increasing over time. Dark green shows the 50% CI and light green shows the 95% CI.

Using the model fit, we can forecast the expected trajectory for cumulative deaths, which is shown in the figure below. This assumes a severity pattern by age that is consistent with that observed in China, Europe and the U.S to date. This projection assumes that transmission is maintained at the current level of transmission as estimated by the final $R_t$ value.

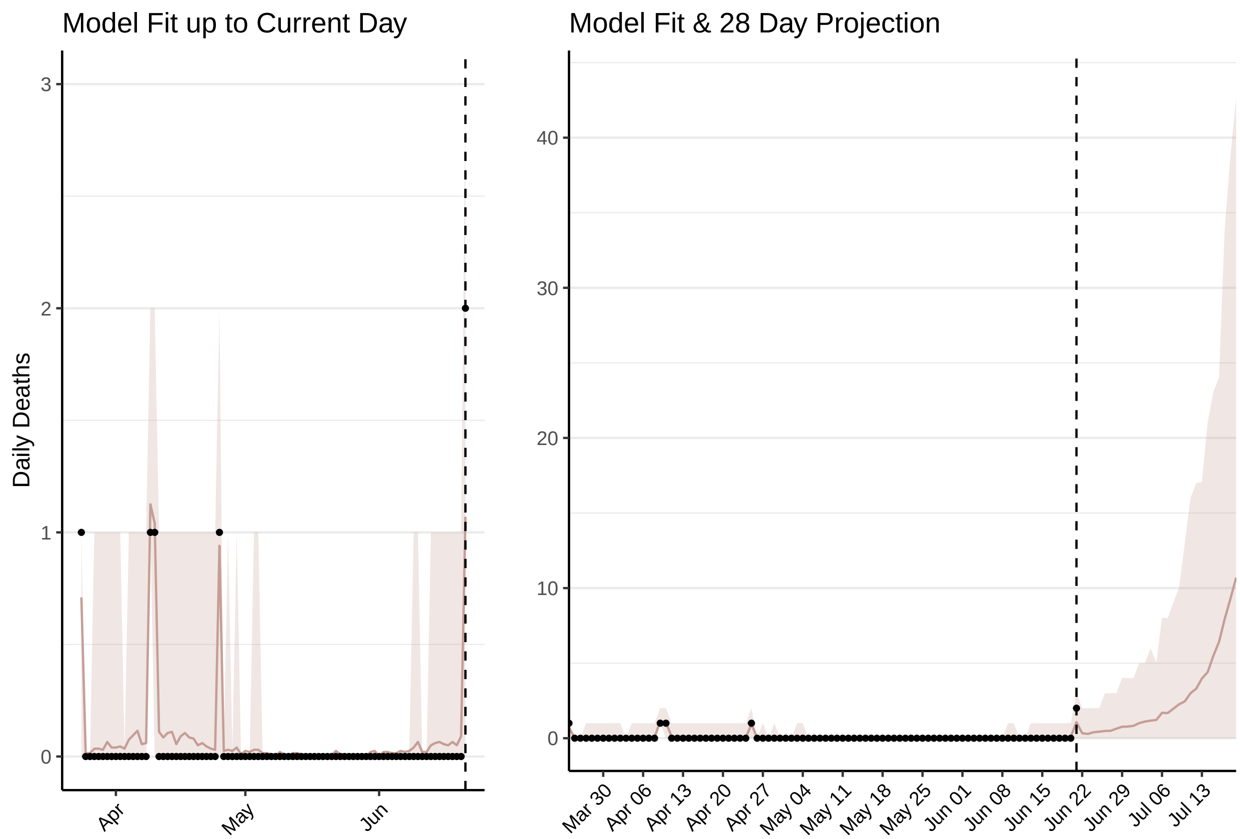


Figure 4: **Estimated daily deaths.** Projected deaths assuming the current level of interventions are maintained are shown in red (mean and 95% quantile). Reported deaths are plotted in black. The plot on the left is focussed on the model fit prior to today, while the plot on the right forecasts the next 28 days.

**Short-term Epidemic Scenarios**

We make the following short-term projections of healthcare demand and new infections under the following three scenarios:

- **Scenario 1.** The epidemic continues to grow at the current rate.
- **Scenario 2.** Countries will further scale up interventions (either increasing current strategies or implementing new interventions) leading to a further 50% reduction in transmission.
- **Scenario 3.** Countries will relax current interventions by 50%

**N.B. These scenarios currently assume that the impact of mobility on transmission will remain the same in the future as it has in the past. We are working to extend methods to estimate the impact of increases in mobility on transmission as lockdown and interventions are reversed. Consequently, projection are likely to represent an upper estimate of the healthcare demand and case load for each scenario**

We estimate that over the next 4 weeks demand for hospital beds will change from 17 (95% CI: 15-19) patients requiring treatment with high-pressure oxygen at the current date to 558 (95% CI: 446-671) hospital beds being required on 2020-07-19 if no further interventions are introduced (Scenario 1). Similarly, we estimate that over the next 4 weeks demand for critical care (ICU) beds will change from 5 (95% CI: 4-5) patients requiring treatment with mechanical ventilation at the current date to 139 (95% CI: 115-163) by 2020-07-19. These projections assume that approximately 5% of all infections will require treatment with high-pressure oxygen and that approximately 30% of hospitalised cases will require treatment with mechanical ventilation (based on analysis of ongoing epidemics in Europe). **N.B. These scenarios are unlikely to show significant differences for the first week since there is a delay of approximately 10 days between infection and hospital admission. Consequently, the effectiveness of a change in policy is likely to be better captured by hospital admission data approximately 2 weeks after the policy change is implemented.**

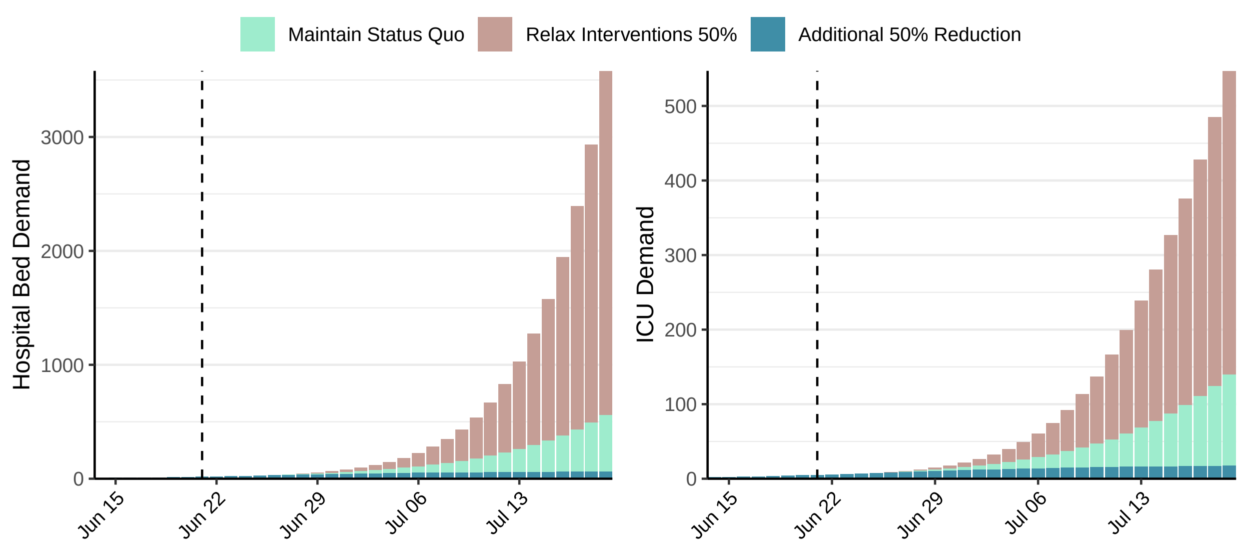


Figure 5: **Healthcare demands in the next 28 days.** Individuals needing an ICU bed are assumed to need mechanical ventilation. Projected demand for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

The impact of each scenario has a more immediate effect on the daily number of infections. The figure below shows the impact of each scenario on the estimated daily incidence of new infections. If interventions are scaled up (Scenario 2), the daily number of infections will change from 354 (95% CI: 305-403) at the current date to 509 (95% CI: 402-615) by 2020-07-19. If current interventions were relaxed by 50%, we estimate the daily number of infections will change from 354 (95% CI: 305-403) at the current date to 119,160 (95% CI: 97,422-140,898) by 2020-07-19.

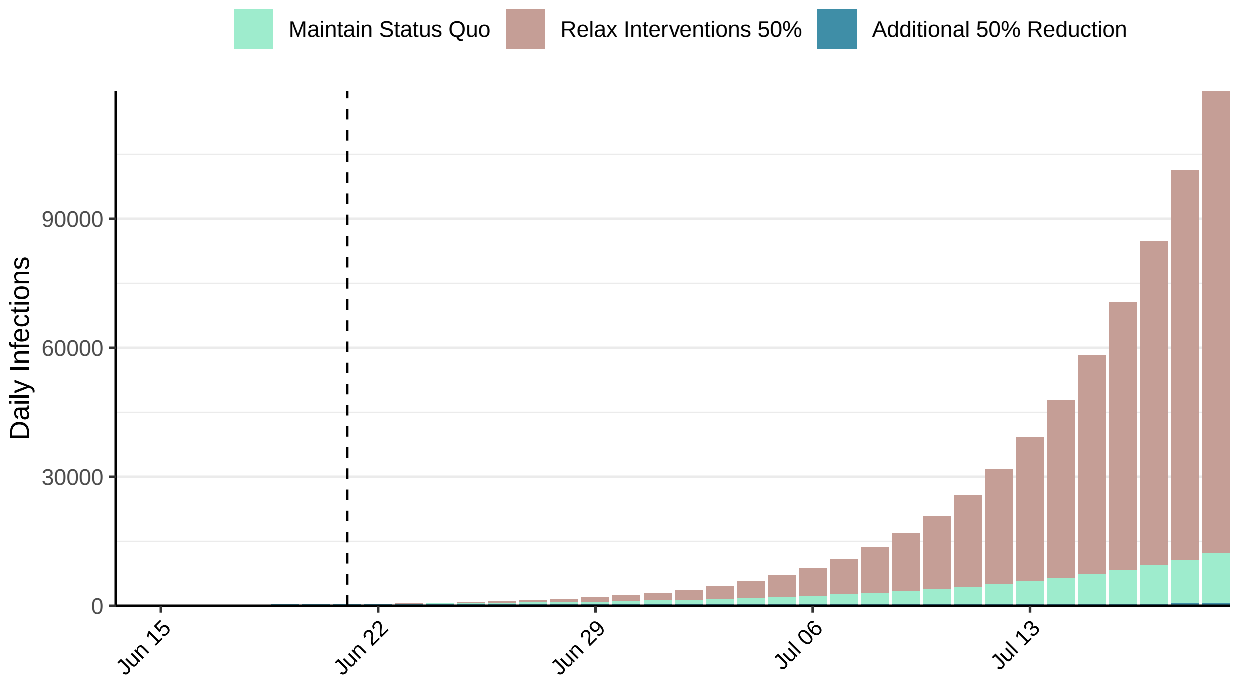


Figure 6: **Daily number of infections estimated by fitting to deaths.** Projected infections for Scenario 1 (the epidemic continues to grow at the current rate) are shown in green (Maintain status quo). Projections for Scenario 2 (a further 50% reduction in transmission) are shown in blue. Projections for Scenario 3 (relaxing interventions by 50%) are shown in red. Current date shown with dashed line.

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To explore different scenarios, we recommend using our COVID-19 Scenario Analysis Tool - https://covidsim.org/, which can be used to simulate different intervention scenarios and explore the long term impact on healthcare demand.

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