Coronavirus Disease (COVID-19) – Statistics and Research

by Max Roser, Hannah Ritchie and Esteban Ortiz-Ospina

We thank Bernadeta Dadonaite, Jason Hendry, and Moritz Kraemer for helpful comments and suggestions on earlier versions of this work.
We also thank Tom Chivers for editorial review and feedback.

Cite this research

*Note: To inform yourself and understand the risk to the public we recommend to rely on your government body responsible for health and the World Health Organization – **their site is here**.*

The mission of *Our World in Data* is to make data and research on the world's largest problems understandable and accessible.

Read more about our mission →

While most of our work focuses on large problems that humanity has faced for a long time – such as child mortality, natural disasters, poverty and almost 100 other problems (see here) – this article focuses on a new, emerging global problem: the ongoing outbreak of the coronavirus disease [COVID-19].

The outbreak started in late 2019 and developed into a global pandemic by March 2020.

This article covers a developing situation and the Our World in Data team is regularly updating it: **The last update was made on March 24, 2020** (11:30 London time).

About this page

Limitations of current research and limitations of our presentation of current research

The purpose of this article on COVID-19 is to aggregate existing research, bring together the relevant data and allow readers to make sense of the published data and early research on the coronavirus outbreak.

Most of our work focuses on established problems, for which we can refer to well-established research and data. COVID-19 is different. All data and research on the virus is preliminary; researchers are rapidly learning more about a new and evolving problem. It is certain that the research we present here will be revised in the future. But based on our mission we feel it is our role to present clearly what the current research and data tells us about this emerging problem and especially to provide an understanding of what can and cannot be said based on this available knowledge.

As always in our work, one important strategy of dealing with this problem is to always link to the underlying original research and data so that everyone can understand how this data was produced and how we arrive at the statements we make. But scrutiny of all reported research and data is very much required. We welcome your feedback. In the current situation we read and consider all feedback, but can not promise to reply to all.

Our World in Data relies on data from the European CDC

In this document and the associated charts we report and visualize the data from the *European Center for Disease Control and Prevention* (ECDC). Established in 2005 and based in Stockholm it is an EU agency with the aim to strengthen Europe's defense against infectious diseases.

The European CDC publishes daily statistics on the COVID-19 pandemic. Not just for Europe, but for the entire world.

The European CDC collects and aggregates data from countries around the world. The most up-to-date data for any particular country is therefore typically earlier available via the national health agencies than via the ECDC.

This lag between nationally available data and the ECDC data is not very long as the ECDC publishes new data daily. But it can be several hours.

We rely on the ECDC as they collect and harmonize data from around the world which allows us to compare what is happening in different countries. The European CDC data provides a global perspective on the evolving pandemic.

The ECDC makes all their data available in a daily updated clean downloadable file. This gets updated daily reflecting data collected up to 6:00 and 10:00 CET. The data made public via the downloadable data file is published at 1pm CET, and is used to produce a page that gets updated daily under the name Situation Update Worldwide.

Why we stopped relying on data from the World Health Organization

Until March 18 we relied on the World Health Organization (WHO) as our source. We aimed to rely on the WHO as

they are the international agency with the mandate to provide official estimates on the pandemic. The WHO reports this data for each single day and they can be found here at the WHO's site.

Since March 18 it became unfortunately impossible to rely on the WHO data to understand how the pandemic is developing over time. With Situation Report 58 the WHO shifted the reporting cutoff time from 0900 CET to 0000 CET. This means that comparability is compromised because there is an overlap between these two WHO data publications (Situation Reports 57 and 58).

Additionally we found many errors in the data published by the WHO when we went through all the daily Situation Reports. We immediately notified the WHO and are in close contact with the WHO's team to correct the errors that we pointed out to them. We document all errors we found. The main problem we see with the WHO data is that these errors are not communicated by the WHO itself (some Errata were published by the WHO – in the same place as the Situation Reports –, but most errors were either retrospectively corrected without public notice or remain uncorrected).

Here is our detailed documentation of where the WHO's data is sourced from and how we corrected its data – we also provide several options to download all corrected data there. As of March 18 we no longer maintain this database for the reason that the WHO data can not be used for reliable time-series information.

Other data sources on the COVID-19 pandemic

A number of other organizations – including Johns Hopkins University and other research teams – publish their own lists of the number of confirmed cases and deaths. Johns Hopkins also publishes data on 'recovered cases' while the WHO and the ECDC do not.

At the end of this page we link to their visualizations and list links to other data sources.

Deaths from COVID-19

Confirmed deaths to date is what we know

What we know is the total number of confirmed deaths due to COVID-19 *to date*.

The *European Center for Disease Control and Prevention* (ECDC) publishes daily updates of confirmed deaths due to COVID-19. We rely on this data as explained above.

Based on the ECDC data we can track how the number of deaths has changed over time.

In an ongoing outbreak the final outcomes – death or recovery – for all cases is not yet known. The time from symptom onset to death ranges from 2 to 8 weeks for COVID-19.[1] This means that some people who are currently infected with COVID-19 will die at a later date. As we explain below, this needs to be kept in mind when comparing the current number of deaths with the current number of cases.

What does the data on deaths and cases tell us about the mortality risk of COVID-19?

To understand the risks and respond appropriately we would also want to know the mortality risk of COVID-19 – the likelihood that someone who catches the disease will die from it.

We will look into this question in more detail below and explain that this requires us to know (or estimate) the number of total cases and the final number of deaths for a given infected population. Because these are not known, we discuss what the current data can and can not tell us about the risk of death (scroll there).

The growth rate of COVID-19 deaths

How long did it take for the number of confirmed deaths to double?

In the section below we present the latest data on the *number* of confirmed deaths by country.

But in an outbreak of an infectious disease it is important to not only study the number of deaths, but also the **growth rate** at which the number of deaths is increasing.

This is because even if the current numbers of deaths are small when compared with other diseases, a fast growth rate can lead to very large numbers rapidly.

To report the rate of change we focus on the question: How long did it take for the number of confirmed deaths to double?

Let's take an example: if the number of confirmed deaths as of today is 1000, and there were only 500 deaths three days ago then we would say that it took three days for the number of confirmed deaths to double.[2]

The doubling time of deaths has changed and it will change in the future. It would be wrong to extrapolate current growth into the future.[3]

It is important to understand what it means for deaths to double. As long as deaths are doubling at a constant rate the growth is exponential. We humans tend to think in linear growth processes even when the growth is exponential, as

psychological research has shown for decades. Below we give some intuition about exponential growth and provide the referenced psychological research on this.

Understanding exponential growth

It is important to be reminded of the nature of exponential growth because most of us do not grasp exponential growth intuitively.

The visualization **here**, allows you to compare of linear and exponential growth. The numbers shown here do not represent any actual data points: they're simply used an example comparison.

Both lines start at value of 10 at time 0. The linear trend (in blue) increases by 10 at every time increment (10, 20, 30, 40, 50, 60).

The exponential growth line (in red) doubles each increment (10, 20, 40, 80, 160, 320).

Early on in the growth chart the absolute difference remains small, but over time the exponential growth leads to very large numbers – to see this pull the blue time slider below the chart slowly to the right.

If during an outbreak the number of deaths is in fact doubling and this doubling time stays constant, then the outbreak is spreading exponentially.

Under exponential growth 500 deaths grow to more than 1 million deaths after 11 doubling times.[4] And after 10 more doubling times it would be 1 billion deaths.

This is in no way a prediction for the number of deaths we should expect; it is a reminder that exponential growth leads to very large numbers very quickly, even when starting from a low base.

Psychologists find that humans tend to think in linear growth processes (1, 2, 3, 4) even when this is not appropriately describing the reality in front of our eyes. This bias – to "linearize exponential functions when assessing them intuitively" – is referred to as *exponential growth bias*.[5]

Psychological research also shows that "neither special instructions about the nature of exponential growth nor daily experience with growth processes" improved the failure to grasp exponential growth processes.[6]

The global average hides more than it reveals: why we show this data country by country

Some countries – like China and Korea – have very substantial countermeasures in place and new daily confirmed deaths have declined (see the chart here).

Many other countries do not have comparable measures in place and, as the table below shows, numbers are quickly rising.

Because of these large differences between countries it is crucial to not only study the global situation, but the situation in each country. The global average hides these differences.

Growth: Country by country view

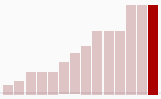
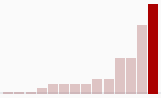
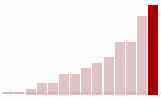
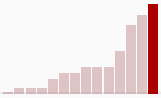
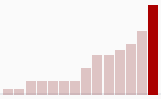
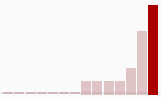
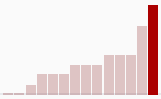
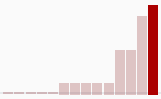
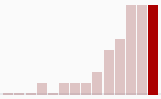
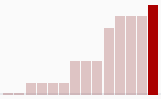
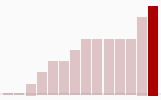
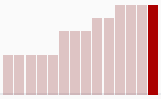
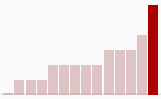
For these reasons the following table focuses on the following question for all countries: How long did it take for the number of confirmed deaths to double?

The table *also* shows how the total number of confirmed deaths, and the number of daily new confirmed deaths has changed over the last 14 days.

You can sort the table by any of the columns by clicking on the column header.

Data: The data shown here is published by the *European Center for Disease Control and Prevention* (ECDC). Here is our documentation of the data and an option to download all data.

Germany	3 days	126 total March 24	+32 new March 24
South Korea	doubled in 13 days	120 total March 24	+7 new March 24
Belgium	doubled in 3 days	88 total March 24	+13 new March 24
Switzerland	doubled in 4 days	66 total March 24	+6 new March 24
Indonesia	doubled in 4 days	49 total March 24	+1 new March 24
Japan	doubled in 10 days	42 total March 24	+1 new March 24
Turkey	doubled in 3 days	37 total March 24	+7 new March 24
Brazil	doubled in 3 days	34 total March 24	+9 new March 24
Philippines	doubled in 6 days	33 total March 24	+8 new March 24
Austria	doubled in 2 days	25 total March 24	+9 new March 24
Sweden	doubled in 4 days	25 total March 24	+4 new March 24
Canada	doubled in 3 days	24 total March 24	+6 new March 24
Denmark	doubled in 3 days	24 total March 24	+11 new March 24
Iraq	doubled in 6 days	23 total March 24	+3 new March 24
Portugal	doubled in 3 days	23 total March 24	+9 new March 24

	doubled in			
San Marino	7 days		20 total March 24	+0 new March 24
Ecuador	2 days		18 total March 24	+4 new March 24
Algeria	4 days		17 total March 24	+2 new March 24
Greece	3 days		17 total March 24	+2 new March 24
Egypt	3 days		14 total March 24	+4 new March 24
Malaysia	2 days		14 total March 24	+4 new March 24
India	2 days		9 total March 24	+2 new March 24
Hungary	2 days		8 total March 24	+1 new March 24
Luxembourg	4 days		8 total March 24	+0 new March 24
Norway	5 days		8 total March 24	+1 new March 24
Poland	7 days		8 total March 24	+1 new March 24
Australia	9 days		7 total March 24	+0 new March 24
Romania	1 day		7 total March 24	+5 new March 24
Ireland	2 days		6 total March 24	+2 new March 24
Pakistan	2 days			

Countries with less than 5 confirmed deaths are not shown. Deaths from the Diamond Princess cruise ship are also not shown since these numbers are no longer changing over time.

Data source: ECDC. Download the full dataset.

Confirmed COVID-19 deaths by country

In our visualizations here you can explore the number of *total* deaths and daily *new* deaths for all countries with reported deaths. This is shown in absolute numbers, and adjusted for population size by showing total and new deaths per million people.

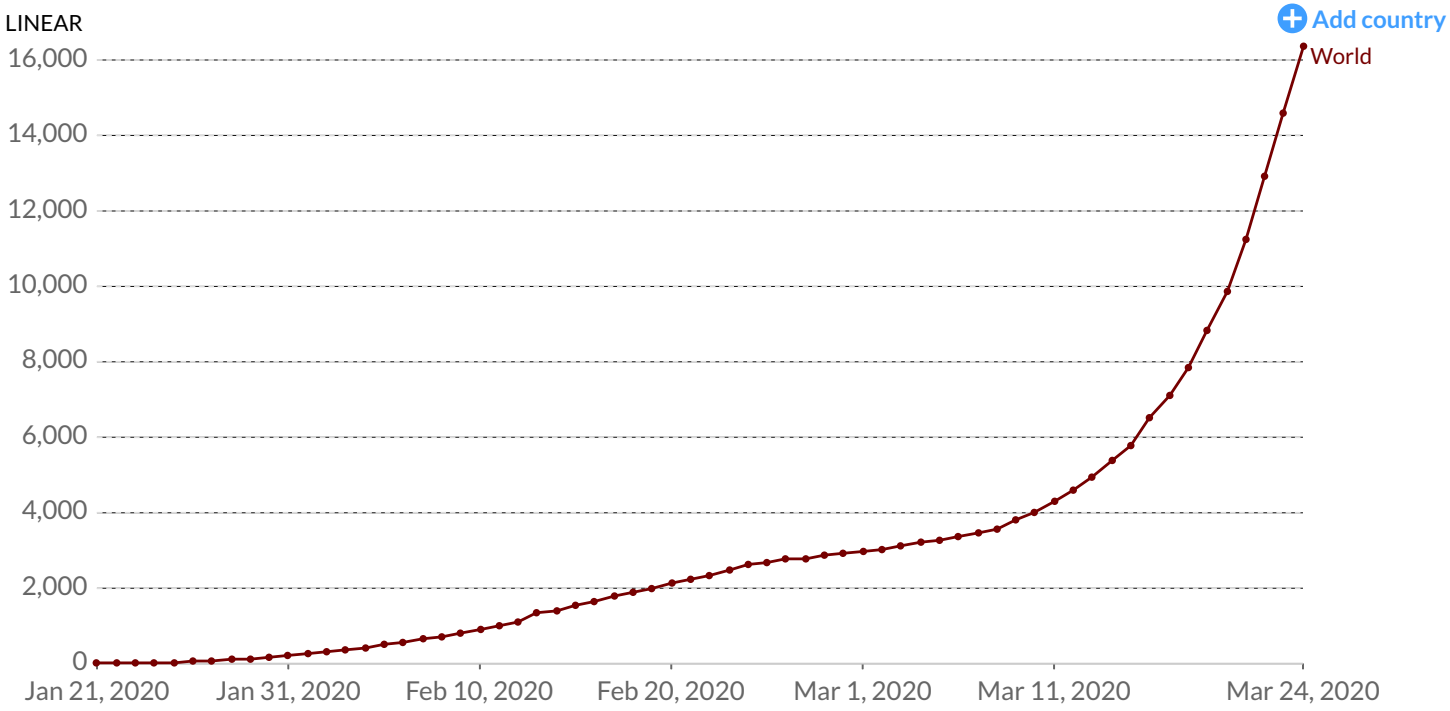
These charts are interactive: the data is shown as the worldwide figures by default but can be explored by country – by clicking on + **Add Country** within the chart.

The data shown here is published by the *European Center for Disease Control and Prevention* (ECDC). Here is the documentation of the data and an option to download all data.

Total confirmed deaths due to COVID-19

Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.

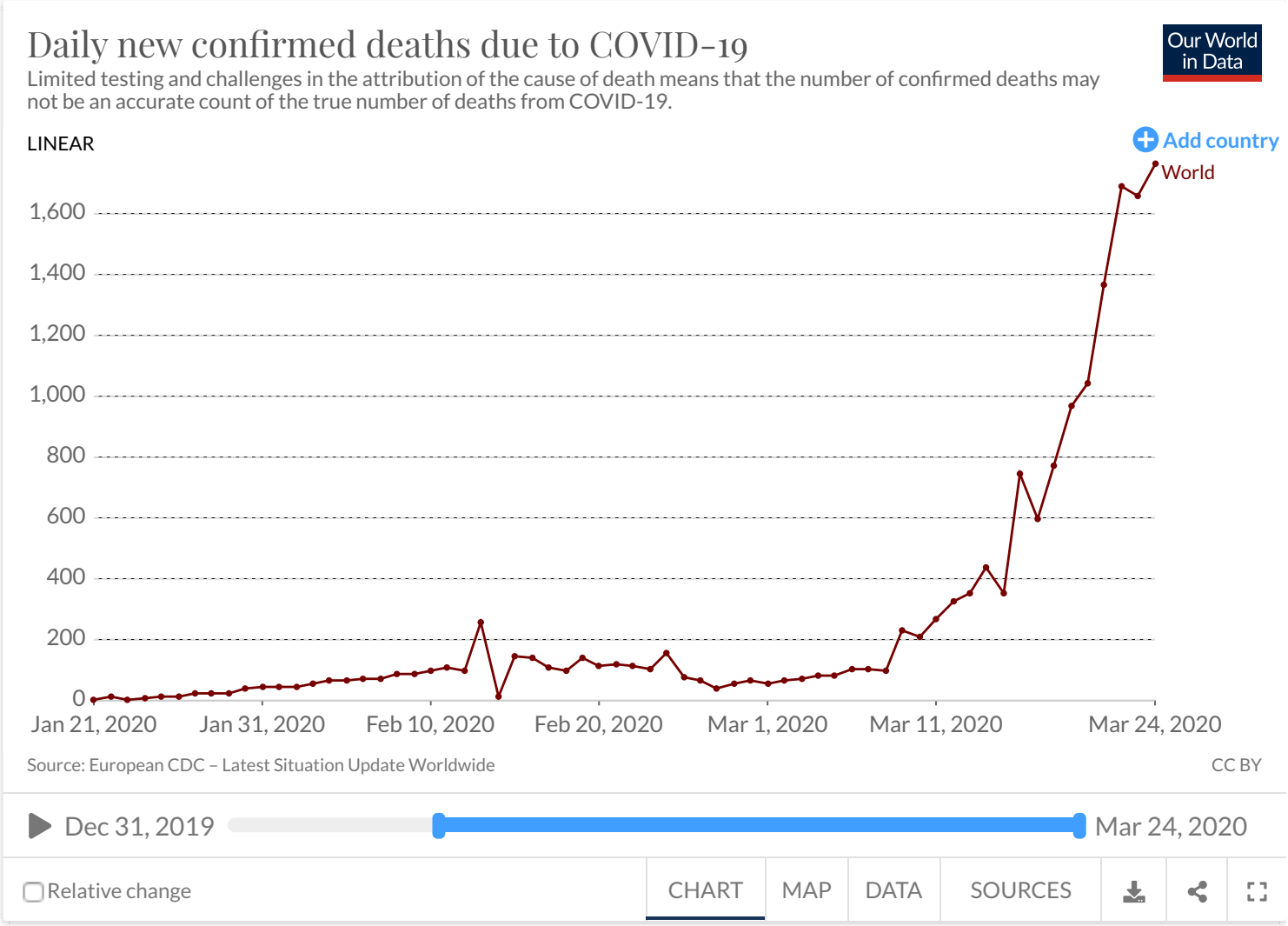
Our World in Data



Source: European CDC – Latest Situation Update Worldwide

Dec 31, 2019 Mar 24, 2020

Relative change CHART MAP DATA SOURCES



Confirmed COVID-19 deaths relative to the size of the population

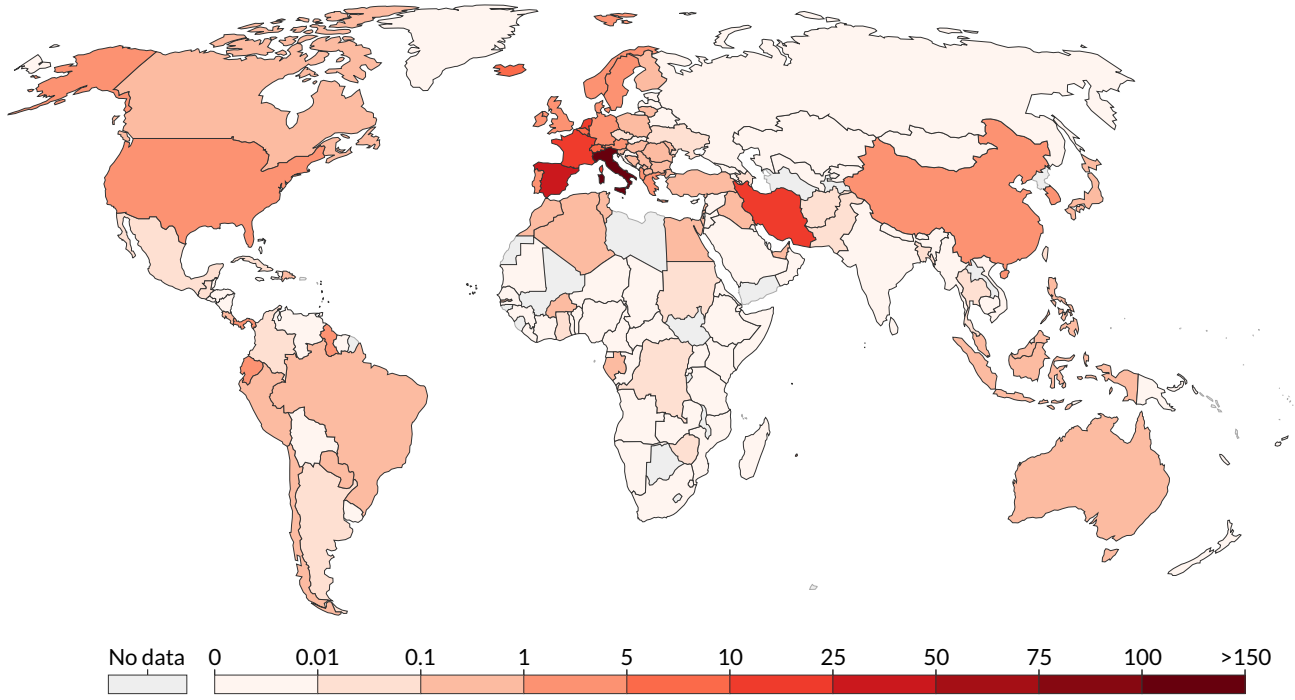
Deaths per million were calculated by *Our World in Data* based by dividing these death numbers from the *European Center for Disease Control and Prevention* (ECDC) by population figures published in the United Nations' World Population Prospects.

By clicking on any country on the map you see the change over time in this country – and on the chart tab you can compare the change over time between different countries.

Total confirmed deaths due to COVID-19 per million people, Mar 24, 2020

Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.

Our World in Data



Source: European CDC – Latest Situation Update Worldwide

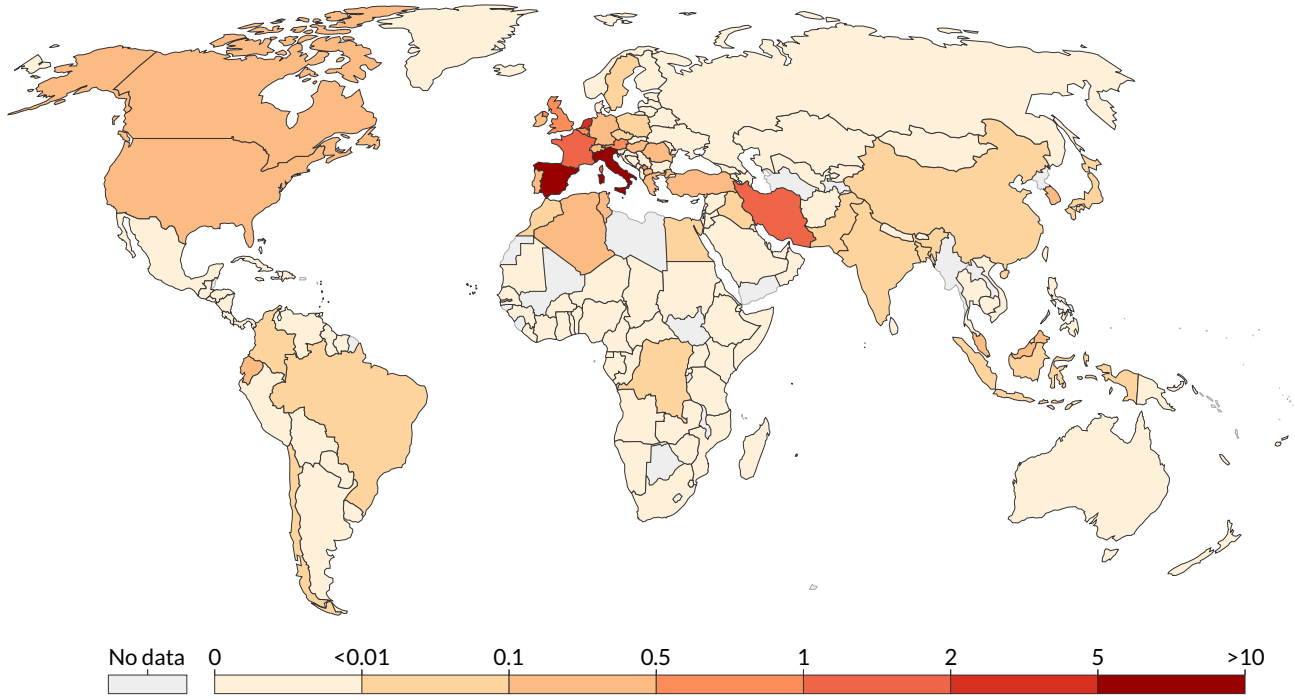
Dec 31, 2019 Mar 24, 2020

CHART MAP DATA SOURCES

Daily new confirmed deaths due to COVID-19 per million people, Mar 23, 2020

Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.

Our World in Data



Source: European CDC – Latest Situation Update Worldwide

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Dec 31, 2019 Mar 23, 2020

CHART MAP DATA SOURCES

Testing for COVID-19

One of the most important things that countries need to be doing to help understand and stop the spread of COVID-19 is *testing*. Here we explain why testing is important, what it involves, and how many tests countries are doing based on available data from official sources.

It's important to remember that these numbers change very quickly, so they're provisional and uncertain; but data

about testing is extremely important, and at the moment there is no central database compiling them, so we are bringing together the best available numbers, after reviewing a large number of data sources from individual national reports, country by country.

Why is testing important?

Testing allows infected people to *know* that they are infected. This can help them receive the care they need; and it can help them take measures to reduce the probability of infecting others. People who don't know they are infected might not stay at home and thereby risk infecting others.

Testing is also crucial for an appropriate response to the pandemic. It allows us to understand the spread of the disease and to take evidence-based measures to slow down the spread of the disease.[7]

Unfortunately, the capacity for COVID-19 testing is still low in many countries around the world. For this reason we still do not have a good understanding of the spread of the pandemic.

How are COVID-19 tests done?

The most common tests for COVID-19 involve taking a swab from a patient's nose and throat and checking them for the genetic footprint of the virus. They are called "PCR tests". The first PCR tests for COVID-19 were developed very rapidly – within two weeks of the disease being identified – and they are now part of the World Health Organisation (WHO)'s recommended protocol for dealing with the disease.[8]

Here you can find an explainer video on how the tests for coronavirus disease work.

What information about test coverage do we currently have?

Ideally, we would like to have as much detail about COVID-19 tests as possible. We would like to know how many people in the world are being tested for COVID-19 every day, and in which countries. We'd like to know what the results of these tests are, and how the available tests are being used – are countries testing only people in hospitals? People with symptoms?

Unfortunately, the WHO does not have a centralized database for COVID-19 testing data, so at the moment it is very hard to know.

That said, several countries do publish statistics on the total number of tests performed. But these reports are published across individual websites, statistical reports and press releases – often in multiple languages and updated with different periodicity.

Because a global overview was not available from a single source, at Our World in Data we are bringing together a large number of data sources from individual national reports, in order to provide a global picture with the best available estimates.

Below we show the most recent data **as of 20 March 2020, 18.00 GMT**. This requires a lot of careful work, but we will do our best to expand and update these estimates regularly.[9]

Current COVID-19 test coverage estimates

Total tests by country

These two charts show the most up-to-date estimates of testing levels that we've been able to find (**as of 20 March 2020, 18.00 GMT**). You'll see that some countries' data is older than others, meaning that they can't be directly compared. For instance, the estimate for the province of Guangdong in China has not been updated since 24 February.

The first chart plots the total number of tests against the total number of confirmed cases. The more tests a country has done the higher it is; the more confirmed cases it has, the further it is to the right.

Naturally, since you can only get a positive test if you carry out a test in the first place, countries that have performed more tests will tend to have more confirmed cases. In other words: there is a positive correlation between tests performed and cases confirmed. That doesn't necessarily mean that countries that have done more tests really have more cases, although in many cases they will.

However, the differences between countries can tell us important things. For instance, we can see that some countries have done more tests per confirmed case. The UK, for example, has done many more tests than other European countries with a similar number of confirmed cases.

The second chart plots the number of tests performed in each country. The most obvious point is that the data shows South Korea has done many more tests than other countries. That means we can expect that in South Korea the number of confirmed cases – positive tests – is closer to the real number of infected people than it is in other countries.

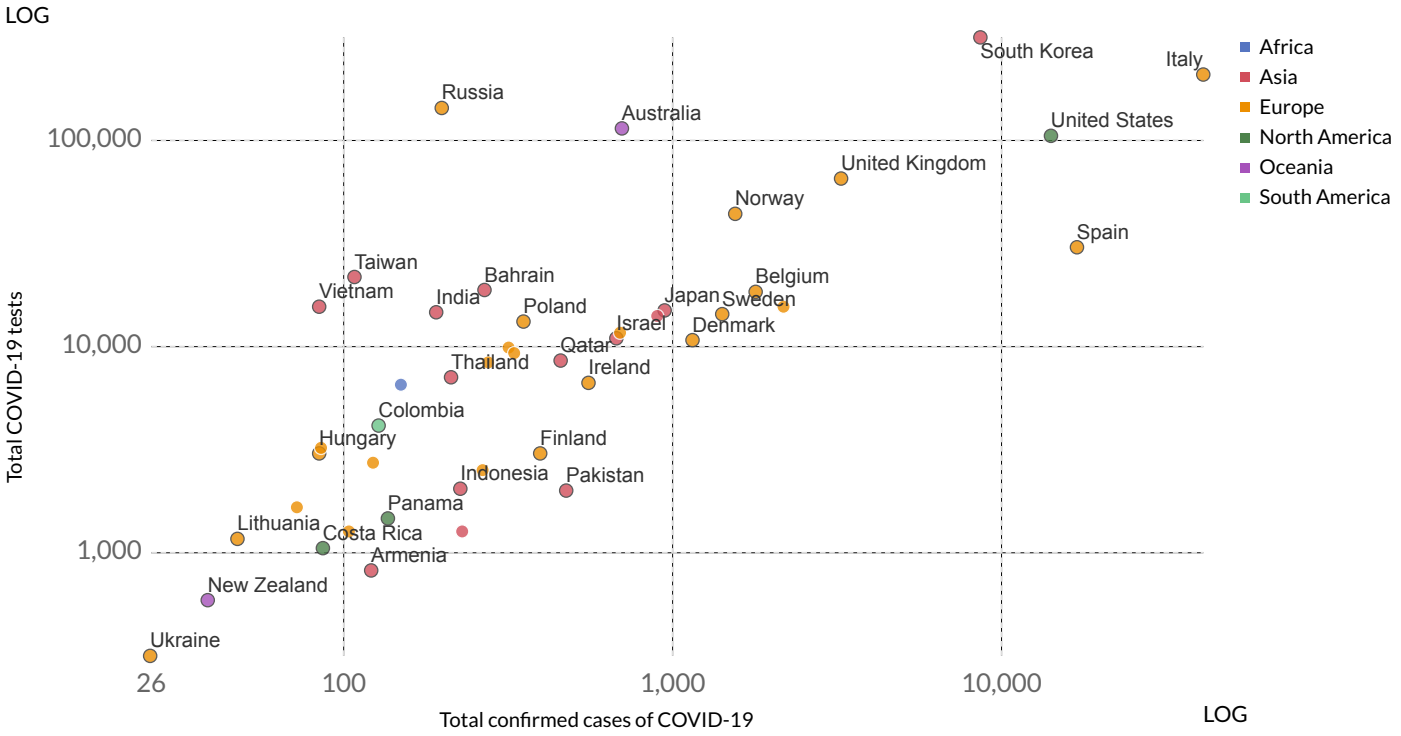
That makes it encouraging to see that the number of daily confirmed cases in South Korea has gone down. (Here you find our chart that shows the decline of confirmed new cases in South Korea.) South Korea was able to quickly manufacture and use a huge number of tests, showing that it is possible. Testing is crucial, so it is vital that other countries follow South Korea's lead.

A note about the chart: There are now too many countries in our dataset to show them all at once, so not all countries with available data are shown by default. If you want to see a different country, you can select the option 'add country' to find it.

[NB. We provide two estimates for the US. The estimate labelled "US – CDC samples tested" is from the Centers for Disease Control and Prevention, and refers to the number of tests conducted, not the number of individuals tested. The estimates labeled "United States" correspond to estimates of people tested, according to data gathered by the COVID Tracking Project – these estimates are updated more frequently.]

Tests conducted vs. Total confirmed cases of COVID-19

Most recent data as of 20 March [18.00GMT]. Data collected by Our World in Data from official country reports.
For some countries the number of tests corresponds to the number of individuals who have been tested, rather than the number of samples.



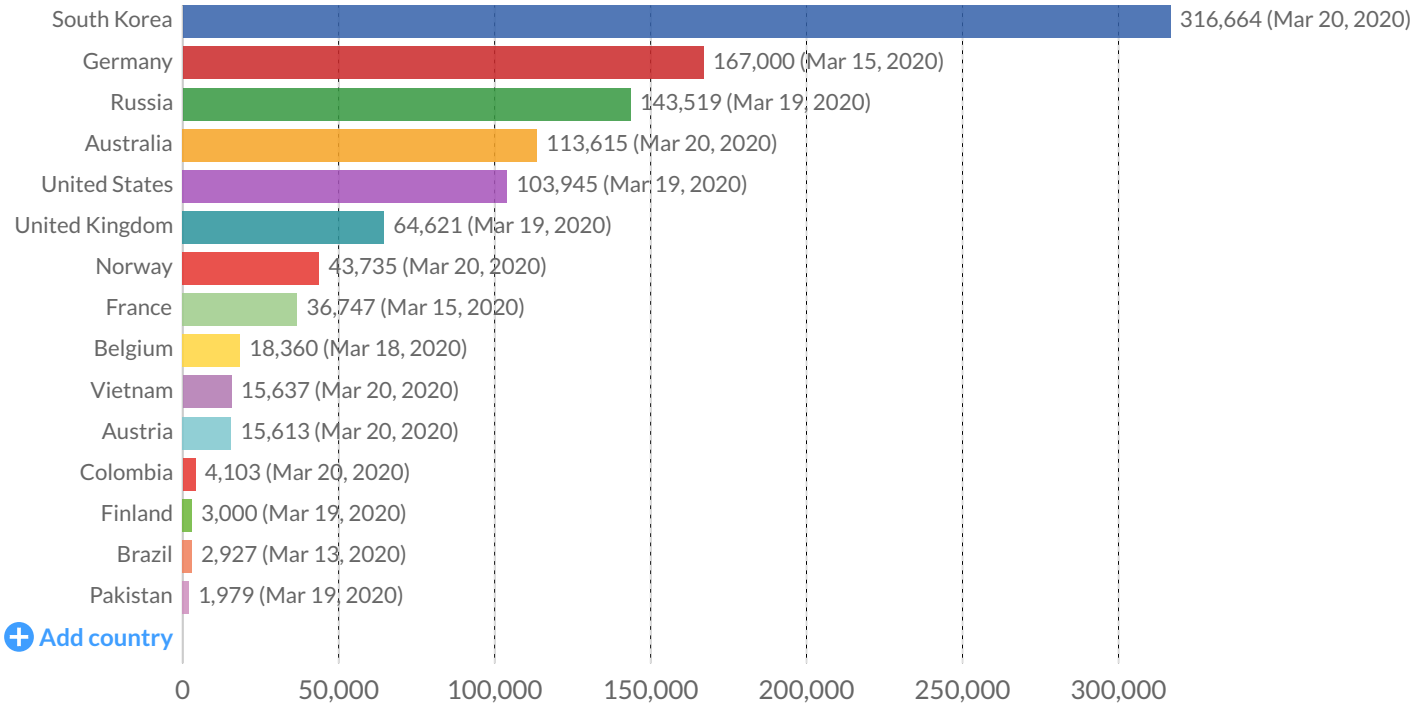
Source: Our World in Data based on official sources
Note: Data for the US corresponds to estimates from the COVID-Tracking Project

Search CHART DATA SOURCES

Total COVID-19 tests performed by country

Most recent data as of 20 March [18.00GMT]. Data collected by Our World in Data from official country reports.
For some countries the number of tests corresponds to the number of individuals who have been tested, rather than the number of samples.

Our World in Data



Source: Our World in Data
Note: Data for the United States corresponds to estimates from the COVID-Tracking Project.

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CHART DATA SOURCES

Per capita tests by country

These two charts show the most up-to-date estimates of testing levels that we've been able to find (**as of 20 March 2020, 18.00 GMT**). You'll see that some countries' data is older than others, meaning that they can't be directly compared. For instance, the estimate for the province of Guangdong in China has not been updated since 24 February.

The first chart takes the size of the population into account. It plots the total number of tests per million people, against the total number of confirmed cases, also per million people. The higher the dot representing a country is, the more tests per million people it has carried out; the further right it is, the more tests per million people have come back positive.

We see that countries with higher rates of confirmed cases tend to be also countries where a larger share of the total population has been tested. Again, since you can only get a positive test if you carry out a test in the first place, countries that have performed more tests will tend to have more confirmed cases.

But again there are important differences between countries. Vietnam, for example, shows a much higher testing rate than Indonesia, although at this point in time (20 March 2020) both have a similar number of confirmed cases per million people.

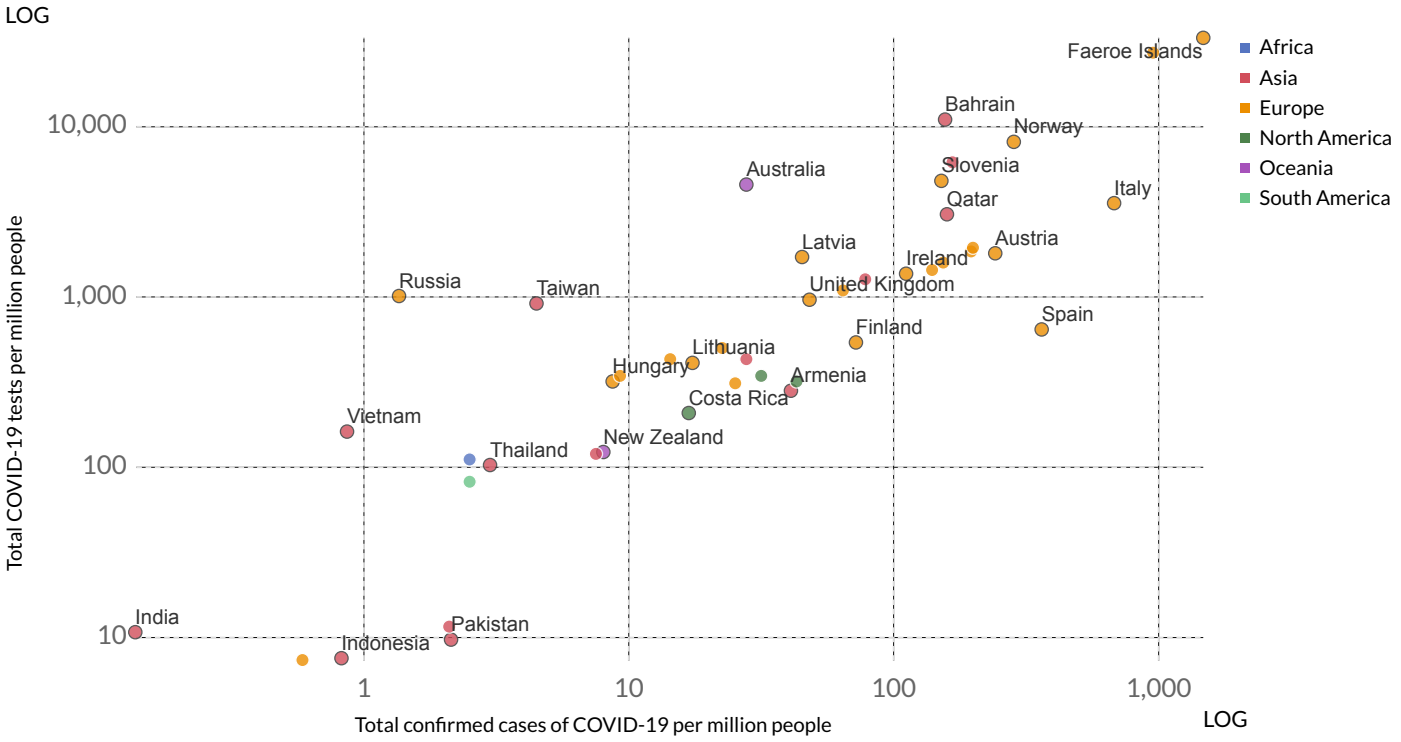
From this perspective, it is clear that the US is lagging behind. The number of tests per million people in the US is almost 10 times lower than in Canada, and about 20 times lower than in South Korea. The US has had big problems rolling out their testing strategy, although they seem to be slowly catching up.

The second chart plots the number of tests per million people, country by country. Not all countries with available data are shown by default – you can select the option 'add country' to see the available estimates for other countries.

Per million people: Tests conducted vs. Total confirmed cases of COVID-19

Our World in Data

Most recent data as of 20 March [18.00GMT]. Data collected by Our World in Data from official country reports.
For some countries the number of tests corresponds to the number of individuals who have been tested, rather than the number of samples.

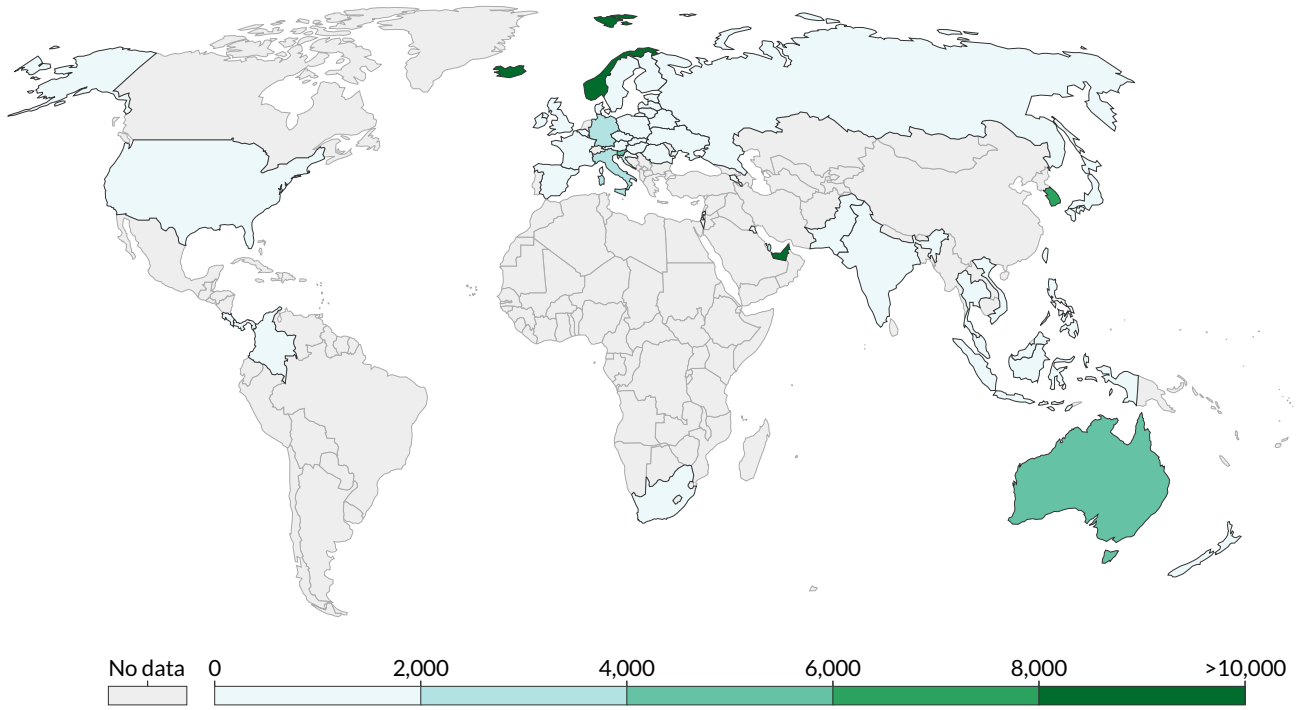


Source: Our World in Data based on official sources
Note: Data for the US corresponds to estimates from the COVID-Tracking Project

Search CHART DATA SOURCES

Total COVID-19 tests performed per million people

Most recent data as of 20 March [18.00GMT]. Data collected by Our World in Data from official country reports.
For some countries the number of tests corresponds to the number of individuals who have been tested, rather than the number of samples.



Source: Our World in Data
Note: Data for the United States corresponds to estimates from the COVID-Tracking Project.

CHART | MAP | DATA | SOURCES

The full documentation of our sources on testing data

We list estimates country by country, including exact dates and links to the underlying source, in a companion page here.

The tests are not perfect: sometimes, people who have the disease will be wrongly told that they do not

Some people require more than one test because of false-negative outcomes

The number of COVID-19 tests carried out will be similar to the number of people tested, but they won't be quite the same, because some people may need to be tested multiple times. The reason for this is that there are "false-negative" test outcomes.[10,11,12,13]

A "false-negative" outcome is when someone is tested and found to be clear of the disease, but when tested again, are found to have it. The WHO's guidelines for laboratory testing of COVID-19 say that negative results "do not rule out the possibility of COVID-19 virus infection."[14]

This means that even in countries that have done lots of tests, the true number of COVID-19 cases is still uncertain, although of course more testing still means more certainty.

There haven't been many studies into how common false negatives are, so it's hard to know how big an impact they have on our understanding – but research is going on.[15]

Why might COVID-19 tests fail?

There are several reasons why someone infected with COVID-19 may produce a false-negative result when tested:[16,17]

- They may be in the early stage of the disease with a viral load that is too low to be detected.
- They may have no major respiratory symptoms, so there could be little detectable virus in the patient's throat and nose.
- There may have been a problem with sample collection, meaning there was very little sample to test.
- There may have been poor handling and shipping of samples and test materials.
- There may have been technical issues inherent in the test, e.g. virus mutation.

The WHO suggests that these issues should be taken into account and that for some people, tests should be carried out several times.[18]

Cases of COVID-19

The number of total cases is what we want to know, but their number is not known

To understand the scale of the COVID-19 outbreak, and respond appropriately, we would want to know how many people are infected by COVID-19. We would want to know the *total* number of cases.

However, the total number of COVID-19 cases is not known. When media outlets claim to report the 'number of cases' they are not being precise and omit to say that it is the number of *confirmed cases* they speak about.

The total number of cases is not known, not by us at *Our World in Data,* nor by any other research, governmental or reporting institution.

Confirmed cases is what we do know

What we *do* know is the number of *confirmed* cases.

A confirmed case is "a person with laboratory confirmation of COVID-19 infection" as World Health Organization (WHO) explains.[19] But specifics can differ and the European CDC, on which we rely, reports confirmed cases according to the applied case definition in the countries.[20]

What is important however is that the number of confirmed cases is certainly not the same as the number of total cases. Confirmed cases are therefore only a subset of the total number of cases. It is a count of only those people who have COVID-19 and for whom a lab has confirmed this diagnosis. For this reason we emphasized the importance of testing in the section before.

The total number of confirmed cases is of course also not the same as the total number of all *current* cases. This is because for some of them the disease has ended and they have either recovered or died from it. We discuss how long the disease lasts further below (scroll there).

Why is the number of confirmed cases lower than the number of total cases?

The number of confirmed cases is lower than the number of total cases because not everyone is tested. Not all cases have a "laboratory confirmation", testing is what makes the difference between the number of confirmed and total cases.

All countries have been struggling to test a large number of cases, which meant that not every person that should have been tested, has in fact been tested.

Since an understanding of testing for COVID-19 is crucial for an interpretation of the reported numbers of confirmed cases we have looked into the testing for COVID-19 in more detail.

You find our work on testing further below in this document (click **here** to scroll there).

Growth of cases: How long did it take for the number of confirmed cases to double?

As for the number of deaths, it is not only important to study the number of cases, but also how they increase over time. Their growth rate.

To report the rate of change we focus on the question: How long did it take for the number of confirmed cases to double?

The global average hides more than it reveals: why we show this data country by country

Some countries – like China and Korea – have very substantial countermeasures in place and new daily confirmed cases have declined.

Many other countries do not have comparable measures in place and, as the table shows, numbers are rising fast.

Because of these large differences between countries it is crucial to not only study the global situation, but the situation in each country.

The global average hides the differences between countries that are successfully reducing the number of new daily confirmed cases and those that do not achieve this.

Growth: Country by country view

For these reasons the following table answers the following question for all countries: How long did it take for the number of total confirmed cases to double?

The table also shows how the total number of confirmed cases has increased and how the number of daily new confirmed has changed over the last 14 days.

You can sort the table by any of the columns by clicking on the column header.

Data: The data shown here is published by the *European Center for Disease Control and Prevention* (ECDC). Here is our documentation of the data and an option to download all data.

World	7 days	378,041 total March 24	+39,738 new March 24
China	doubled in 43 days	81,748 total March 24	+99 new March 24
Italy	doubled in 6 days	63,927 total March 24	+4,789 new March 24
United States	doubled in 3 days	46,442 total March 24	+11,236 new March 24
Spain	doubled in 5 days	33,089 total March 24	+4,517 new March 24
Germany	doubled in 4 days	29,212 total March 24	+4,438 new March 24
Iran	doubled in 10 days	23,049 total March 24	+1,411 new March 24
France	doubled in 5 days	19,856 total March 24	+3,838 new March 24
South Korea	doubled in 22 days	9,037 total March 24	+76 new March 24
Switzerland	doubled in 4 days	8,015 total March 24	+1,044 new March 24
United Kingdom	doubled in 4 days	6,650 total March 24	+967 new March 24
Netherlands	doubled in 5 days	4,749 total March 24	+545 new March 24
Austria	doubled in 4 days	4,486 total March 24	+855 new March 24
Belgium	doubled in 4 days	3,743 total March 24	+342 new March 24
Norway	doubled in 7 days	2,371 total March 24	+239 new March 24


Portugal
doubled in
3 days
2,060 total
March 24
+460 new
March 24
Sweden
doubled in
9 days
2,016 total
March 24
+110 new
March 24
Brazil
doubled in
3 days
1,891 total
March 24
+345 new
March 24
Australia
doubled in
3 days
1,823 total
March 24
+114 new
March 24
Canada
doubled in
5 days
1,646 total
March 24
+216 new
March 24
Turkey
doubled in
3 days
1,529 total
March 24
+293 new
March 24
Malaysia
doubled in
6 days
1,518 total
March 24
+212 new
March 24
Denmark
doubled in
11 days
1,460 total
March 24
+65 new
March 24
Israel
doubled in
3 days
1,442 total
March 24
+371 new
March 24
Czech Republic
doubled in
5 days
1,236 total
March 24
+71 new
March 24
Japan
doubled in
14 days
1,128 total
March 24
+39 new
March 24
Ireland
doubled in
4 days
1,125 total
March 24
+219 new
March 24
Ecuador
doubled in
3 days
981 total
March 24
+192 new
March 24
Pakistan
doubled in
5 days
887 total
March 24
+103 new
March 24
doubled in
Luxembourg

Luxembourg	4 days	875 total March 24	+77 new March 24
Thailand	doubled in 3 days	827 total March 24	+106 new March 24
Poland	doubled in 4 days	749 total March 24	+115 new March 24
Chile	doubled in 4 days	746 total March 24	+114 new March 24
Finland	doubled in 6 days	700 total March 24	+74 new March 24
Greece	doubled in 8 days	695 total March 24	+71 new March 24
Iceland	doubled in 5 days	588 total March 24	+20 new March 24
Indonesia	doubled in 4 days	579 total March 24	+65 new March 24
Romania	doubled in 4 days	576 total March 24	+143 new March 24
Saudi Arabia	doubled in 3 days	562 total March 24	+51 new March 24
Singapore	doubled in 7 days	509 total March 24	+54 new March 24
Qatar	doubled in 13 days	501 total March 24	+7 new March 24
India	doubled in 3 days	492 total March 24	+53 new March 24
Philippines	doubled in 3 days	462 total March 24	+82 new March 24
Slovenia	doubled in 8 days	442 total March 24	+28 new March 24

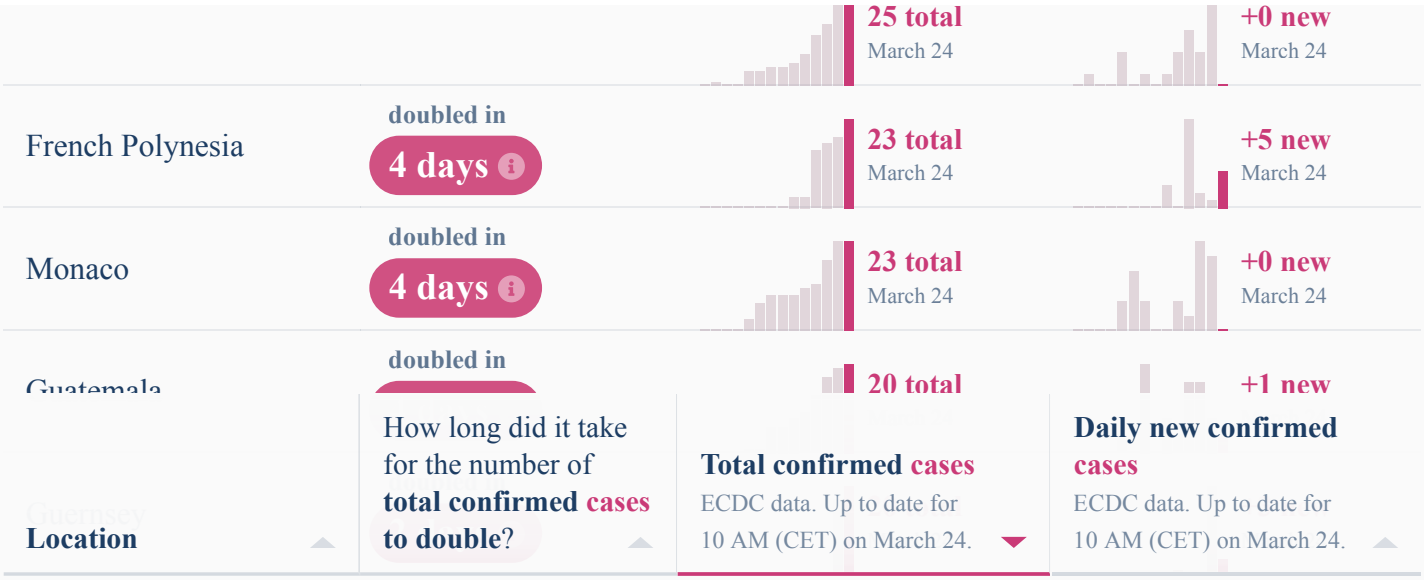
	doubled in				
Russia	4 days		438 total March 24		+0 new March 24
South Africa	4 days		402 total March 24		+128 new March 24
Peru	5 days		395 total March 24		+32 new March 24
Mexico	4 days		367 total March 24		+51 new March 24
Estonia	8 days		352 total March 24		+26 new March 24
Panama	4 days		345 total March 24		+32 new March 24
Bahrain	11 days		339 total March 24		+5 new March 24
Egypt	7 days		327 total March 24		+33 new March 24
Croatia	3 days		306 total March 24		+71 new March 24
Argentina	4 days		301 total March 24		+35 new March 24
Lebanon	5 days		267 total March 24		+19 new March 24
Iraq	7 days		266 total March 24		+33 new March 24
Dominican Republic	2 days		245 total March 24		+43 new March 24
Colombia	5 days		235 total March 24		+0 new March 24
Serbia	doubled in				

	5 days	222 total March 24	+34 new March 24
Bulgaria	doubled in 5 days	201 total March 24	+16 new March 24
United Arab Emirates	doubled in 7 days	198 total March 24	+45 new March 24
Taiwan	doubled in 6 days	195 total March 24	+30 new March 24
Armenia	doubled in 6 days	194 total March 24	+4 new March 24
Slovakia	doubled in 7 days	191 total March 24	+6 new March 24
Algeria	doubled in 2 days	189 total March 24	+87 new March 24
Kuwait	doubled in 11 days	189 total March 24	+1 new March 24
Hungary	doubled in 3 days	187 total March 24	+20 new March 24
San Marino	doubled in 9 days	187 total March 24	+36 new March 24
Latvia	doubled in 4 days	180 total March 24	+41 new March 24
Lithuania	doubled in 3 days	179 total March 24	+36 new March 24
Uruguay	doubled in 5 days	162 total March 24	+4 new March 24
Costa Rica	doubled in 5 days	158 total March 24	+24 new March 24
New Zealand	doubled in 2 days	142 total March 24	+40 new March 24

	doubled in		
Macedonia	4 days	136 total March 24	+22 new March 24
Morocco	4 days	134 total March 24	+19 new March 24
Andorra	5 days	133 total March 24	+20 new March 24
Bosnia and Herzegovina	3 days	129 total March 24	+4 new March 24
Vietnam	6 days	123 total March 24	+5 new March 24
Faeroe Islands	Not enough data available	118 total March 24	+3 new March 24
Cyprus	4 days	116 total March 24	+21 new March 24
Jordan	4 days	112 total March 24	+13 new March 24
Moldova	4 days	109 total March 24	+15 new March 24
Malta	4 days	107 total March 24	+17 new March 24
Albania	8 days	100 total March 24	+11 new March 24
Sri Lanka	5 days	97 total March 24	+10 new March 24
Brunei	9 days	91 total March 24	+3 new March 24
Tunisia	4 days	89 total March 24	+14 new March 24
Cambodia	doubled in		

	4 days	87 total March 24	+1 new March 24
Venezuela	doubled in 1 day	84 total March 24	+48 new March 24
Belarus	doubled in 6 days	81 total March 24	+5 new March 24
Senegal	doubled in 4 days	79 total March 24	+12 new March 24
Burkina Faso	doubled in 4 days	75 total March 24	+11 new March 24
Ukraine	doubled in 3 days	73 total March 24	+26 new March 24
Azerbaijan	doubled in 5 days	72 total March 24	+7 new March 24
Oman	doubled in 6 days	66 total March 24	+11 new March 24
Kazakhstan	doubled in 7 days	62 total March 24	+2 new March 24
Georgia	doubled in 8 days	61 total March 24	+7 new March 24
Kosovo	doubled in 2 days	61 total March 24	+30 new March 24
Palestine	doubled in 13 days	59 total March 24	+0 new March 24
Cameroon	doubled in 1 day	56 total March 24	+29 new March 24
Trinidad and Tobago	doubled in 3 days	51 total March 24	+1 new March 24
Uzbekistan	doubled in 4 days	49 total March 24	+3 new March 24
	doubled in		

Liechtenstein	doubled in 6 days		46 total March 24	+0 new March 24
Afghanistan	doubled in 8 days		40 total March 24	+6 new March 24
Cuba	doubled in 4 days		40 total March 24	+5 new March 24
Nigeria	doubled in 3 days		40 total March 24	+10 new March 24
Mauritius	doubled in 2 days		36 total March 24	+8 new March 24
Rwanda	doubled in 2 days		36 total March 24	+17 new March 24
Bangladesh	doubled in 4 days		33 total March 24	+6 new March 24
Honduras	doubled in 5 days		30 total March 24	+3 new March 24
Guam	doubled in 3 days		29 total March 24	+2 new March 24
Bolivia	doubled in 5 days		28 total March 24	+1 new March 24
Ghana	doubled in 4 days		27 total March 24	+3 new March 24
Montenegro	doubled in 4 days		27 total March 24	+6 new March 24
Paraguay	doubled in 4 days		27 total March 24	+5 new March 24
Democratic Republic of Congo	doubled in 6 days		26 total March 24	+0 new March 24
Cote d'Ivoire	doubled in 4 days			



Countries with less than 20 confirmed cases are not shown. Cases from the Diamond Princess cruise ship are also not shown since these numbers are no longer changing over time.

Data source: ECDC. Download the full dataset.

Confirmed COVID-19 cases by country

In our visualizations here you can explore the number of *total* confirmed cases and daily *new* confirmed cases for all countries with reported cases. This is shown in absolute numbers, and adjusted for population size by showing total and new confirmed cases per million people.

These charts are interactive: the data is shown as the worldwide figures by default but can be explored by country – by clicking on + **Add Country** within the chart.

Data: The data shown here is published by the *European Center for Disease Control and Prevention* (ECDC). Here is the documentation of the data and an option to download all data.

Total confirmed COVID-19 cases

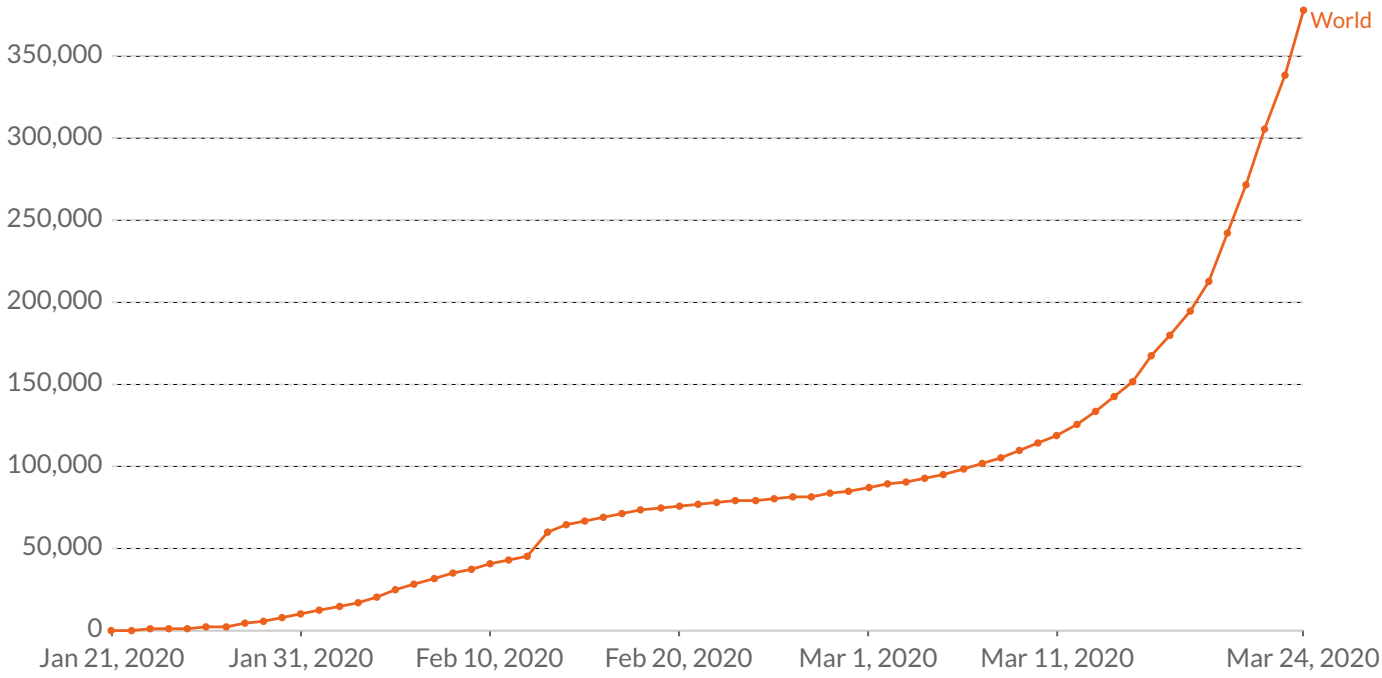
The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing.

Our World in Data

LINEAR

Add country

World



Source: European CDC – Latest Situation Update Worldwide

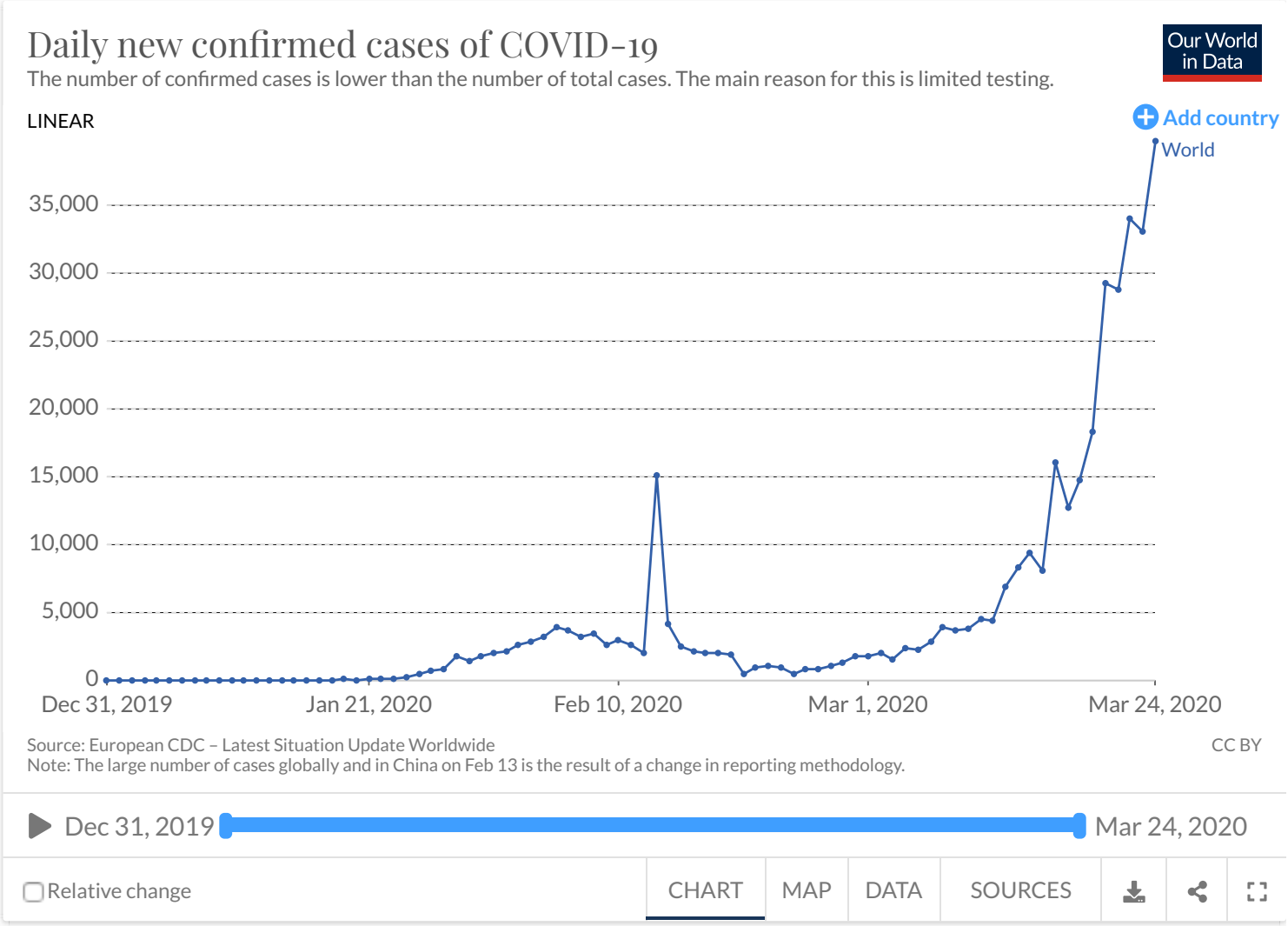
CC BY

Note: The large increase in the number of cases globally and in China on Feb 13 is the result of a change in reporting methodology.

Dec 31, 2019 Mar 24, 2020

Relative change

CHART MAP DATA SOURCES



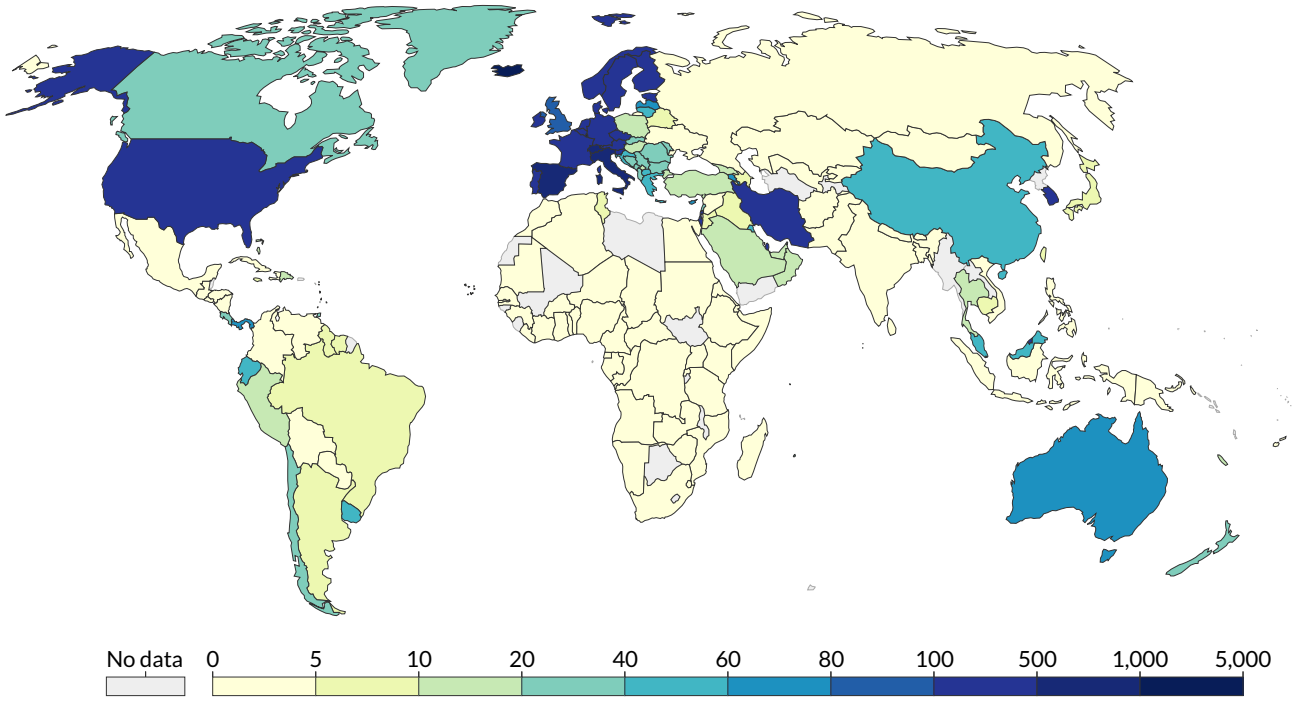
Confirmed COVID-19 cases relative to the size of the population

We calculated the shown confirmed cases per million by diving the case numbers from the ECDC by population figures published in the United Nations' World Population Prospects.

Total confirmed cases of COVID-19 per million people, Mar 23, 2020

The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing.

Our World in Data



Source: European CDC – Latest Situation Update Worldwide
Note: The large number of cases globally and in China on Feb 17 is the result of a change in reporting methodology.

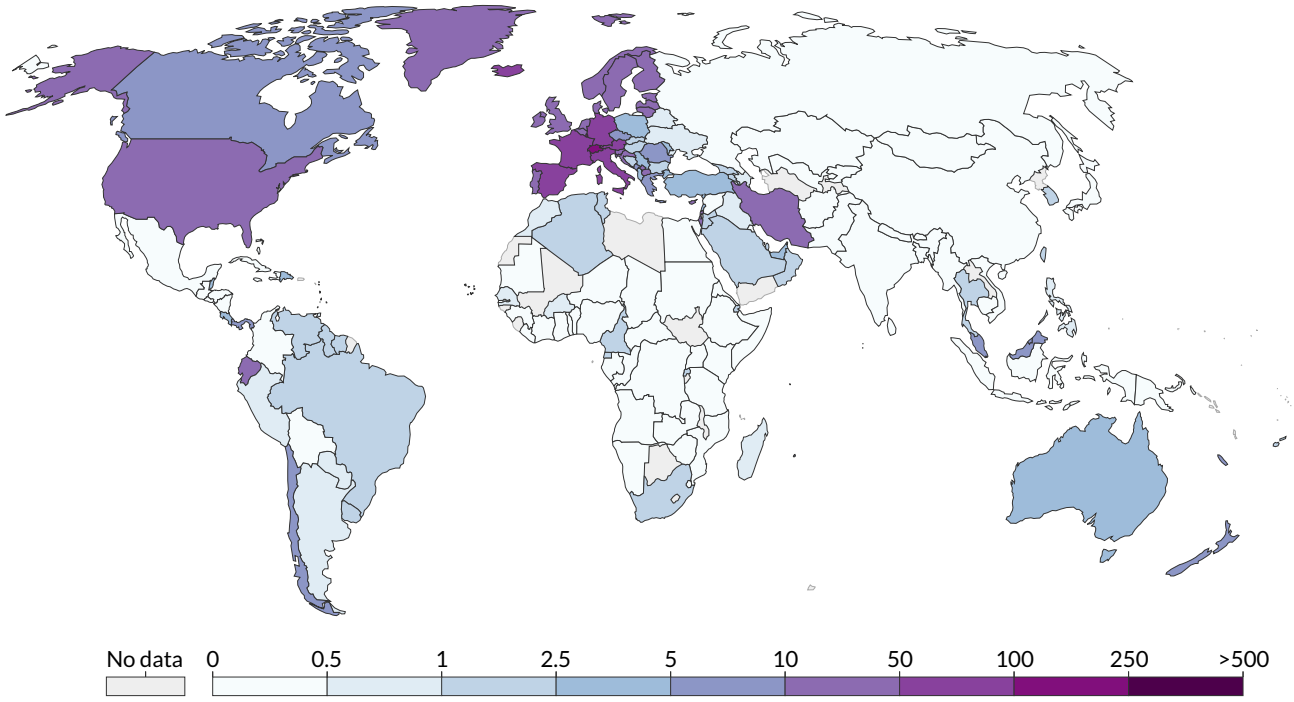
Dec 31, 2019 Mar 23, 2020

CHART MAP DATA SOURCES

Daily new confirmed cases of COVID-19 per million people, Mar 24, 2020

The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing.

Our World in Data



Source: European CDC – Latest Situation Update Worldwide

Note: The large number of cases globally and in China on Feb 17 is the result of a change in reporting methodology.

Dec 31, 2019 Mar 24, 2020

CHART MAP DATA SOURCES

Trajectories since the 100th confirmed case

Did the number of confirmed cases rise faster in China, Italy, South Korea, or the US?

The charts above are not very useful to answer these types of questions, because the outbreak of COVID-19 did not happen at the same day in all countries.

The chart shown here is designed to allow these comparisons.

This chart allows the reader to compare the trajectory of confirmed cases between countries. The starting point for each country is the day that particular country had reached 100 confirmed cases.

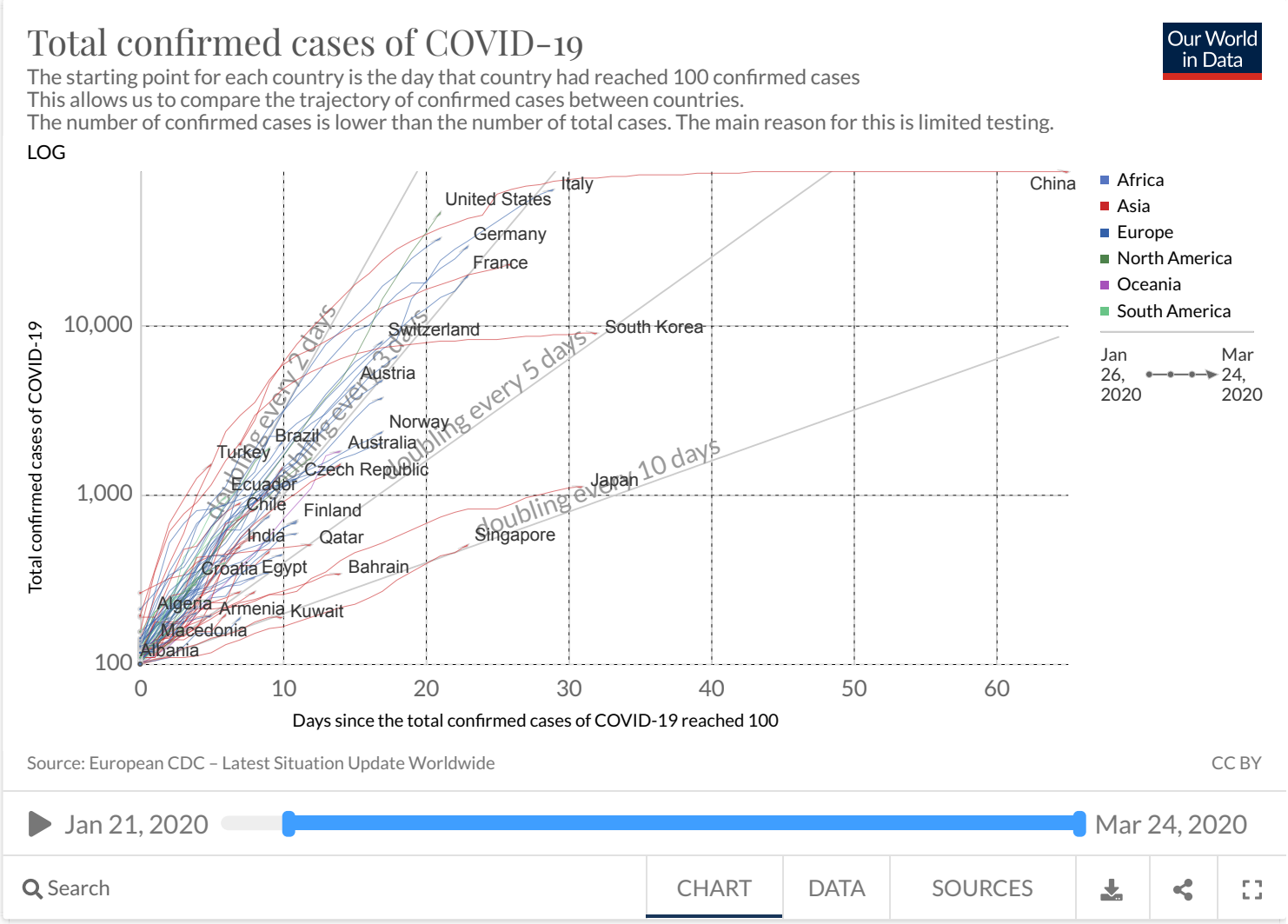
China had a particular fast rise. Just 10 days after the 100th confirmed case the country already confirmed the 10,000th

case.

Other countries saw a much slower increase. The speed at which the number of confirmed cases increased in Singapore and Japan was much slower than in other countries.

The grey lines show trajectories for a doubling time of 2 days and a doubling time of 3 days. Countries that follow a steeper rise have seen a doubling time faster than that.

The trajectory of China and South Korea shows that the speed at which cases rise is not necessarily constant over time. Both countries saw a rapid initial rise but then implemented severe countermeasures (see here). As the chart shows the trajectory became flatter, the speed of the outbreak has decreased.



The COVID-19 pandemic

The name of the disease and the virus

The names for the virus and the disease it causes have been announced by the World Health Organization and the International Committee on Taxonomy of Viruses.[21]

The disease is called *coronavirus disease*. It is abbreviated as COVID-19.

The virus is called *severe acute respiratory syndrome coronavirus 2* and it is abbreviated as SARS-CoV-2. In the same statement the WHO also explains that they themselves also refer to the virus as "the virus responsible for COVID-19" or "the COVID-19 virus" when communicating with the public. We follow the same conventions here.

How did the outbreak start?

On 29 December 2019 Chinese authorities identified a cluster of similar cases of pneumonia in the city of Wuhan in China. Wuhan is a city with 11 million inhabitants and is the capital of the Hubei Province.

These cases were soon determined to be caused by a novel coronavirus that was later named SARS-CoV-2.[22]

Coronaviruses are a group of viruses that are common in humans and are responsible for up to 30% of common colds.[23] Corona is Latin for "crown" – this group of viruses is given its name due to the fact that its surface looks like a crown under an electron microscope.

Two outbreaks of new diseases in recent history were also caused by coronaviruses – SARS in 2003 that resulted in around 1,000 deaths[24] and MERS in 2012 that resulted in 862 deaths.[25]

The first cases of COVID-19 outside of China were identified on January 13 in Thailand and on January 16 in Japan.

On January 23rd the city of Wuhan and other cities in the region were placed on lockdown by the Chinese Government.

Since then COVID-19 has spread to many more countries – cases have been reported in all world regions. You can see the latest available data in the dashboards of cases and deaths which are kept up-to-date by Johns Hopkins University and the WHO discussed here.

Related work by Our World in Data

- The Spanish flu (1918-20): The global impact of the largest influenza pandemic in history – We look at the global death toll and mortality rate of the Spanish flu and compare it with three other large influenza pandemics in the last century.

- Pneumonia – Severe cases of COVID-19 can progress to pneumonia.[26] Our entry on pneumonia provides an overview of the data and research on this disease that kills 2.6 million annually.

- Age Structure – Since the mortality risk for COVID-19 varies by age, the age structure of the population matters for the risk that the disease poses to the population. This entry looks in detail at the age structure of countries around the world.

- Vaccination – Vaccines are key in making progress against infectious diseases and save millions of lives every year. A vaccine against COVID-19 would be the scientific breakthrough that could end this pandemic.

- Healthcare financing – A strong healthcare system is key to make progress against the infectious disease. In this entry we are studying how healthcare is financed.

- Causes of death – 56 million people die every year. What do they die from? How did the causes of death change over time?

Strategies to respond to COVID-19

The intention of early containment

A lower peak of the outbreak allows the healthcare system to provide care for more people

The total mortality of an epidemic can be high even if the symptoms for the vast majority are mild. While it might not seem intuitive, it is possible for the following two things to be true at the same time:

- For the majority of people, symptoms are mild and in some cases similar to the common flu.
- An epidemic of the same disease can cause a very high number of deaths.

As we discuss here, the symptoms of COVID-19 can be very severe in many cases. Many of these patients require treatment in intensive care units (ICUs). The WHO reports that "about a quarter of severe and critical cases require mechanical ventilation."[27]

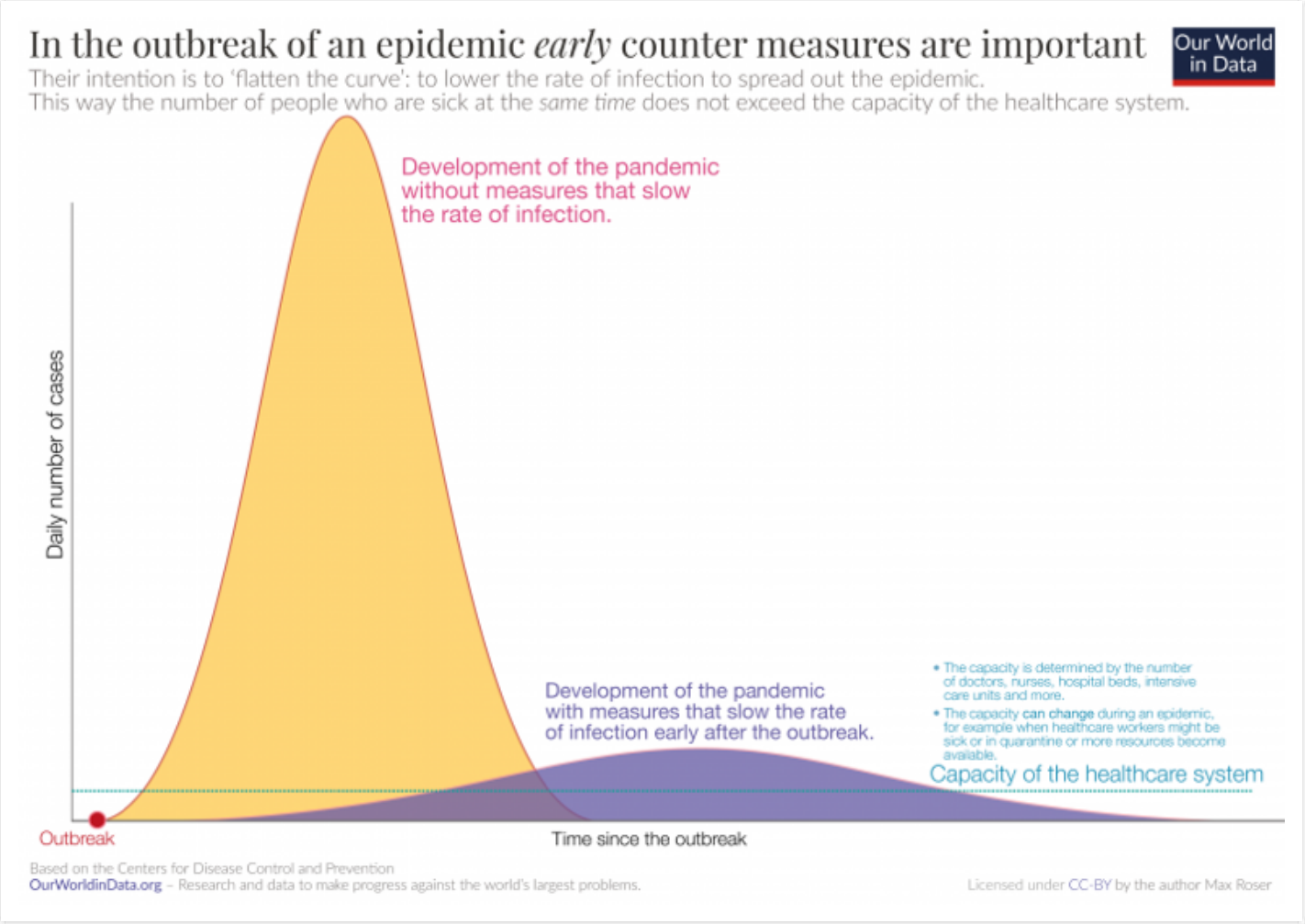
'Flattening the curve'

This is why early counter measures are important in an epidemic. Their intention is to lower the rate of infection so that the epidemic is spread out over time such that the peak demand on the healthcare system is lower.

Containment measures are intended to avoid an outbreak trajectory in which a large number of people get sick *at the same time*. This is what the visualization shows.

This is the reason that limiting the magnitude of peak incidence of an outbreak is important. Health systems can care for more patients across an outbreak when the number of cases is spread out over a long period rather than condensed in a very short period.

What such counter measures to the pandemic attempt to avoid is that the number of patients at one point in time is so large that health systems fail to provide the required care for some patients.[28]



COVID-19: What are the symptoms? How does the disease progress?

If you suspect that you have COVID-19 please see the official guidance, information and advice provided by the WHO or the health agency of your country (COVID-19 information by the National Health Service of the UK is here; and by the US CDC here).

Why we need to study *data* to know the symptoms of COVID-19

COVID-19 leads to a number of symptoms, but from what is known currently some symptoms are much more common than others and for this reason we need to look at the available *data*.

The danger of relying solely on text and not on numbers is that crucial nuance can get lost. This is the case for the media coverage of the symptoms of COVID-19.

Coverage of the disease, even in reputable sources, includes long lists of symptoms without conveying to the reader how common or rare the listed symptoms are – here is a poor example from the BBC. It is crucial to know *how common* the various symptoms of COVID-19 are, as it allows a better assessment of whether one suffers from the disease or not. This is lost in reporting that relies on text – especially if the list of potential symptoms is long, and overlaps strongly with many other types of illness.

In a simple list of COVID-19 symptoms the reader might see that muscle pain is listed as a symptom and then wrongly conclude that they do not have the disease if they are not suffering from muscle pain. Knowing the frequency of symptoms means knowing that the vast majority of known cases (85% in the sample below) did *not* suffer from this symptom.

The symptoms of COVID-19

The WHO described the symptoms of 55,924 laboratory confirmed cases of COVID-19 in China in the period up to February 20.[29]

The visualization here shows this data.

It is most crucial to know **the common symptoms: fever and a dry cough.**

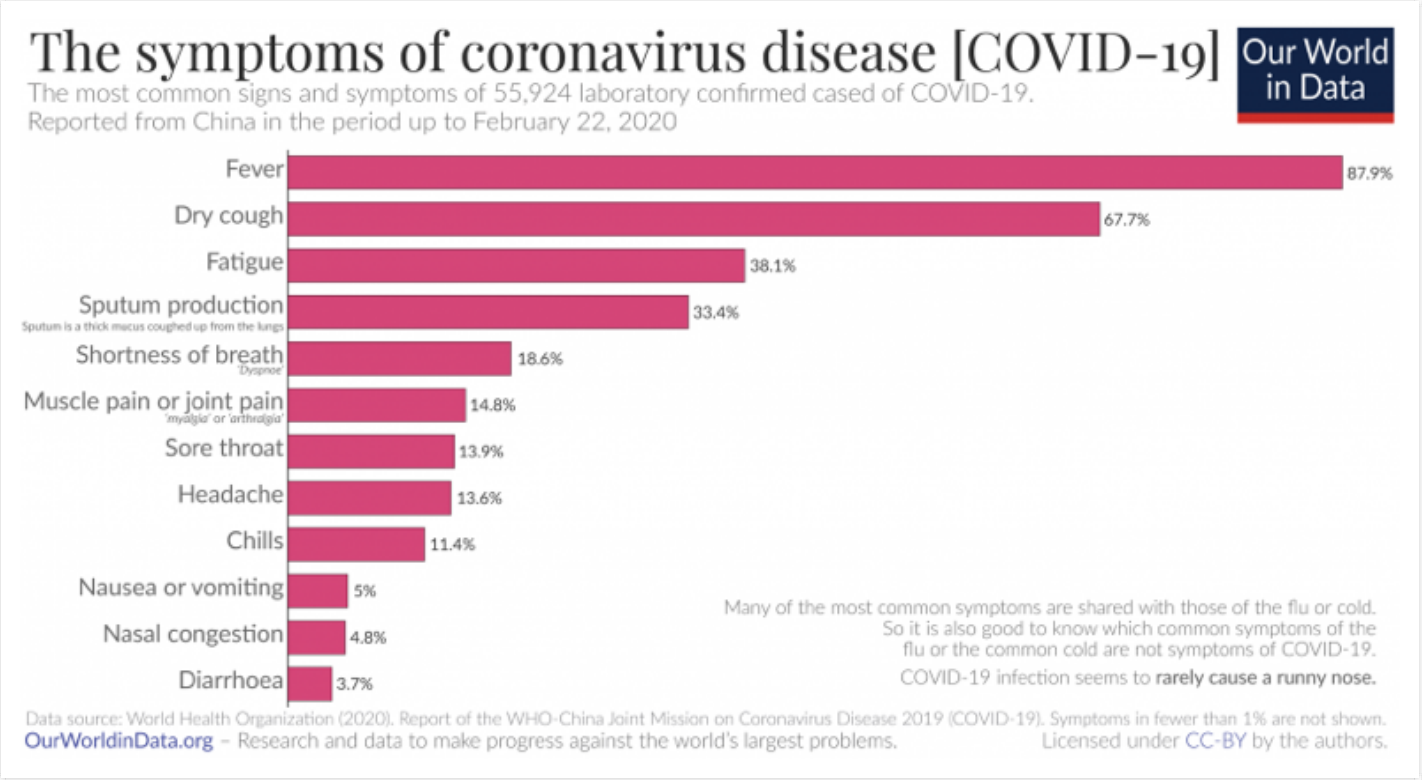
As the visualization shows, close to 90% of cases had a fever and two-thirds had a dry cough.

The third most common symptom was fatigue. Almost 40% of cases suffered from it.

'Sputum production' was experienced by every third person. Sputum is not saliva. It is a thick mucus which is coughed up from the lungs (see here).

Of the 55,924 cases fewer than 1-in-5 (18.6%) experienced shortness of breath ('dyspnoea'). An earlier study, reported that a much higher share (55%) of cases suffered from dyspnoea, but this was based on a much smaller number of cases (835 patients).[30]

Many of the most common symptoms are shared with those of the common flu or cold. So it is also good to know which common symptoms of the common flu or the common cold are *not* symptoms of COVID-19. COVID-19 infection seems to **rarely cause a runny nose**.



How long is the incubation period of COVID-19?

The WHO writes "people with COVID-19 generally develop signs and symptoms, including mild respiratory symptoms and fever, on an average of 5-6 days after infection."[31]

While the mean incubation period is 5 to 6 days, the WHO adds that the incubation period can vary in a wide range of between 1 to 14 days.[32]

This is based on the 55,924 confirmed cases in China. There are reports of cases with longer incubation periods in the media (a case of 27 days is reported here).

How long does COVID-19 last?

On average the disease lasts two weeks. The WHO reports that "the median time from onset to clinical recovery for mild cases is approximately 2 weeks."[33]

Again this is based on the 55,924 confirmed cases in China

For severe and critical cases it is 3 to 6 weeks according to the same study.

And for those who eventually died, the time from symptom onset to death ranged from 2 to 8 weeks. This is important when interpreting the case fatality rate (see below). Measures of the CFR of an ongoing outbreak do (obviously) not include deaths of patients who will eventually die, but have not died yet at the time of measurement. This means that the current CFR would be lower than the eventual CFR.

How does COVID-19 progress?

The symptoms of the disease develop and change over time.

It seems to be common that symptoms start with a fever, followed by a dry cough.[34]

After several days some patients experience shortness of breath.

Symptoms can increase in severity as emphasised in the following section. In severe and critical cases it can lead to severe pneumonia, respiratory failure, septic shock, and multiple organ dysfunction or failure.

As we discuss in detail below, for some cases COVID-19 leads to death.

The severity of the symptoms of COVID-19

This visualization shows the severity of symptoms suffered by 44,415 Chinese patients confirmed to have coronavirus in the early period up to February 11.[35]

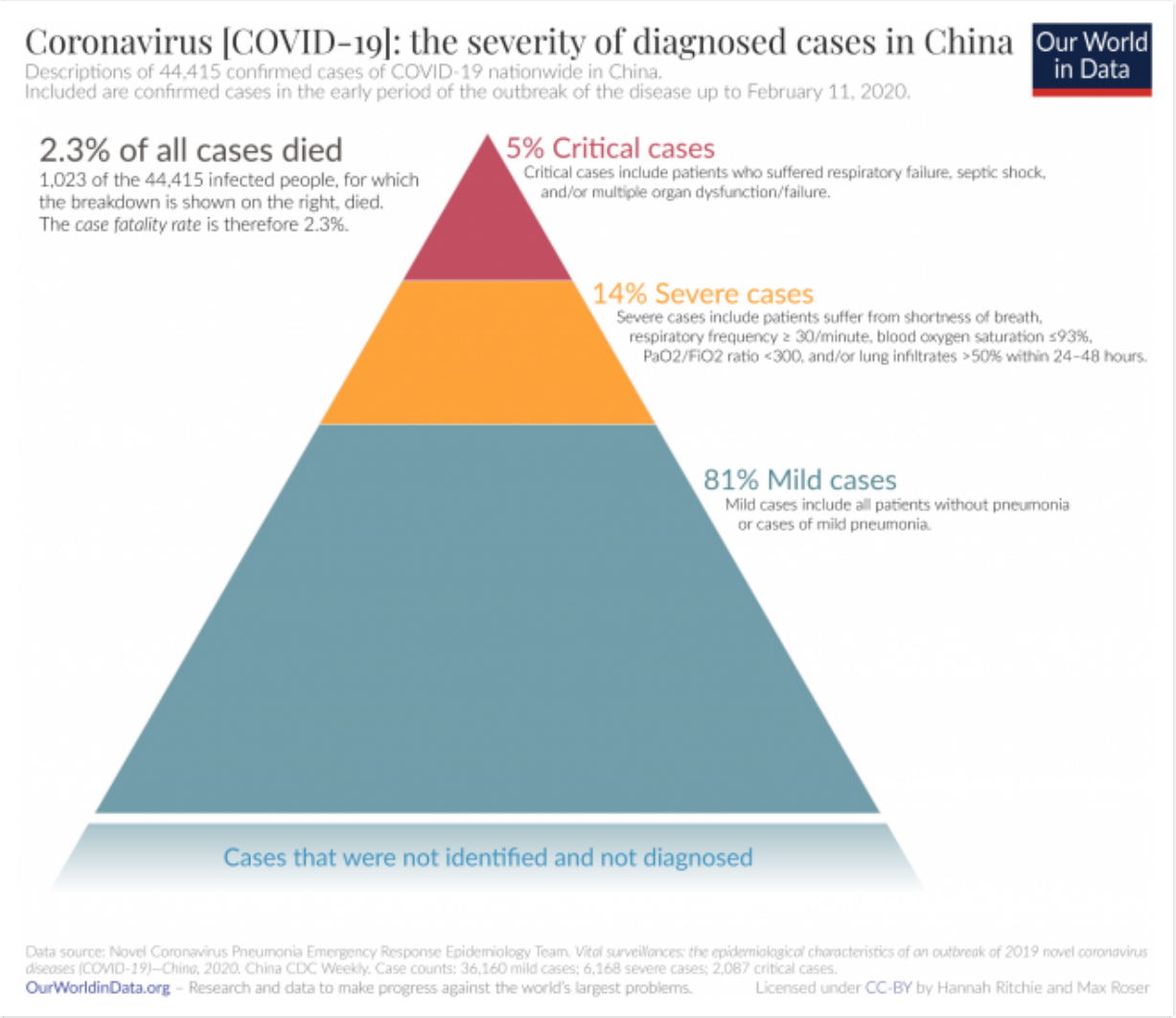
It is likely that many more cases were so mild that they were not identified as COVID-19. Estimates published by Read et al. (2020) suggest that only around 5% of cases in China have been diagnosed and recorded.[36]

Symptoms were categorized as mild, severe, or critical and the research article describes these as follows:

Critical cases: Critical cases include patients who suffered respiratory failure, septic shock, and/or multiple organ dysfunction or failure.

Severe cases: This includes patients who suffered from shortness of breath, respiratory frequency ≥ 30/minute, blood oxygen saturation ≤93%, PaO2/FiO2 ratio <300,[37] and/or lung infiltrates >50% within 24–48 hours.

Mild cases: The majority (81%) of these coronavirus disease cases were mild cases. Mild cases include all patients without pneumonia or cases of mild pneumonia.



What do we know about the risk of

dying from COVID-19?

There is a straightforward question that most people would like answered. If someone is infected with COVID-19, how likely is that person to die?

This question is simple, but surprisingly hard to answer. There are several numbers that can help us get towards it – statistics such as the total number of confirmed cases, and the number of deaths so far – but those measures don't tell us everything we need to know. In this section, we'll explain why that is, and what we can be sure about. We'll discuss the "case fatality rate", the "crude mortality rate", and the "infection fatality rate", and why they're all different.

The key point is that the "case fatality rate", the most commonly discussed measure of the risk of dying, is not the true answer to the question, for two reasons. One, it relies on the number of *confirmed* cases, and many cases are not confirmed; and two, it relies on the total number of deaths, and with COVID-19, some people who are sick and will die soon have not yet died. These two facts mean that it is extremely difficult to make accurate estimates of the true risk of death.

The case fatality rate (CFR)

In the media, the risk of death from COVID-19 is usually presented as the "case fatality rate", sometimes called case fatality risk or case fatality ratio, or CFR.

But this is not the same as the risk of death for an infected person – even though, unfortunately, journalists often suggest that it is. It is relevant and important, but far from the whole story.

The CFR is very easy to calculate. You take the number of people who have died, and you divide it by the total number of people diagnosed with the disease. So if 10 people have died, and 100 people have been diagnosed with the disease, the CFR is [10 / 100], or 10%.

But it's important to note that it is the ratio between the number of confirmed deaths from the disease and the number of *confirmed* cases, not total cases. That means that it is not the same as – and, in fast-moving situations like COVID-19, probably not even very close to – the true risk for an infected person.

$$\text{Case Fatality Rate (CFR, in \%)} = \frac{\text{Number of deaths from disease}}{\text{Number of diagnosed cases of disease}} \times 100$$

Another important metric, which is very different from the CFR, is the crude mortality rate.

The crude mortality rate

The "crude mortality rate" is another very simple measure, which like the CFR gives something that *sounds* like the answer to the question that we asked earlier: if someone is infected, how likely are they to die? But, just as with CFR, it is actually very different.

The crude mortality rate – sometimes called the crude death rate – measures the probability that any individual in the population will die from the disease; not just those who are infected, or are confirmed as being infected. It's calculated by dividing the number of deaths from the disease by the *total population*. For instance, if there were 10 deaths in a population of 1,000, the crude mortality rate would be 10/1,000, or 1%, even if only 100 people had been diagnosed with the disease.

This difference is important: unfortunately, people sometimes confuse case fatality rates with crude death rates. A common example is the Spanish flu pandemic in 1918. One estimate, by Johnson and Mueller (2002), is that that pandemic killed 50 million people.[38] That would have been 2.7% of the world population at the time. This means the *crude* mortality rate was 2.7%.

But 2.7% is often misreported as the *case* fatality rate – which is wrong, because not everyone in the world was infected with Spanish flu. If the crude mortality rate really was 2.7%, then the case fatality rate was much higher – it would be the percentage of people who died *after being diagnosed with* the disease. *[We look at the global death count of this pandemic and others* ***here****.]*

Before we consider what the CFR tells us about the mortality risk it is helpful to see what the CFR does not tell us.

What we want to know isn't the *case fatality rate*: it's the *infection fatality rate*

Remember the question we asked at the beginning: if someone is infected with COVID-19, how likely is it that they will die? The answer to that question is captured by the *infection fatality rate*, or IFR.

The IFR is the number of deaths from a disease divided by the *total number of cases*. If 10 people die of the disease, and 500 actually have it, then the IFR is 10/500, or 2%.[39,40,41,42,43]

To work out the IFR, we need two numbers: the total number of *cases* and the total number of *deaths*.

However, as we explained above (scroll **there**) the *total* number of cases is not known. That's partly because not everyone with COVID-19 is tested.[44,45]

We may be able to *estimate* the total number of cases and use it to calculate the IFR – and researchers do this. But the total number of cases is not known, so the IFR cannot be accurately calculated. And despite what some media reports imply, the CFR is not the same as – or, probably, even similar to – the IFR. Next, we'll discuss why.

Interpreting the case fatality rate

In order to understand what the case fatality rate can and cannot tell us about a disease outbreak such as COVID-19, it's important to understand why it is difficult to measure and interpret the numbers.

The case fatality rate isn't constant: it changes with the context

The media tend to talk about the CFR as if it's a single, steady number, an unchanging fact about the disease. But it's not a biological constant; instead, it reflects the severity of the disease *in a particular context, at a particular time, in a particular population.*

The probability that someone dies from a disease doesn't just dependent on the disease itself, but also on the treatment they receive, and on the patient's own ability to recover from it.

This means that the CFR can decrease or increase over time, as responses change, and that it can vary by location and by the characteristics of the infected population, such as age, or sex. For instance, older populations would expect to see a higher CFR from COVID-19 than younger ones.

The CFR of COVID-19 differs by location and has changed during the early period of the outbreak

As this chart shows, the case fatality rate of COVID-19 is not constant. This chart was published in the *Report of the WHO-China Joint Mission on Coronavirus Disease 2019 (COVID-19)*, in February 2020.[46]

It shows the CFR values for COVID- in several locations in China during the early stages of the outbreak, from the beginning of January 2020 to 20th February 2020.

You can see that in the earliest stages of the outbreak the CFR was much higher: 17.3% across China as a whole (in yellow) and greater than 20% in the centre of the outbreak, in Wuhan (in blue).

But in the weeks that followed, the CFR declined. The WHO says that "the standard of care has evolved over the course of the outbreak". The CFR fell to 0.7% for patients with the onset of symptoms after February 1st.

You can also see that the CFR was different in different places. By 1st February, the CFR in Wuhan was still 5.8% while it was 0.7% across the rest of China.

This shows that what we said about the CFR more generally – that it changes from time to time and place to place – is true for the CFR of COVID-19 specifically. When we talk about the CFR of a disease, we need to talk about it *in a specific time and place* – the CFR in Wuhan on 23rd February, or in Italy on 4th March – rather than as a single unchanging value.

Case fatality ratio for COVID-19 in China over time and by location, as of 20 February 2020 – Figure 4 in WHO (2020)[47]

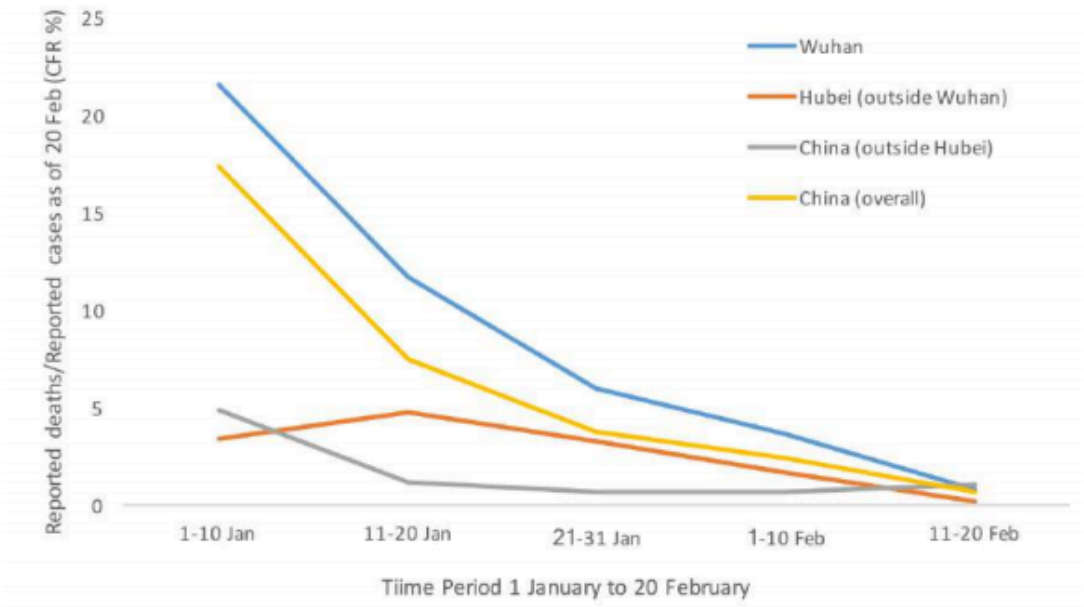


Figure 4 Case fatality ratio (reported deaths among total cases) for COVID-19 in China over time and by location, as of 20 February 2020

There are two reasons why the case fatality rate does not reflect the risk of death

If the case fatality rate does not tell us the risk of death for someone infected with the disease, what does it tell us? And how does the CFR compare with the actual (unknown) probability?

There are two reasons why we would expect the CFR not to represent the real risk. One of them would tend to make the CFR an overestimate – the other would tend to make it an underestimate.

When there are people who have the disease but are not diagnosed, the CFR will *overestimate* the true risk of death. With COVID-19, we think there are many undiagnosed people.

As we saw above, in our discussion on the difference between total and confirmed cases (**here**), we do not know the number of total cases. Not everyone is tested for COVID-19, so the total number of cases is higher than the number of confirmed cases.

And whenever there are cases of the disease that are not counted, then the probability of dying from the disease is lower than the reported case fatality rate. Remember our imaginary scenario with 10 deaths and 100 cases. The CFR in that example is 10% – but if there are 500 real cases, then the real risk (the IFR) is just 2%.

Or in one sentence. If the number of total cases is higher than the number of confirmed cases, then the ratio between deaths and *total cases* is smaller than the ratio between deaths and *confirmed cases*.

Importantly, this means that the number of tests carried out affects the CFR – you can only confirm a case by testing a patient. So when we compare the CFR between different countries, the differences do not only reflect rates of mortality, but also differences in the scale of testing efforts.

When some people are currently sick and will die of the disease, but have not died yet, the CFR will *underestimate* the true risk of death. With COVID-19, many of those who are currently sick and will die have not yet died.

In ongoing outbreaks, people who are currently sick will eventually die from the disease. This means that they are currently counted as a case, but will eventually be counted as a death too. This will mean the CFR is lower than the true risk.

With the COVID-19 outbreak, it can take between two to eight weeks for people to go from first symptoms to death, according to data from early cases (we discuss this here).[48]

That means that some people who are now counted as confirmed cases and who will die are not yet included in the number of deaths. This means the CFR right now is an underestimate of what it will be when the disease has run its course.

This is not a problem once an outbreak has finished. Afterwards, the total number of deaths will be known, and we can use it to calculate the CFR. But during an outbreak, we need to be careful with how to interpret the CFR because the outcome (recovery or death) of a large number of cases is still unknown.

This is a common source for misinterpretation of a rising CFR in the earlier stages of an outbreak.[49]

This is what happened during the SARS-CoV outbreak in 2003: the CFR was initially reported to be 3-5% during the early stages of the outbreak, but had risen to around 10% by the end.[50,51]

This is not just a problem for statisticians: it had real negative consequences for our understanding of the outbreak. The low numbers that were published initially resulted in an underestimate of the severity of the outbreak. And the rise of the CFR over time gave the wrong impression that SARS was becoming more deadly over time. These errors made it harder to come up with the right response.

The current case fatality rate of COVID-19

We should stress again that there is no single figure of CFR for any particular disease. The CFR varies by location, and is typically changing over time. But, if we are careful to acknowledge its limitations, CFR can help us understand more about the severity of the disease, and how best to respond.

Based on the discussion of the definition of the case fatality rate (CFR), we should stress again that there is no single figure of CFR for any particular disease. The CFR varies by location, and is changing over time.

As this paper published in *The Lancet* highlights clearly: better data is needed to give a clear understanding of the differences in CFR and how they should guide decision-making.[52]

The paper compares the CFR of different countries – showing a very broad range from 0.2% in Germany to 7.7% in Italy. But it states clearly that this does not necessarily give an accurate comparison of the probability of dying from COVID-19 if someone is infected. We do not know how many cases are asymptomatic versus symptomatic; and

whether the same criteria for testing are being applied. Without better and more homogenous criteria for testing and recording of deaths, the real mortality rate is unknown.

But with a good understanding of the measure and its limitations, CFR can be helpful for understanding what we currently know about the severity of the disease and for responding accordingly.

In the chart shown here we can see how these early CFR values might compare. It shows the total number of confirmed cases of COVID-19 (on the x-axis) versus the total number of deaths (on the y-axis). Since the CFR is the ratio between the total deaths and total confirmed cases, we can use this comparison to see where each country would lie in terms of its CFR.

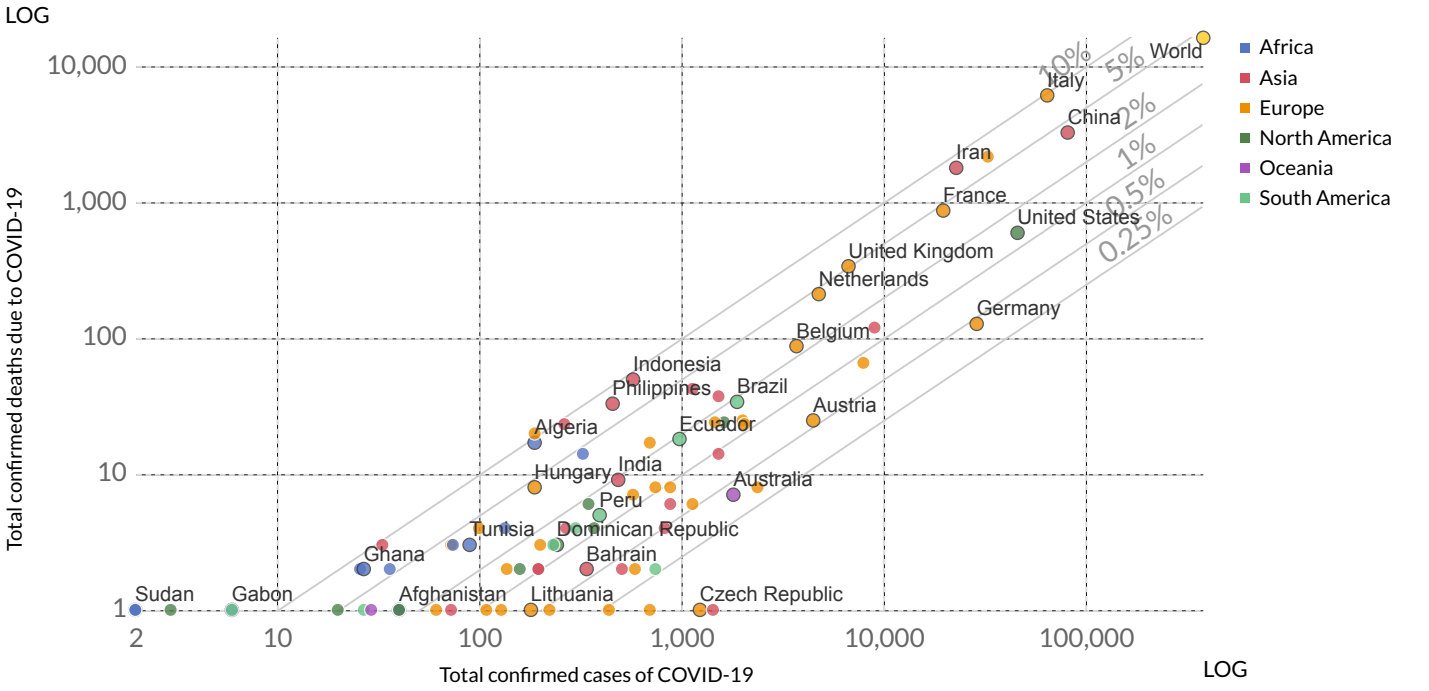
The grey lines show a range of CFR values – ranging from 0.25% to 10%. Where each country lies gives an indication of its CFR i.e. if a country lies along the 2% line, its current confirmed cases and death figures indicate it has a CFR of 2%.

With these caveats in mind, the other visualization here shows the CFR for countries which have more than 100 confirmed cases. This means we have excluded countries which still have a relatively small number of confirmed cases: this is because CFR is a particularly poor metric to understand mortality risk with a small sample size.

We see this if we **look at** the trajectory of cases and deaths in Iran: on February 24th it had 2 confirmed cases and 2 deaths, which would have a CFR of 100%. With time its CFR begins to fall as the number of confirmed cases increases, but it's not until it reaches hundreds of cases that the CFR falls below 20%.

COVID-19: Total confirmed cases vs. Total confirmed deaths, Mar 24, 2020

The number of confirmed cases is lower than the number of total cases. The main reason for this is limited testing. The grey lines show the corresponding case fatality rates, CFR (the ratio between confirmed deaths and confirmed cases).



Source: European CDC – Latest Situation Update Worldwide CC BY

Dec 31, 2019 Mar 24, 2020

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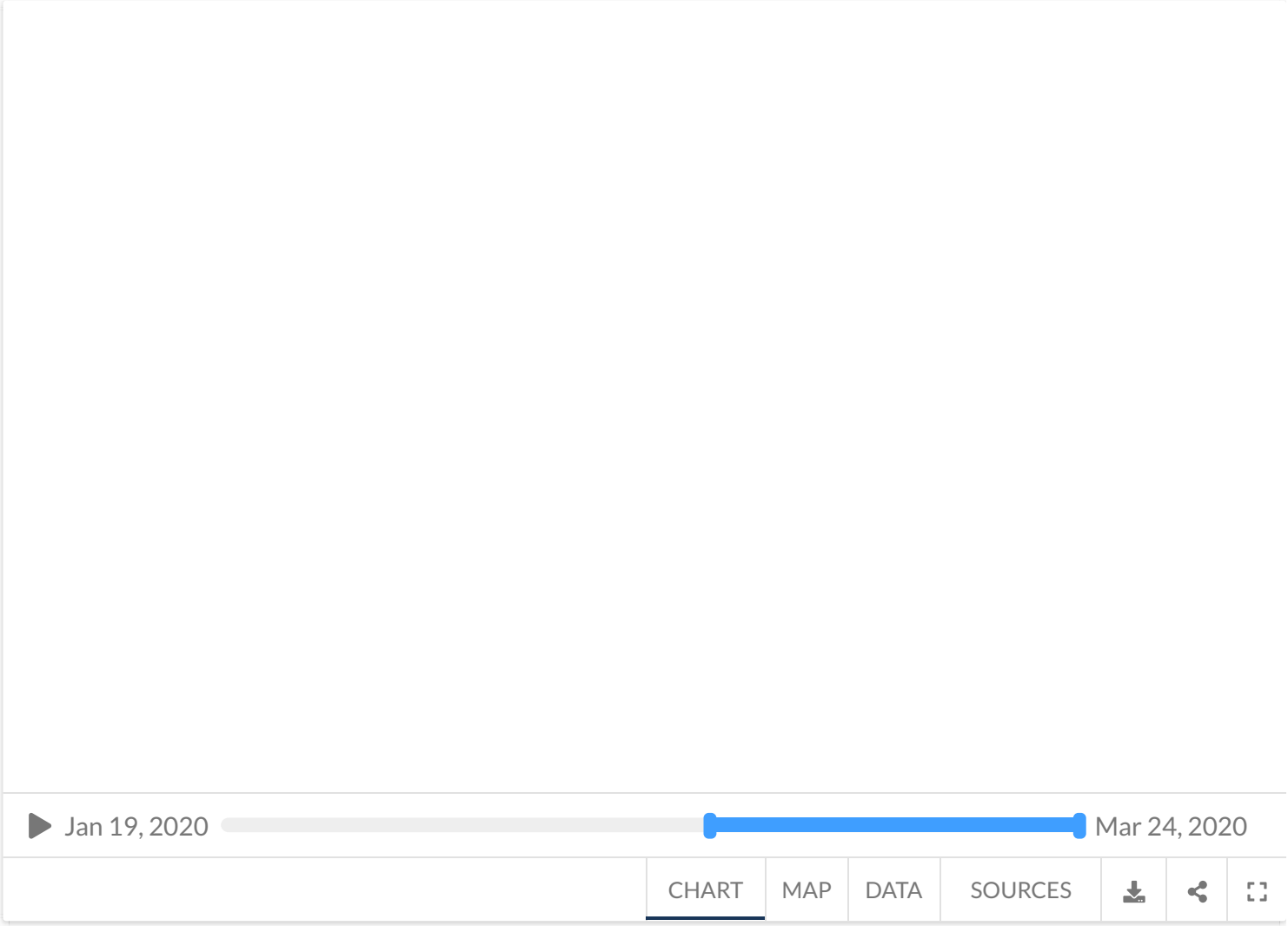


Case fatality rate of COVID-19 by age

Early data from China suggests that the elderly are most at risk

The total population-level estimate of the case fatality rate (CFR) above is useful for understanding the average severity of an outbreak, but does not tell us who within a population is most at risk. But this understanding is crucial in an outbreak. Understanding the relative risk to different sections of a population allows us to focus on the most vulnerable, and improve the allocation of health resources to those who need them most.

The *Chinese Center for Disease Control and Prevention* has published an analysis of recorded cases and deaths in China for the period until February 11th 2020 which provides a breakdown of all known cases, deaths and the CFR by

specific demographics (age, sex, preexisting condition etc.).[53]

A breakdown of the CFR by age group is shown in the visualization. It shows very large differences of the CFR by age.

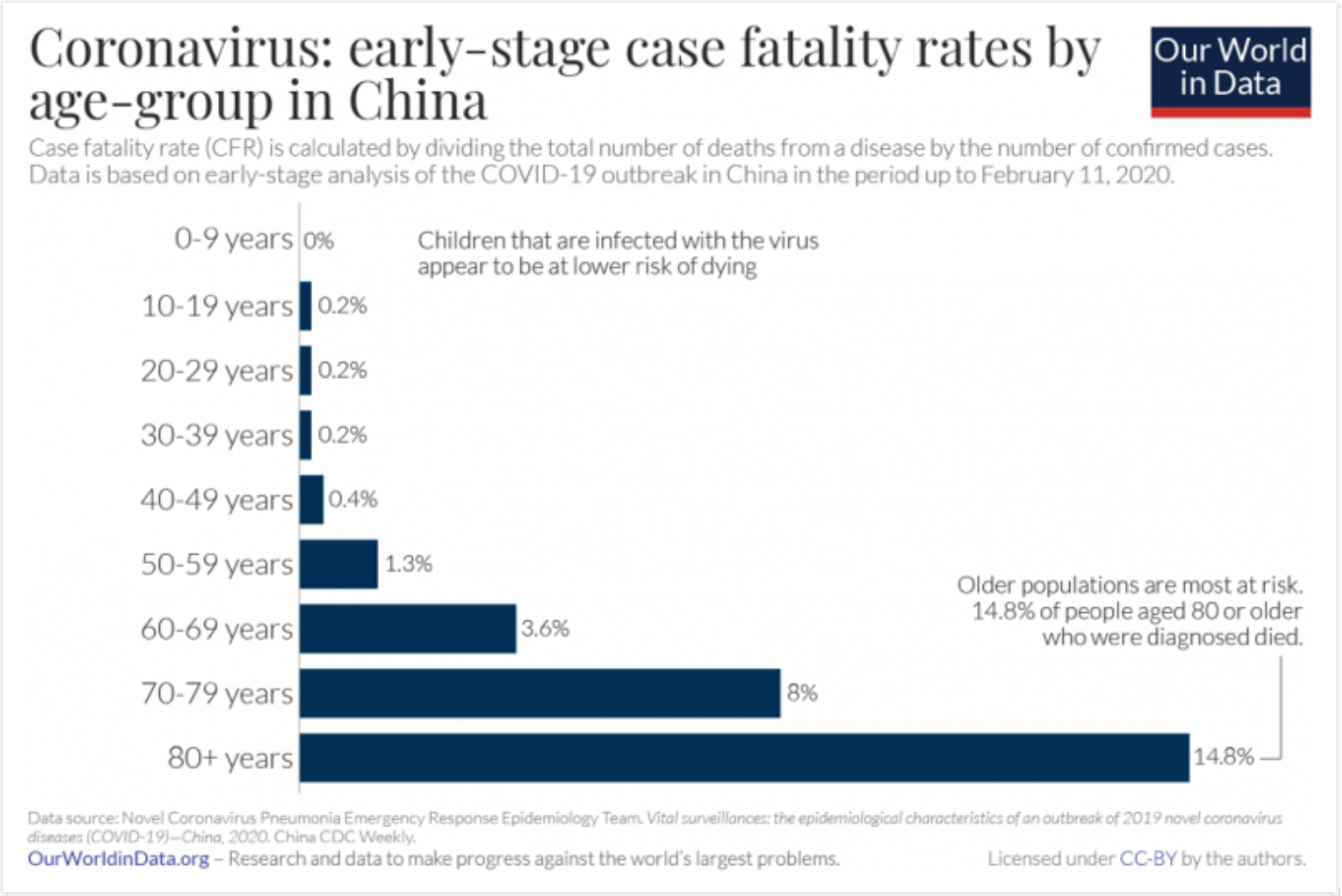
For many infectious diseases young children are most at risk. We see this for malaria: the majority of deaths (57% globally) are in children under five years of age. The same was true for the largest pandemic in recorded history: During the 'Spanish flu' in 1918 it was primarily children and young adults who died from the pandemic (we write more about this in the article here).

For the COVID-19 cases in China the opposite seems to be true, at least based on the information available at the time of writing. The elderly are at the greatest risk of dying if infected with this virus.

Based on the data from China – shown in the visualization – 14.8% of those who are 80 years and older who were infected by COVID-19 died as a result. As explained above, these figures represent the share of people *diagnosed as having the disease* who die from it. This does not represent the share of people in the entire population who die from it.

The case fatality rate for children is much lower. There were no reported deaths in children under 10 years old; 0.2% of those aged 10 to 19 years who were diagnosed with COVID-19 died from it according to the early Chinese data.

As we show in the following section, the CFR for people with underlying health conditions is higher than for those without. One possible reason why the elderly might be most at risk is that they are also those who are most likely to have underlying health conditions such as cardiovascular diseases, respiratory diseases or diabetes.



Case fatality rate of COVID-19 by preexisting health conditions

Early data from China suggests that those with underlying health conditions are at a higher risk

The visualization here shows the case fatality rate for populations within China based on their health status or underlying health condition.

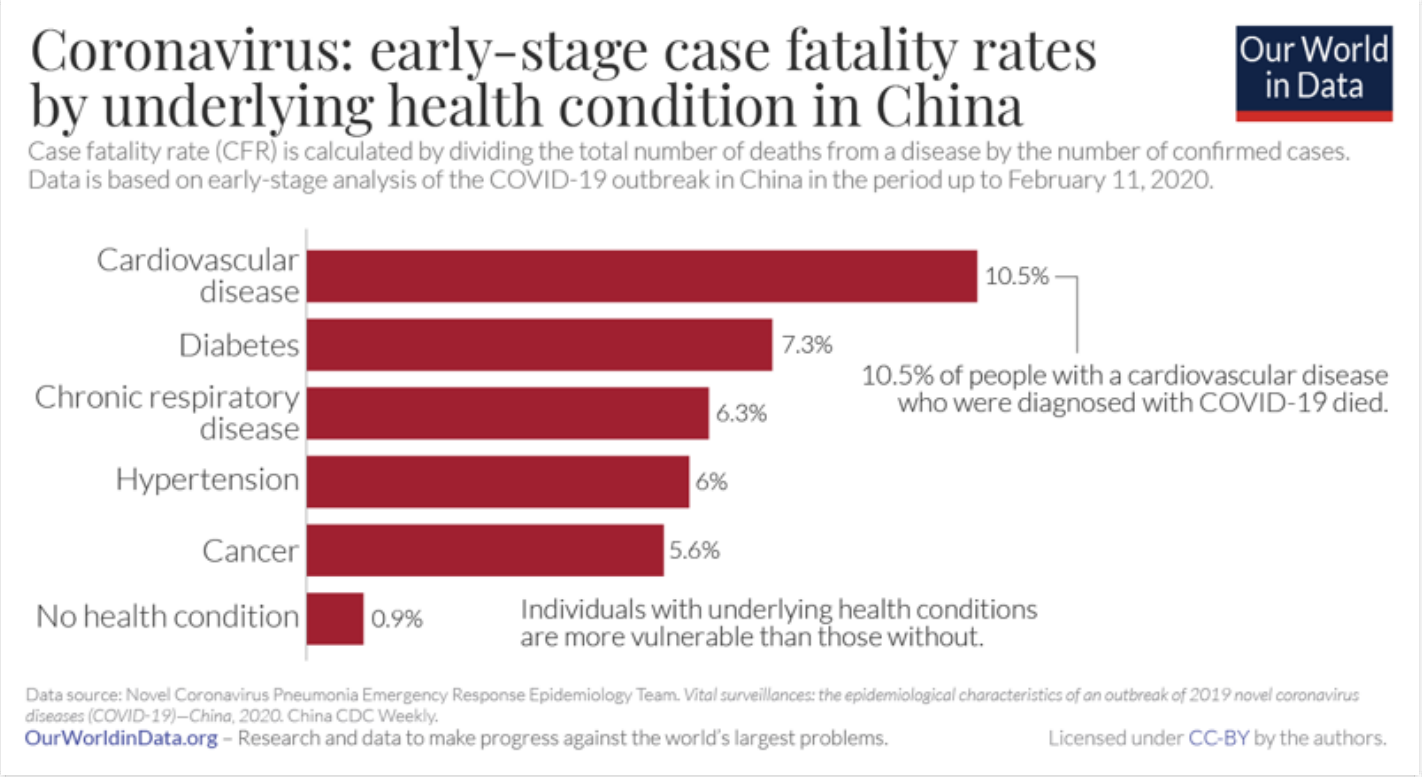
This is based on the same data from the Center for Disease Control and Prevention's initial breakdown of cases, deaths and CFR among specific demographics in the population.[54] This analysis was based on recorded deaths and cases in China in the period up to February 11th 2020.

The researchers found that the CFR for those with an underlying health condition is much higher than for those without.

More than 10% of those diagnosed with COVID-19 who already had a cardiovascular disease, died as a result of the virus. Diabetes, chronic respiratory diseases, hypertension, and cancer were all risk factors as well, as we see in the chart.

The CFR was 0.9% for those without a preexisting health condition.

Above we saw that the elderly are most at risk of dying from COVID-19. This might be partly explained by the fact that they are also most likely to have underlying health conditions such as cardiovascular disease, respiratory disease and diabetes; these health conditions make it more difficult to recover from the COVID-19 infection.



Case fatality rate of COVID-19 compared to other diseases

How does the case fatality rate (CFR) of COVID-19 compare to other virus outbreaks and diseases?

Once again, we should stress what we discussed above. One has to understand the measurement challenges and the definitions to interpret estimates of the CFR for COVID-19, particularly those relating to an ongoing outbreak.

As comparisons, the table shows the case fatality rates for other disease outbreaks. The CFR of SARS-CoV and MERS-CoV were high: 10% and 34%, respectively.[55]

The US seasonal flu has a case fatality rate of approximately 0.1% – much lower than the current CFR for COVID-19.

Sources of data shown in the table:
SARS-CoV: Venkatesh, S. & Memish, Z.A. (2004). SARS: the new challenge to international health and travel medicine. *EMHJ – Eastern Mediterranean Health Journal, 10 (4-5), 655-662, 2004.*
SARS-CoV and MERS-CoV: Munster, V. J., Koopmans, M., van Doremalen, N., van Riel, D., & de Wit, E. (2020). A novel coronavirus emerging in China—key questions for impact assessment. *New England Journal of Medicine*, *382*(8), 692-694.

Seasonal flu: US Centers for Disease Control and Prevention (CDC). Influenza Burden, 2018-19.
Ebola: Shultz, J. M., Espinel, Z., Espinola, M., & Rechkemmer, A. (2016). Distinguishing epidemiological features of the 2013–2016 West Africa Ebola virus disease outbreak. *Disaster Health*, *3*(3), 78-88.
Ebola: World Health Organization (2020). Ebola virus disease: Factsheet.

Disease	Estimated case fatality rate (CFR)
SARS-CoV	10% Venkatesh and Memish (2004) Munster et al. (2020)
MERS-CoV	34% Munster et al. (2020)
Seasonal flu (US)	0.1% US CDC
Ebola	50% 40% in the 2013-16 outbreak WHO (2020) Shultz et al. (2016)

How do case fatality rates from COVID-19 compare to those of the seasonal flu?

This question is answered in the visualization here. We compare the CFR during the outbreak of COVID-19 in China with the CFR of the US seasonal flu in 2018-19.

The case fatality rate of the seasonal flu in the US is around 0.1% to 0.2%, while the case fatality rate for COVID-19, measured in the cited study, was 2.3%.

The US data is sourced from the US CDC. Here we present an upper and lower estimate for the 2018-19 flu season. These two figures reflect whether we look at the percentage of deaths out of the number of symptomatic illnesses (giving us 0.1%), or the number of medical visits (giving us 0.2%). In the traditional calculation of CFR, we would tend to focus on the number of *symptomatic illnesses*. This is analogous to the number of confirmed cases, on which the COVID-19 figures are based. However, the US CDC derives these figures based on disease outbreak modelling which attempts to account for underreporting – you can read more about how it derives its annual flu figures **here**.

This means that some of the biases which tend to underestimate the actual number of cases have been corrected for. This is not the case for the COVID-19 figures, so it may be an unfair comparison.

Looking at estimates based on the number of medical visits may discount from the US seasonal flu data many of the kind of mild cases that may have been missed in the COVID-19 confirmed cases. However, this is likely to skew the comparison slightly in the other direction: we know that not all of the confirmed cases included in COVID-19 figures were of a severity such that they would have received a medical visit in the absence of the heightened surveillance of the outbreak.

So, here we present both figures of the US seasonal flu figures: the CFR based on symptomatic illnesses, and those based on medical visits (shown in square brackets). It's likely that the fairest comparison to COVID-19 lies

somewhere between these two values.

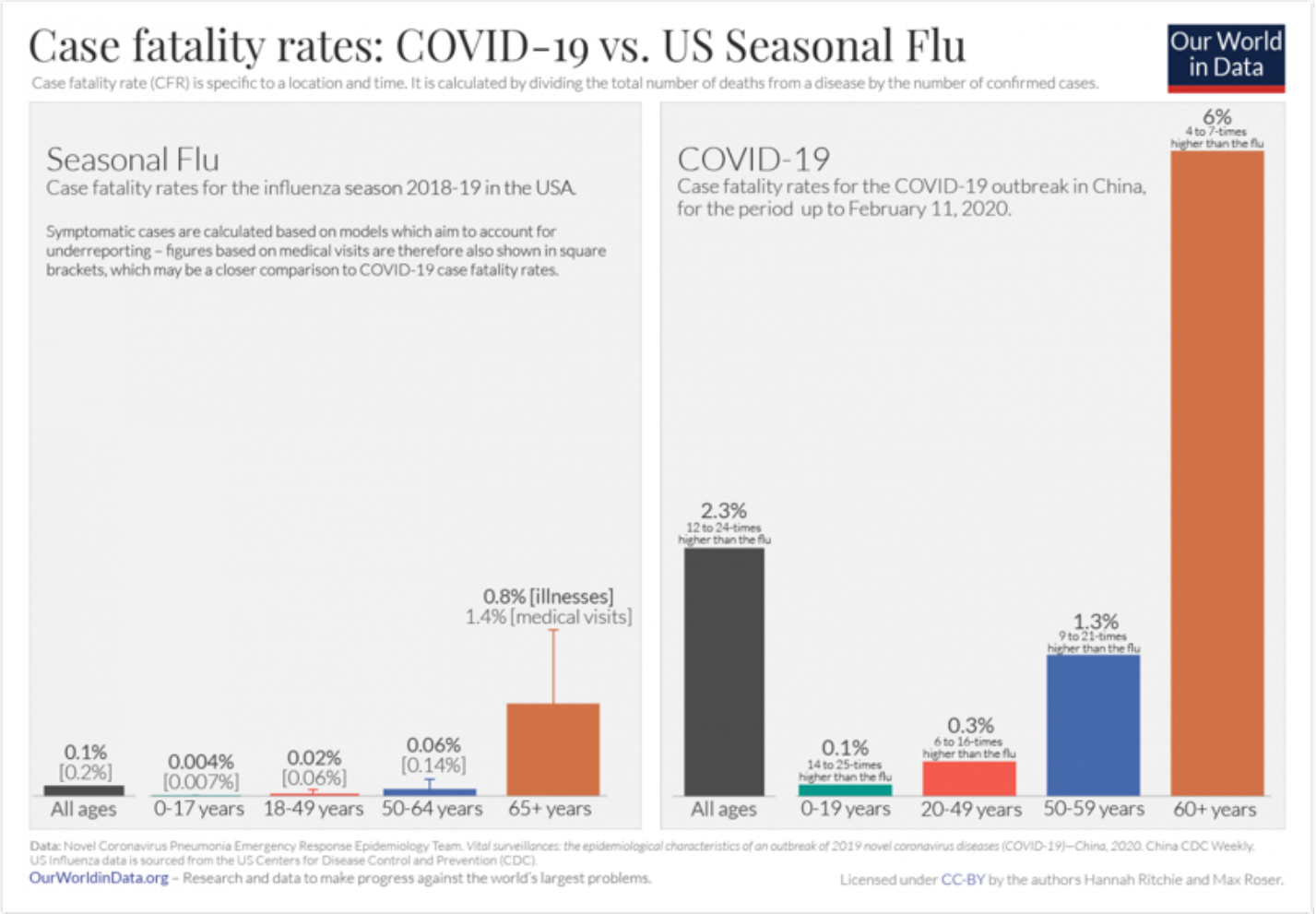
You can find the data for the reported cases, medical visits and deaths from the US Centers for Disease Control and Prevention (CDC) here. The CDC reports 35,520,883 symptomatic cases of influenza in the US and 34,157 deaths from the flu. To calculate the CFR based on symptomatic illnesses, we divide the number of deaths by the number of confirmed cases and find a case fatality rate of 0.1%.[56]

The CFRs for COVID-19 are again based on the numbers reported by the *Chinese Center for Disease Control and Prevention*.[57] As before, the Chinese data refers to recorded deaths and confirmed cases in China as of February 11th 2020.

As we emphasise, the global CFR for COVID-19 continues to change over time, and can vary significantly by location.

While the CFR for COVID-19 is much higher than the CFR of the seasonal flu the two diseases are similar in the profile of the fatality rate by age: elderly populations have higher case fatality rates.

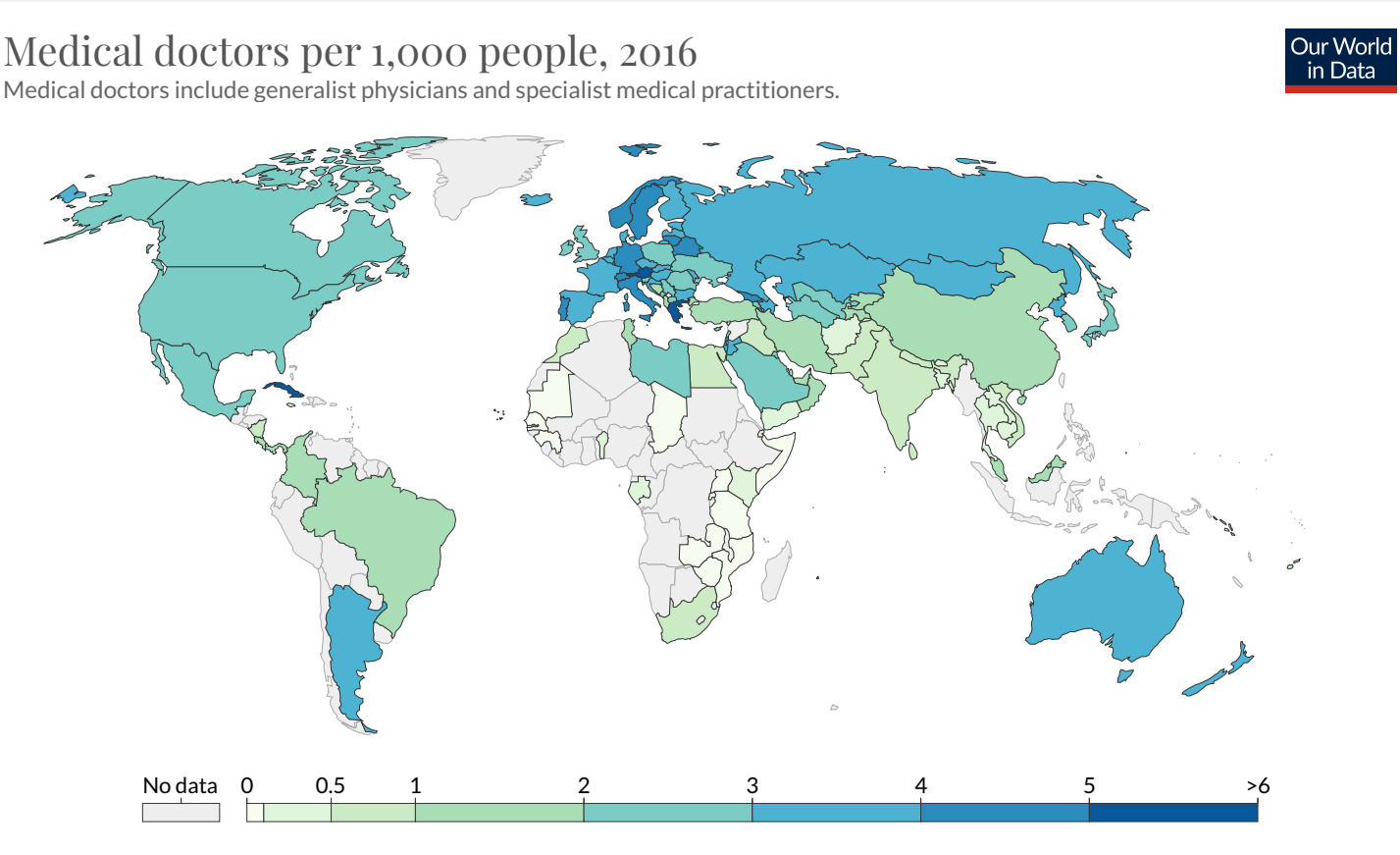
However, the CFR of COVID-19 is much higher for all age groups, including young people. On top of each bar we have indicated how much higher the CFR for COVID-19 is for each age group.



Healthcare capacity

To respond to the pandemic, the capacity of the healthcare system if of great importance.

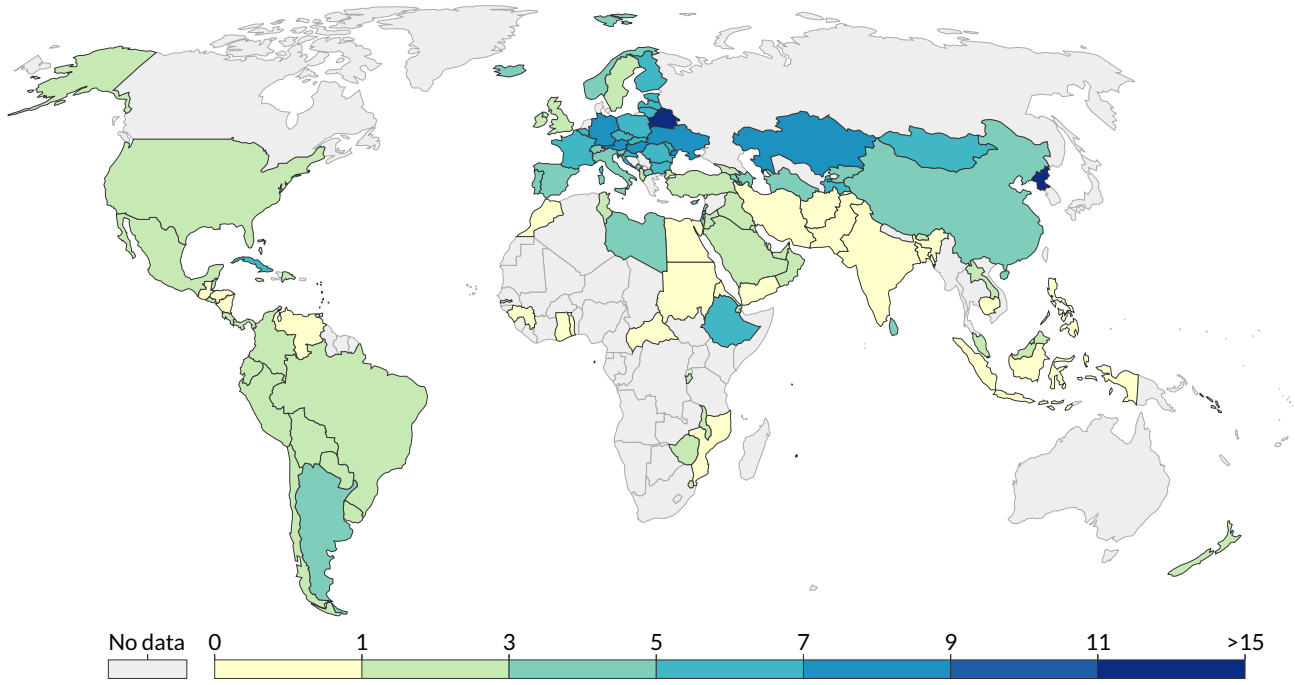
The two maps here show the number of medical doctors and hospital beds relative to the size of each country's population.



Hospital beds per 1,000 people, 2014

Hospital beds include inpatient beds available in public, private, general, and specialized hospitals and rehabilitation centers. In most cases beds for both acute and chronic care are included.

Our World in Data



Source: World Health Organization (via World Bank) CC BY

1960 2014

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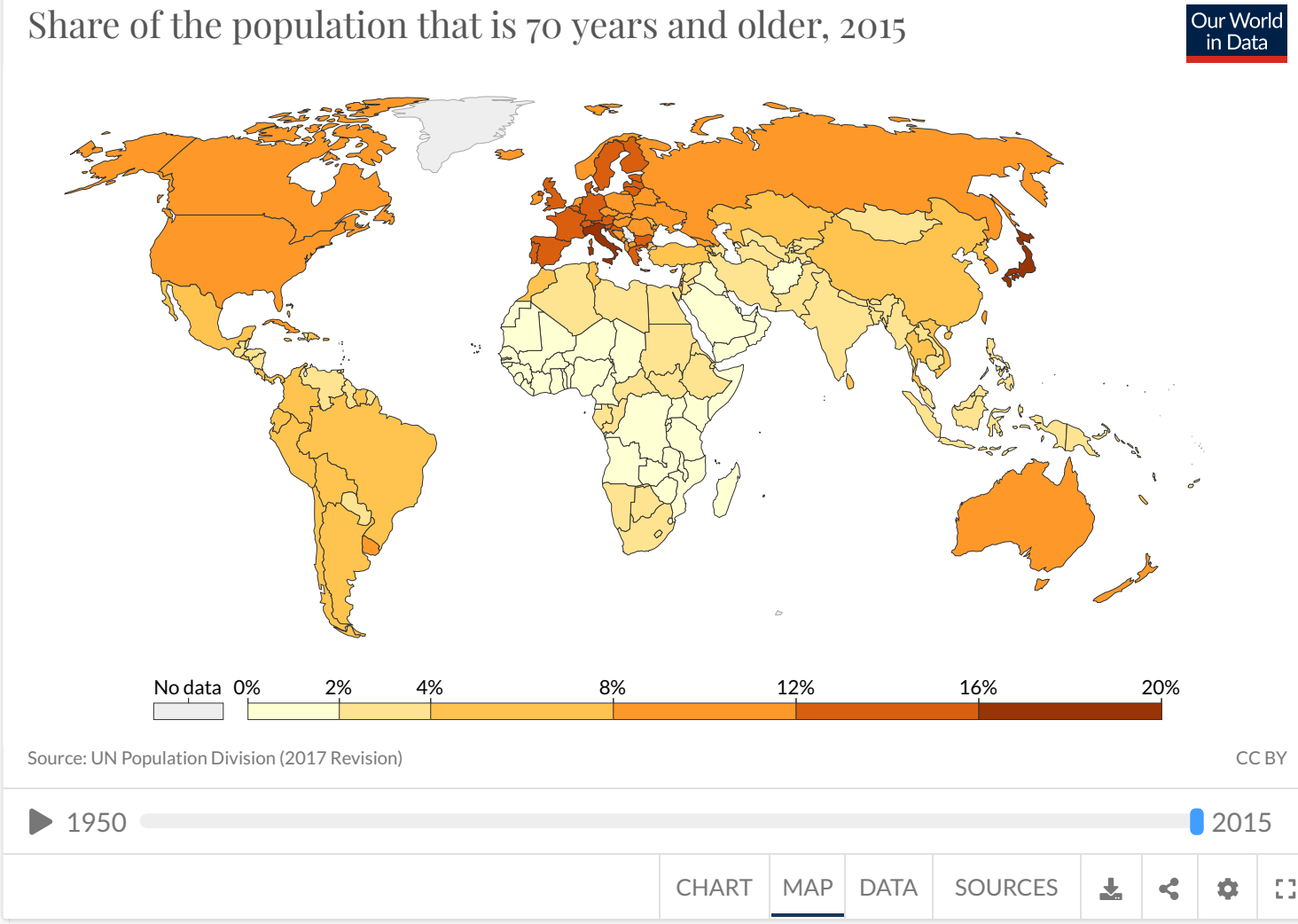
Age structure

The discussion of the age-specific mortality above showed that the current evidence suggests that older population are at a higher risk from COVID-19.

The map shows the share of the population that is 70 years and older.

In our entry on the age structure we study this in much more detail.



Data and dashboards from other sources

The World Health Organization (WHO), researchers from Johns Hopkins University, and other institutions all maintain datasets on the number of cases, deaths, and recoveries from the disease.

These are presented in a number of useful dashboards and websites listed below.

Johns Hopkins data on COVID-19

A dashboard is published and hosted by researchers at the Center for Systems Science and Engineering, Johns Hopkins University. It shows the number and location of confirmed COVID-19 cases, deaths, and recoveries in all affected countries.

The researchers have the intention to "continue hosting and managing the tool throughout the entirety of the COVID-19 outbreak".

Scientific Paper: The background paper for the Johns Hopkins' dashboard was published by Dong, Du, and Gardner (2020) in *The Lancet Infectious Disease*.[58] This paper also includes a comparison of this data with the data reported by the WHO and the Chinese CDC.

Data: All collected data in this effort from the Johns Hopkins University is made freely available by the researchers through this GitHub repository. You can download all the data shown in the dashboard. Information on the sources of their data can also be found directly there.

Link: **Here** is the Johns Hopkins dashboard. A here is a mobile friendly version of the same dashboard.

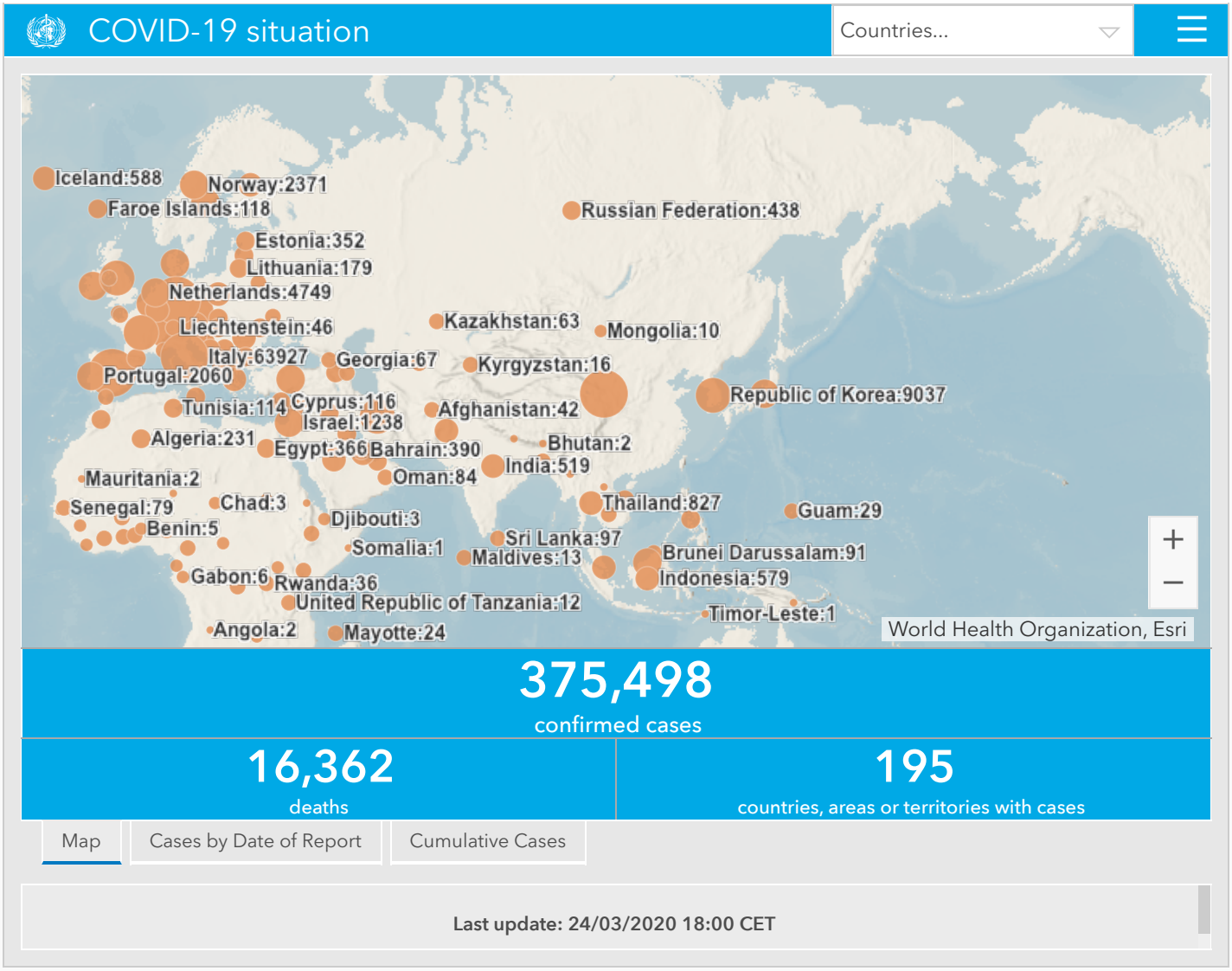
WHO data on COVID-19

The World Health Organization (WHO) publishes a dashboard similar to that of Johns Hopkins above.

The **WHO dashboard** on global cases and deaths is embedded here. In this dashboard it is possible to see up-to-date country specific data by selecting the country in the top right.

In addition to this dashboard, the WHO publishes **daily Situation Reports** which can be found here. It is the daily Situation reports that we rely on in our own published datasets on case and death numbers. Unlike the daily Situation Reports, the WHO dashboard is updated three times per day: any inconsistencies between the WHO dashboard and the data we present will be explained by this fact.

As we explained above, the Our World in Data team found several minor errors in the WHO data – we documented these errors, corrected them, reported them to the WHO, and are in close contact with colleagues at the WHO. Here is the documentation of our adjustments to the WHO data and an option to download all data.



nCoV-2019 Data Working Group data

The nCoV-2019 Data Working Group, which includes colleagues from the University of Oxford, publishes epidemiological data from the outbreak via this global dashboard. From this dashboard it is possible to obtain the underlying data which includes demographic and epidemiological descriptions of a long list of individual cases.

Their data on the list of cases includes individual travel history and key dates for each patient – date of onset of symptoms, date of hospitalisation and date of laboratory confirmation of whether the person was infected with the COVID-19 virus or not.

This data is intended to be helpful in the estimation of key statistics for the disease: Incubation period, basic reproduction number (R0), age-stratified risk, risk of importation.

In previous disease outbreaks such global individual data was not openly available.

Data from the Chinese Center for Disease Control and Prevention

The Chinese Center for Disease Control and Prevention publishes data via their dedicated site 'Tracking the epidemic'.

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2. Note that this metric is distinct from another way in which a doubling time can be calculated. It is also possible to calculate the doubling time implied by the current daily rate of change. But the reporting of confirmed cases and deaths is very 'noisy' – one day the statistical agency does not report new confirmed cases, but the next day it is reporting all the new cases within the last two days for example. Doubling time based on the most recent *daily* growth rate is therefore more susceptible to this type of noise from day-to-day variability in reporting.
3. One way to see that this is true is to ask when the number of deaths would be larger than the total world population. To give a concrete example: starting from 4,500 deaths it would only take 23 doublings for the number of deaths to be larger than the world population.
4. 500, 1000, 2000, 4000, 8000, 16,000, 32,000, 64,000, 128,000, 256,000, 512,000, 1,024,000
5. See for example Stango, Victor, and Jonathan Zinman (2009) – "Exponential growth bias and household finance." The Journal of Finance 64.6 (2009): 2807-2849.
6. This is quoted from Wagenaar and Sagaria (1975). Wagenaar, W.A., Sagaria, S.D. Misperception of exponential growth. Perception & Psychophysics 18, 416–422 (1975). https://doi.org/10.3758/BF03204114
7. For example, the report of the WHO-China Joint Mission on Coronavirus Disease, 16-24 February 2020, online here, explains on page 34: "Development of rapid and accurate point-of-care tests which perform well in field settings are especially useful if the test can be incorporated into presently commercially available multiplex respiratory virus panels. This would markedly improve early detection and isolation of infected patients and, by extension, identification of contacts."
8. The report of the WHO-China Joint Mission on Coronavirus Disease, 16-24 February 2020, online here, explains that in addition to PCR tests, there are other diagnostic methods that remain less common, including serological diagnostic tests that rely on antibody assays using a blood sample. According to the WHO-China Joint Mission, the timeline for the development of the PCR tests was as follows: (i) On 29 December 2019 Chinese authorities identified a cluster of similar cases of pneumonia in the city of Wuhan in China; (ii) on 7 January, the virus found to cause COVID-19 was initially isolated from a clinical sample; (iii) on 16 January, the first PCR assays for COVID-19 were distributed to Hubei, China. You can find more information on the WHO protocols for COVID-19 laboratory testing in humans here: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/laboratory-guidance
9. Note: The Wikipedia page on COVID-19 Testing also compiles available estimates. These often cover more countries, but they are sometimes inaccurate or out of date; the estimates are often incorrect, or trace back to unreliable sources. That's why we use official reports, and do not rely on Wikipedia as our source.
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18. This advice from the WHO is also implemented at national and local levels for testing. For example, the Centers for Disease Control and Prevention in the US publishes a Fact Sheet for testing COVID-19, explaining the following : *"A negative test result for this test means that SARSCoV-2 RNA was not present in the specimen above the limit of detection. However, a negative result does not rule out COVID-19 and should not be used as the sole basis for treatment or patient management decisions. A negative result does not exclude the possibility of COVID-19. When diagnostic testing is negative, the possibility of a false negative result should be considered in the context of a patient's recent exposures and the presence of clinical signs and symptoms consistent with COVID-19."* CDC (2020) Fact sheet for healthcare providers, CDC – 2019-nCoV Real-Time RT-PCR Diagnostic Panel, March 15, 2020.

19. See any Situation Report by the WHO – for example Situation Report 50.

    The WHO also speaks of 'suspected cases' and 'probable cases', but the WHO Situation Reports do not provide figures on 'probable cases', and only report 'suspected cases' for Chinese provinces ('suspected cases' by country is not available).

    In Situation Report 50 they define these as follows:

    Suspect case
    A. A patient with acute respiratory illness (fever and at least one sign/symptom of respiratory disease (e.g., cough, shortness of breath), AND with no other etiology that fully explains the clinical presentation AND a history of travel to or residence in a country/area or territory reporting local transmission (See situation report) of COVID-19 disease during the 14 days prior to symptom onset.
    OR
    B. A patient with any acute respiratory illness AND having been in contact with a confirmed or probable COVID19 case (see definition of contact) in the last 14 days prior to onset of symptoms;
    OR
    C. A patient with severe acute respiratory infection (fever and at least one sign/symptom of respiratory disease (e.g., cough, shortness breath) AND requiring hospitalization AND with no other etiology that fully explains the clinical presentation.
    Probable case
    A suspect case for whom testing for COVID-19 is inconclusive.
    • Inconclusive being the result of the test reported by the laboratory

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28. For a discussion of this principle in a model of the outbreak of COVID-19 see Leon Danon, Ellen Brooks-Pollock, Mick Bailey, Matt Keeling (2020) – A spatial model of CoVID-19 transmission in England and Wales: early spread and peak timing. Preprint online here.

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