Global projections of potential lives saved from COVID-19 through universal mask use

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Abstract

Background: Social distancing mandates have been effective at reducing the health impacts of COVID-19. The ensuing economic downturns and unemployment increases have led many nations to progressively relax mandates. As COVID-19 transmission and deaths rise in many low and middle-income countries (LMICs), with continuing widespread transmission elsewhere, policymakers are searching for options to reduce COVID-19 mortality without re-imposing strict social distancing mandates.

Methods: Using a Bayesian meta-regression of 40 studies measuring the impact of mask use on respiratory viral infections, we estimated the reduction in transmission associated with the use of cloth or paper masks used in a general population setting. We used data from daily surveys conducted by Facebook, YouGov, and Premise, on the proportion of people reporting always wearing a mask outside their home for nearly all countries. We predicted deaths and infections until January 1st 2021 under a reference and universal mask use scenario using a deterministic transmission dynamics model with categories for susceptible, exposed, infected and recovered (SEIR). In the reference scenario, we assume continued easing of mandates but with action to re-impose mandates for a period of six weeks, at a level of eight daily deaths per million population. The universal mask scenario assumed scaling up of mask use to 95% over a one-week period.

Findings: Use of simple masks can reduce transmission of COVID-19 by 40% (95% uncertainty interval [UI] 20% – 54%). Universal mask use would lead to a reduction of 815,600 deaths (95% UI 430,600 to 1,491,000 deaths) between August 26th 2020 and January 1st 2021, the difference between the predicted 3.00 million deaths (95% UI 2.20 to 4.52 million) in the reference and 2.18 million deaths (95%

UI 1.71 to 3.14 million) in the universal mask scenario over this time period. Mask use was estimated at 59.0% of people globally on August 18th, ranging from 41.9% in North Africa and the Middle East to 79.2% in Latin America and the Caribbean. The effect of universal mask use is greatest in countries such as India (158,832 fewer deaths in universal mask scenario, 95% UI 75,152 to 282,838 deaths), the United States of America (93,495 fewer deaths; 95% UI 59,329 to 150,967 deaths), and Russia (68,531 fewer deaths; 95% UI 34,249 to 145,960 deaths).

Interpretation: The rising toll of the COVID-19 pandemic can be substantially reduced by the universal adoption of masks. This low-cost policy, whether customary or mandated, has enormous health benefits and likely large economic benefits as well, by delaying the need for re-imposition of social distancing mandates.

Research in context

Evidence before this study

One meta-analysis of 21 studies reported a pooled reduction in the risk of respiratory virus infection of 47% (95% CI 36-79%) from a subset of eight studies reporting on mask use in non-health workers but it did not distinguish type of mask. Another meta-analysis reported on 26 studies of mask use in health workers and three studies in non-healthcare settings, reported a pooled effect of a 66% (55-74%) reduction in infections and a reduction by 44% (21-60%) in the three non-healthcare setting studies. Several survey series regularly measure self-reported mask use but results from these different sources have not previously been pooled to derive daily estimates of mask use over the course of the epidemic. Global models of the impact of scaled up mask use have to our knowledge not been published.

Added value of this study

We combined the studies on mask use identified in the two meta-analyses and added one further study. In a Bayesian meta-regression approach, we derived the effect of simple cloth or paper masks used outside of a healthcare setting. In the meta-regression we make use of all the information provided by all of these studies, rather than subsetting to just those studies that provided the direct comparison of interest. Pooling estimates on the prevalence of self-reported mask use from three survey series provides up-to-date information on trends in mask use in almost all countries. We use extensive survey data covering nearly every country in the world to assess recent trends and current mask use. We then use an SEIR transmission dynamics model with good predictive validity to assess the potential of scaled up mask use to reduce global mortality from COVID-19.

Implications of all the available evidence

Universal mask use can save many lives and avoid or, at least, delay the need for re-imposition of social mandates (such as stay-at-home orders, curfews, *etc*.), which would also contribute to ameliorating the negative effects of COVID-19 on the economy and unemployment. Until an affordable vaccine becomes universally available, mandating mask use is the most attractive policy option available to all countries, particularly if an expected increased transmission risk occurs in the Northern hemisphere's fall and winter. Simple face coverings are cheap and effective; one of the few available interventions that is widely available to everyone. Countries with currently low mask use will need to determine the optimal balance between encouraging the use of masks through advocacy and information about their benefits, and governance of a compulsory use associated with penalties for non-compliance.

Introduction

COVID-19 has spread to all regions of the world and as of August 30th 2020, with over 25 million cases and 845,414 deaths have been reported globally[1]. This is undoubtedly an underestimate and only one direct measure, among many, that may be used to refer to the impact of the pandemic on health and health systems around the world. In March 2020, nearly all nations put in place a set of social distancing mandates that have contributed to blunting the effects of COVID-19. Economic downturns and the associated mass unemployment caused by these measures has led most nations to progressively relax social distancing mandates. As COVID-19 transmission and deaths rise in many low and middle-income countries (LMICs) and some high-income countries, policymakers are keen to identify policy options to reduce COVID-19 mortality without re-imposing strict social distancing mandates.

One attractive strategy is the imposition of mandates requiring the wearing of masks in public spaces when physical distancing is not feasible. Initially, the World Health Organization (WHO) discouraged mask use by public questioning of the evidence supporting general use and arguing it might lead to mask shortages for healthcare providers[2,3]. Several systematic reviews, however, have suggested that cloth and other non-medical masks worn by the general public can markedly reduce transmission.[4,5] A growing number of national and local governments have recently adopted mask use mandates, with now over 150 countries mandating mask use either nationally, or in specific transmission hotspots, focused in enforcing their use within on public transit or indoor public spaces.[6] In nations such as the United States (US) and Brazil, mask use has become a political issue, with widely varying viewpoints on the ethics, legality and enforcement of mask use mandates.[7,8] Evidence of the individual benefits, population health impacts, and the potential economic benefits of increased mask use may be a useful input in these national debates.

Masks can affect the transmission of respiratory pathogens in a number of ways, thereby providing a complement to stringent social distancing mandates without the associated severe economic impacts, and in settings such as indoor public spaces where distancing may not be possible. Simple cloth masks are also affordable and equitably accessible. At the individual level masks reduce transmission *via* a physical barrier whereby the force of exhalation, coughing, or sneezing leads to impaction and interception of viral droplets (> 5µm in diameter) and aerosol (≤ 5 µm in diameter, resulting from evaporation of expired droplets, also described as droplet nuclei) onto the fibers of the mask.[9–11] Given greater impaction efficiency for droplets, masks are most effective in blocking outward exhalation[12], although evidence from studies of air pollution aerosol indicates some protection of non-medical masks in blocking a small fraction of aerosol inhalation.[13] Thus mask wearing is effective both for the infected and the uninfected[14] and is also relevant to the recent discussions regarding airborne transmission of SARS-CoV-2.[15] Airborne transmission is, by definition, caused by droplet nuclei (*i.e.* evaporated droplets) that may remain infectious when suspended in the air over extended distances or time periods.[11] As masks can effectively block exhalation of droplets, they also reduce production of droplet nuclei by evaporation, and therefore offer a practical intervention against airborne transmission to complement ventilation and less widely accessible interventions such as air filtration and UV disinfection.

In this paper, we provide a meta-regression of the reduction in transmission associated with mask use, use survey data to assess current levels and trends in use of masks globally, and quantify the benefits of universal mask use (here defined as 95% of individuals always wearing a mask when outside their home) on COVID-19 mortality using a COVID-19 transmission dynamics model. We provide estimates of lives saved through universal mask use globally and at the national level between July 26th 2020 and January 1st 2021.

Methods

Our analysis is comprised of three main components: a literature scoping analysis and meta-regression of the benefits of mask use with an emphasis on non-medical mask use amongst the general (non-healthcare) population; an analysis of survey data on the levels and trends in mask use; and modeling two scenarios (reference and universal mask use) of COVID-19 incidence and death using a deterministic transmission dynamics model with categories for susceptible, exposed, infected and recovered (SEIR). Each component is discussed in more detail below.

Estimating the effectiveness of masks in preventing transmission

We performed a meta-regression of 63 observations from 40 studies of the effectiveness of masks in preventing the transmission of respiratory virus infections. These studies were included in two published meta-analyses[4,5] with one further study of mask use for COVID-19 in the general population added.[16] The studies varied in setting (general population versus healthcare), type of mask (which we dichotomized into medical-grade masks, including surgical and N95 masks, and non-medical masks, including cloth masks), comparator group (no mask use or “occasional” mask use), type of diagnosis (clinical or laboratory), country of study (dichotomized into Asian and non-Asian countries) and type of respiratory virus (SARS-CoV-1 or 2 versus H_1N_1, influenza, or other respiratory viruses); details on the details of all included studies[16–55] can be found in SI Table 2 in the Appendix. From the identified papers, we extracted all relevant observations that assessed mask effectiveness, allowing for multiple observations per study based on variations in mask type, virus studied, or comparison group. From the two meta-analyses, four identified studies were excluded where a relative risk was not available[56,57], we were unable to extract mask use from general PPE use[58], or because the comparison group was of less protective masks rather than no or infrequent mask use[59]. In order to derive the most relevant pooled estimate for the effect of mask use on preventing the spread of COVID-19 in populations, we performed a meta-regression of all 63 observations and their characteristics to predict the effect of non-medical mask use in a community setting to prevent laboratory-confirmed SARS-CoV-2 compared to no use of masks. For studies with zero counts in the numerator, we used a continuity correction of 0.001 to estimate the RR in order to ensure inclusion in our analyses; sensitivity analyses considering other continuity corrections produced highly consistent results (see Appendix). To generate summary estimates we used a custom Bayesian mixed-effects meta-regression tool (MR-BRT – "meta-regression – Bayesian, regularized, trimmed")[60] which accounted for between-study heterogeneity in the width of the uncertainty interval (see Appendix for more details).

Past, current and future prevalence of mask use

We used three main sources of data on self-reported use of masks: the Facebook Global Symptom Survey[61], the PREMISE surveys[62], and the YouGov COVID-19 Behaviour Tracker surveys.[63] Between April 23rd and August 18th, Facebook has surveyed 23.3 million Facebook users from 102 countries using an instrument with multiple items on behaviours related to COVID-19, including mask use. For the US, we used data collected through PREMISE. There were 190,216 total PREMISE responses representing all 50 states and the District of Columbia with responses collected between April 21st and August 21st. The YouGov surveys cover 29 countries and have interviewed around 493,400 individuals since March 1st and up until August 8th 2020. From the Facebook surveys, we used the item: "In the last 7 days, how often did you wear a mask when in public?" to which there are the following responses "All of the time; Most of the time; About half of the time; Sometimes; Never; I have not been in public during the last 7 days". Respondents for "All of the time" were the numerator in our proportion. From the PREMISE surveys, we use the following question: "When you leave your home do you typically wear a face mask (SELECT_ONE)" with responses "Yes, always; Yes, sometimes; No never". Respondents for "Yes, always" were the numerator in our proportion. From YouGov, we use the following question: "Thinking about the last 7 days, have you worn a face mask outside your home (*e.g.* when on public transport, going to a supermarket, going to a main road)" with responses "Always", "Frequently", "Sometimes", "Rarely", and "Not at all". Respondents for "Always" were the numerator in our proportion.

Mask use for each location was estimated using a spline-based smoothing process. This smoothing process averages each data point with five neighboring data points. To arrive at smooth, flat values at the ends of the observed data, we computed the average of the change in mask use over the three following days (left tail) and three preceding days (right tail). For locations without data on mask use, we used, in order of preference, national level estimates (for subnational locations), regional estimates, and super-regional estimates based on the regional groupings used by the Global Burden of Disease Study (GBD). The only exception was for countries in Oceania, a region where no data are available through any of the three survey platforms. In the GBD hierarchy, these countries are part of the East Asia and Southeast Asia super-region; however, mask use in Oceania is likely to be more similar to mask use in Australia and New Zealand and so the mask use from that region was used for countries in Oceania.

To construct our scenario of universal mask use, we assume that current mask use in all locations would increase to 95% over the course of 7 days. We use 95% as that is the highest level of mask use reported at the national level to date during the COVID-19 pandemic; this level was reported in Singapore. Our "universal mask use" scenario assumes that this level of mask use can be achieved through the adoption and enforcement of mask use mandates around the world.

COVID-19 SEIR model construction for each location

The IHME COVID-19 prediction model has been described in detail elsewhere.[64] For the results presented in this analysis, the SEIR part of the model are most relevant. We construct an SEIR model for each location we model; the Appendix shows the basic states included in the model and the transition parameters. The critical driver of the epidemic is the rate at which susceptible individuals become infected in each location which is assumed to be represented as:

$$\frac{dS}{dt} = -\beta(t)\frac{S(I_1 + I_2)^\alpha}{N}$$

Where β_t is the transmission parameter for time period t, α represents a mixing coefficient to account for imperfect mixing within each location, S is the fraction of each location's population that is susceptible, and I_1 and I_2 is the fraction that are infectious. Effective R_t, the number of new infections caused by each case is a simple monotonic transformation of β_t and the fraction of the population that is susceptible. We use an efficient algorithm to directly estimate β_t in the past – see appendix for details. To determine the strength of the relationship between β_t and various covariates, we perform a log-linear regression using the open source mixed effects solver SLIME[5]. All covariates are assumed to have fixed effects while the intercept is allowed to vary by location. For location l, the regression is calculated as:

$$\ln(\beta_{p,l}) = \alpha_{0,l} + \boldsymbol{X}_l\boldsymbol{\alpha}$$

where $\alpha_{0,l}$ is the random intercept for location l, $\boldsymbol{X}_l$ is a matrix with a column for each covariate in the regression and a row for each day, and $\boldsymbol{\alpha}$ is the coefficient indicating the strength of the relationship between $\log\beta$ and each of the covariates. We tested many covariates and included the following in the model: population density measured as the share of the population living in areas with more than 2,500 individuals per square kilometer, the fraction of the population living below 100 meters above sea level, smoking prevalence, particulate matter air pollution (PM2.5 population-weighted annual average concentration), mobility measured using cell phone apps, mask use, COVID-19 testing *per capita*, and pneumonia seasonality. Pneumonia seasonality was constructed as an index using medical certification of cause of death data on pneumonia deaths by week and normalized annually. In locations without 4- or 5-star quality cause of death data[65], we used latitude as a predictor of the pattern of pneumonia seasonality. To avoid over-estimating the effects of pneumonia seasonality and mask use we used constraints on each in the regression – see Appendix for details. Specifically, for mask use, we did not let the regression estimate an effect size larger than what was consistent with the mask use meta-analysis of the individual level effect. To capture uncertainty in the input data, model parameters and regression coefficients linking β_{jt} to covariates, we generated 1,000 models for each location – see Appendix for details.

We evaluated out of sample predictive validity for this modeling approach by holding out the last five weeks of data and compared predictions from the held-out data to what occurred; median absolute percent error for cumulative deaths at five weeks was 7%.[66] We also compared this model to other COVID-19 prediction models that make their estimates publicly available; overall, we find that our model has the best performance at 5- and 6-weeks out-of-sample.[66]

We used the set of 1,000 SEIR models for each location to generate two types of scenarios: a reference scenario and a universal mask use scenario. In the reference scenario, or what we think is most likely to occur, key drivers such as mobility and testing *per capita* evolve according to past trends – see Appendix for details. In the universal mask use scenario, we assume that mask mandates and other campaigns lead to scale-up of mask use to 95% within seven days of enactment. We also assume both in the reference and in the universal mask use scenario that social distancing mandates would be re-imposed when the daily death rate reaches eight per million people per day. This daily death rate represents the 90th percentile across countries of the observed daily death rate in the past few months before each country imposed the maximum number of social distancing mandates. This daily death rate also represents the observed average daily death rate to date among the small number of locations that are experiencing a resurgence and are re-imposing social distancing mandates.

Results

Figure 1 shows the relative risk of viral respiratory infection among users of different types of facemasks. Studies of general population use (13 observations of 63 total) included cluster randomized trials of household member mask use living with an infected individual, cohort analyses of close contacts of infected individuals, and case control analyses of mask use prior to infection amongst the general population or of secondary infections amongst household members of an infected individual. A total of 19 observations were of non-medical masks, with eight of these focused on use by the general public. The meta-regression suggested the benefits of non-medical masks in the general population to be a 40% (UI 20% – 54%) reduction in transmission. The benefits of wearing surgical or medical masks in the general population were slightly larger, a 43% reduction (23% - 59%) in transmission. Even larger reductions in transmission were estimated for non-medical (54% [40%-64%] and medical (56% [48%-64%]) mask use amongst healthcare worker populations. More details are provided in the Appendix.

Based on survey data collected through smartphone hosted questionnaires, Figure 2 shows a map of mask use by location as of August 18th, the last date of fully observed data in the model. Mask use is high in most parts of Latin America and South-East and East Asia. The highest mask use on August 18th was in Chile (93.6%), followed by Puerto Rico (93.5%), and Guatemala (92.2%). The lowest rates are seen in Northern Europe (Sweden, Norway, and Denmark < 1%) and North Africa (Tunisia 6.5%). Lower rates are seen in some parts of sub-Saharan Africa, Northern Europe, and states and provinces in the United States, Canada, and Australia. Mask use is highest among people who live in cities and lowest in people who live in rural communities (see Appendix).

Figure 3 shows the global and super-region trends in mask use since the beginning of the epidemic. Mask use data start only in the beginning of April so the rapid expansion from likely a very low baseline pre-COVID-19 outside of East Asia most probably occurred in March. Mask use was estimated at 59.0% of people globally on August 18th, ranging from 41.9% in North Africa and the Middle East to 79.2% in

Latin America and the Caribbean (Figure 3). Mask use has increased in some locations where mandates have been put into place such as Australia, Belgium, and the United Kingdom (SI Figure 7). Mask use has declined in some settings where death rates are declining such as Poland, Czechia, and Italy (SI Figure 7). Mask use varied by gender in some regions, with higher use by females in all regions except for South Asia, (globally 54.2% in females vs to 52.3% in males) and by age with generally lower use amongst 18-24 year olds (50.0%) and those over 65 years (46.4%) compared to 55-54 year old adults (56.5%) who were the most likely to wear masks (percentages on July 21, see Appendix).

Global projections of COVID-19 deaths with and without a universal mask use mandate are shown in Figure 4. In our reference scenario, we expect daily COVID-19 deaths to increase in October through December leading to 3.00 million deaths (95% UI 2.20 to 4.52 million) by January 1st 2021. Uncertainty in daily deaths and cumulative deaths widens steadily over time such that there is considerable uncertainty in global deaths by January 1st. In contrast, the universal mask use scenario leads to a mean estimate of 2.18 million deaths (95% UI 1.71 to 3.14 million) by January 1st. The difference in mortality between the reference and universal mask use scenario suggests that 0.82 million lives (95% UI 0.43 to 1.49 million) could be saved over this time period if 95% of people were to always wear masks when outside their home. Table 1 provides estimates by location of the expected deaths in the reference and universal mask use scenario along with the number of deaths saved through the mask use mandate. The countries where mask mandates would have the largest effect are populous countries such as India (158,832 fewer deaths in universal mask scenario, 95% UI 75,152 to 282,838 deaths), the United States of America (93,495 fewer deaths; 95% UI 59,329 to 150,967 deaths), and Russia (68,531 fewer deaths; 95% UI 34,249 to 145,960 deaths). The greatest magnitude difference in mortality rate occurred in the Netherlands (23,282 fewer deaths, 136 deaths per 100,000), Switzerland (6,062 fewer deaths, 86 deaths per 100,000).

Figure 5 shows a map of the percent reduction in expected deaths from the reference scenario compared to the mask use scenario in the deaths from August 28th to January 1st. The largest percent reduction in expected deaths occurred in Tanzania (80.4% difference, 95% UI 63.4 to 94.4%), Poland (78.8% difference, 95% UI 60.4 to 93.5%), and Algeria (78.4% difference, 95% UI 61.9 to 92.2%). Expected deaths were greater in the universal mask use scenario than in the reference scenario in some locations due to the delay in re-imposition of mandates such as in Kazahkstan (more deaths in mask use scenario, 95% UI 7.2 to 45.3% increase). There are large variations in the number of lives saved globally, regionally, nationally, and subnationally and these are detailed in full in Table 1.

Discussion

Wearing a mask reduces the risk of contracting COVID-19 for individuals by 40% (20%-54%). Given global mask use is currently at 59.0%, increasing mask use to 95% through mandates could decrease cumulative COVID-19 deaths by January 1st 2021 by 0.82 million deaths (95% UI 0.43 to 1.49 million). This represents a 26.5% reduction in the number of deaths expected from August 28th to January 1st 2021. The benefits of increased mask use are greatest in settings with ongoing substantial transmission and low current levels of mask use regardless of sociodemographic status. Our models also show that in many settings, increased mask use will delay the need re-imposition of social distancing mandates by many weeks or even months; in addition to the lives saved, a delay in re-imposition of social mandates might also be accompanied by substantial economic benefits.

The estimate of 40% effectiveness of non-medical mask use by the general public is based on 13 observations (from 9 studies) specific to the general population, from a total of 63 observations from 40 separate studies included in the meta-regression. The uncertainty interval is wide, from 20% to 54% reduction in transmission. Even with this uncertainty interval, there was absolutely no indication of any harmful impacts of mask use, such as tendencies for engaging in riskier behaviour or self-contamination *via* more frequent face touching, as has been suggested.[67,68] Further, the published studies of SARS-CoV-2 included in our analysis of mask effectiveness demonstrated reductions in relative risk of 30% - 100%, with the one study of non-medical mask use amongst the general population, indicating a reduction of 42% for any mask use and 70% for consistent mask use.[69] Mask effectiveness is also supported by additional evidence from laboratory studies that report on the efficacy of masks in reducing exhalation of both aerosols and droplets by those infected with SARS CoV-2.[70] Further, a recent case series reported no secondary infections among 139 individuals exposed to two symptomatic hair stylists with confirmed COVID-19 while both the stylists and their clients wore masks.[71] In addition, a study of Swiss soldiers indicated that physical distancing and use of medical masks led to no COVID-19 symptoms despite the presence of virus-specific antibodies[72], while a study of healthcare workers indicated that universal use of medical masks was associated with lower rate of SARS-CoV-2 positive tests[73]. Based on all types of available evidence, it seems critical to encourage mask use throughout the world as the benefits can be substantial with low to zero contraindications. Guidance for specific materials, handling of face coverings and other considerations is rapidly evolving as additional evidence emerges[74].

At the population level, the regression analysis of the determinants of the transmission parameter suggests a much larger effect of mask use than the one seen in the published studies. To avoid the risk of over-stating the benefits of mask use in this analysis, however, we have constrained the regression to yield results that are consistent with the range of the effect sizes found in the individual level studies. In other words, the benefits of a universal mask use mandate could be substantially larger and what we report here can be seen as a conservative estimate of the impact of mask use on lives saved.

Given that the cost of masks is very low, mask mandates and/or the promotion of mask use seems prudent, as the risk of adopting these policies is minimal and the potential benefits very large. In recognition of this, over the last few months we have seen the number of countries and territories with mask mandates in place increase substantially. Nevertheless, there remains reluctance to adopt mask use and to impose mask mandates. In some settings, the current epidemiological context means that mask wearing is not viewed as a necessary part of control, such as in Norway where the Norwegian Institute of Public Health determined that, given their current low prevalence, "200,000 people would need to wear facemasks to prevent one new infection per week."[75] In other settings however, despite increasing cases, public sentiment towards mask wearing hinders universal utilization. Past messages from some governments have not encouraged mask use and may have actually discouraged mask use.[76–78] Early on, WHO stated "*the wide use of masks by healthy people in the community setting is not supported by current evidence and carries uncertainties and critical risks*"[2] and only changed their official position on June 5th to encourage mask use.[79] This reluctance to embrace mask use given no real risks of use and considerable potential health and economic benefits is hard to understand and justify. For those decision-makers who are concerned with the economic effects of social distancing mandates, mask use mandates provide a low-cost strategy to reduce the risk of a further round of social distancing mandates and the associated unemployment and economic downturn.

While the effective R, the number of new infections created by a single infection under the auspices of control, can potentially be reduced by one-third through universal mask use compared to no mask use, mandates alone will likely be insufficient to control the epidemic in many locations. Even with universal mask use, we expect the death toll due to COVID-19 to reach 2.18 million deaths by the end of the year, and many more in 2021, assuming an efficacious vaccine is not discovered, licensed and widely deployed in the interim. Countries will have to consider other policy strategies to reduce transmission, including increasing testing, contact tracing, and isolation, along with "smart mandates", which refers to targeting mandates or restrictions to particular subgroups of the population, such as specific age-groups or local communities for short periods of time. A central policy challenge for many countries is understanding which of these mandates targeting strategies makes the most sense in a given context and at what level of COVID-19 transmission. This is the focus of our ongoing work.

The findings of this study should be interpreted while taking into account its limitations. First, there is a set of limitations related to the meta-regression, including the following. The number of published studies on the protection provided by cloth masks worn by the general public is limited. With rapid development of the COVID-19 literature, new data on the effectiveness of masks can quickly be incorporated into our meta-regression model. Future studies could change our pooled estimate of the effect size and/or the large uncertainty interval around it in the meta-regression. As we looked at multiple observations per study, it was not really feasible to account for all possible clustering. We performed sensitivity analyses (shown in the Appendix) and found minimal differences in investigating the role of clustering in our results. Studies had different endpoints and while we controlled for that in our meta-regression, it would be ideal to have more studies that focus on COVID-19 as an endpoint.

Second, related to the modeling framework, we use an SEIR model to predict the course of the epidemic with and without universal mask use. In general, SEIR models have tended to overestimate the infections and deaths associated with COVID-19. Over-estimation is likely due to the fact that individuals change their behaviours as the epidemic gets worse around them and governments tend to react when hospital systems are nearing capacity. We have built the government response into our reference scenario and have tried to use empirically observed data on mobility and current mask use to reflect the individual behavioural response. Further, our model makes a number of simplifying assumptions associated with mixing and transmission heterogeneity and as such, our conclusions must be considered with these assumptions in mind. Also, we use a log-linear mixed regression which does not take into account the potential for non-linear relationships We acknowledge that there are likely non-linear relationships between some of the drivers of transmission and transmission intensity. Moreover, we expect there to also be complex lagged relationships between covariates and transmission (e.g., fatigue related to duration of mandate altering its impact on transmission). Improving how our model uses covariates to capture temporal variation in new infections is an open avenue of research.

Third, our out-of-sample predictive validity testing has shown that errors tend to progressively get larger the longer the forecast, but has also shown that errors are much larger in settings where there are fewer than 50 total deaths to date. For example, predictions from publicly available models for sub-Saharan Africa have been particularly bad.[66]

Fourth, we assume cases and deaths are accurately reported by JHU except in Ecuador, Kazakhstan and where excess mortality analyses have indicated substantial underreporting of COVID-19 deaths. Other countries may not be detecting or reporting deaths and cases due to lack of testing or other considerations. Overall, though, we believe that our prediction model performs well and where antibody tests have been conducted at the population level, we have found our model based on deaths has matched these results.[64]

Fifth, our models are sensitive to the trends in the last 7-14 days in deaths and somewhat sensitive to the trend in cases. In settings where deaths and cases are steadily rising, the model will tend to have large estimates of β_t. If the rise in transmission is not captured by trends in mobility or other covariates, the unexplained residual in the model increases and this is then reflected in the forecasts by day through to January 1st. The reverse relationship also holds true for when there is a consistent downward trend. The sensitivity of our model to data trends is a strength in that it makes our models reflect the on-the-ground realities; it is also a challenge in the sense that our model results will change when there are changes in recent transmission that are not captured by the covariates.

Sixth, we rely on self-reported data which is collected via mobile phone app-based surveys on use of masks. In addition to the usual biases that accompany self-reported data, in this case we do not know whether in settings with mask mandates in place, respondents may be reporting their behavior differently compared to settings without mask mandates. The respondents to app-based surveys are also likely to not be a truly representative sample of the populations in each location. The degree to which the respondents represent the general population varies across locations, and depends on the prevalence of Facebook and other app use in each country. While this is a limitation of the data that are currently available, we believe that given the samples tend to be biased towards more educated, urban, and younger populations, the reported mask use is likely to be an over-estimate in these locations. If this is true, then the estimates of the impact of expanding mask use to reach 95% coverage in these populations would be an underestimate of the true effect of the intervention.

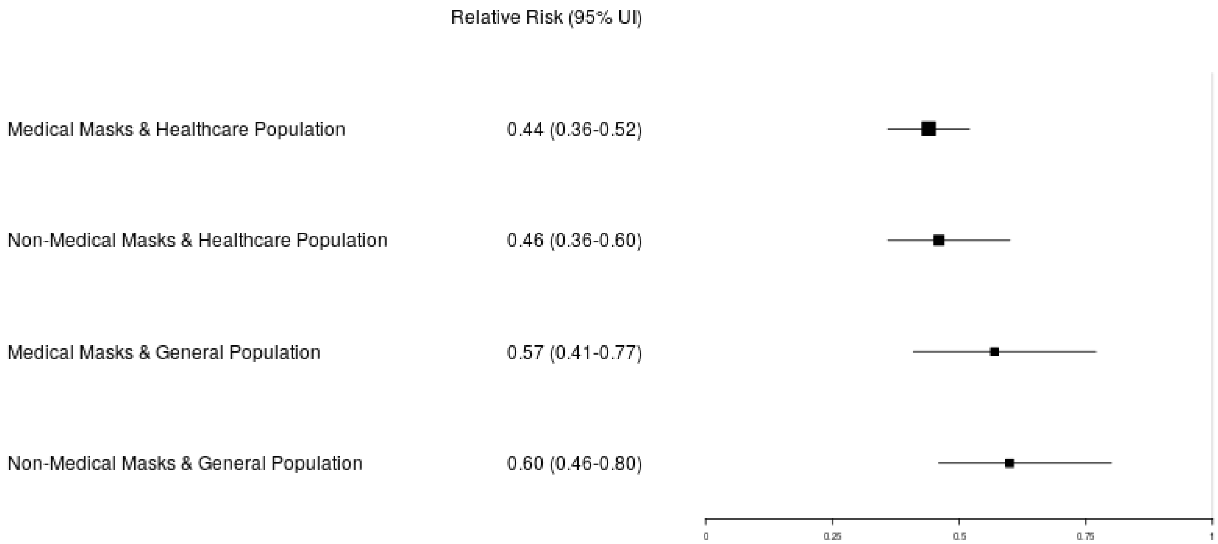
These limitations highlight important areas for improvement across the entire spectrum of research related to COVID-19. There is a critical need for more and higher quality data across the spectrum of information required to understand the trajectory of this pandemic, starting with better and higher-quality information on the numbers of cases and deaths, to improved and more representative data on use of masks among populations across the world, to additional studies that quantify the effect of face coverings on transmission probability of SARS-COV2 among the general population, to better data on social distancing mandates implemented in each location and the extent to which they are enforced. On the modeling side, continued work on making modeling frameworks more flexible and including alternative model specifications, as well as improving on how covariates are used to capture temporal variation in new infections might lead to improvements in the performance of long-range forecasts. A greater understanding of how the drivers of this pandemic interact with each other and affect transmission probabilities is critical for influencing its trajectory over the next few months.

Conclusion

The COVID-19 epidemic is far from over. While a selection of therapeutics is showing promise, a vaccine that can be deployed at global scale does not exist and is unlikely to be widely available in the near future. We expect more deaths in the second half of 2020 than were seen in the first six months. Not only are there large epidemics unfolding in Latin America, the Middle-East and South Asia, but seasonality suggests a second wave can be anticipated in the Northern Hemisphere. The rising toll of the COVID-19 pandemic can be reduced by 0.82 million deaths in the next few months by the adoption of universal mask mandates. This low-cost intervention that is available and accessible to all populations, regardless of socio-economic status or other dimensions of inequity, has enormous health benefits and might also lead to large economic benefits by delaying the need for re-imposition of social distancing mandates. In global health we rarely encounter effective, low-cost, and universally available interventions that can save lives: immediately, equitably and safely. Ensuring that individuals, as well as, local, national and global decision makers are all doing everything in their power to achieve the highest rates of mask use in all exposed populations is one of the best strategies available to us to mitigate the toll of the pandemic in the months to come.

Figures

Figure 1. Relative risk of viral respiratory infection among users of different types of facemasks.



This analysis includes only variables addressing facemask type (non-medical versus medical) and population type of mask user (general population versus healthcare setting). The size of the box is proportional to the precision of the estimate, based on number of observations, with more precise studies having larger boxes.

Figure 2. Proportion of the population that self-report always wearing a facemask when outside the home on July 21, 2020.

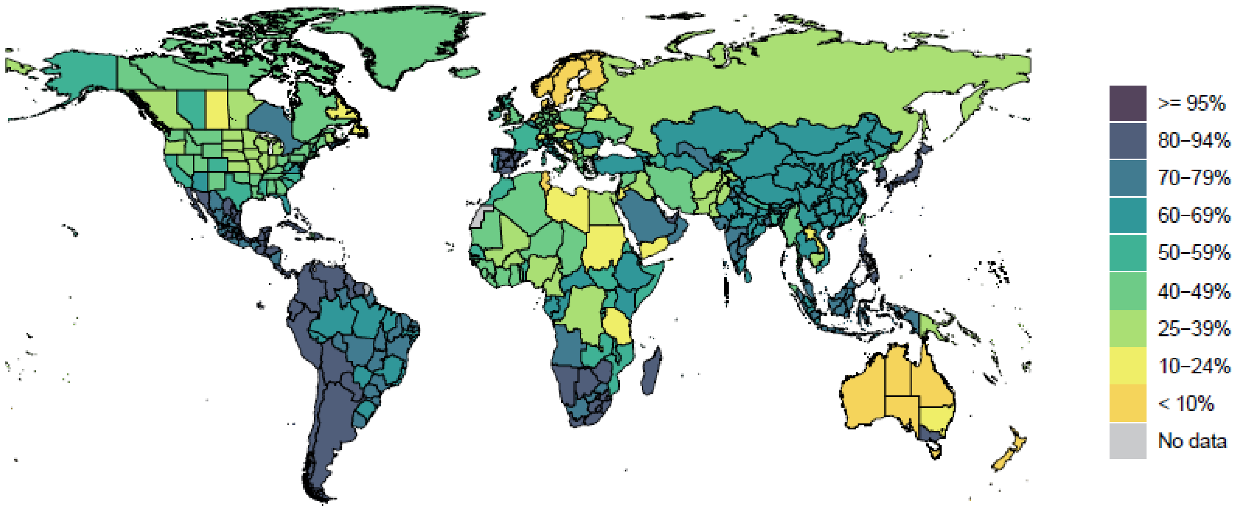
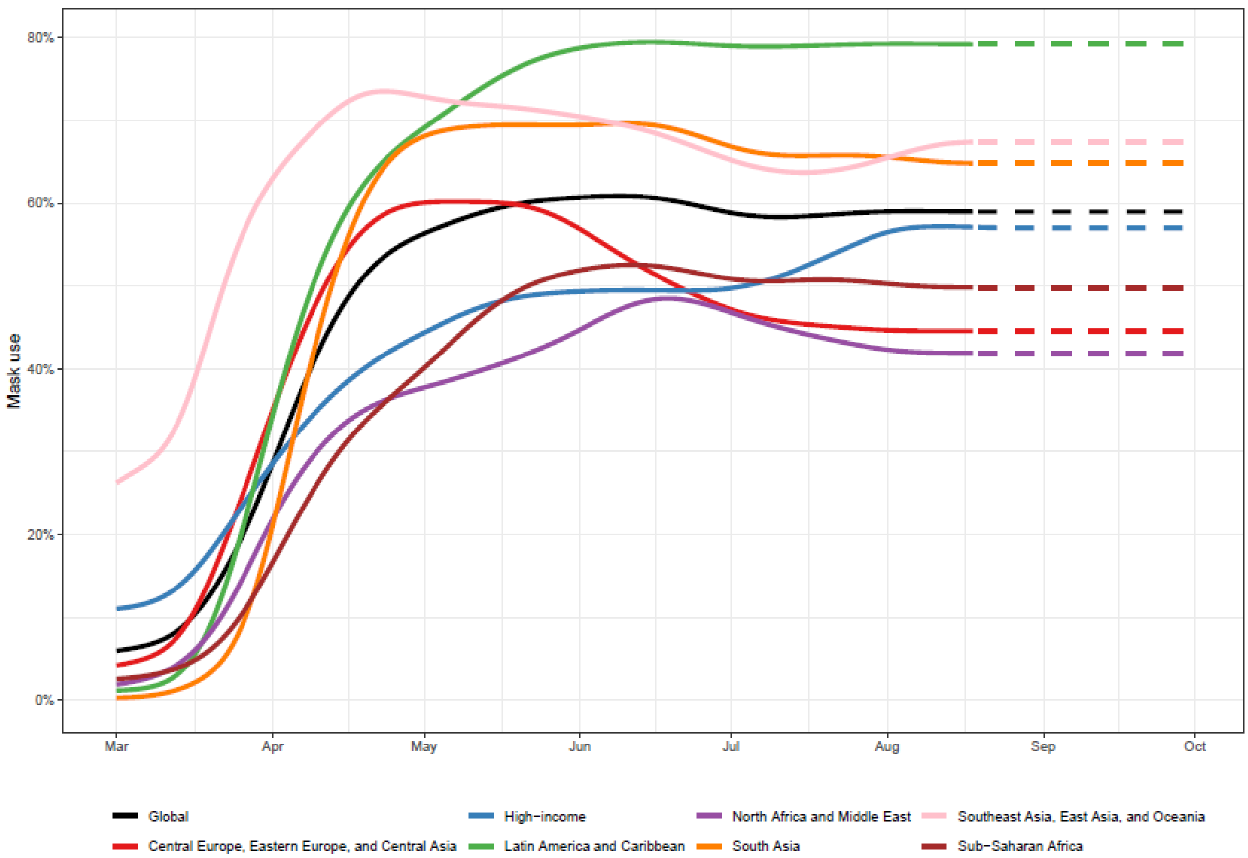


Figure 3. Proportion of the population that self-report always wearing a facemask when outside the home by Global Burden of Disease study super-region between March 1, 2020 and September 30, 2020. Values after the last date of observed survey data are dashed lines and horizontal projections from the last observed values.



450 **Figure 4. Projected global deaths due to COVID-19 up to January 1, 2021 in the scenario for current**
451 **projections of mask use and the scenario with 95% coverage of mask use. Projections are shown for**
452 **the world and for the seven super-regions as defined in the Global Burden of Disease Study.**

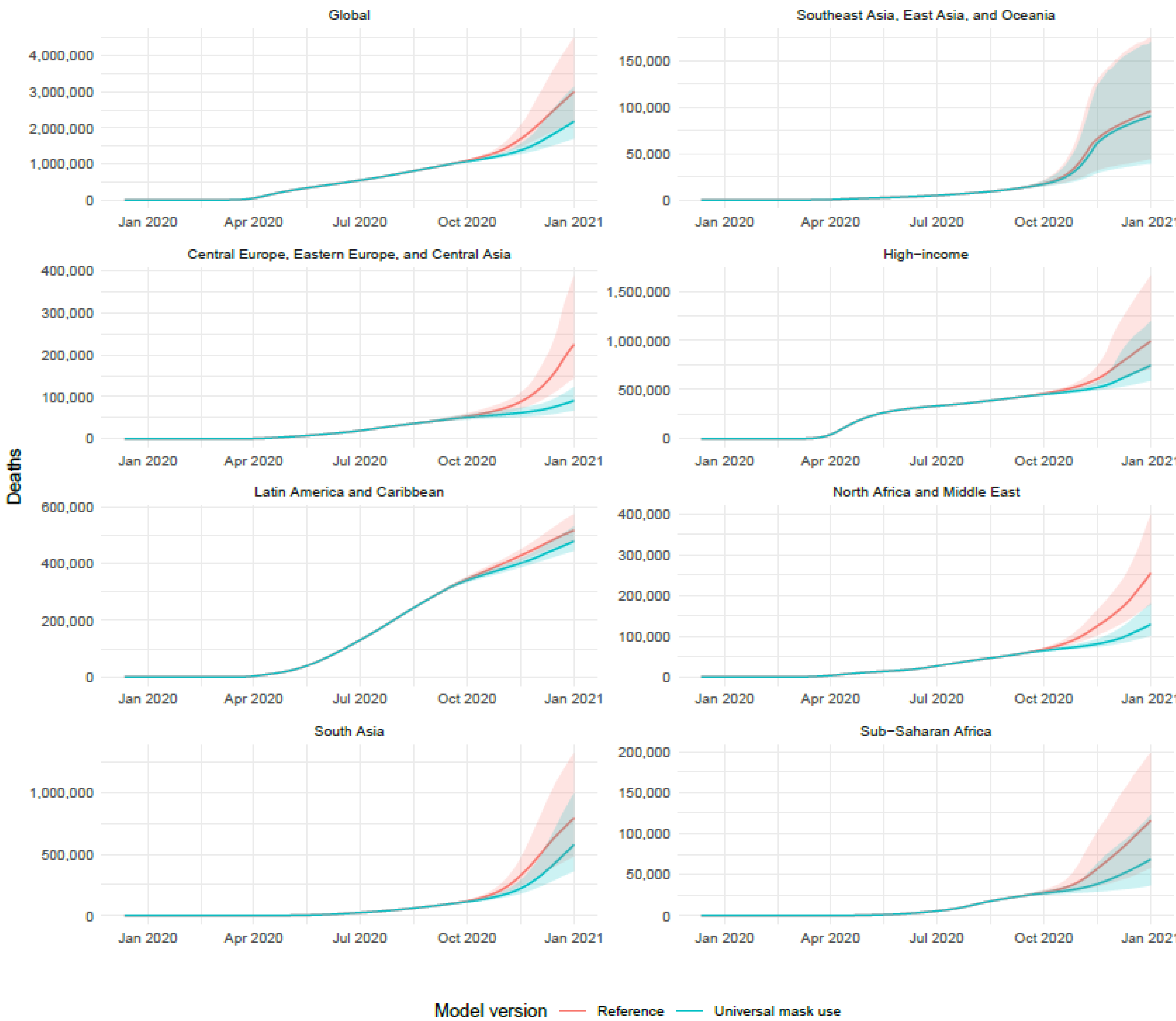


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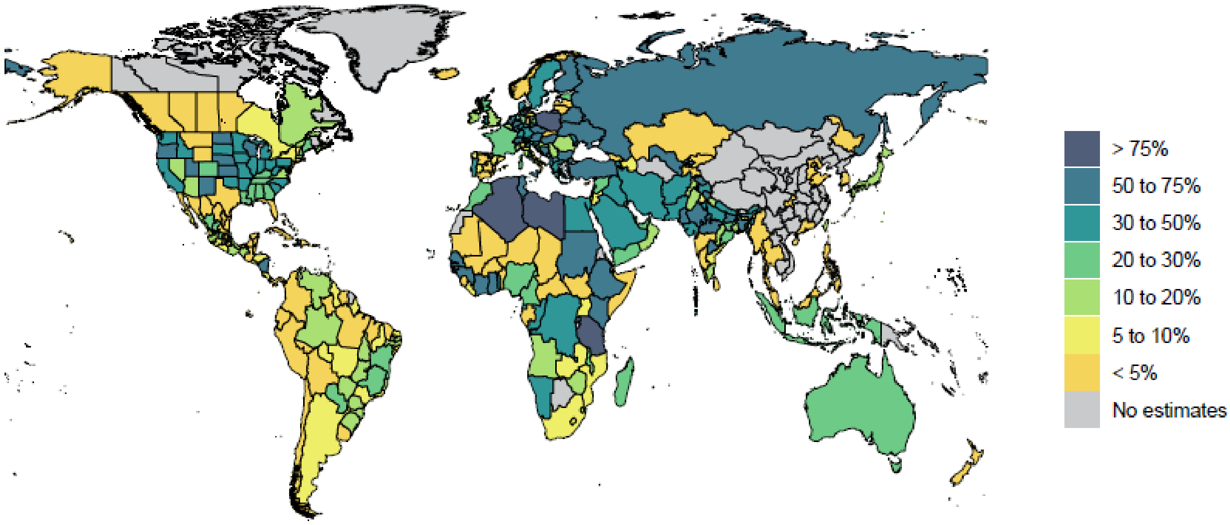
Figure 5. Percent reduction in cumulative deaths on January 1, 2021 in the universal mask use scenario and the reference scenario.



Areas have “no estimates” either because of no available data or because the population size, cases or deaths are so small that the SEIR models do not run.

Table 1. The difference in cumulative deaths between the universal mask use scenario and the reference (current mask use) scenario globally and for each GBD super-region, region, country, and first administrative subnational on January 1, 2021.

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Global	815564 (430556 to 1490969)	-26.5% (-37.1 to -19.1%)	2996714 (2198771 to 4516689)
Central Europe, Eastern Europe, and Central Asia	134421 (64565 to 280696)	-57.7% (-75 to -43.4%)	224915 (143896 to 388691)
Central Asia	2408 (-2708 to 12197)	-6.8% (-29.1 to 10.3%)	30369 (16348 to 53472)
Armenia	1010 (427 to 2641)	-39.3% (-57.9 to -25.7%)	2441 (1601 to 4671)
Azerbaijan	54 (6 to 243)	-7.8% (-29.2 to -1.1%)	620 (557 to 826)
Georgia	0 (0 to 0)	0% (-0.1 to 0%)	17 (17 to 18)
Kazakhstan	-3413 (-7647 to -923)	20% (7.2 to 45.3%)	17510 (7704 to 28212)
Kyrgyzstan	6 (0 to 34)	-0.6% (-3 to 0%)	1082 (1061 to 1126)
Tajikistan	4 (0 to 35)	-2.8% (-31.7 to -0.1%)	76 (70 to 111)
Uzbekistan	4746 (912 to 14648)	-52.4% (-68.1 to -37.2%)	8622 (2248 to 24544)
Central Europe	33643 (12584 to 84666)	-55% (-77.7 to -35.8%)	57864 (31281 to 115111)
Albania	1281 (191 to 3257)	-72.6% (-89.2 to -36.4%)	1649 (527 to 3673)
Bosnia and Herzegovina	1706 (283 to 3958)	-58.7% (-77.2 to -29.1%)	2717 (966 to 5302)
Bulgaria	3255 (108 to 11390)	-69.5% (-91.3 to -14.4%)	4108 (760 to 12672)
Croatia	80 (1 to 665)	-12.4% (-75.5 to -0.5%)	282 (189 to 881)
Czechia	3784 (7 to 18324)	-69.9% (-97.3 to -1.6%)	4245 (439 to 18795)
Hungary	1820 (158 to 10666)	-52.6% (-89 to -19.5%)	2614 (803 to 12065)
Montenegro	299 (4 to 712)	-51.5% (-81.1 to -3.3%)	536 (107 to 1283)
North Macedonia	843 (283 to 2577)	-48.9% (-73.1 to -29.4%)	1602 (957 to 3546)
Poland	17603 (4428 to 53995)	-78.8% (-93.5 to -60.4%)	21056 (6870 to 58691)
Romania	2460 (-594 to 5737)	-15% (-29.2 to 2.8%)	17537 (9418 to 28963)
Serbia	188 (8 to 785)	-15.9% (-48.9 to -1.1%)	959 (758 to 1583)
Slovakia	0 (0 to 0)	-0.4% (-0.8 to -0.1%)	36 (34 to 39)
Slovenia	324 (2 to 2580)	-34.7% (-83.9 to -1.6%)	524 (134 to 3298)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Eastern Europe	98371 (49111 to 201686)	-70% (-83.9 to -56.6%)	136682 (84900 to 248375)
Belarus	4125 (362 to 18176)	-71.4% (-94.3 to -33.4%)	5011 (1083 to 19208)
Estonia	50 (1 to 387)	-24% (-83.3 to -1%)	116 (64 to 462)
Latvia	0 (0 to 0)	-0.1% (-0.3 to 0%)	34 (33 to 35)
Lithuania	0 (0 to 0)	-0.1% (-0.4 to 0%)	84 (82 to 90)
Republic of Moldova	1234 (541 to 2597)	-35% (-49.1 to -23.8%)	3440 (2024 to 6095)
Russian Federation	68531 (34249 to 145960)	-71.3% (-85.7 to -57.4%)	93209 (59097 to 170351)
Ukraine	24431 (8090 to 56899)	-68% (-83 to -54.3%)	34789 (13634 to 73926)
High-income	250073 (108951 to 571964)	-24% (-40.2 to -15.1%)	995094 (712918 to 1660553)
Australasia	477 (65 to 1619)	-29.4% (-58.2 to -7.8%)	1387 (812 to 2788)
Australia	477 (65 to 1619)	-29.9% (-58.7 to -8%)	1364 (790 to 2766)
New Zealand	0 (0 to 0)	0% (-0.1 to 0%)	22 (22 to 23)
High-income Asia Pacific	13358 (1388 to 36167)	-14.2% (-22.9 to -3%)	127298 (9560 to 506645)
Japan	13358 (1388 to 36167)	-14.4% (-23.6 to -3%)	126947 (9215 to 506285)
Republic of Korea	0 (0 to 1)	-0.1% (-0.3 to 0%)	324 (316 to 337)
Singapore	0 (0 to 0)	0% (0 to 0%)	27 (27 to 27)
High-income North America	96640 (60284 to 158525)	-23.6% (-34.1 to -16.3%)	404455 (348869 to 486600)
Canada	3145 (370 to 13910)	-15.5% (-37.5 to -3.6%)	16562 (10435 to 41631)
Alberta	1 (0 to 2)	-0.3% (-0.8 to -0.1%)	256 (244 to 275)
British Columbia	0 (0 to 0)	-0.1% (-0.2 to 0%)	203 (199 to 209)
Manitoba	0 (0 to 1)	-1.4% (-3 to -0.3%)	20 (15 to 27)
Nova Scotia	14 (0 to 93)	-10.7% (-48.8 to -0.7%)	84 (65 to 191)
Ontario	421 (69 to 2389)	-9.2% (-37.1 to -2.2%)	3666 (3078 to 6544)
Quebec	2710 (213 to 13540)	-17.4% (-40.7 to -3.2%)	12307 (6612 to 37237)
Saskatchewan	0 (0 to 0)	-0.6% (-1.5 to -0.2%)	26 (24 to 31)
United States of America	93495 (59329 to 150967)	-23.9% (-34.3 to -16.6%)	387893 (335888 to 465041)
Alabama	1178 (137 to 3210)	-28.4% (-51.9 to -5.9%)	3684 (2319 to 6213)
Alaska	1 (0 to 4)	-1.1% (-8.1 to -0.2%)	37 (34 to 50)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Arizona	1723 (727 to 3349)	-19.2% (-29 to -10.6%)	8723 (6723 to 12227)
Arkansas	1458 (116 to 3691)	-43.3% (-64 to -13%)	2999 (908 to 6138)
California	18044 (7422 to 33622)	-32.6% (-44.2 to -21.9%)	54014 (32829 to 84006)
Colorado	1049 (186 to 3797)	-27.3% (-59 to -8.4%)	3288 (2233 to 6371)
Connecticut	255 (53 to 1102)	-4.9% (-18.7 to -1.2%)	4846 (4580 to 5853)
Delaware	138 (14 to 577)	-14.6% (-42.4 to -2.2%)	793 (628 to 1324)
District of Columbia	271 (60 to 745)	-21.9% (-39.6 to -8.1%)	1119 (740 to 2084)
Florida	-1116 (-5457 to 1416)	4.1% (-4.6 to 17.8%)	26485 (16989 to 39801)
Georgia	3126 (1373 to 5395)	-22.4% (-31.8 to -13.6%)	13769 (8994 to 20009)
Hawaii	4 (0 to 8)	-1.7% (-9.2 to -0.3%)	66 (51 to 91)
Idaho	757 (157 to 1922)	-42.9% (-59.4 to -23.8%)	1670 (636 to 3542)
Illinois	6912 (2353 to 17123)	-37% (-58.2 to -20.2%)	17496 (11463 to 30332)
Indiana	3571 (1580 to 8283)	-42.2% (-61.5 to -28.2%)	8059 (5578 to 13589)
Iowa	1158 (406 to 2576)	-31.2% (-45.4 to -18.9%)	3580 (1985 to 6780)
Kansas	1386 (408 to 3868)	-63.9% (-84.1 to -42.6%)	2027 (960 to 4656)
Kentucky	1284 (385 to 2965)	-29.8% (-43.5 to -16.8%)	4299 (1857 to 10252)
Louisiana	2029 (886 to 3158)	-22.3% (-29.9 to -13.1%)	8946 (6638 to 11541)
Maine	109 (11 to 618)	-30% (-75.7 to -7.6%)	263 (147 to 811)
Maryland	1383 (540 to 2822)	-23.7% (-39.5 to -11.8%)	5626 (4566 to 7222)
Massachusetts	2725 (1096 to 6933)	-18.9% (-35.5 to -9.5%)	13788 (11213 to 19579)
Michigan	4550 (1465 to 12387)	-33% (-57.2 to -16.3%)	12758 (8938 to 21972)
Minnesota	2479 (1052 to 5096)	-40.6% (-56.3 to -26.4%)	5888 (3796 to 9798)
Mississippi	1420 (527 to 2386)	-28.3% (-38.6 to -15.5%)	4869 (3372 to 6526)
Missouri	2357 (381 to 6592)	-36.4% (-53.7 to -16.1%)	6020 (2281 to 16923)
Montana	1 (0 to 8)	-1.2% (-6.5 to -0.2%)	107 (96 to 130)
Nebraska	1081 (446 to 2533)	-61% (-79.5 to -44.1%)	1693 (965 to 3241)
Nevada	643 (-150 to 1451)	-14.6% (-26.9 to 2.8%)	4479 (2301 to 7272)
New Hampshire	186 (28 to 659)	-23.9% (-55.4 to -5.8%)	674 (482 to 1230)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
New Jersey	407 (80 to 1521)	-2.4% (-8.3 to -0.5%)	16730 (16199 to 18212)
New Mexico	1369 (570 to 2896)	-51.2% (-67.9 to -35.6%)	2577 (1602 to 4385)
New York	1913 (311 to 6275)	-5.2% (-15.5 to -0.9%)	35560 (33519 to 40959)
North Carolina	5472 (1544 to 11963)	-49.9% (-67.3 to -30.3%)	10415 (4927 to 18600)
North Dakota	355 (169 to 733)	-55.1% (-70.8 to -41.4%)	621 (400 to 1055)
Ohio	5620 (2206 to 13363)	-47.1% (-68.1 to -30.4%)	11347 (7296 to 20017)
Oklahoma	1665 (580 to 3646)	-43.6% (-57.7 to -29.9%)	3714 (1794 to 7090)
Oregon	2267 (550 to 6464)	-68.1% (-85.7 to -47%)	3119 (1173 to 7598)
Pennsylvania	6137 (1732 to 19494)	-30.8% (-50.7 to -15.4%)	18168 (11151 to 38785)
Rhode Island	421 (73 to 1592)	-20.5% (-45.1 to -6.1%)	1755 (1194 to 3735)
South Carolina	2279 (905 to 4332)	-34.3% (-46.8 to -21.1%)	6426 (4269 to 9660)
South Dakota	240 (63 to 567)	-48.3% (-69.5 to -24.5%)	463 (256 to 829)
Tennessee	1991 (777 to 3818)	-29.1% (-38.9 to -20.1%)	6757 (3342 to 12108)
Texas	-5057 (-11946 to -860)	16.6% (3 to 38.8%)	30644 (21885 to 40804)
Utah	1370 (414 to 3312)	-64.5% (-83.1 to -44.9%)	1998 (916 to 4211)
Vermont	3 (0 to 21)	-4.1% (-25.4 to 0%)	62 (58 to 83)
Virginia	780 (28 to 2603)	-17.3% (-41.5 to -1.1%)	3777 (2574 to 6416)
Washington	3164 (1216 to 6444)	-44.7% (-61.2 to -30.3%)	6863 (3864 to 12327)
West Virginia	282 (43 to 890)	-41.3% (-69.4 to -15.4%)	584 (279 to 1315)
Wisconsin	2658 (480 to 7754)	-56.9% (-81.4 to -27.3%)	4213 (1747 to 9555)
Wyoming	0 (0 to 0)	-0.3% (-0.5 to -0.2%)	34 (32 to 36)
Southern Latin America	2096 (885 to 3789)	-5.2% (-7.9 to -2.9%)	39535 (29734 to 49870)
Argentina	1998 (798 to 3724)	-7.8% (-11.1 to -4.9%)	24972 (15882 to 35043)
Chile	98 (46 to 194)	-0.7% (-1.2 to -0.3%)	14513 (12932 to 16643)
Uruguay	0 (0 to 0)	-0.2% (-0.6 to -0.1%)	50 (46 to 58)
Western Europe	137502 (34764 to 400664)	-29.1% (-52.4 to -12.9%)	422419 (265320 to 786956)
Andorra	32 (1 to 160)	-24% (-62.2 to -2.2%)	97 (56 to 270)
Austria	4262 (523 to 22283)	-70.9% (-95.5 to -39.6%)	5130 (1303 to 23275)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Belgium	2951 (420 to 9818)	-12.3% (-25 to -3.4%)	21299 (12103 to 53485)
Cyprus	0 (0 to 0)	-0.1% (-0.2 to 0%)	21 (20 to 21)
Denmark	844 (111 to 4271)	-42.9% (-85.9 to -14.3%)	1530 (777 to 4973)
Finland	2488 (52 to 15439)	-62.8% (-97.6 to -13.2%)	2846 (393 to 15840)
France	26193 (4775 to 123424)	-29.7% (-61.9 to -11.4%)	72074 (41454 to 207948)
Germany	35016 (5447 to 133085)	-58.5% (-83.8 to -31.8%)	52402 (16961 to 176009)
Baden-Wurttemberg	4735 (215 to 32693)	-40.6% (-88 to -9.5%)	7278 (2266 to 37786)
Bavaria	7705 (287 to 52186)	-38.7% (-73.6 to -8.6%)	14073 (3300 to 77704)
Berlin	1293 (2 to 13290)	-34.9% (-94.4 to -0.8%)	1596 (226 to 13983)
Brandenburg	96 (5 to 490)	-25.4% (-72.4 to -3%)	271 (174 to 677)
Bremen	40 (0 to 299)	-21.3% (-81.6 to -0.8%)	98 (56 to 372)
Hamburg	1183 (63 to 4921)	-39.2% (-63.2 to -14.4%)	2789 (409 to 13787)
Hesse	674 (63 to 3228)	-41.5% (-82.6 to -10.4%)	1255 (603 to 3847)
Lower Saxony	377 (20 to 2420)	-23.5% (-73.8 to -2.9%)	1071 (681 to 3279)
Mecklenburg-Vorpommern	0 (0 to 0)	0% (0 to 0%)	20 (20 to 20)
North Rhine-Westphalia	12592 (1985 to 52956)	-70.4% (-92.1 to -45.2%)	15781 (4319 to 57544)
Rhineland-Palatinate	2175 (65 to 16503)	-61.9% (-94.2 to -19.9%)	2588 (323 to 17724)
Saarland	434 (3 to 4258)	-28.1% (-75.4 to -1.4%)	796 (188 to 6016)
Saxony	2119 (2 to 19528)	-43.8% (-93 to -1.1%)	2642 (228 to 21613)
Saxony-Anhalt	0 (0 to 0)	-0.1% (-0.1 to 0%)	65 (64 to 66)
Schleswig-Holstein	581 (2 to 3027)	-55.3% (-91.3 to -0.9%)	781 (161 to 3315)
Thuringia	1013 (15 to 8697)	-49.5% (-92.3 to -7.2%)	1299 (209 to 9388)
Greece	307 (7 to 1523)	-33.2% (-81.7 to -2.3%)	615 (292 to 1859)
Iceland	0 (0 to 0)	0% (0 to 0%)	11 (11 to 11)
Ireland	442 (114 to 1583)	-15.5% (-41.2 to -5.5%)	2502 (2073 to 3889)
Israel	318 (-424 to 911)	-4.8% (-11.5 to 4.6%)	7259 (4198 to 12909)
Italy	11414 (2840 to 43608)	-18.8% (-46.2 to -6.8%)	53593 (41492 to 93274)
Abruzzo	29 (6 to 103)	-5% (-15.6 to -1.2%)	548 (507 to 656)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Basilicata	0 (0 to 0)	0% (0 to 0%)	28 (28 to 28)
Calabria	12 (0 to 54)	-9.3% (-35.3 to -0.4%)	109 (96 to 153)
Campania	180 (3 to 1109)	-17.7% (-67.4 to -0.6%)	643 (442 to 1626)
Emilia-Romagna	524 (183 to 1545)	-9.3% (-23.4 to -3.7%)	5379 (4934 to 6581)
Friuli-Venezia Giulia	452 (9 to 3052)	-22.4% (-52.6 to -2.4%)	1348 (388 to 7194)
Lazio	2157 (213 to 12406)	-38.9% (-68.1 to -15.4%)	4301 (1374 to 20065)
Liguria	184 (69 to 567)	-9.3% (-24 to -3.9%)	1903 (1750 to 2406)
Lombardia	1630 (312 to 7450)	-7.3% (-27.8 to -1.8%)	19525 (17681 to 26987)
Marche	400 (33 to 1999)	-13.4% (-32.4 to -2.8%)	2357 (1153 to 8319)
Molise	24 (0 to 178)	-25.6% (-83 to -1.3%)	49 (24 to 206)
Piemonte	743 (215 to 2604)	-12.7% (-34.3 to -4.6%)	5319 (4656 to 7605)
Provincia autonoma di Bolzano	451 (28 to 1549)	-29.9% (-51.5 to -7.6%)	1294 (368 to 4953)
Provincia autonoma di Trento	201 (15 to 1306)	-20% (-63.7 to -3.3%)	693 (449 to 2007)
Puglia	60 (17 to 159)	-8.5% (-19.7 to -2.8%)	680 (617 to 810)
Sardegna	171 (1 to 1246)	-23% (-84.7 to -0.5%)	320 (134 to 1444)
Sicilia	2513 (32 to 23857)	-55.5% (-92.5 to -9.8%)	3053 (326 to 25558)
Toscana	188 (42 to 833)	-11.3% (-37.6 to -3.3%)	1452 (1254 to 2215)
Umbria	59 (1 to 431)	-20.9% (-77 to -1%)	146 (80 to 564)
Valle d'Aosta	10 (-17 to 46)	-4.6% (-13.9 to 3.6%)	232 (160 to 541)
Veneto	1424 (438 to 4813)	-30.2% (-59.1 to -14.5%)	4214 (3018 to 8085)
Luxembourg	222 (2 to 1798)	-32.2% (-79.7 to -1.5%)	410 (131 to 2217)
Malta	0 (0 to 0)	-0.2% (-0.7 to 0%)	11 (10 to 12)
Netherlands	23283 (2449 to 70697)	-55.2% (-77 to -23.8%)	37734 (10128 to 112518)
Norway	1 (0 to 3)	-0.3% (-0.9 to -0.1%)	273 (269 to 283)
Portugal	4040 (842 to 16130)	-40.6% (-63.7 to -22.2%)	8625 (3616 to 26575)
San Marino	2 (1 to 6)	-4% (-12.5 to -1.3%)	46 (44 to 51)
Spain	2172 (842 to 4217)	-3.4% (-5 to -2%)	62759 (40401 to 114006)
Andalucia	233 (9 to 943)	-3.2% (-7.3 to -0.5%)	7248 (1728 to 30953)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Aragon	304 (32 to 568)	-8.7% (-13.5 to -2%)	3309 (1515 to 5909)
Asturias	108 (3 to 357)	-6.1% (-13.1 to -0.8%)	1622 (368 to 6480)
Balearic Islands	41 (0 to 237)	-3.5% (-10.3 to -0.1%)	820 (242 to 5117)
Basque Country	62 (10 to 177)	-1.8% (-3.8 to -0.5%)	3233 (1888 to 7052)
Canary Islands	88 (1 to 672)	-10.8% (-32.6 to -0.6%)	456 (182 to 2132)
Cantabria	3 (-14 to 20)	-0.8% (-2.6 to 1.4%)	526 (260 to 1404)
Castile and Leon	49 (-8 to 137)	-1.3% (-2.9 to 0.2%)	3825 (2493 to 7854)
Castilla-La Mancha	76 (11 to 238)	-1.5% (-3.6 to -0.3%)	4438 (3274 to 9137)
Catalonia	140 (-16 to 556)	-1.3% (-3.7 to 0.1%)	10137 (6343 to 29466)
Community of Madrid	543 (114 to 1101)	-3.3% (-5.5 to -1%)	15711 (11045 to 25243)
Extremadura	139 (22 to 305)	-7.2% (-11.1 to -2.8%)	1840 (735 to 5117)
Galicia	289 (18 to 562)	-5.4% (-8.6 to -1.2%)	6021 (895 to 16290)
La Rioja	42 (3 to 90)	-4.4% (-8.3 to -0.7%)	876 (399 to 2053)
Murcia	24 (1 to 287)	-3.7% (-22.4 to -0.3%)	255 (162 to 1135)
Navarre	24 (2 to 113)	-2.2% (-6.2 to -0.3%)	883 (574 to 2814)
Valencian Community	7 (1 to 22)	-0.4% (-1.3 to -0.1%)	1558 (1514 to 1642)
Sweden	5877 (723 to 33748)	-34.7% (-80.9 to -10.3%)	12630 (7010 to 43042)
Switzerland	6062 (523 to 29072)	-55.7% (-91 to -19.4%)	8494 (2693 to 32047)
United Kingdom	11576 (2407 to 41847)	-14.4% (-39.2 to -4%)	72058 (59867 to 109943)
England	6788 (836 to 32436)	-10.5% (-38.5 to -1.7%)	57268 (50309 to 83352)
Northern Ireland	513 (14 to 2526)	-18% (-48.9 to -1.6%)	2035 (899 to 8106)
Scotland	2183 (114 to 10057)	-20.5% (-51.4 to -2.6%)	7953 (4417 to 23462)
Wales	2093 (423 to 9185)	-36.5% (-74.8 to -13.8%)	4803 (3051 to 12082)
Latin America and Caribbean	37504 (25393 to 53623)	-7.2% (-9.9 to -5%)	516699 (480313 to 573553)
Andean Latin America	770 (551 to 979)	-1% (-1.3 to -0.8%)	74343 (71361 to 77374)
Bolivia (Plurinational State of)	300 (147 to 463)	-4.2% (-5.8 to -2.4%)	7029 (6055 to 8255)
Ecuador	296 (217 to 367)	-1.4% (-1.7 to -1%)	21830 (20856 to 22758)
Peru	174 (108 to 258)	-0.4% (-0.6 to -0.2%)	45484 (43143 to 47828)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Caribbean	2837 (224 to 8748)	-15.2% (-37.7 to -1.9%)	16272 (7722 to 30615)
Bahamas	3 (0 to 31)	-2% (-12.5 to -0.1%)	83 (42 to 254)
Barbados	0 (0 to 0)	0% (0 to 0%)	8 (8 to 8)
Belize	8 (0 to 62)	-4.1% (-37.3 to -0.1%)	107 (12 to 769)
Cuba	0 (0 to 0)	0% (0 to 0%)	91 (89 to 94)
Dominican Republic	162 (-30 to 356)	-2.2% (-4.4 to 0.3%)	8068 (3761 to 14541)
Guyana	20 (0 to 85)	-5.6% (-22.2 to 0%)	263 (35 to 1350)
Haiti	2536 (9 to 8390)	-65.3% (-91 to -4.3%)	3315 (222 to 11298)
Jamaica	43 (0 to 441)	-3.7% (-33.6 to 0%)	324 (17 to 3744)
Puerto Rico	52 (13 to 91)	-1.6% (-2.5 to -0.9%)	3448 (912 to 7194)
Suriname	4 (-9 to 10)	-1.3% (-4.1 to 1.1%)	458 (147 to 961)
Trinidad and Tobago	3 (0 to 35)	-1.3% (-14.7 to 0%)	40 (21 to 115)
United States Virgin Islands	5 (0 to 22)	-6.7% (-15.8 to 0%)	68 (11 to 350)
Central Latin America	10228 (4278 to 20014)	-4.4% (-8.1 to -1.8%)	230480 (200713 to 277348)
Colombia	-5432 (-9115 to -3011)	10.8% (6.6 to 16.9%)	50114 (41136 to 59430)
Costa Rica	213 (80 to 405)	-6.8% (-12.4 to -1.8%)	3573 (1229 to 7714)
El Salvador	296 (104 to 620)	-8.2% (-14 to -4.1%)	3756 (1438 to 8258)
Guatemala	365 (139 to 737)	-4.7% (-7.3 to -2.8%)	7500 (4493 to 11832)
Honduras	339 (6 to 1100)	-8.8% (-19.9 to -0.3%)	3250 (1719 to 6566)
Mexico	11813 (7537 to 17383)	-8.2% (-12.1 to -5.5%)	143326 (126904 to 163923)
Aguascalientes	249 (165 to 378)	-17.5% (-28.5 to -10.3%)	1454 (988 to 1854)
Baja California	136 (24 to 243)	-2.4% (-4.3 to -0.4%)	5688 (4567 to 6842)
Baja California Sur	59 (17 to 96)	-7.8% (-12 to -3.4%)	751 (445 to 1111)
Campeche	50 (19 to 79)	-3.5% (-5.4 to -1.9%)	1422 (926 to 1822)
Chiapas	201 (40 to 688)	-12.1% (-29.9 to -3.5%)	1461 (1128 to 2388)
Chihuahua	114 (-101 to 280)	-3.6% (-8.3 to 2.2%)	3412 (2089 to 4950)
Coahuila	-22 (-210 to 90)	0.4% (-3 to 4.9%)	3547 (2010 to 4973)
Colima	123 (60 to 177)	-11.8% (-17.2 to -7.6%)	1058 (626 to 1485)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Durango	368 (20 to 814)	-24.4% (-38.1 to -4.4%)	1384 (464 to 2828)
Guanajuato	1292 (79 to 2490)	-21.5% (-35.7 to -4.3%)	5806 (1819 to 11217)
Guerrero	332 (101 to 624)	-8% (-13.9 to -1.9%)	4258 (2848 to 6945)
Hidalgo	-303 (-688 to -54)	7.9% (1.3 to 17.8%)	3839 (2994 to 4716)
Jalisco	1164 (480 to 1915)	-15.2% (-23.1 to -9.2%)	7685 (4015 to 12106)
Mexico	3193 (1835 to 4891)	-16.6% (-22.9 to -11.8%)	19063 (14149 to 25313)
Mexico City	253 (-188 to 556)	-1.5% (-3.4 to 1%)	17385 (15277 to 20112)
Michoacan de Ocampo	255 (66 to 447)	-5.8% (-10.3 to -1.1%)	4615 (2838 to 6901)
Morelos	-101 (-391 to 72)	4.3% (-2.6 to 14.8%)	2367 (1417 to 3828)
Nayarit	96 (-9 to 203)	-6.3% (-12.4 to 0.6%)	1540 (935 to 2272)
Nuevo Leon	-19 (-239 to 142)	0.2% (-2.4 to 3.3%)	6202 (3850 to 8277)
Oaxaca	585 (316 to 907)	-14.8% (-21.5 to -9.5%)	3961 (2524 to 5680)
Puebla	580 (315 to 895)	-7.2% (-11.2 to -3.8%)	8202 (5675 to 10584)
Queretaro	115 (7 to 222)	-5.4% (-10.1 to -0.3%)	2212 (1251 to 3357)
Quintana Roo	-1 (-59 to 37)	0% (-1.4 to 2.1%)	2776 (2413 to 3213)
San Luis Potosi	117 (-59 to 254)	-4.1% (-8.5 to 1.4%)	3152 (1543 to 4610)
Sinaloa	464 (105 to 906)	-10.7% (-17.5 to -3.4%)	4158 (3082 to 5636)
Sonora	113 (3 to 434)	-3.4% (-10.5 to -0.1%)	2987 (2551 to 4237)
Tabasco	196 (134 to 268)	-5% (-6.6 to -3.6%)	3915 (3461 to 4405)
Tamaulipas	168 (18 to 354)	-4.3% (-9.3 to -0.7%)	4159 (2110 to 6819)
Tlaxcala	212 (124 to 322)	-12.5% (-17.6 to -8.4%)	1691 (1302 to 2129)
Veracruz de Ignacio de la Llave	1436 (672 to 2519)	-15.9% (-22.6 to -10.5%)	8908 (6002 to 12896)
Yucatan	15 (-24 to 42)	-0.5% (-1.5 to 0.7%)	2971 (2018 to 3895)
Zacatecas	372 (66 to 787)	-26.9% (-40.9 to -11.1%)	1297 (605 to 2307)
Nicaragua	753 (187 to 2822)	-59.5% (-81.5 to -39.6%)	1156 (419 to 3664)
Panama	80 (44 to 132)	-1.7% (-2.7 to -1%)	4642 (3566 to 5919)
Venezuela (Bolivarian Republic of)	1802 (306 to 4744)	-14.5% (-22.7 to -8.8%)	13163 (2198 to 42916)
Tropical Latin America	23670 (16514 to 32318)	-12.1% (-15.1 to -9.1%)	195605 (177261 to 216305)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Brazil	22980 (16107 to 31013)	-11.9% (-14.9 to -9.1%)	192567 (172939 to 213949)
Acre	30 (9 to 59)	-4% (-7.1 to -1.4%)	729 (656 to 830)
Alagoas	143 (82 to 216)	-6% (-8.4 to -3.8%)	2355 (2179 to 2569)
Amapa	70 (26 to 126)	-8.4% (-13.7 to -3.6%)	819 (719 to 932)
Amazonas	689 (277 to 1344)	-12.5% (-20.5 to -6.4%)	5340 (4291 to 6750)
Bahia	3701 (2163 to 5740)	-23.1% (-30.5 to -16%)	15826 (12202 to 20682)
Ceara	252 (86 to 578)	-2.6% (-5.6 to -1%)	9386 (8799 to 10382)
Distrito Federal	85 (56 to 126)	-2.2% (-3 to -1.6%)	3872 (3330 to 4509)
Espirito Santo	513 (326 to 772)	-10.9% (-14.5 to -7.9%)	4659 (4059 to 5429)
Goias	1054 (300 to 1712)	-15% (-21.3 to -7.7%)	6888 (3846 to 10016)
Maranhao	120 (60 to 223)	-3.1% (-5.3 to -1.6%)	3870 (3685 to 4137)
Mato Grosso	208 (110 to 330)	-5.6% (-7.9 to -3.4%)	3656 (3217 to 4392)
Mato Grosso do Sul	379 (197 to 600)	-19% (-25 to -13.1%)	1971 (1444 to 2668)
Minas Gerais	4156 (1787 to 7668)	-26.3% (-35.1 to -17.5%)	15470 (9735 to 23790)
Para	306 (59 to 889)	-4.2% (-10.9 to -0.9%)	7002 (6314 to 8226)
Paraiba	473 (267 to 887)	-11.7% (-17.8 to -8.1%)	3975 (3313 to 5110)
Parana	711 (269 to 1448)	-12% (-18.3 to -6.1%)	5686 (4357 to 8096)
Pernambuco	1081 (575 to 1983)	-10.3% (-16.3 to -6.2%)	10358 (9119 to 12465)
Piaui	212 (76 to 372)	-8.4% (-13 to -3.7%)	2451 (2064 to 2919)
Rio de Janeiro	2573 (566 to 5619)	-10% (-17.6 to -3.3%)	24472 (17382 to 34146)
Rio Grande do Norte	163 (17 to 444)	-5.7% (-12.7 to -0.7%)	2701 (2264 to 3492)
Rio Grande do Sul	1071 (255 to 2297)	-15.6% (-24.9 to -6%)	6485 (4277 to 9733)
Rondonia	82 (33 to 156)	-5.5% (-9.2 to -2.6%)	1453 (1257 to 1769)
Roraima	35 (7 to 65)	-4.9% (-8.3 to -1.2%)	707 (625 to 804)
Santa Catarina	835 (210 to 1788)	-16.1% (-25.5 to -6.8%)	4887 (3075 to 7767)
Sao Paulo	3721 (1565 to 6722)	-8.3% (-12.8 to -4.4%)	43949 (35894 to 56669)
Sergipe	78 (36 to 123)	-3.4% (-5 to -1.8%)	2238 (2051 to 2500)
Tocantins	240 (95 to 385)	-17.3% (-22.7 to -10.6%)	1365 (886 to 1885)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Paraguay	690 (149 to 1616)	-23.1% (-34.5 to -13.5%)	3038 (902 to 8437)
North Africa and Middle East	124534 (70240 to 225566)	-48.1% (-60.5 to -37.6%)	253851 (177663 to 398457)
Afghanistan	4415 (125 to 21891)	-45.9% (-86.8 to -7.8%)	6643 (1596 to 29983)
Algeria	11791 (3936 to 30808)	-78.4% (-92.2 to -61.9%)	14313 (6230 to 33896)
Bahrain	369 (149 to 806)	-52.4% (-70.9 to -35.3%)	672 (411 to 1193)
Egypt	4910 (1868 to 16575)	-41.5% (-72.4 to -24.5%)	10803 (7569 to 22541)
Iran (Islamic Republic of)	35201 (20644 to 63386)	-49.2% (-62.4 to -37.7%)	70238 (52788 to 103293)
Iraq	15293 (9647 to 22648)	-46.9% (-57.7 to -37%)	32454 (24889 to 45236)
Jordan	448 (0 to 9494)	-6.7% (-98.3 to 0%)	497 (12 to 9530)
Kuwait	354 (107 to 801)	-29.8% (-47.4 to -14.3%)	1117 (732 to 1763)
Lebanon	221 (20 to 733)	-38.8% (-69.7 to -8.9%)	471 (222 to 1095)
Libya	3678 (1320 to 6985)	-76.7% (-88 to -62.5%)	4789 (1753 to 9222)
Morocco	4642 (-1692 to 9591)	-21.1% (-39.4 to 4%)	25438 (11257 to 46725)
Oman	501 (332 to 748)	-15.8% (-26.2 to -8.1%)	3302 (2035 to 4788)
Palestine	1853 (820 to 3022)	-61.2% (-81.2 to -29.2%)	3225 (1219 to 6136)
Qatar	302 (0 to 1205)	-24.9% (-62.3 to 0%)	716 (196 to 2324)
Saudi Arabia	7691 (4241 to 12879)	-38.6% (-50.7 to -28.2%)	19591 (14083 to 27591)
Sudan	3444 (717 to 11761)	-69.8% (-92 to -43.9%)	4448 (1653 to 12853)
Syrian Arab Republic	1455 (-1737 to 4381)	-28.4% (-57.5 to 8.8%)	8355 (1003 to 28240)
Tunisia	3547 (6 to 24378)	-70.5% (-98.8 to -6.2%)	3729 (105 to 24591)
Turkey	23128 (7823 to 57393)	-56.9% (-75.8 to -38.7%)	37993 (19853 to 78767)
United Arab Emirates	1005 (250 to 2349)	-27.2% (-44.4 to -10.3%)	4152 (1070 to 11276)
Yemen	288 (27 to 1383)	-24.8% (-67.8 to -4.4%)	906 (617 to 2041)
South Asia	216549 (100735 to 392702)	-27% (-35.8 to -18.9%)	794413 (484774 to 1325944)
Bangladesh	43206 (14774 to 98187)	-71.1% (-83.9 to -55.3%)	58297 (25558 to 121943)
India	158832 (75152 to 282838)	-22.5% (-30.7 to -14.9%)	703364 (431127 to 1173219)
Andhra Pradesh	2379 (-1672 to 4927)	-7.2% (-16.2 to 3.4%)	36635 (23600 to 54621)
Arunachal Pradesh	300 (0 to 1325)	-40.6% (-98.9 to -0.4%)	492 (8 to 1735)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Assam	5248 (2212 to 9030)	-30.9% (-49.5 to -8.3%)	19529 (6619 to 37744)
Bihar	24344 (1648 to 74027)	-72.4% (-87.6 to -54.8%)	32362 (2913 to 100770)
Chhattisgarh	2538 (213 to 4418)	-17.3% (-33.6 to -0.7%)	18305 (6076 to 34827)
Delhi	2299 (945 to 5317)	-25.7% (-40.3 to -15%)	8522 (6051 to 14860)
Goa	297 (199 to 390)	-19.5% (-28 to -10.4%)	1563 (1061 to 2029)
Gujarat	5945 (1814 to 17281)	-41.5% (-60.9 to -25.6%)	13314 (6658 to 29470)
Haryana	5260 (2419 to 9633)	-35.8% (-49 to -21.7%)	15107 (7050 to 28373)
Himachal Pradesh	1635 (44 to 6071)	-60% (-80.3 to -31.3%)	2581 (140 to 10776)
Jammu & Kashmir and Ladakh	3392 (1796 to 5393)	-43.8% (-58.6 to -32%)	7782 (4469 to 12519)
Jharkhand	3878 (1597 to 6240)	-23.3% (-40.3 to -5.5%)	19114 (5975 to 34217)
Karnataka	107 (-4501 to 2826)	-0.7% (-7.3 to 8%)	45119 (27297 to 68596)
Kerala	1351 (97 to 2712)	-8.2% (-15 to -0.2%)	21021 (6293 to 50017)
Madhya Pradesh	22319 (6449 to 47305)	-58.7% (-73.5 to -46.4%)	37537 (12689 to 83736)
Maharashtra	143 (-6264 to 4200)	-0.4% (-4.9 to 5.2%)	100542 (77736 to 129249)
Manipur	933 (234 to 1745)	-43.5% (-78.5 to -5.1%)	2621 (723 to 4765)
Meghalaya	168 (0 to 1078)	-8.1% (-58.1 to -0.1%)	771 (8 to 3612)
Nagaland	0 (0 to 0)	-0.2% (-0.4 to -0.1%)	8 (8 to 9)
Odisha	5463 (2020 to 9416)	-23.3% (-38 to -4.2%)	27328 (9552 to 54951)
Punjab	1386 (-913 to 2787)	-7.5% (-17 to 3%)	21415 (11810 to 33224)
Rajasthan	12962 (3658 to 35725)	-66.1% (-81.3 to -49.4%)	18581 (6866 to 46819)
Tamil Nadu	8089 (2076 to 15881)	-14.4% (-24.6 to -2.6%)	59039 (31558 to 98024)
Telangana	3694 (666 to 11479)	-52.9% (-73.2 to -32.5%)	6405 (1913 to 16536)
Tripura	815 (485 to 1121)	-23.7% (-43.1 to -9.4%)	3733 (2188 to 5269)
Uttar Pradesh	36143 (16879 to 62750)	-33.1% (-47.5 to -14.3%)	116309 (48420 to 215109)
Uttarakhand	720 (60 to 1329)	-14.3% (-32.3 to -0.6%)	6737 (986 to 13967)
West Bengal	7022 (-19 to 12481)	-13.2% (-24.2 to 0%)	60895 (29712 to 107570)
Nepal	5341 (1607 to 10032)	-41% (-65.8 to -11%)	15455 (3199 to 33368)
Pakistan	9170 (2600 to 32238)	-47.5% (-73.8 to -27%)	17297 (9490 to 45445)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Azad Jammu & Kashmir	1312 (0 to 3255)	-66.2% (-96.6 to -0.5%)	1781 (64 to 4302)
Balochistan	884 (0 to 5894)	-49.6% (-94.6 to -0.3%)	1091 (141 to 6891)
Gilgit-Baltistan	349 (72 to 912)	-72.9% (-89.7 to -46.9%)	451 (152 to 1054)
Islamabad Capital Territory	503 (233 to 776)	-49.8% (-66.8 to -25.3%)	1038 (516 to 1633)
Khyber Pakhtunkhwa	215 (27 to 920)	-12.4% (-40 to -2.1%)	1510 (1298 to 2373)
Punjab	479 (51 to 2398)	-14% (-50.1 to -2.2%)	2728 (2265 to 4628)
Sindh	5428 (975 to 23812)	-52.6% (-83.4 to -26.4%)	8697 (3709 to 31172)
Southeast Asia, East Asia, and Oceania	5600 (1897 to 11136)	-6.6% (-14.4 to -1.3%)	95856 (43874 to 175366)
East Asia	2119 (1 to 6399)	-20.2% (-66.6 to -0.8%)	16367 (173 to 45930)
China	2118 (0 to 6398)	-20.1% (-66.7 to -0.2%)	16357 (164 to 45920)
Beijing	0 (0 to 0)	0% (-0.1 to 0%)	10 (10 to 10)
Chongqing	0 (0 to 0)	0% (-0.1 to 0%)	7 (6 to 7)
Guangdong	0 (0 to 0)	-0.1% (-0.1 to 0%)	10 (10 to 10)
Hainan	0 (0 to 0)	0% (-0.1 to 0%)	7 (7 to 7)
Hebei	0 (0 to 0)	0% (-0.1 to 0%)	7 (7 to 7)
Heilongjiang	0 (0 to 0)	0% (0 to 0%)	15 (14 to 15)
Hong Kong Special Administrative Region of China	2118 (0 to 6398)	-20.8% (-70.7 to -0.2%)	16286 (92 to 45848)
Shandong	0 (0 to 0)	-0.1% (-0.1 to 0%)	9 (9 to 9)
Shanghai	0 (0 to 0)	-0.1% (-0.1 to 0%)	8 (8 to 8)
Taiwan (Province of China)	2 (0 to 5)	-15.3% (-35.7 to -5.7%)	9 (8 to 13)
Oceania	0 (0 to 1)	-1.1% (-5.9 to 0%)	9 (7 to 14)
Guam	0 (0 to 1)	-1.1% (-5.9 to 0%)	9 (7 to 14)
Southeast Asia	3480 (410 to 6914)	-5.2% (-12.6 to -0.3%)	79480 (40114 to 139194)
Indonesia	3238 (1690 to 6213)	-20.6% (-30.9 to -13.9%)	15271 (11804 to 20779)
Malaysia	0 (0 to 0)	0% (0 to 0%)	123 (123 to 124)
Maldives	97 (34 to 171)	-47.1% (-69.2 to -26.4%)	214 (80 to 385)
Mauritius	0 (0 to 0)	0% (0 to 0%)	11 (11 to 11)
Myanmar	0 (0 to 0)	-0.1% (-0.2 to 0%)	7 (7 to 7)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Philippines	145 (-2641 to 1689)	-0.8% (-4.4 to 2.6%)	63785 (23465 to 125601)
Sri Lanka	0 (0 to 0)	-0.1% (-0.3 to 0%)	12 (11 to 13)
Thailand	0 (0 to 0)	0% (0 to 0%)	57 (57 to 58)
Sub-Saharan Africa	46883 (19950 to 88259)	-40.1% (-53.9 to -28.4%)	115886 (58348 to 198596)
Central Sub-Saharan Africa	677 (183 to 1735)	-37.2% (-59.7 to -19.1%)	1705 (966 to 2926)
Angola	48 (7 to 136)	-19.6% (-38.2 to -5.1%)	219 (135 to 381)
Central African Republic	0 (0 to 0)	0% (-0.1 to 0%)	61 (60 to 61)
Congo	135 (1 to 704)	-31.1% (-71.8 to -0.8%)	286 (93 to 1033)
Democratic Republic of the Congo	246 (70 to 723)	-38.1% (-66.7 to -18.8%)	581 (368 to 1114)
Equatorial Guinea	248 (19 to 476)	-47.3% (-66.8 to -15.4%)	501 (125 to 940)
Gabon	0 (0 to 1)	-0.2% (-0.8 to 0%)	56 (55 to 60)
Eastern Sub-Saharan Africa	36329 (14053 to 69160)	-48% (-66.1 to -30.6%)	78765 (27000 to 151857)
Comoros	0 (0 to 0)	0% (-0.1 to 0%)	7 (7 to 7)
Djibouti	0 (0 to 0)	0% (0 to 0%)	59 (59 to 60)
Ethiopia	28639 (9671 to 51209)	-60.6% (-78.8 to -40%)	48905 (16095 to 92152)
Kenya	2700 (100 to 10740)	-52.7% (-77.9 to -13.4%)	4355 (766 to 14289)
Madagascar	290 (8 to 1413)	-23.6% (-46 to -3.4%)	939 (229 to 3487)
Malawi	128 (3 to 516)	-25.9% (-59.4 to -1.7%)	381 (196 to 869)
Mozambique	3 (0 to 27)	-8.8% (-46.4 to -0.5%)	28 (22 to 57)
Rwanda	1074 (11 to 6945)	-66.4% (-88.5 to -24.7%)	1473 (42 to 10664)
Somalia	0 (0 to 0)	0% (0 to 0%)	92 (92 to 92)
South Sudan	0 (0 to 0)	0% (0 to 0%)	47 (46 to 47)
Uganda	-108 (-5317 to 2423)	-5.1% (-35 to 23.1%)	17925 (1519 to 43838)
United Republic of Tanzania	3569 (832 to 11986)	-80.4% (-94.4 to -63.4%)	4182 (1312 to 12706)
Zambia	32 (0 to 113)	-7.5% (-20.8 to -0.1%)	373 (281 to 545)
Southern Sub-Saharan Africa	1935 (766 to 3645)	-8.2% (-13 to -4.2%)	22913 (18441 to 28851)
Eswatini	67 (26 to 119)	-19.3% (-26.6 to -12.5%)	337 (199 to 502)
Lesotho	145 (1 to 473)	-26.9% (-48.2 to -1.3%)	447 (43 to 1546)

Location	Lives saved (95% UI)	Percent difference in deaths (95% UI)	Cumulative deaths in reference scenario (95% UI)
Namibia	290 (79 to 545)	-30.3% (-43.8 to -19.9%)	987 (297 to 2073)
South Africa	1360 (434 to 2792)	-6.3% (-11 to -2.5%)	20680 (16918 to 25940)
Zimbabwe	73 (5 to 287)	-13% (-25.9 to -2.4%)	461 (220 to 1137)
Western Sub-Saharan Africa	7941 (2767 to 21231)	-59.6% (-80.7 to -40.3%)	12504 (6801 to 26726)
Benin	0 (0 to 0)	-0.1% (-0.3 to 0%)	41 (40 to 42)
Burkina Faso	0 (0 to 1)	-0.2% (-1 to -0.1%)	59 (58 to 61)
Cabo Verde	204 (0 to 615)	-47.1% (-91 to -0.5%)	331 (42 to 898)
Cameroon	149 (7 to 709)	-21% (-59.4 to -1.6%)	588 (426 to 1183)
Chad	0 (0 to 0)	0% (-0.1 to 0%)	74 (74 to 75)
Cote d'Ivoire	431 (69 to 1811)	-65.5% (-91 to -34.7%)	578 (197 to 1948)
Gambia	527 (111 to 1007)	-51.9% (-71.8 to -28.9%)	985 (342 to 1767)
Ghana	3168 (148 to 13458)	-70.4% (-91 to -32.3%)	3994 (469 to 15532)
Guinea	1261 (0 to 7123)	-71.9% (-98.3 to -0.3%)	1370 (57 to 7761)
Guinea-Bissau	297 (2 to 1158)	-54.6% (-90.8 to -4.1%)	396 (49 to 1498)
Liberia	26 (0 to 394)	-5.6% (-80 to 0%)	109 (80 to 483)
Mali	0 (0 to 0)	0% (-0.1 to 0%)	128 (127 to 130)
Mauritania	0 (0 to 0)	0% (0 to 0%)	157 (157 to 158)
Niger	0 (0 to 0)	0% (0 to 0%)	70 (69 to 70)
Nigeria	471 (140 to 1001)	-28% (-45.6 to -11.4%)	1608 (1214 to 2233)
Sao Tome and Principe	10 (0 to 80)	-21.4% (-78.2 to -0.2%)	26 (15 to 100)
Senegal	1239 (284 to 4326)	-65.6% (-87.3 to -42.9%)	1723 (634 to 5065)
Sierra Leone	0 (0 to 0)	-0.1% (-0.1 to 0%)	69 (69 to 70)
Togo	158 (0 to 1242)	-39.2% (-94.4 to -0.1%)	199 (27 to 1362)

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Code Availability Statement

Our study follows the Guidelines for Accurate and Transparent Health Estimate Reporting. All code used for these analyses is publicly available online (http://github.com/ihmeuw/).

Online content

Results for each scenario are accessible through a visualization tool at http://covid19.healthdata.org. The estimates presented in this tool will be iteratively updated as new data are incorporated and will ultimately supersede the results in this paper.

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Competing interests

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