Actuaries Institute

Research Note 3

With a full year of mortality experience since the beginning of the pandemic, what does it tell us about deaths worldwide and in Australia? And how might future morbidity and mortality be impacted?

Impact of COVID-19 on Mortality and Morbidity in 2020

JUNE 2021

Karen Cutter, Jennifer Lang and Richard Lyon

About the authors

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Karen worked as a consulting actuary in the general insurance field for 25 years before taking a career break a few years ago. Finding herself at a loose end during lockdown in March, she developed an interest in COVID-19-related matters. Karen has authored a number of professional papers and has served on the GIPC and other Institute committees.

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Introduction

This paper looks at a number of ways in which COVID-19 mortality has been measured around the world and in Australia. We then take a closer look at the impact of COVID-19 (including border closures and other non-pharmaceutical measures) on the mortality experience of Australia during 2020. And finally, we take a brief look at the impact of COVID-19 on long term illness, based on studies from the US, the UK and Denmark.

An important way in which the impact of COVID-19 on mortality can be measured is by looking at the total deaths from a population and comparing them with some measure of expected deaths (either deaths in recent years, or some more sophisticated projection). This information is not available for all countries, but for many countries it shows that the impact of COVID-19 on mortality has been higher than the reported COVID-19 deaths.

In Australia, by contrast, because COVID-19 outbreaks and deaths have been very low in comparison with the rest of the world, we can see the effect of border closures and other non-pharmaceutical measures. Overall, Australian mortality has been much lower than our model predicts, with around 3,900 (2.7%) fewer deaths in 2020 than predicted. This is driven by lower numbers of deaths directly attributed to respiratory illness (around 3,200 fewer than predicted). Higher than expected deaths from pneumonia at the end of March (likely undiagnosed COVID-19) have been more than offset by the much lower numbers of all respiratory deaths since mid-April. Dementia and 'other' deaths, where, in normal years, respiratory illness is likely to be a significant contributing factor, have also been much lower than predicted (by around 1,500 deaths). Overall, the various non pharmaceutical measures to reduce the spread of COVID-19 across Australia (lockdowns, social distancing measures, wearing of facemasks, etc) have almost certainly reduced mortality from other causes.

In other countries, a significant number of those who contract COVID-19 stay ill with a wide variety of long-term symptoms including organ damage, neurological issues and psychiatric issues. The long-term morbidity implications for countries which have had significant outbreaks are likely to be material. Any insurer that covers morbidity or health care costs will need to understand the prevalence of long-term post-COVID-19 illnesses in the population, both from those in their insured population currently (whichever country they are located in) and from those who may become insured in the future. Insurers (where permitted by legislation) will need to consider the appropriateness of underwriting for previous COVID-19 disease when selecting new customers, noting that in Australia health insurers do not underwrite individual customers due to community rating.

Australian mortality in 2020 has been much lower than expected. The measures used to reduce the spread of COVID-19 have almost certainly reduced mortality from other causes.

1. Excess mortality around the world

The official global death toll from COVID-19 passed 3 million in April 2021. However, this statistic will not correctly measure the mortality impact of the pandemic, for reasons including:

- deaths from COVID-19 may have been recorded as from other causes;
- deaths from other causes may have been recorded as from COVID-19; and
- the disruption caused by COVID-19 had flow-on effects on activity and, hence, on mortality.

Therefore, the interesting question is what overall excess mortality has been experienced in different countries. Fortunately, a rich data source is available in the form of Our World in Data (OWID: ourworldindata.org). Except where otherwise specified, all data for the charts and tables in this section comes from this source.

1.1. Handle with care!

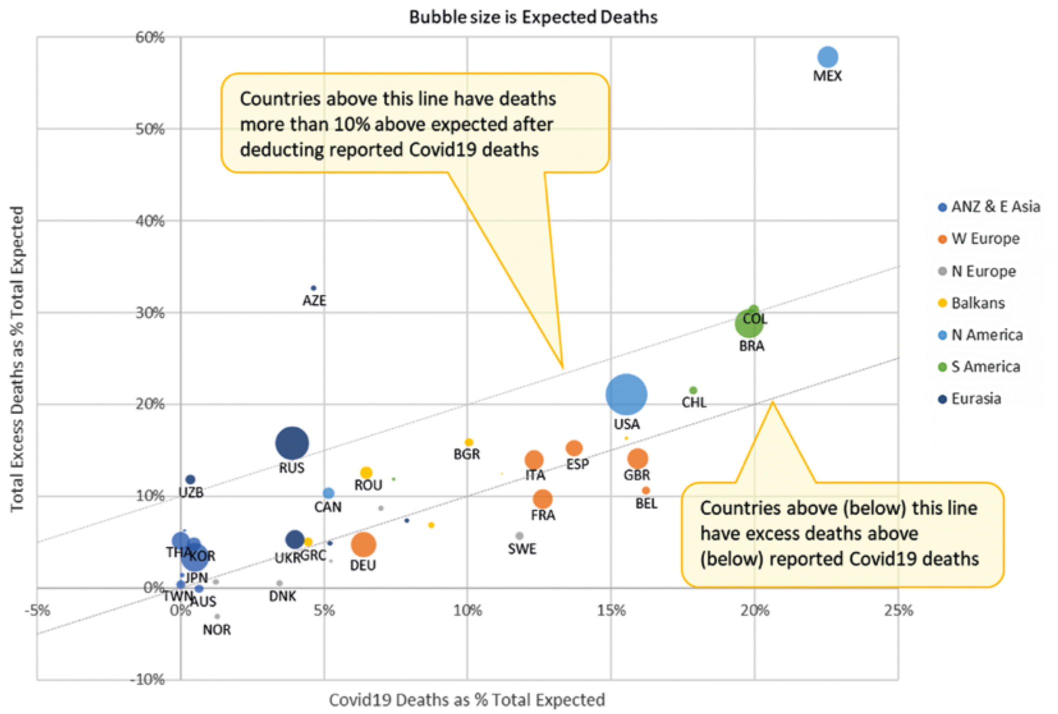
We note that the standard approach used by OWID to calculate excess mortality is to compare reported deaths for each week or month with the average for the equivalent period across 2015 to 2019. This is subject to general uncertainty, to the extent that there may be reporting delays or errors, but it also fails to take account of both the demographic change in this time and any trends in experience. This is illustrated in our discussion of excess deaths in Australia in Section 2.

1.2. National and Regional Differences

Different countries have experienced significantly different mortality since January 2020, each relative to its 2015-19 average. Appendix A contains a table, derived from OWID data, showing COVID-19 deaths and total excess deaths from January 2020 to the latest available date, for 38 countries. The table also expresses these deaths as a percentage of 'expected deaths', being the 2015-19 average.

The chart below shows that several countries have experienced very high excess mortality from all causes in 2020, while a few have experienced close to 'expected'. The chart also indicates the

Excess Mortality – COVID-19 and Total – Australia and Selected Others



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

contribution of reported COVID-19 deaths to the total excess. Countries sitting above (below) the parity line on the chart have experienced excess deaths above (below) reported COVID-19 deaths. We have also shown a higher line, above which excess deaths **other than those reported as COVID-19** were more than 10% of the 2015-19 average.

Note that the table in Appendix A can be used to identify the individual countries represented by codes in this chart.

Mexico, Azerbaijan, Russia, Uzbekistan, Colombia and Brazil sit above or near this higher line – and therefore well above the parity line. This suggests a major level of underreporting and indicates the pitfalls of relying on reported COVID-19 deaths in some countries.

On the other hand, several countries sit well below the line. We have not investigated in detail why this may be so. However, in the case of Belgium, it may be because nursing home deaths where COVID-19 was suspected but not confirmed were generally counted as COVID-19 deaths, thus shifting deaths primarily from other causes into the COVID-19 column. Similarly, but to a lesser extent, we understand that the UK counts as a COVID-19 death any death up to 28 days after a positive test.

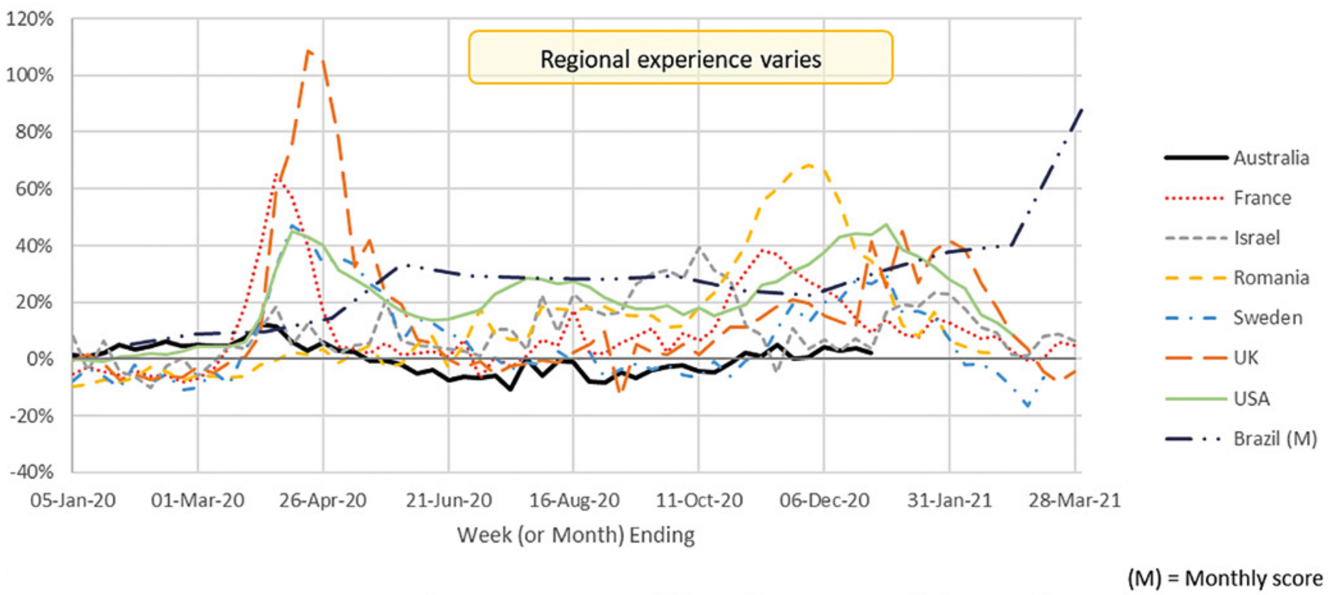
Countries such as the USA and Chile have experienced total deaths more than 20% above expected.

It is also noteworthy that countries such as the USA and Chile have experienced total deaths more than 20% above expected. 12 other countries in the OWID data set but not in the chart also exceeded +20%, including Ecuador at +64.3% and Bolivia at +55.0%.

Unfortunately at the time of our analysis, data was not available for China, India, Indonesia, Papua New Guinea or Peru, among others which have had significant outbreaks and/or are close to Australia.

The next chart compares Australia with a selection of other countries, broadly representative of various regions. It illustrates the regional variations in excess mortality experience, using a measure that OWID calls a P Score but that is simply the proportion by which actual deaths exceed expected deaths.

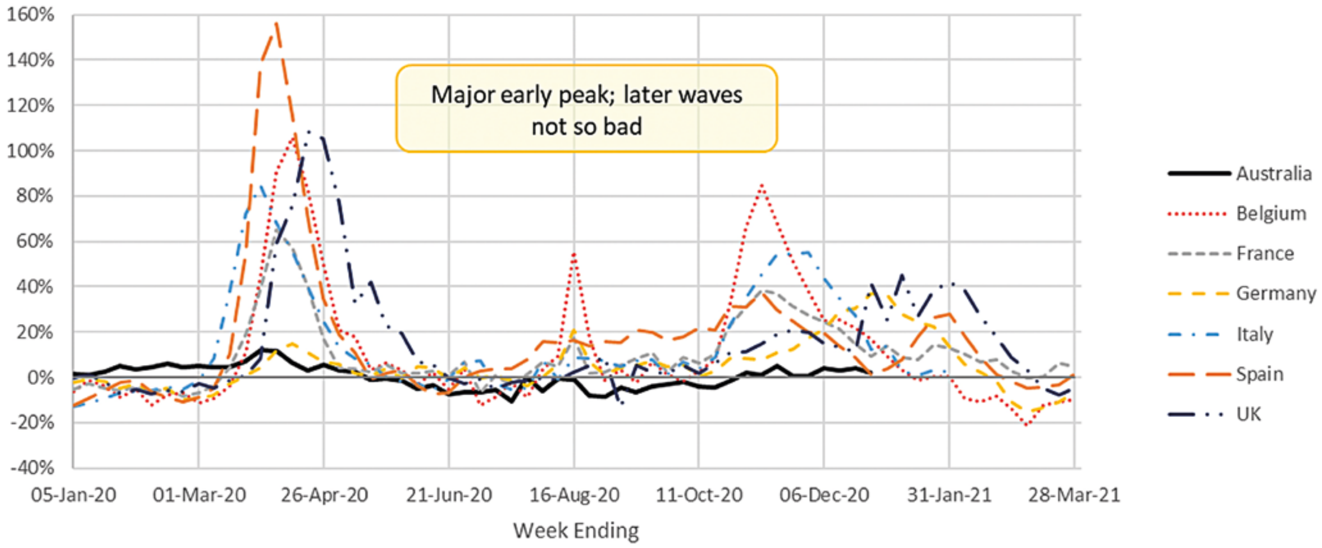
Weekly Excess Mortality P Score – Australia and Selected Others



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

There was a strong early peak in excess mortality in Western Europe as the pandemic spread, exacerbated by international travel. A subsequent peak occurred in the northern winter but was generally lower, in percentage terms at least. The following chart shows Western Europe, with Australia included as a frame of reference.

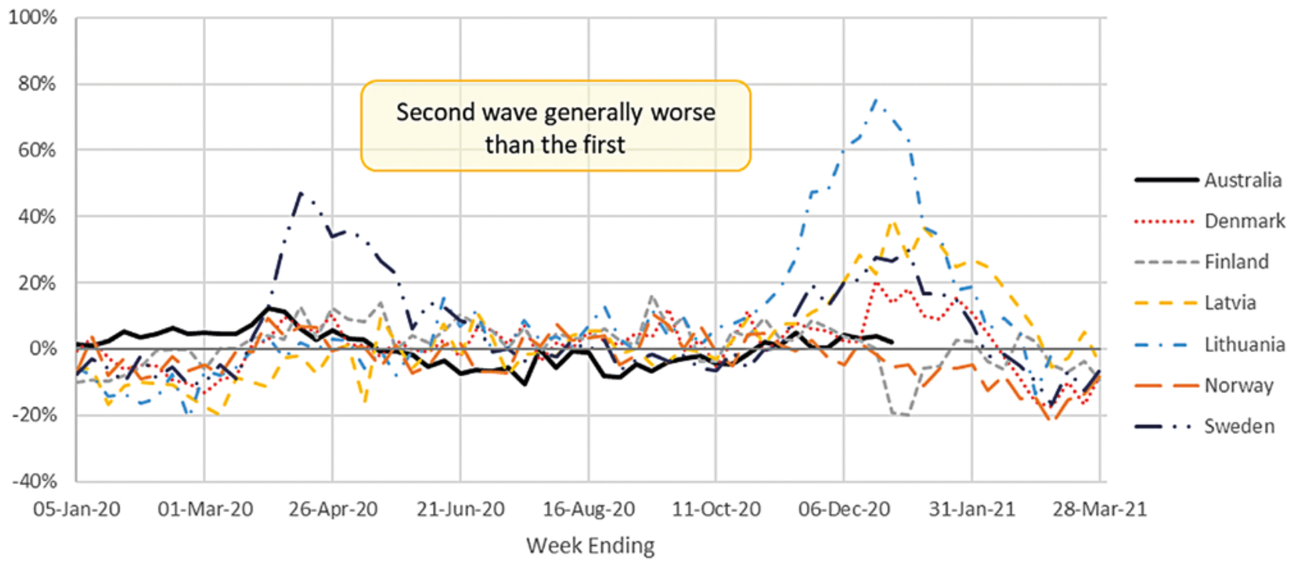
Weekly Excess Mortality P Score – Australia and Western Europe



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

The next chart shows that Northern Europe generally avoided a significant early peak (apart from Sweden) but several countries had poor experience towards the end of 2020.

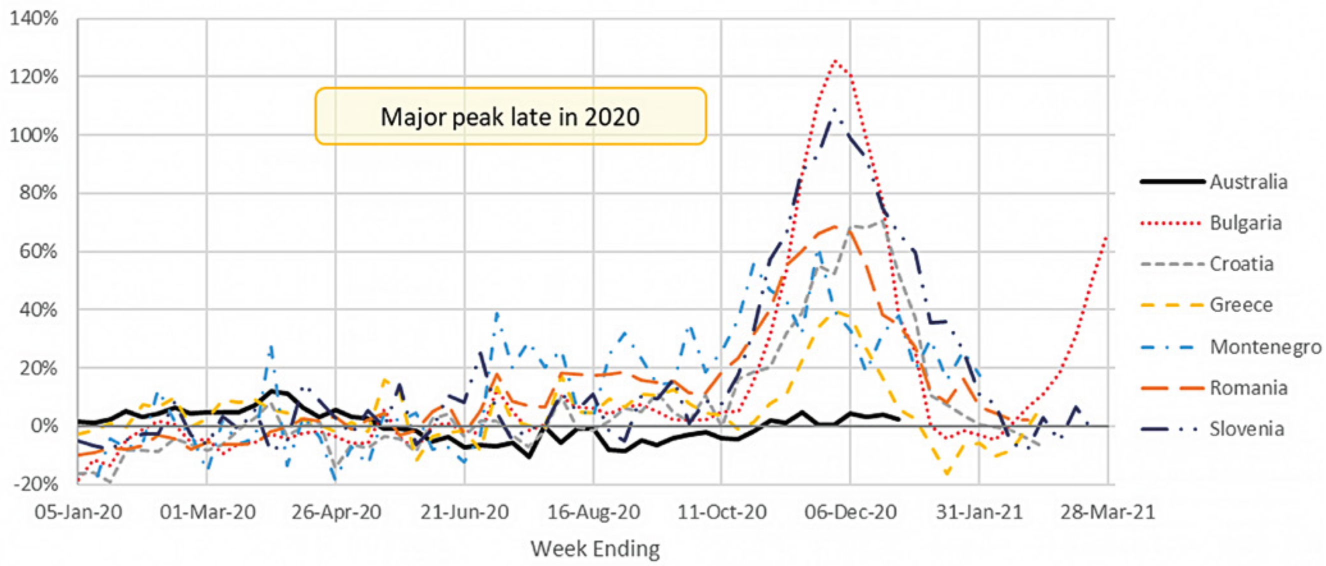
Weekly Excess Mortality P Score – Australia and Northern Europe



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

The impact of COVID-19 seems to have been felt in the Balkans later than most, perhaps because they receive less international traffic. The next chart shows that, in some cases, such as Bulgaria and Slovenia, more recent mortality experience has been extremely poor.

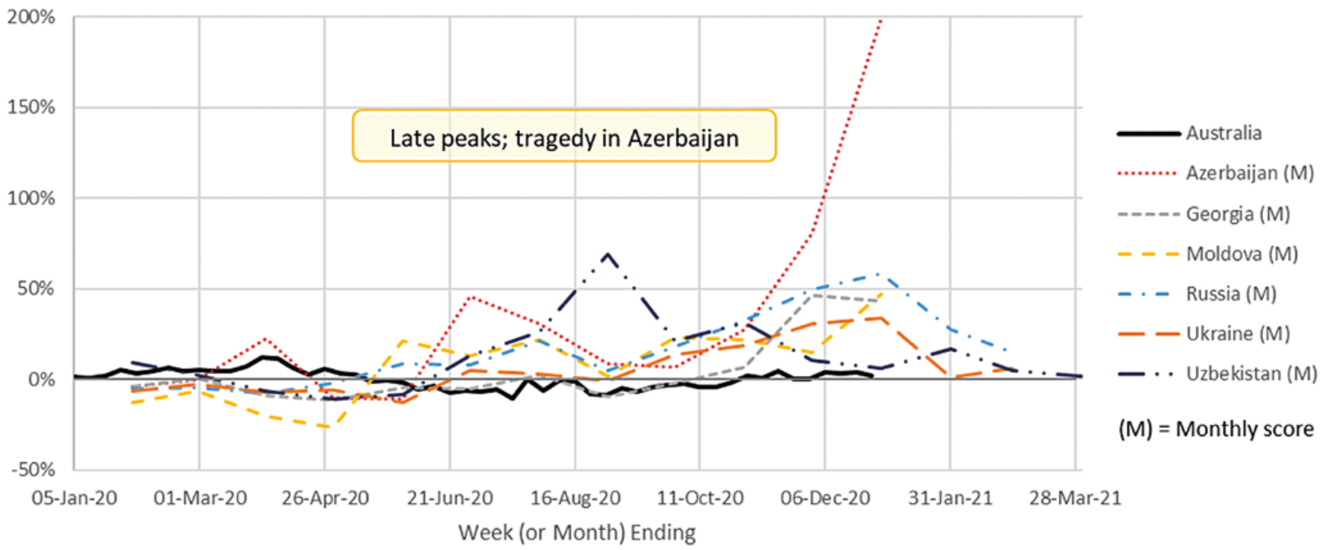
Weekly Excess Mortality P Score – Australia and Balkans



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

Similarly, the next chart shows that Eurasia has generally had a delayed impact from COVID-19, again perhaps because of less international traffic. Azerbaijan's 200% excess mortality in December 2020 contrasts starkly with COVID-19 deaths averaging four per million (perhaps 25% of normal mortality).

Weekly Excess Mortality P Score – Australia and Eurasia

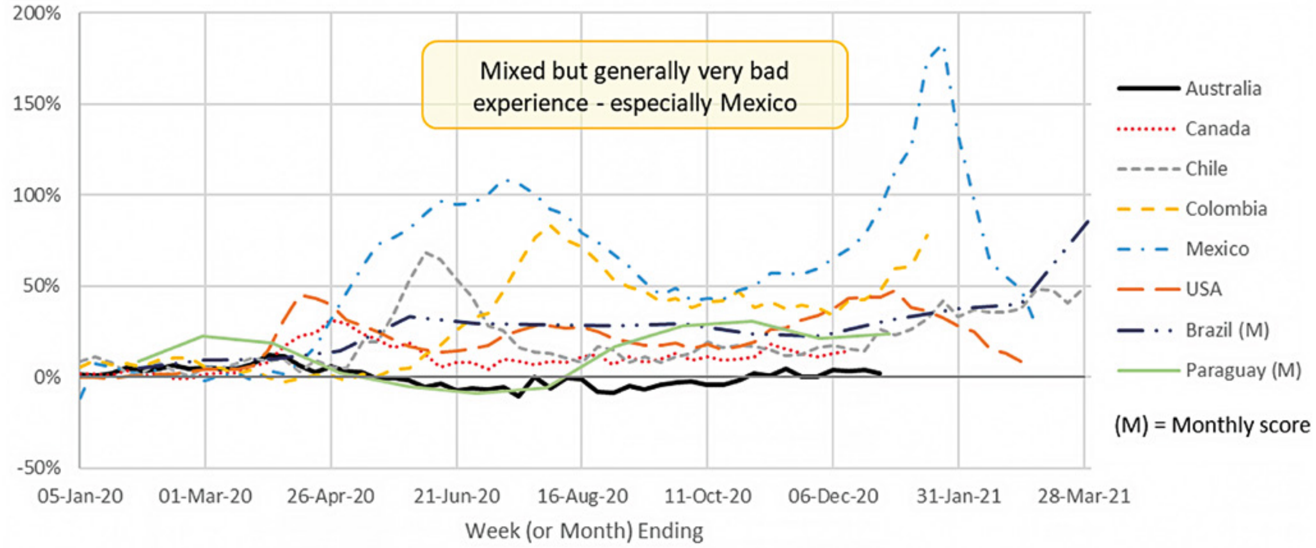


Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

Due to a number of influencing factors, deaths from COVID-19 have varied markedly around the world.

Experience in the Americas (see following chart) varies significantly by country. The USA and Canada broadly follow the Western European experience, but Mexico has suffered a very high second peak. In South America, each country seems to be different, but all seem to have experienced recent deterioration.

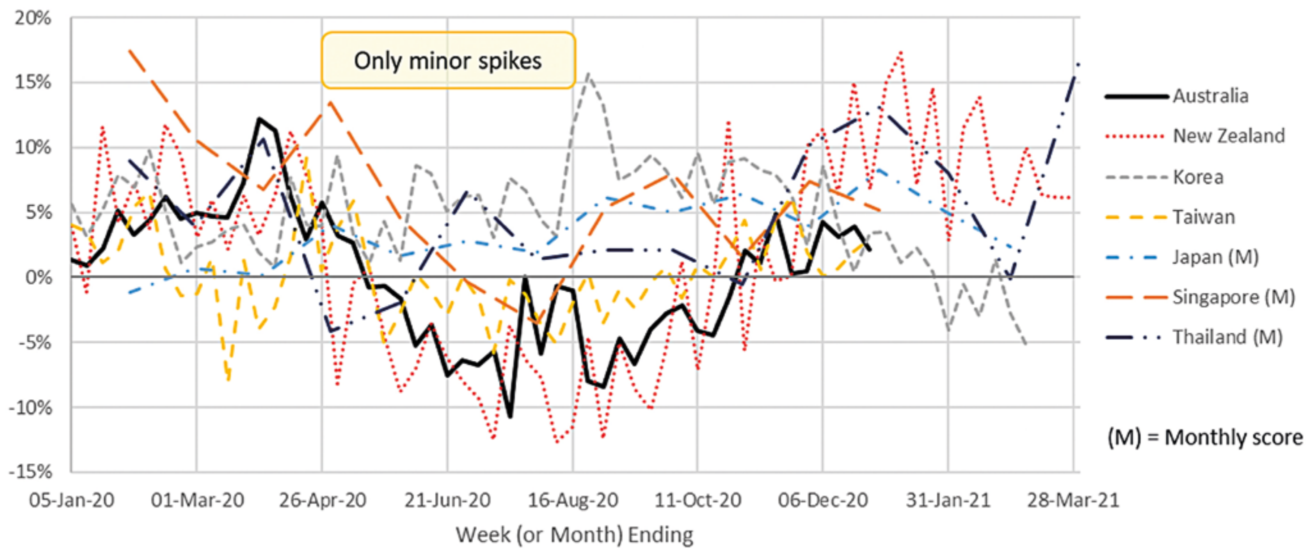
Weekly Excess Mortality P Score – Australia and Americas



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

Australia, like many of its time-zone neighbours, has experienced low COVID-19 mortality and overall mortality close to the 2015-19 average. Accordingly, the selected countries and areas from this region (see below) are in the lower left of the bubble chart. There is a clear reduction in winter mortality in both Australia and New Zealand. We discuss this further in our analysis of Australian mortality.

Weekly Excess Mortality P Score – Australia, NZ and E Asia



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

1.3. Dry tinder and COVID-19 shadows

There have been several attempts to explain some of what we have seen during the pandemic. One interesting argument that first appeared around October 2020 concerns the much higher mortality in Sweden than in its neighbours and has been termed the 'dry tinder' effect. While many might put Sweden's higher mortality down to the alleged pursuit of 'herd immunity', an article by Jonas Herby[1] argues that Sweden had experienced benign flu seasons for two years, unlike its neighbours. In effect, the argument goes that this is like an area that often burns not experiencing bushfires for a longer period than usual. There will simply be more 'dry tinder' to burn next time a bushfire occurs. Thus, the vulnerable in Sweden's population (the dry tinder) had been spared death for a year or two but would succumb at the next opportunity. In other words, the article suggests that extra deaths experienced in 2020 had been deferred from earlier years, albeit the catalyst was COVID-19 rather than the more usual respiratory diseases.

1 American Institute for Economic Research, article by Jonas Herby, November 2020 https://www.aier.org/article/swedens-dry-tinder-accounts-for-many-covid-19-deaths/

It has been clear from the very beginning of the pandemic that the risk of death from a COVID-19 infection is very different by age.

Another suggestion is that countries such as the UK will experience 'COVID-19 shadows'. As the vulnerable have been taken early by COVID-19, deaths will be lower than expected for a short period. (Perhaps, if the dry tinder argument holds, that period might be as much as two years or more.)

On the other hand, it appears that countries that had effective lock-downs during winter have experienced relatively low levels of respiratory infection, including flu. This has certainly been the case in Australia, as we shall see in Section 2. Is it possible that this has resulted in the build-up of some dry tinder in those countries? Certainly, the excess mortality in New Zealand in late 2020 and early 2021 suggests that this might be true – all the more so when we understand (but have not tested) that this higher mortality is among the elderly, the same age group that had a large reduction in mortality in the winter.

1.4. Age-based mortality

It has been clear from the very beginning of the pandemic that the risk of death from a COVID-19 infection is very different by age. In a very broad sense, it is somewhat proportional to the underlying risk of death. Understanding the risk of death from a COVID-19 infection relies on identifying all cases of COVID-19 and all deaths from COVID-19. Different countries and different phases of the outbreak have had difficulty with both of these. Early in the COVID-19 pandemic, most infections identified (even with testing) were symptomatic. Studies have shown that up to half of all infections are asymptomatic, even more if mild symptoms are ignored.

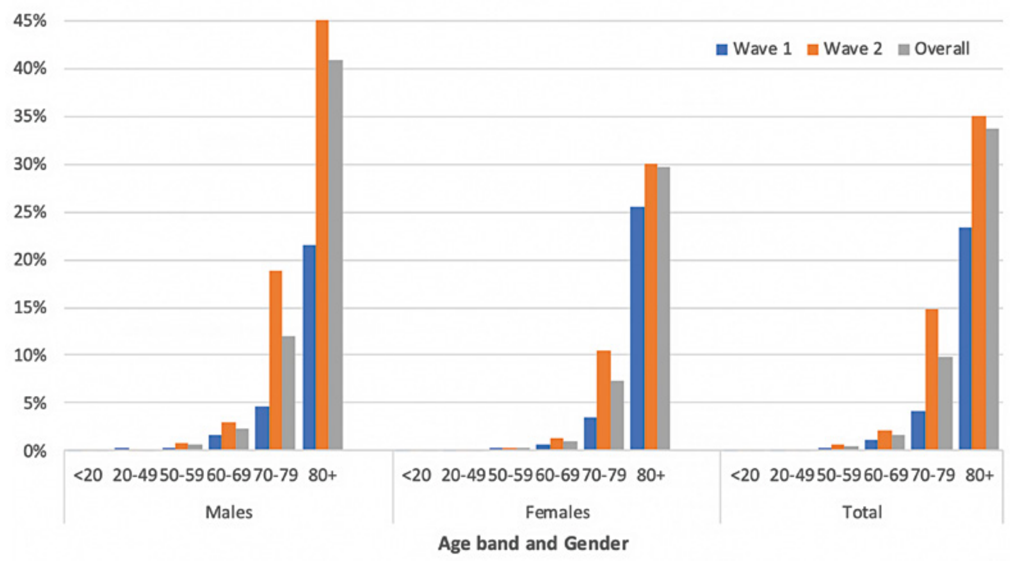
In addition, in phases of the pandemic where hospital resources were very stretched, not all deaths from COVID-19 were identified as such, particularly in aged care facilities in a number of countries.

Australia

With these caveats, we have previously looked at the case fatality rates in Australia, which show that the overall case fatality rate (deaths from COVID-19 divided by diagnosed cases) at 4 November is 3.3% for Australia as a whole[2]. We urge caution when using case fatality rates. They could be too high if, as in most populations, the diagnosed cases of COVID-19 are underestimated (as not all asymptomatic or minor cases are tested, even when testing is quite comprehensive), and too low if not all deaths from COVID-19 have been counted.

As in other countries, the case fatality rate in Australia at older ages is, as expected, significantly higher than the average case fatality rate. The graph shows the case fatality rate for each age band and gender, and also spilt between wave 1 (cases and deaths at 31 May) and wave 2 (cases and deaths after 1 June). The overall case fatality rate for wave 1 is 1.5% and for wave 2 is 3.9%.

Case Fatality Rates



2 Calculated using data from Australian Government Department of Health website. https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/coronavirus-COVID-19-current-situation-and-case-numbers#tests-conducted-and-results

There have been no reported deaths in Australia from COVID-19 in any males under the age of 20 or females under the age of 50. At all ages, the case fatality rate for males is higher than that of females, as is the case for mortality from most causes.

The case fatality rate at older ages was much higher in Wave 2 compared with Wave 1 for both males and females. This may reflect some under-count of COVID-19 deaths during Wave 1 (discussed further in section 2), and the relatively better health of those infected in wave 1 (largely travellers) versus Wave 2 (dominated by those in aged care).

Worldwide

https://link.springer.com/content/pdf/10.1007/s10654-020-00698-1.pdf

A more comprehensive world-wide study has recently been published in the European Journal of Epidemiology[3]. It analysed the data to systematically understand the level of underreporting of infection in each country, by age, to develop an aged-based infection fatality rate (IFR) around the world.

These graphs show the overall results.

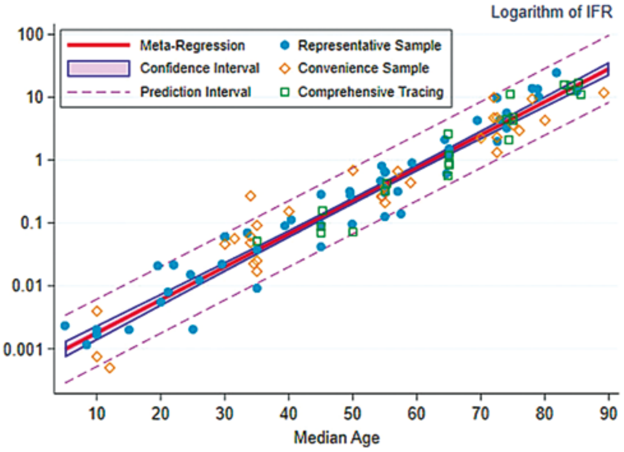


Fig. 3 The log-linear relationship between IFR and age. Note: Our metaregression indicates that the infection fatality rate (IFR) increases exponentially with age, and hence this figure uses a base-10 logarithmic scale so that the relationship is evident across all ages from 5 to 95 years. Each marker denotes a specific metaregression observation, that is, the IFR for a particular age group in a particular location. The marker style reflects the type of observation: circles for observations from seroprevalence studies of representative samples, diamonds for seroprevalence studies of convenience samples, and squares for countries with comprehensive tracing programs. The red line denotes the metaregression estimate of IFR as a function of age, the shaded region depicts the 95% confidence interval for that estimate. The dashed lines denote the prediction interval (which includes random variations across studies and age groups), and almost all of the 108 metaregression observations lie within that interval.

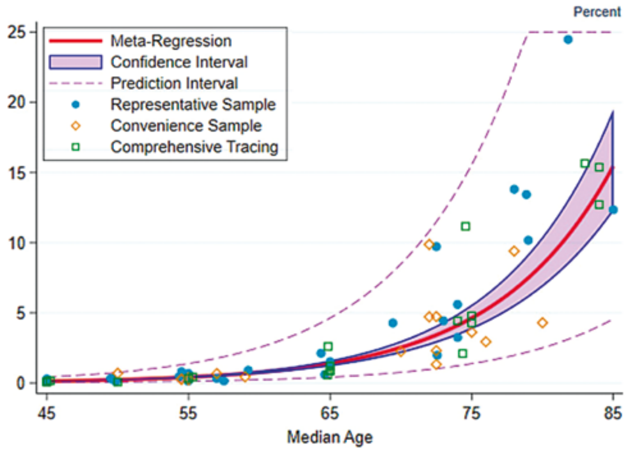


Fig. 4 Benchmark analysis of the link between age and IFR. Note: This figure depicts the relationship between the infection fatality rate (IFR) and age, where IFR is shown in percentage terms. Each marker denotes a specific metaregression observation, that is, the IFR for a particular age group in a particular location. The marker style reflects the type of observation: circles for observations from seroprevalence studies of representative samples, diamonds for seroprevalence studies of convenience samples, and squares for countries with comprehensive tracing programs. The red line denotes the metaregression estimate of IFR as a function of age, the shaded region depicts the 95% confidence interval for that estimate. The dashed lines denote the prediction interval (which includes random variations across studies and age groups); almost all of the 104 metaregression observations lie within that interval.

The estimated age-specific IFR is very low for children and younger adults but increases progressively with age. The table below compares these rates with the underlying mortality rates in the Australian population and the Australia COVID-19 case fatality rates in the second wave (when testing was more comprehensive).

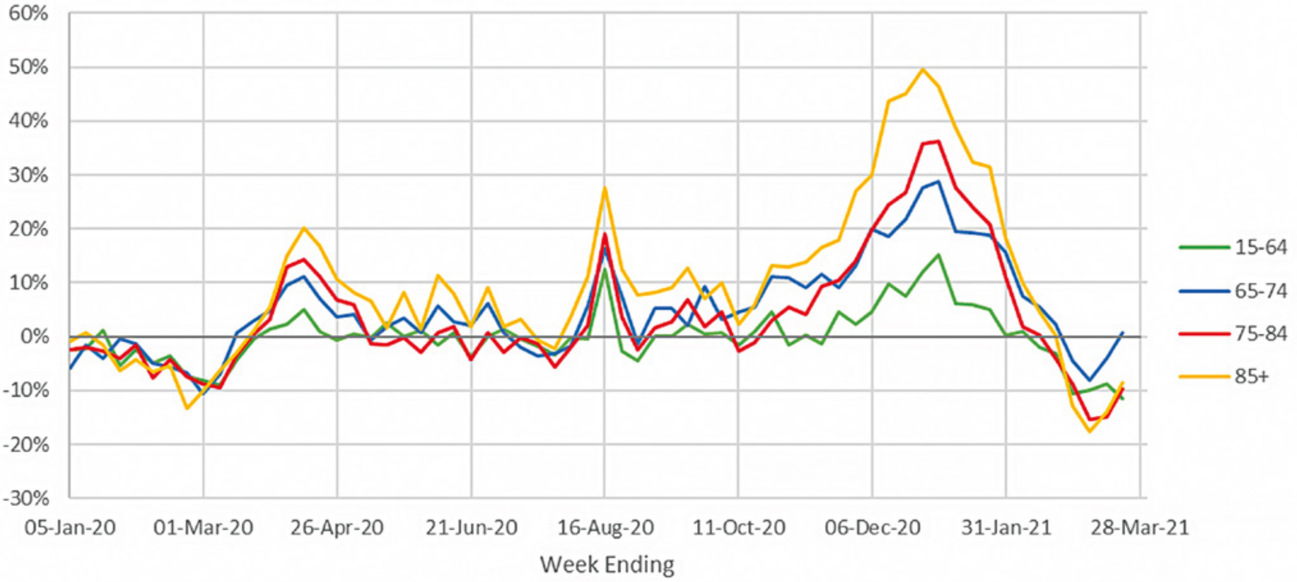
AGE	AUSTRALIAN POPULATION MORTALITY RATE (PER 1,000)	AUSTRALIAN COVID-19 CASE FATALITY RATE (PER 1,000)	COVID-19 INFECTION FATALITY RATE (PER 1,000)
10	0.1	0.0	0.02
25	0.5	0.2	0.1
55	4.1	6.1	4.0
65	7.8	21.0	14.0
75	25.8	148	46.0
85	72.8	315	150

3 Assessing the age specificity of infection fatality rates for COVID-19: systematic review, meta analysis, and public policy implications, Andrew T. Levin,· William P. Hanage, Nana Owusu Boaitey, Kensington B. Cochran, Seamus P. Walsh,· Gideon Meyerowitz Katz, European Journal of Epidemiology (2020)

The Australian case fatality rates are considerably higher than the estimated infection fatality rates across all age groups. At older ages (75+), we expect that this is due to the dominance of aged care residents in the infected population.

On the basis of the relative mortality in the charts and previous table, and assuming that overall excess mortality is largely explained by COVID-19, we would expect to see a higher excess mortality P score for older people than for the young if infection rates are broadly independent of age. This relationship is clear in Germany, as this chart shows.

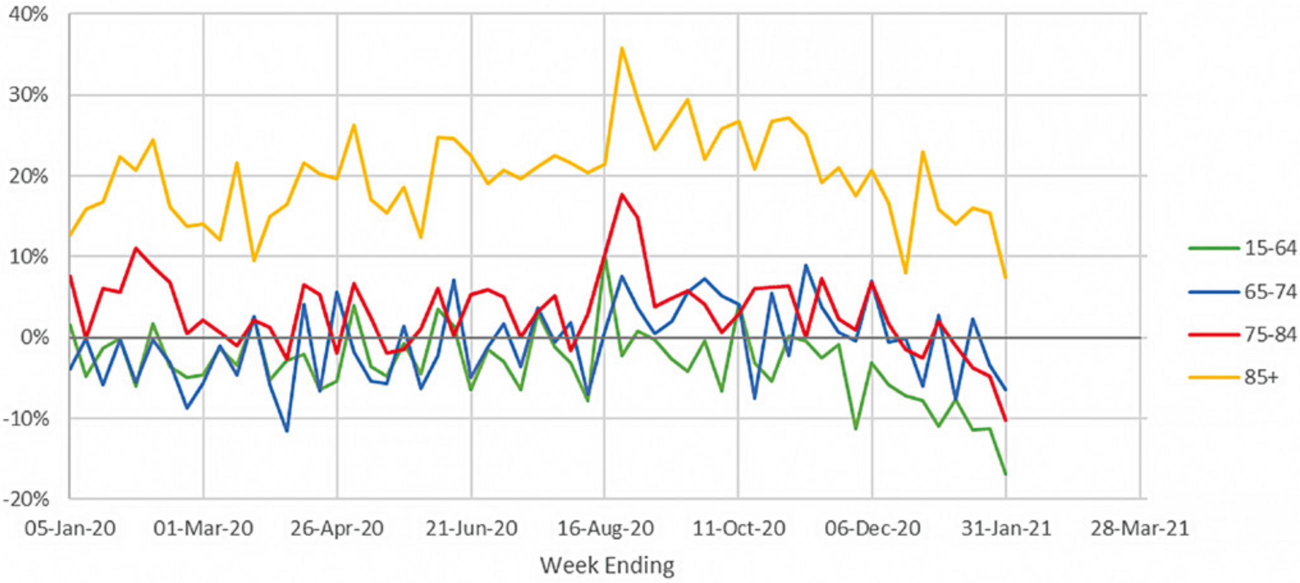
Weekly Excess Mortality P Score by Age Group – Germany



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

South Korea also demonstrates this relationship.

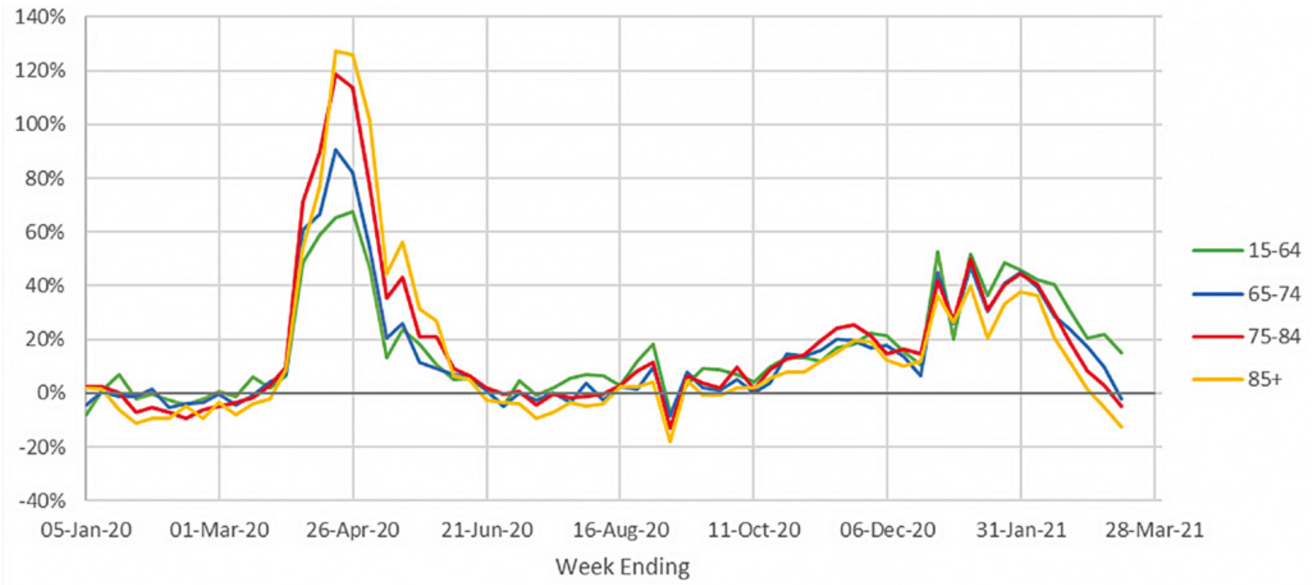
Weekly Excess Mortality P Score by Age Group – South Korea



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

In the UK (see following chart), the relationship held in the initial peak, but it has since inverted, perhaps reflecting increasing risk aversion by age and/or the operation of a COVID-19 shadow – given the height of the initial peak – and potentially the effect of the vaccine in the last month or two.

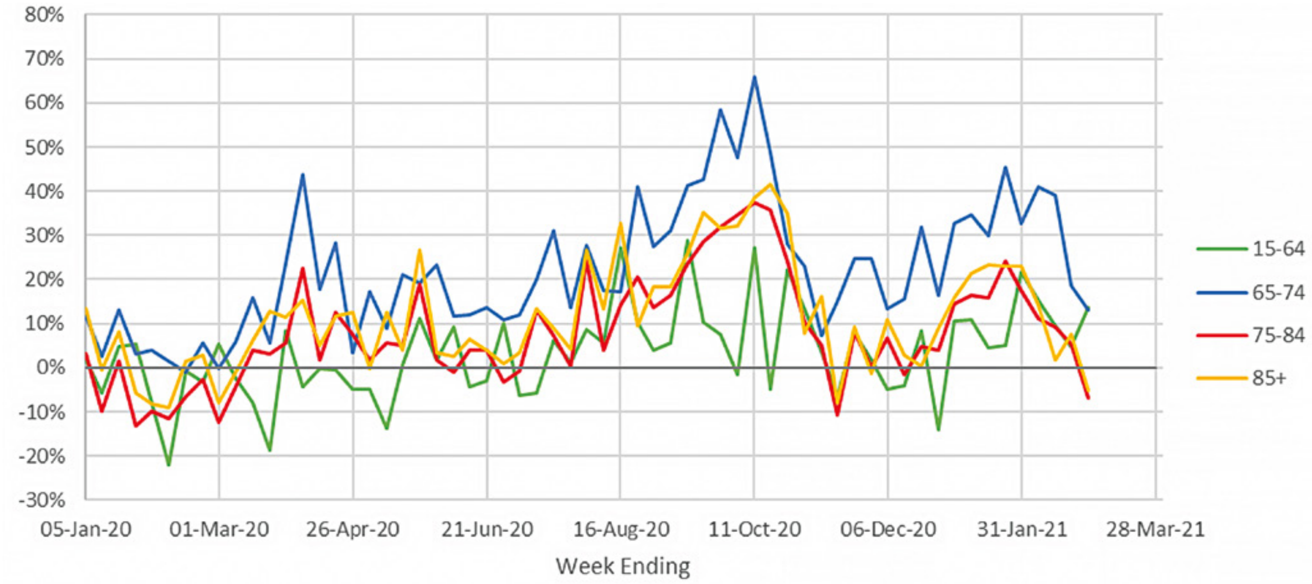
Weekly Excess Mortality P Score by Age Group – United Kingdom



Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

In Israel, we see the greatest excess mortality among what might be called the 'active old', perhaps because of greater shielding by those over 75.

Weekly Excess Mortality P Score by Age Group – Israel

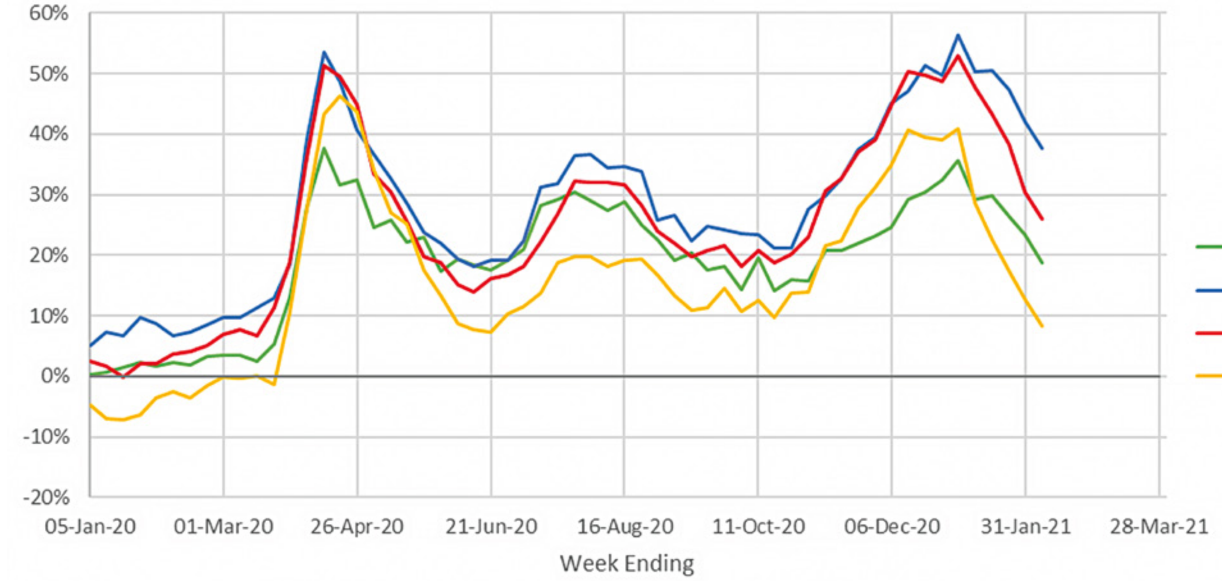


Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

Though the elderly are more susceptible to COVID-19 the relative excess mortality ratio for each age group has varied in different countries, perhaps reflecting different rates of infection.

In the USA (below), the elderly appear to have been far more risk averse than other age groups, with P scores for the 85+ age group generally at or below those for the 15-64 group.

Weekly Excess Mortality P Score by Age Group – United States

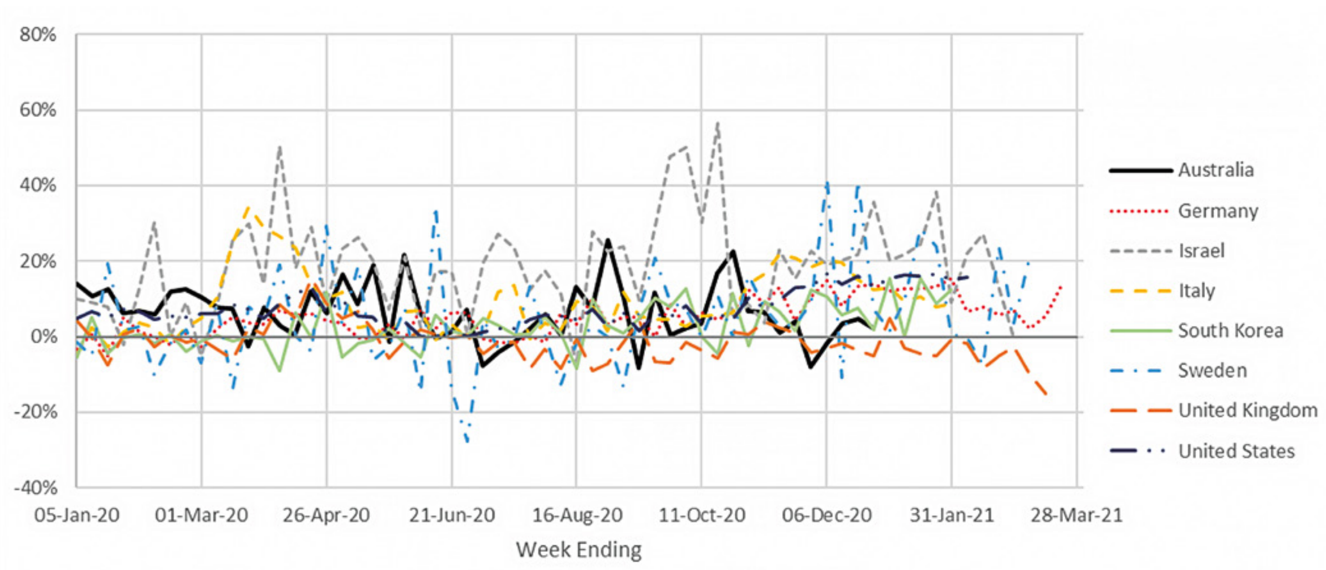


Source: Our World in Data. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

Another way of viewing these relationships is by expressing excess mortality for each age group relative to the 15-64 age group. For example, if the 85+ age group has a P score of 90% and 15-64 is at -5%, the relative score for 85+ is 190/95 – 1 = 100%.

Of the eight selected countries in the chart below, Israel clearly shows the highest relative mortality for ages 65-74. The UK's relationship inversion shows through in the second half of the chart.

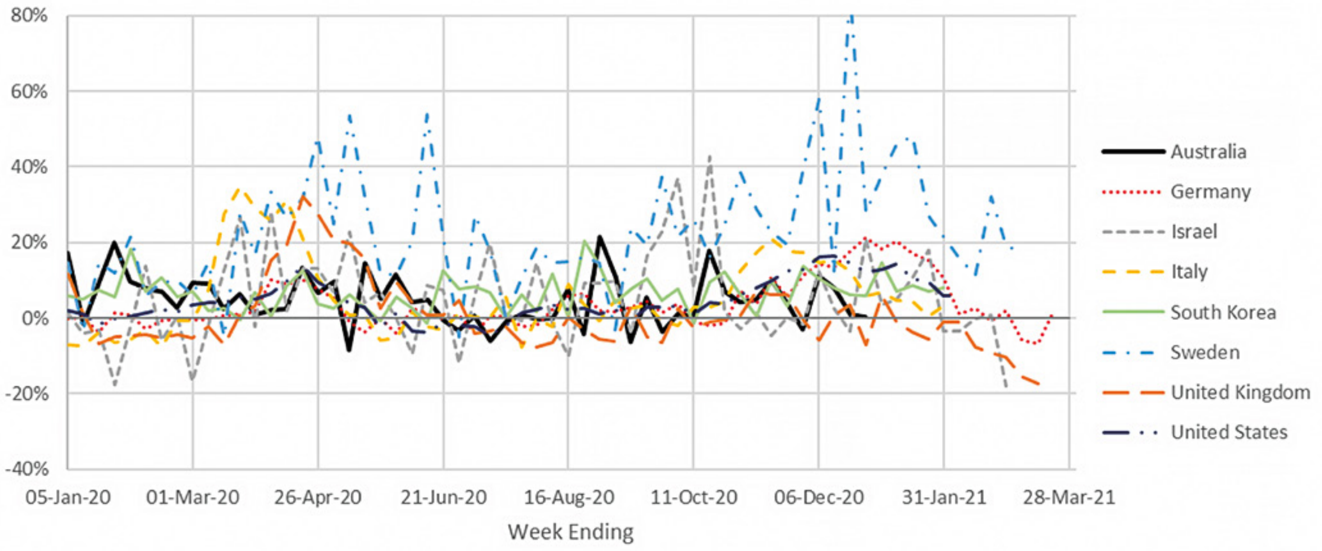
Weekly Excess Mortality P Score – Age 65-74 Relative to 15-64 – Australia and Selected



Source: Our World in Data and analysis. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

By comparison, the next chart shows that it is Sweden that has the highest relative mortality in the 75-84 age group.

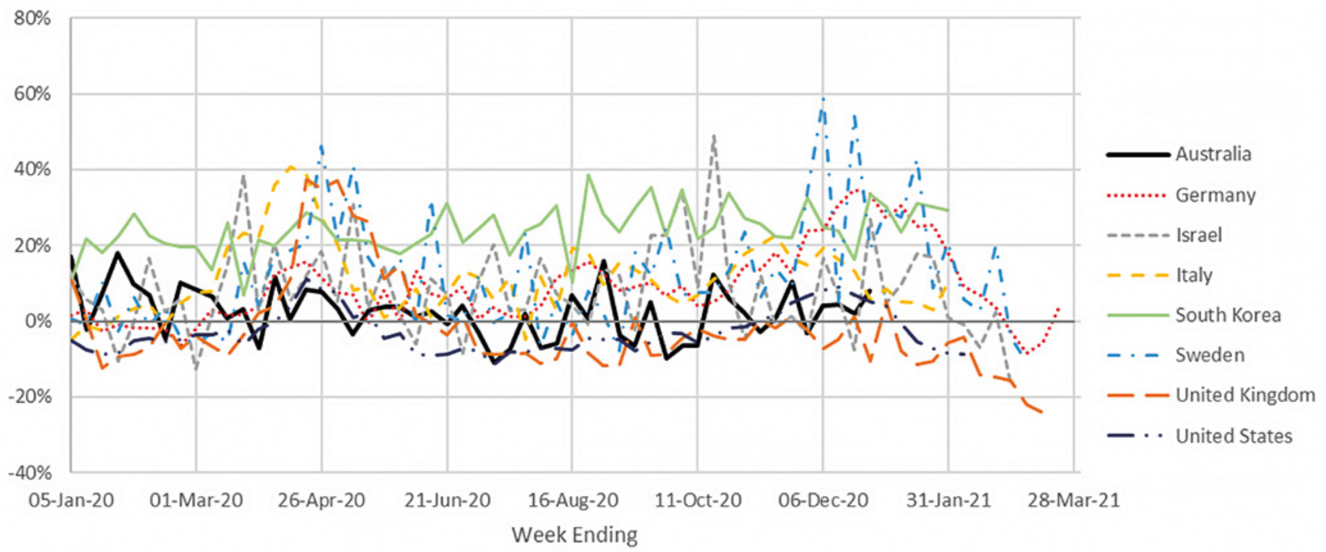
Weekly Excess Mortality P Score – Age 75-84 Relative to 15-64 – Australia and Selected



Source: Our World in Data and analysis. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

Finally, the next chart shows that relative mortality among the elderly is consistently high in South Korea but it is also generally high in other countries when overall excess mortality peaks.

Weekly Excess Mortality P Score – Age 85+ Relative to 15-64 – Australia and Selected



Source: Our World in Data and analysis. Excess mortality as % of 2015-19 average, not adjusted for demographic change.

The previous analysis is very superficial, directly reflecting the unadjusted data. It is quite possible that a more sophisticated analysis, adjusting for demographic changes and mortality trends, would reveal some different insights. We would encourage the interested reader to undertake such analysis!

2. Excess deaths in Australia

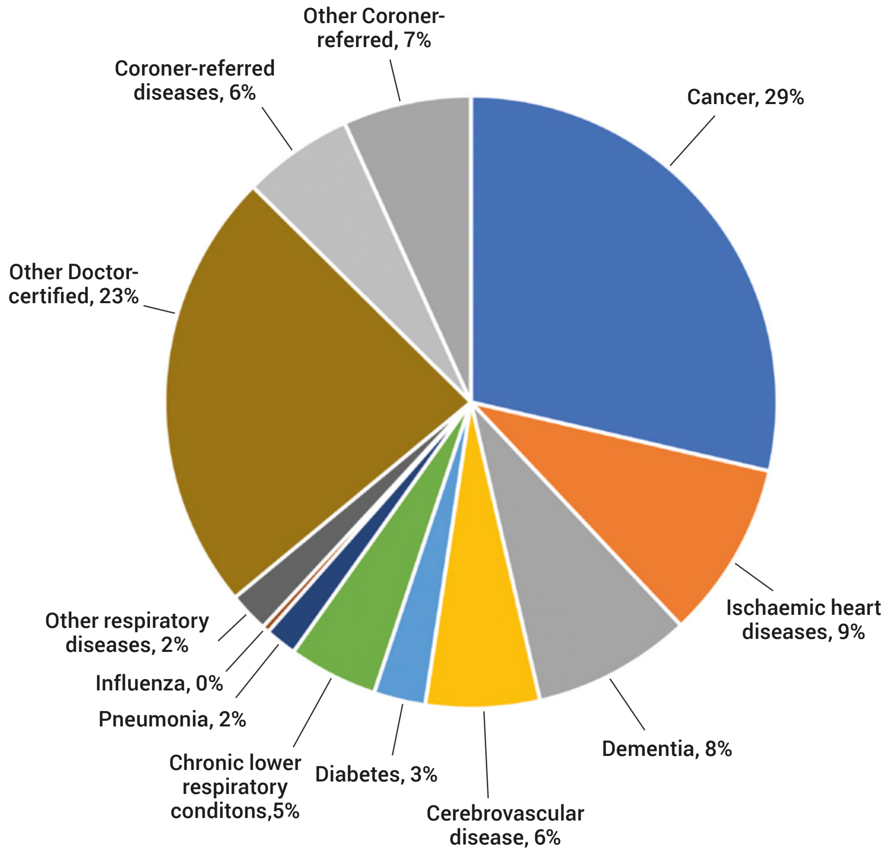
2.1. Data – what is out there?

The main source of death statistics in the public domain in relation to 2020 is the Australian Bureau of Statistics (ABS) release Provisional Mortality Statistics, Australia 2020, showing the numbers of deaths in Australia for each week in 2020 compared with prior years (the 'ABS 2020 data'). However, this data is based solely on doctor-certified deaths, so it does not include any deaths that have been referred to a coroner (e.g. suicides, transport and other accidents, assaults, medical complications, and other unexpected deaths where the cause of death is unknown).

The ABS 2020 data is probably missing around 10% to 15% of all deaths (around 20,000 deaths per annum) – see Appendix B for detail.

Doctor-certified deaths comprise around 85-90% of all deaths in Australia each year.

Causes of Death in Australia 2015-2019



The proportion of deaths that are doctor-certified versus coroner-referred varies by cause (see Appendix B). Almost all cancer and dementia deaths are doctor-certified and thus included in the ABS 2020 data. Around 95% of deaths from other specified diseases are doctor-certified, with the exception of ischaemic heart disease (heart attack, coronary heart disease) where only around 80% of deaths are doctor-certified. This is not surprising given the unexpected nature of many deaths from heart disease and hence their referral to the coroner.

The approximately 20,000 deaths referred to the coroner in any one year include around 6,500 deaths from the specified diseases included in the ABS 2020 data, plus around another 3,000 deaths from other diseases, i.e. they are resolved as deaths from natural causes. The remaining 11,000 or so coroner-referred deaths are from 'external causes'. In a small portion, the cause of death remains unknown even after the coroners' investigations are completed.

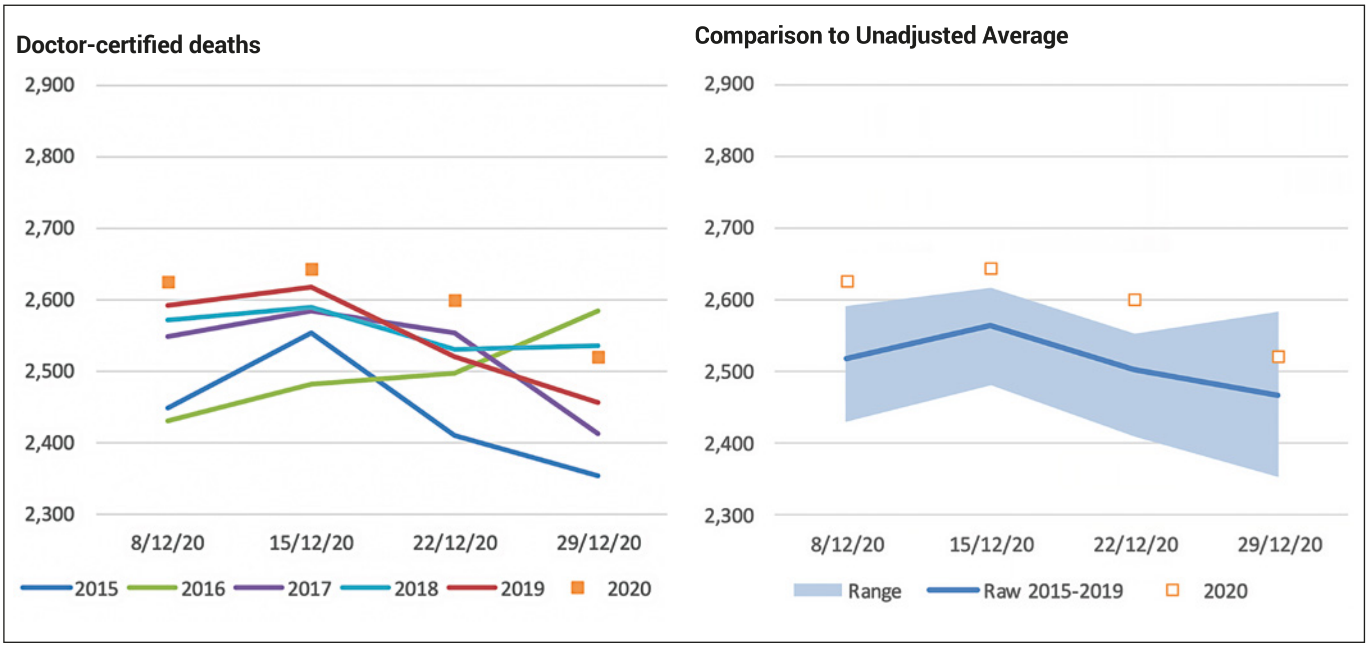
Australia: https://www.abs.gov.au/articles/measuring-excess-mortality-australia-during-covid-19-pandemic

Victoria: https://www.abs.gov.au/articles/measuring-excess-mortality-victoria-during-covid-19-pandemic

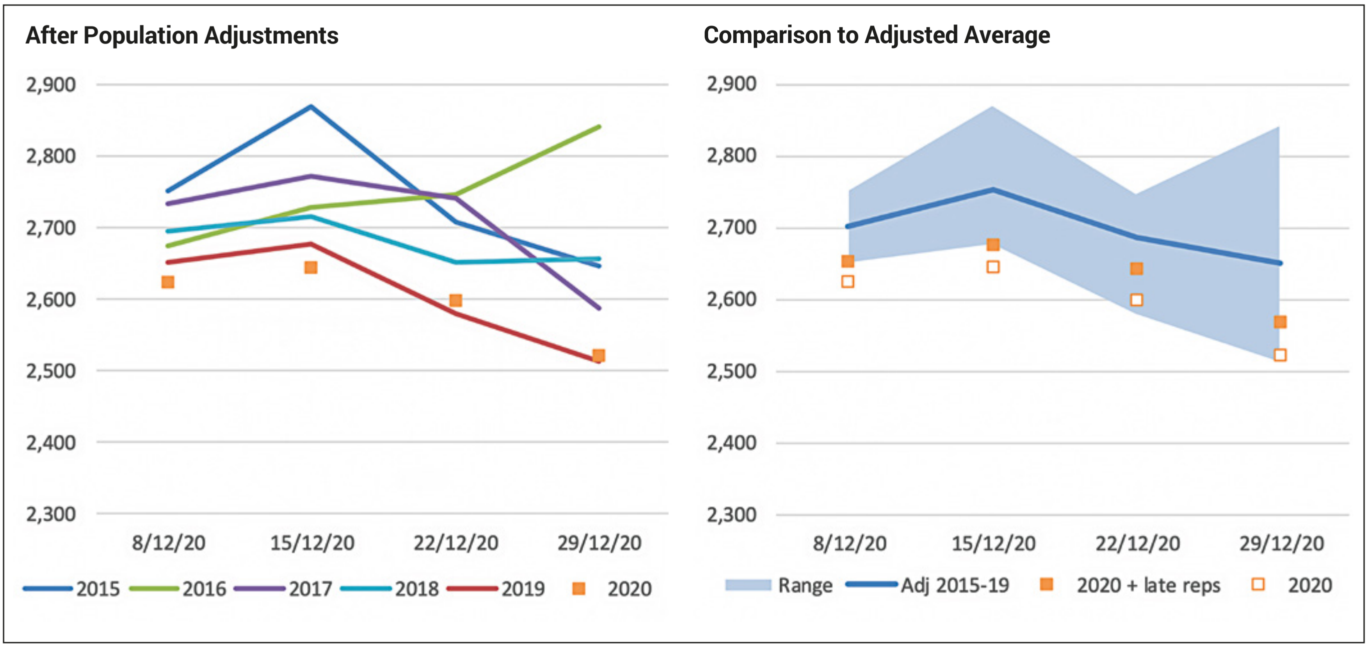
2.2. Measuring excess deaths

While the ABS has produced two papers this year analysing excess deaths in some detail (one for Australia and one for Victoria), their standard monthly reporting of excess deaths compares 2020 deaths to the unadjusted average of 2015-2019 and this is also how most analysis of excess deaths in other countries is presented. However, this analysis does not allow for changes in either the size or the age structure of the population. Further, it does not allow for the continuation of any trends in mortality that may have been expected in the absence of the pandemic. So, in the fortunate situation where there is only a small shock to mortality rates from COVID-19, the comparison with previous years can be misleading.

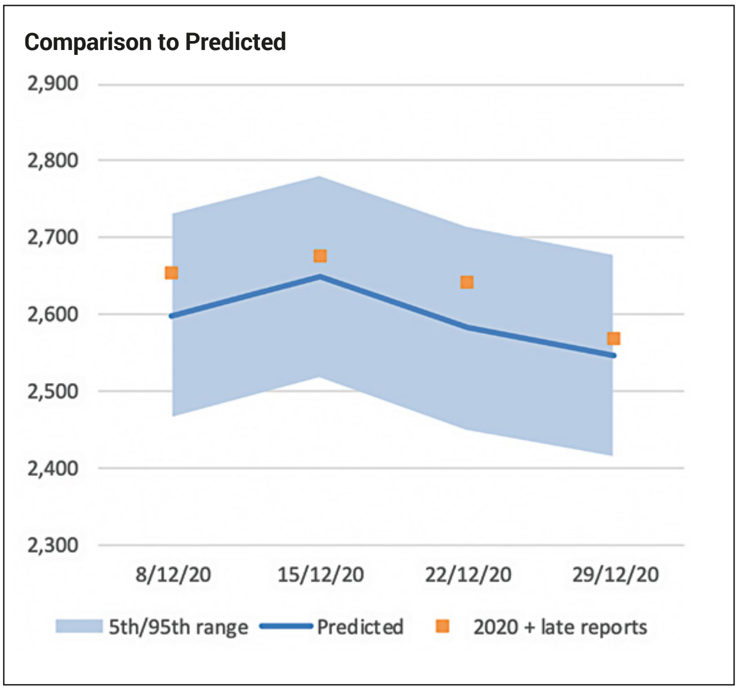
The following graphs demonstrate this using the last four weeks of doctor-certified deaths in 2020 as an example.



When comparing 2020 to the unadjusted data for 2015-2019, all four weeks appear to have excess mortality, and three weeks are above the maximum/minimum range (implying they are significantly higher than previous years). Across the four weeks, excess deaths are measured as 3.3% above 'expected'.



The picture looks quite different after allowing for later reported deaths and changes in the size and age structure of the Australian population. All weeks are now below the average and excess deaths are measured as 2.3% below 'expected'. However, there is a clear trend in mortality, with overall mortality reducing over the five years shown.



After allowing for the trend in mortality to continue into 2020, deaths in 2020 are close to predicted for all weeks shown. Note that we have also moved to a statistical confidence interval based on the observed standard deviation for the last five years (rather than just taking the maximum and minimum values). This allows us to attach a probability to an identified outlier. Excess deaths are 1.6% above predicted, and well within the normal range of expected volatility.

In Australia, where excess mortality has been small, adjustments for population size and age structure can have a material impact on conclusions drawn.

In the Australian context, where excess mortality in 2020 has been small, these adjustments can have a material impact on the conclusions drawn. Across the whole of 2020, excess deaths as measured using the three approaches above are -0.1% (comparison to unadjusted average), -6.6% (comparison to adjusted average) and -2.7% (comparison to predicted). Using the ABS standard reporting approach would indicate that mortality in 2020 is very close to expected, whereas our approach indicates that mortality has been almost 3% better than predicted.

For other countries where excess mortality is very significant, making the adjustments is probably just adding spurious accuracy – it likely would not change the conclusion drawn.

2.3. Doctor-certified deaths in 2020

Specifics on the model

As outlined above, we built a model predicting weekly doctor-certified deaths in 2020, based on the information provided by the ABS about weekly deaths during 2015-2019. For each cause of death:

- we started with weekly deaths from 2015-2019;
- we scaled those deaths for population (an 8% increase over five years), age distribution (a 4% increase over five years) and late-reported deaths; and
- we fitted a model to predict deaths in 2020, incorporating allowance for average mortality improvement over the last five years (a 3.5% decrease over five years). Our model allows for the improving mortality trend over the last five years and predicts that deaths in 2020 would be lower than the 2015-19 average.

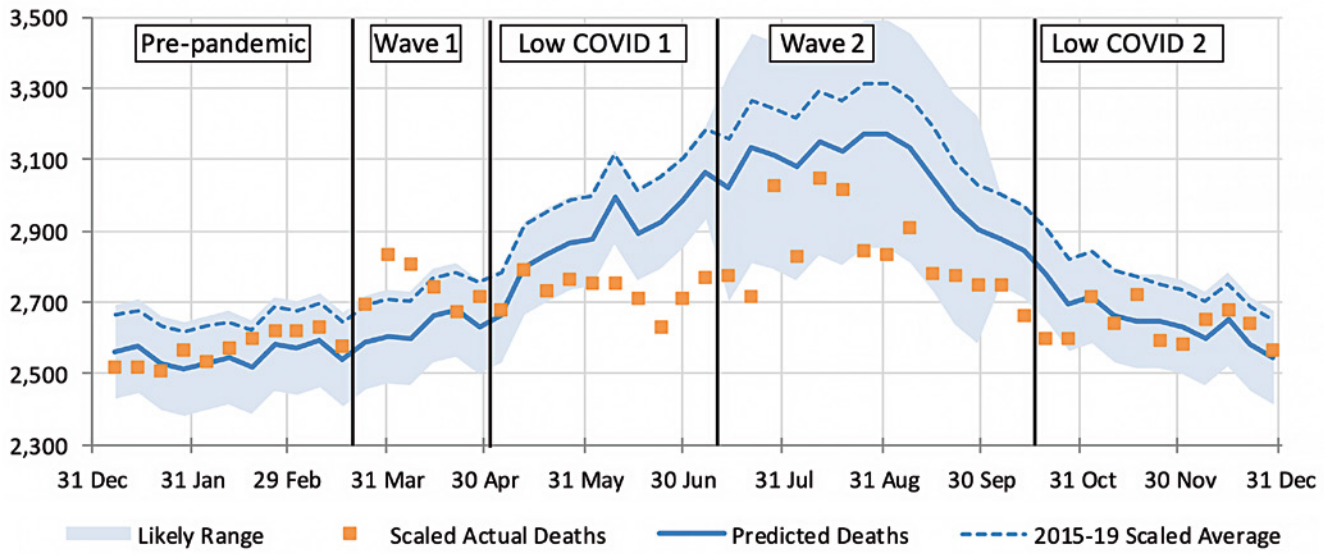
Details of our approach and the adjustments made are included in Appendix C.

The graphs shown in this section include the weekly doctor-certified deaths for:

- 2020, taken from the ABS data and after adding allowance for late reported deaths;
- the average of 2015 to 2019, after adjustments for both population size and age mix; and
- our prediction for 2020, in the absence of COVID-19.

All doctor-certified deaths

Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

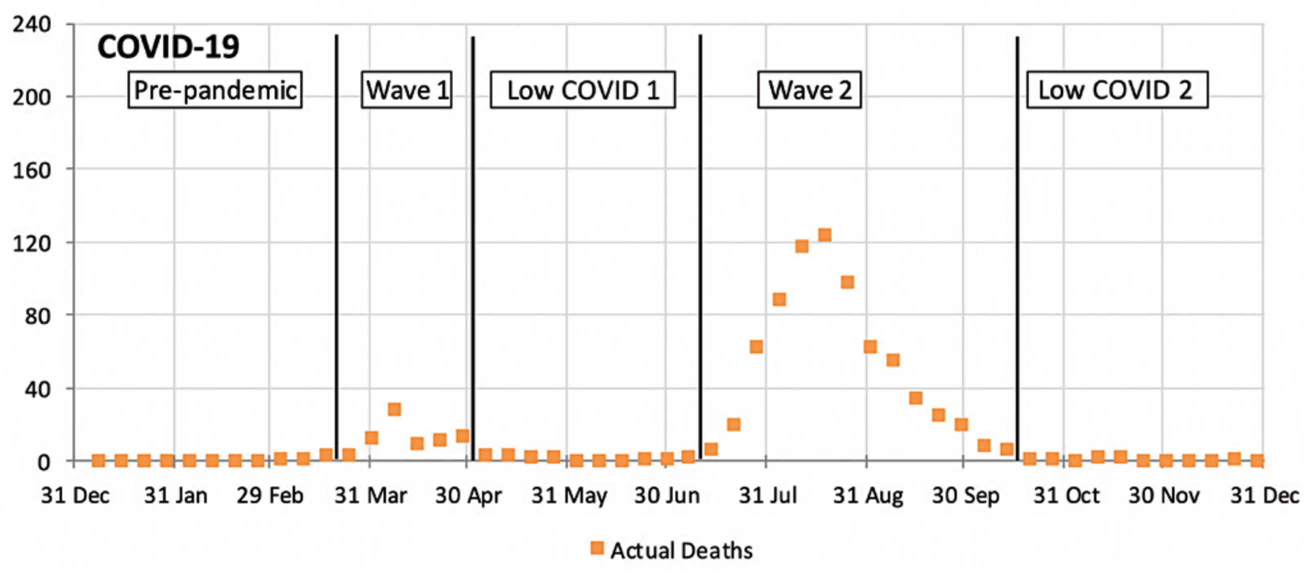
Mortality experience in Australia in 2020 varied across the year.

The experience of doctor-certified deaths in 2020 can be broken into five distinct periods:

- Pre-pandemic (deaths occurring before 17 March) – deaths during this period were reasonably **close** to predicted.
- Wave 1 (for the weeks ending 24 March to 28 April, coinciding with the first wave of COVID-19 infections and deaths) – deaths during this period were **higher** than predicted.
- Low COVID 1 (for the weeks ending 5 May until 7 July, reflecting a period of low numbers of COVID-19 cases) – deaths were **lower** than expected throughout most of this period as the usual seasonal respiratory deaths did not eventuate in 2020, due to the absence of respiratory illness in winter 2020.
- Wave 2 (for the weeks ending 14 July to 13 October, coinciding with the second wave of COVID-19 infections and deaths, mainly in Victoria) – while deaths remained **lower** than predicted, deaths increased to be closer to the predicted number in late July and early August compared with surrounding weeks.
- Low COVID 2 (for the weeks ending 20 October onwards, reflecting a second period of low COVID-19 cases) – deaths were **close** to predicted. This is not because deaths increased, but rather because Australia does not normally have high levels of respiratory disease deaths in summer and hence experienced a lesser benefit from reduced levels of respiratory disease deaths.

How many COVID-19 deaths are included in doctor-certified deaths?

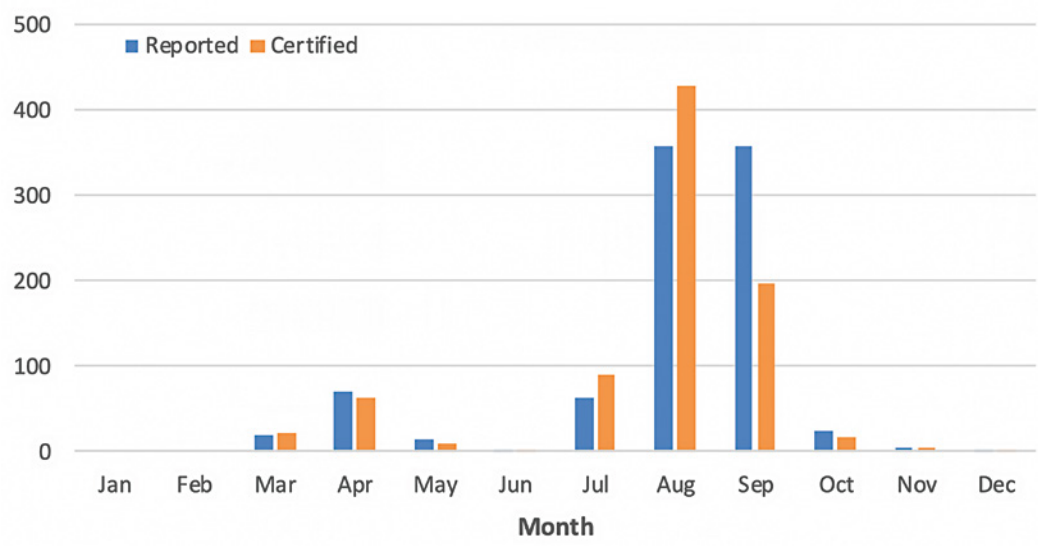
Weekly scaled actual doctor-certified deaths



There are 832 COVID-19 deaths included in the ABS doctor-certified deaths in 2020. 78 of these deaths occurred during the first wave, 730 occurred during the second wave, and a further 26 deaths occurred outside of these two periods.

These deaths are 77 less than the 909 officially recorded COVID-19 deaths. The discrepancy arises as some COVID-19 deaths will have been reported to the coroner (notably some deaths associated with the Ruby Princess and some deaths in aged care homes in Victoria).

COVID-19 Deaths in Australia in 2020

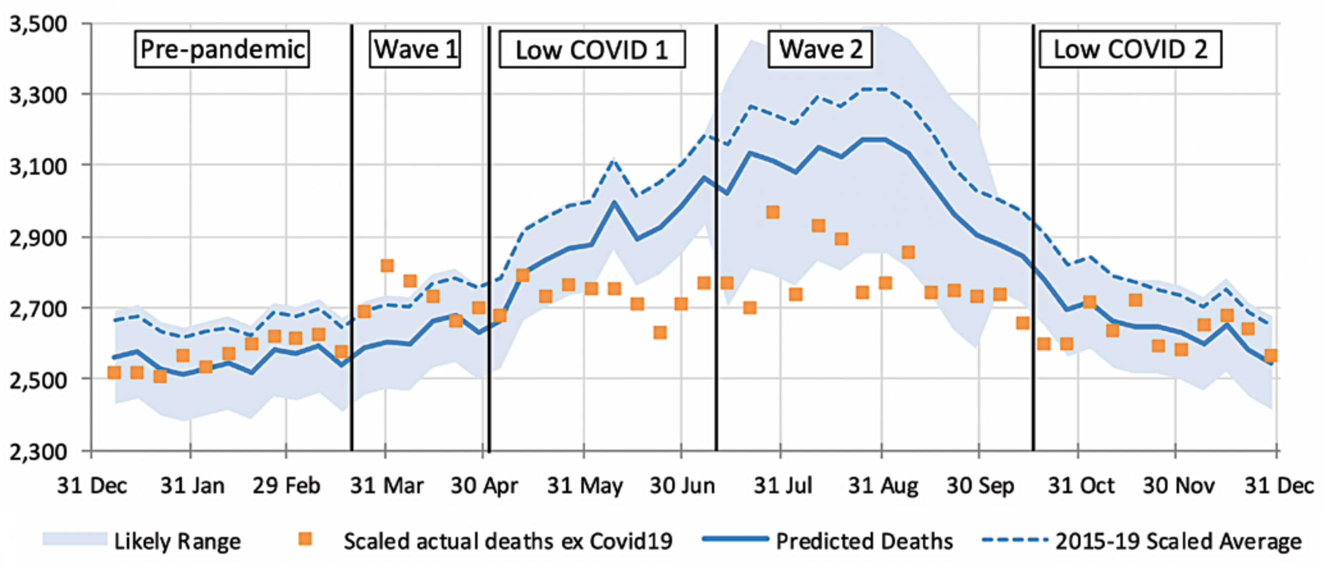


Doctor-certified COVID-19 deaths are lower than officially recorded deaths as some are referred to the coroner.

Non-COVID-19 deaths

The following chart shows weekly doctor-certified deaths in 2020 after removing known COVID-19 deaths.

Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Reported COVID-19 deaths do not account for all of the higher than predicted deaths during periods of high COVID-19.

Reported COVID-19 deaths clearly do not explain all of the higher than predicted numbers of deaths during the first wave, nor the jump in deaths in the second wave:

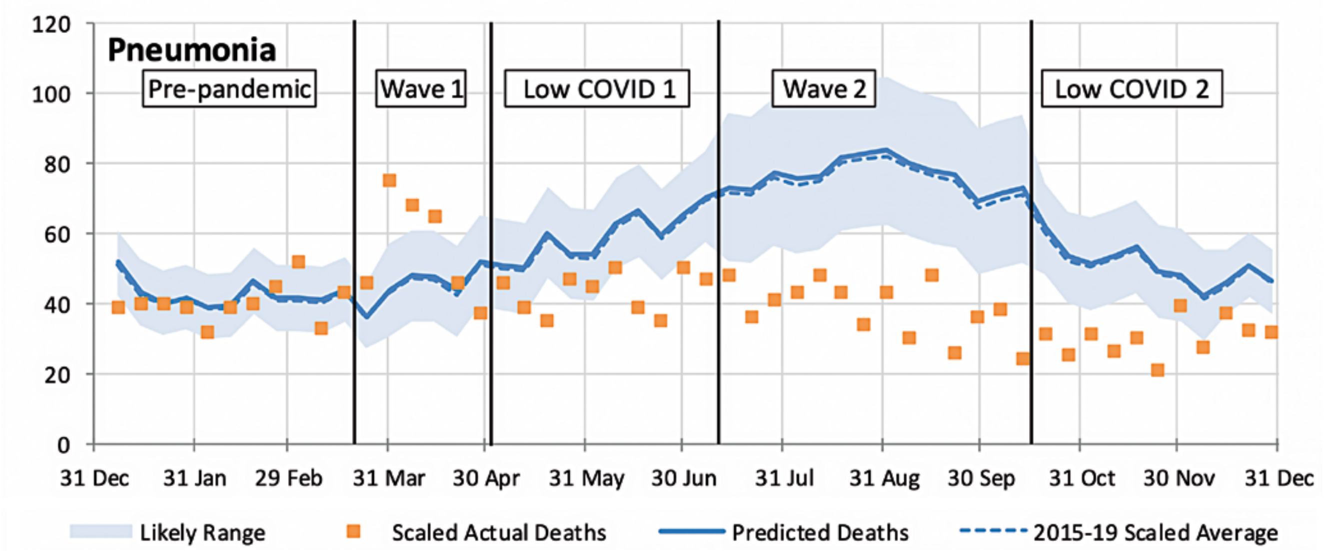
- There are four specific causes of death with potential links to COVID-19 – pneumonia, diabetes, cerebrovascular disease (mainly strokes and brain haemorrhage) and dementia. For all four of these causes, we have observed higher than expected numbers of deaths in the first wave, and also in Victoria in the second wave, although the numbers involved in the second wave are small for both pneumonia and diabetes.
- While we cannot be definitive, we expect that more people probably died because of COVID-19 during the first wave of cases than was reported at the time. This is likely to be because those people were not tested for COVID-19 (testing was limited and only available to those who had travelled overseas or were a close contact of an existing case), so the cause of their illnesses was not known at the time. These extra deaths were probably reported as pneumonia, diabetes and possibly stroke, as deaths from these causes were higher than expected during that period and all of these causes of death are related to COVID-19 in some way.
- It is also possible that a small number of people in Victoria died of COVID-19 during the second wave but were not recorded as such. The numbers involved are much smaller than for the first wave and could be due to random fluctuation.
- For stroke, there could be a genuine increase in deaths from this cause in both the first and second waves due to a reluctance to seek medical treatment during times of high COVID-19 outbreaks.
- For dementia, it is not clear to us whether some of these deaths are also potentially undetected COVID-19 deaths, or if it is a case of our modelling not predicting dementia deaths as well as it predicts other causes. Dementia deaths were also high in one week in Victoria near the start of the second wave which may be related to the significant COVID-19-related issues aged care homes were experiencing at that time.
- The higher numbers of deaths in Victoria in the second wave from COVID-19-linked causes do not fully account for the jump in deaths - the remaining impacts are due to random fluctuation rather than a trend in any particular cause.

Deaths from respiratory disease have driven the lower numbers of deaths since early-May, both where respiratory illness is the primary cause of death and where it is a significant contributing factor. Overall, the various non pharmaceutical measures to reduce the spread of COVID-19 across Australia (lockdowns, social distancing measures, wearing of facemasks, etc) have almost certainly reduced mortality from other causes across Australia.

The following sections show the causes of death in more detail. For the four specific causes of death with potential links to COVID-19 deaths (pneumonia, diabetes, cerebrovascular disease and dementia), we have shown graphs for Australia in total and for Victoria only (concentrating on the second wave).

Respiratory deaths

Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

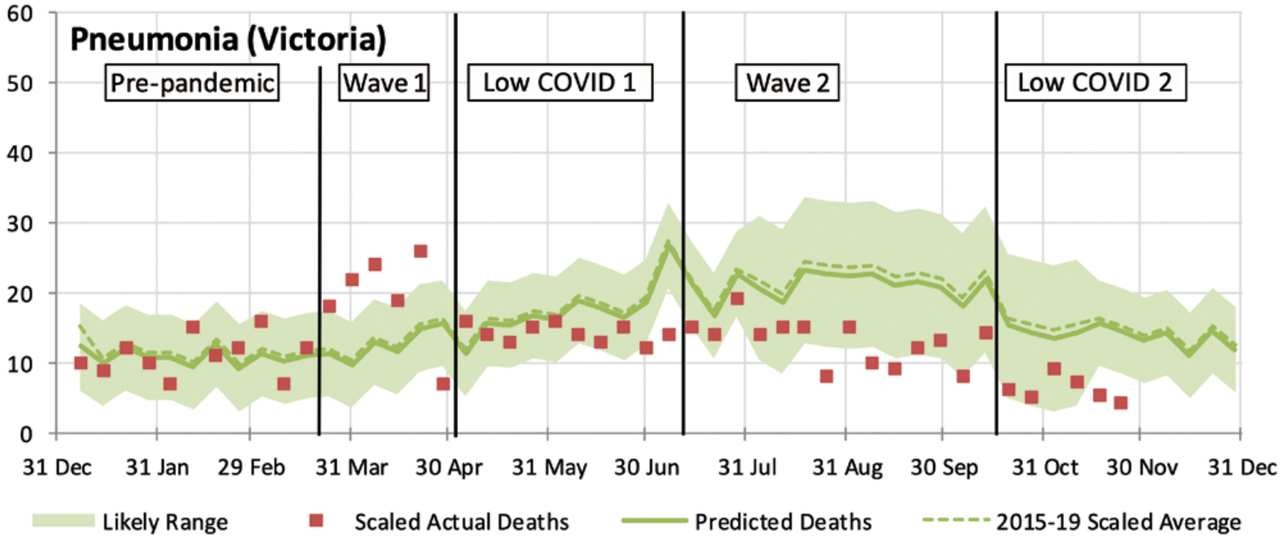
During the first wave, deaths from pneumonia were significantly higher than predicted and well above the 95th percentile for the three weeks ending 31 March, 7 April and 14 April. We understand that COVID-19 often presents as similar to pneumonia, and strongly suspect that some 'pneumonia' deaths during the first wave were undetected COVID-19 deaths.

Since mid-April, deaths from pneumonia have been lower than predicted, and significantly below the 5th percentile from mid-June – in turn, due to measures taken to reduce the spread of COVID-19.

During Wave 2, after testing capacity had been expanded, we did not observe any increase in pneumonia deaths for Australia as a whole.

We strongly suspect some 'pneumonia' deaths during the first wave were undetected COVID-19 deaths.

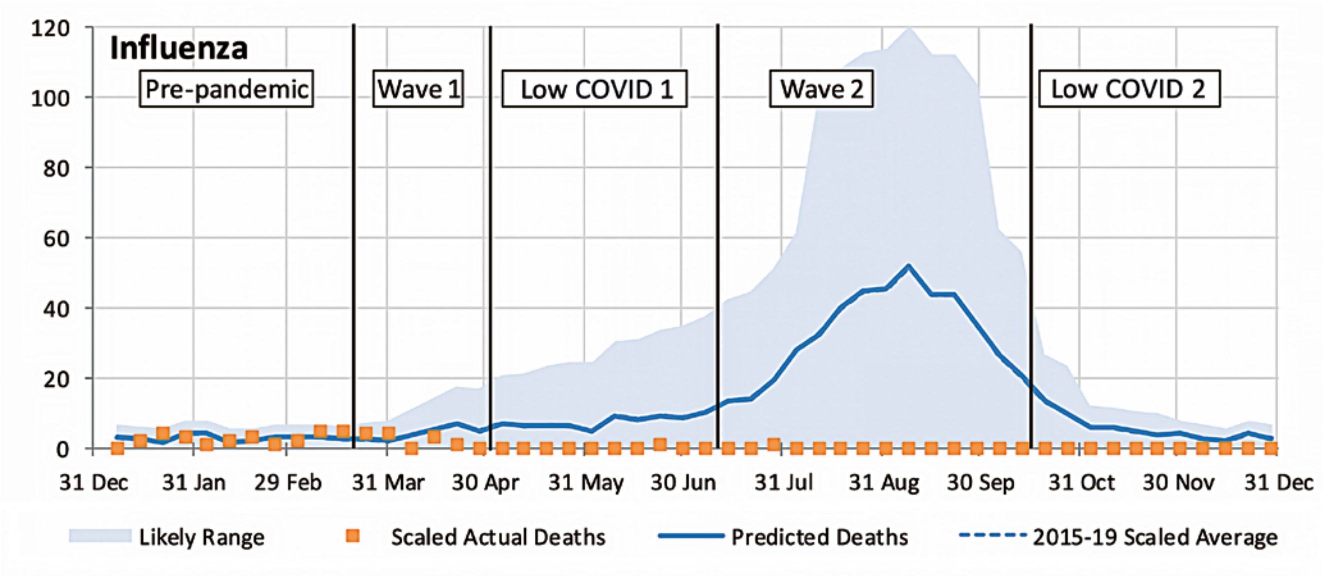
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

In Victoria, there was a small increase in pneumonia deaths in the last week of July, however the number of deaths involved is very small (around five more deaths than the preceding weeks).

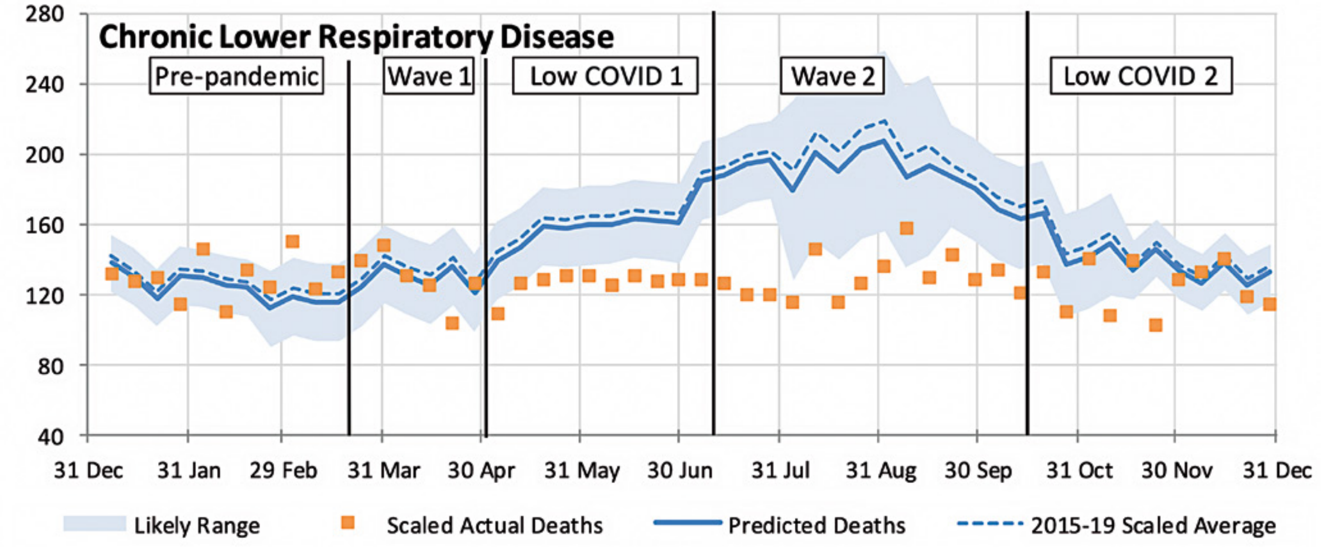
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Influenza deaths have been almost non-existent in Australia since mid-April. There have been only three influenza deaths since 15 April 2020, compared to an expected number of around 600 in a 'normal' flu season. This will be due to the absence of influenza in Australia in 2020 because of social distancing measures and perhaps also because of the closed international borders.

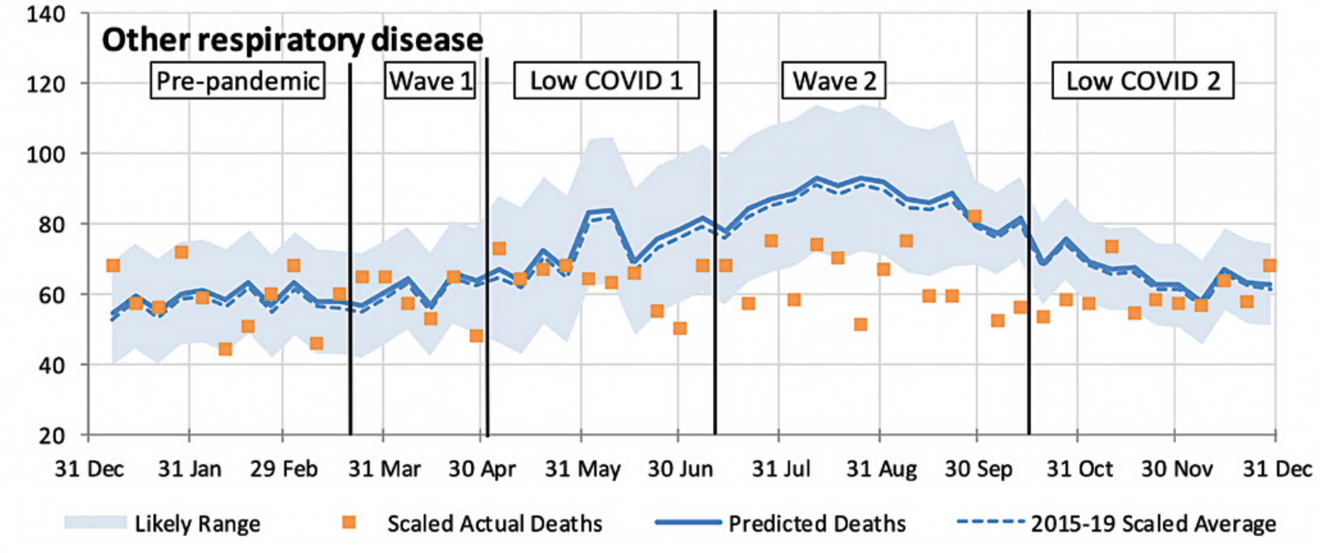
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Deaths from chronic lower respiratory disease have been much lower than usual since end-April. There appears to be a 'baseline' number of deaths from this cause of around 130 deaths per week. Deaths normally increase above this baseline level during the winter flu season. There was no increase this year, with deaths remaining at around 130 per week.

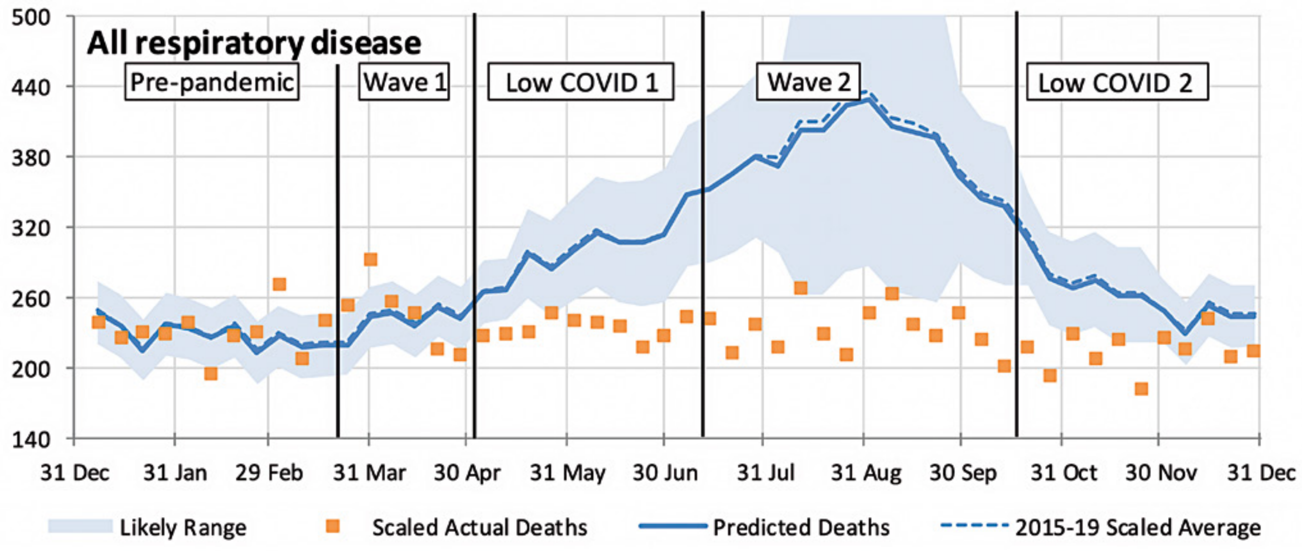
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Deaths from other respiratory diseases have also remained at their baseline level of around 60 deaths per week throughout 2020, with no winter flu impact (noting the seasonal impact on these causes of death are lower than for pneumonia, influenza and lower respiratory disease).

Weekly scaled actual and predicted doctor-certified deaths

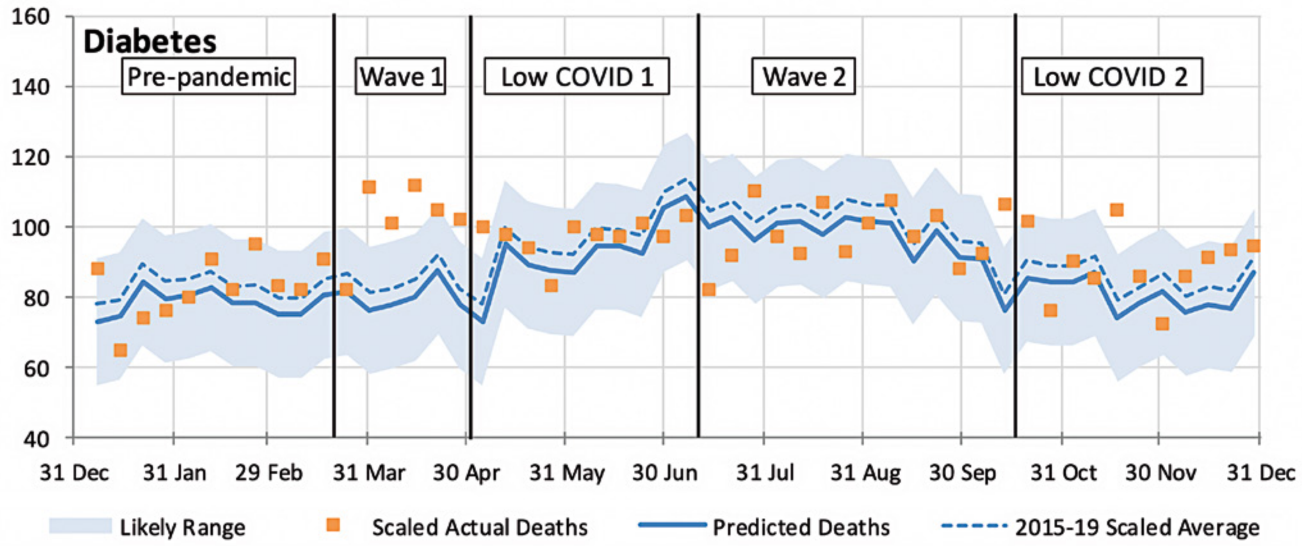


Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

The total graph for all respiratory disease shows that many deaths from respiratory disease have been avoided in Australia as a result of measures to control and eliminate COVID-19.

Causes of death with potential links to COVID-19

Weekly scaled actual and predicted doctor-certified deaths

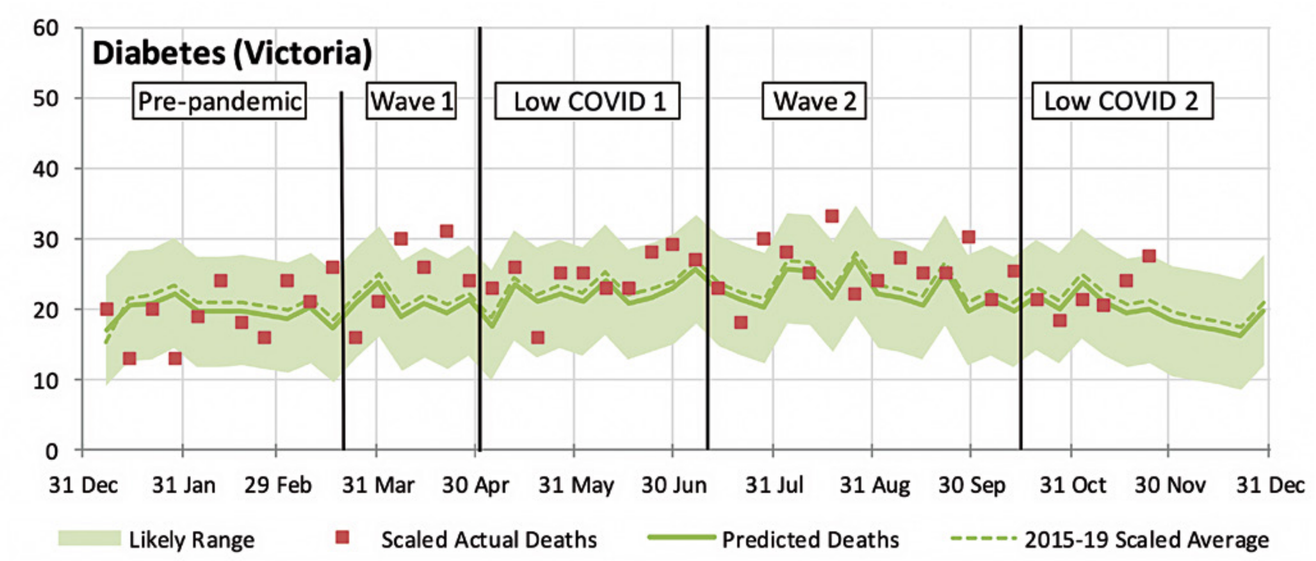


Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Diabetes is a known comorbidity of COVID-19. As for pneumonia, diabetes deaths were significantly higher than predicted and above the 95th percentile for the three weeks ending 31 March, 7 April and 14 April. Diabetes deaths continued to be higher than the 95th percentile for the next three weeks, possibly indicating undiagnosed COVID-19 deaths.

Since early-May, diabetes deaths have generally been close to expected, aside from three outliers in mid-October and mid-November. We did not observe any increase in diabetes deaths for Australia in total during the second wave.

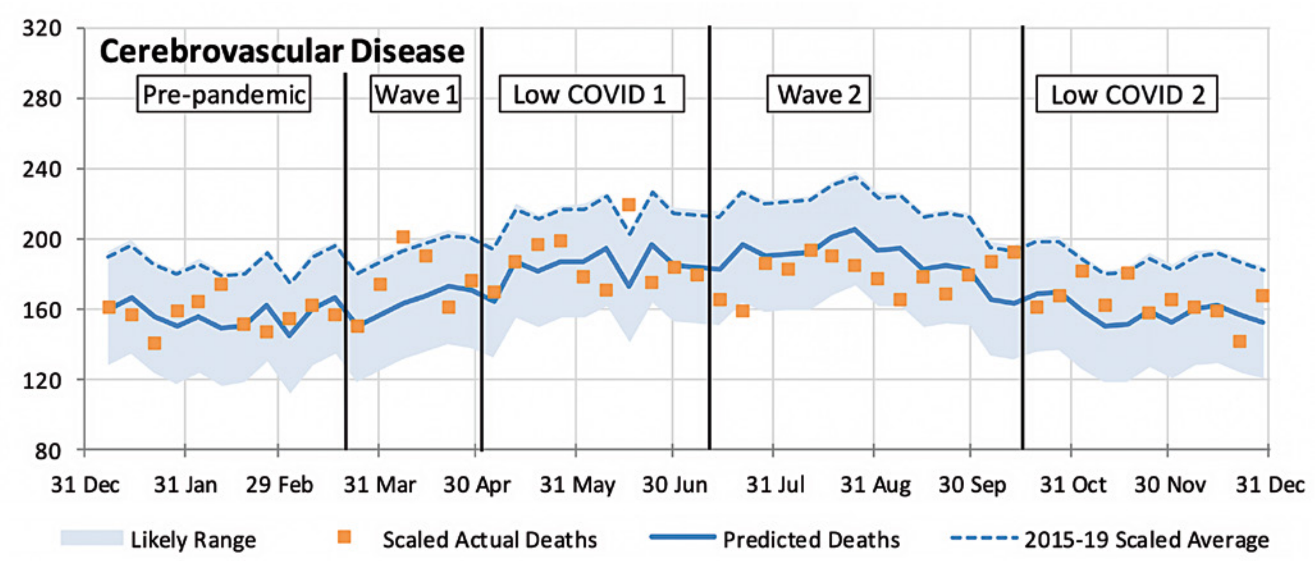
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

In Victoria, there were two weeks during the second wave where diabetes deaths were higher than predicted by around 7-10 deaths, possibly indicating a small number of undiagnosed COVID-19 deaths.

Weekly scaled actual and predicted doctor-certified deaths



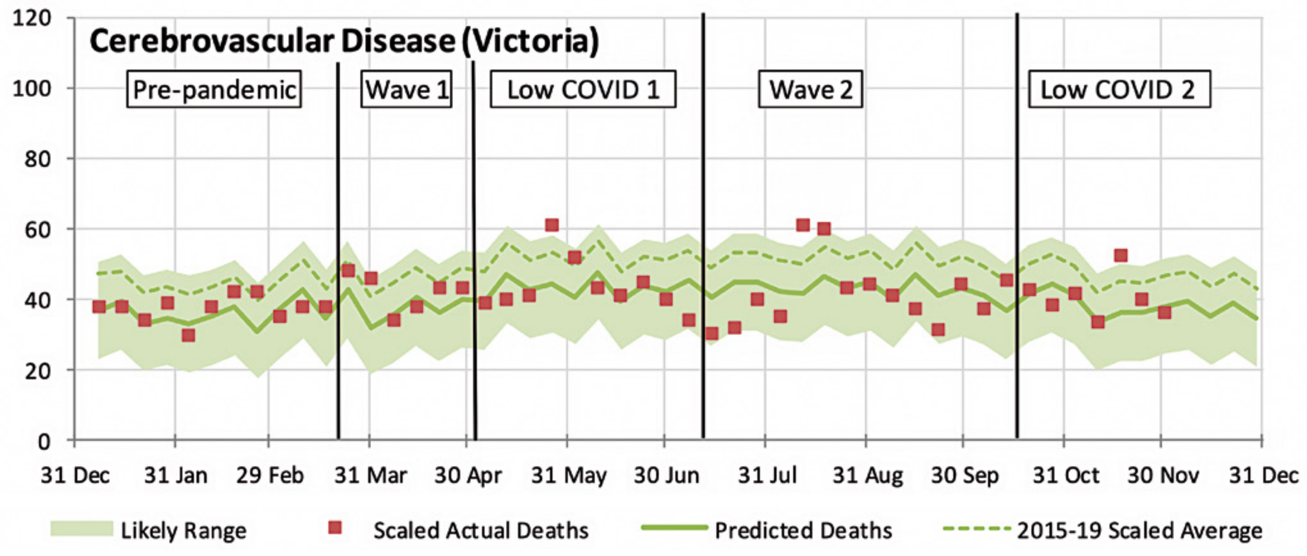
Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Deaths from cerebrovascular disease have generally been reasonably close to or lower than predicted numbers. The exception to this is the three-week period during the first wave (31 March to 14 April), where deaths from this cause were higher than predicted, and above the 95th percentile for the week ending 7 April.

Information from Monash University indicates that the number of brain scans for stroke reduced quite dramatically in the week ending 31 March 2020 (down by around one third). This may indicate people were not presenting to hospital with stroke as early as they normally would, possibly due to fears of visiting healthcare settings. For a disease where time is of the essence, this may be a contributor to the much higher number of stroke deaths than usual over this three-week period. We also note that stroke is a known complication of COVID-19.

During the second wave, deaths from cerebrovascular disease were lower than predicted Australia-wide. However, if we examine Victoria in isolation, we can see that there were two weeks during the second wave when deaths from this cause were higher than predicted and higher than the 95th percentile.

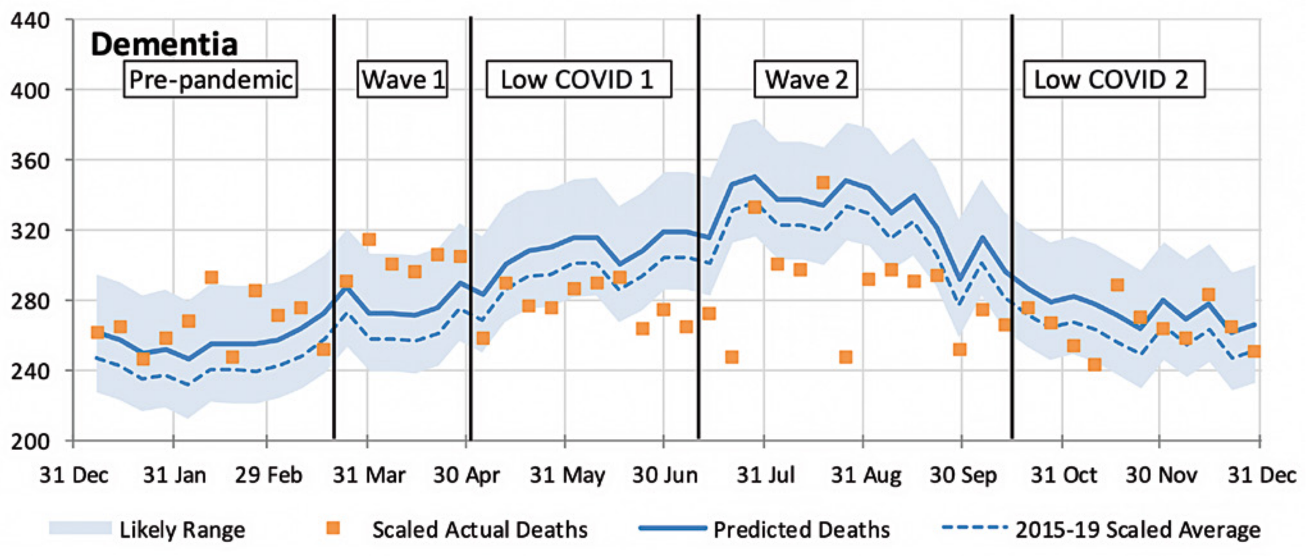
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

There were around 20 more stroke deaths than predicted in Victoria in each of the two high weeks in August.

Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

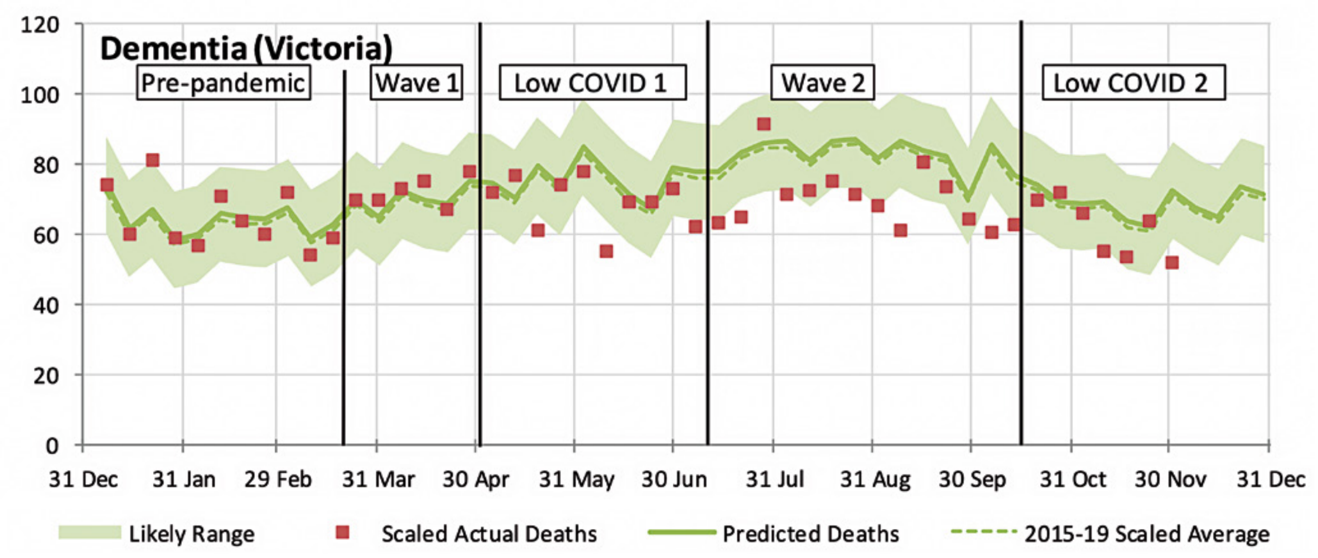
Deaths from dementia were significantly higher than predicted for five out of six weeks during the first wave, although only the first of those weeks was above the 95th percentile. Have some

COVID-19 deaths been missed here? If so, we find it hard to believe that there would be many, since many of these deaths would have taken place in nursing homes. Experience of outbreaks in nursing homes suggests that COVID-19 would likely have spread quickly and widely in any home and would therefore have been detected. We think it more likely that our simple linear trend calculations do not model dementia deaths as well as those from other causes.

Deaths from dementia have since fallen below predicted numbers for almost all weeks. It is plausible that the reduction in common respiratory illnesses in the community led to lower deaths from dementia and other causes, as any illness is likely to increase the mortality of the very frail or otherwise unwell in our community.

There are two weeks during the second wave where dementia deaths are higher than surrounding weeks. We have again examined Victorian in isolation.

Weekly scaled actual and predicted doctor-certified deaths



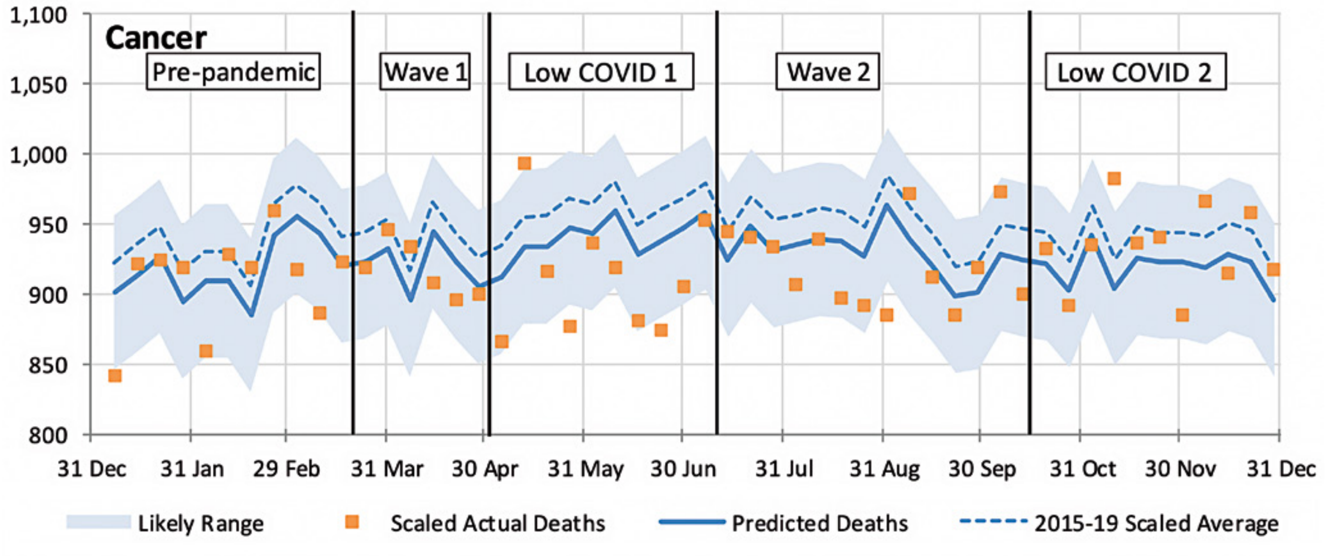
Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

There was one week in Victoria where dementia deaths were high (around 20 more deaths than surrounding weeks), which coincides with one of the high Australia-wide points (week ending 28 July). These higher deaths may be related to the significant issues aged care homes were experiencing at that time.

Lower dementia deaths over winter are likely due to the lower prevalence of respiratory disease.

Deaths from Other Causes

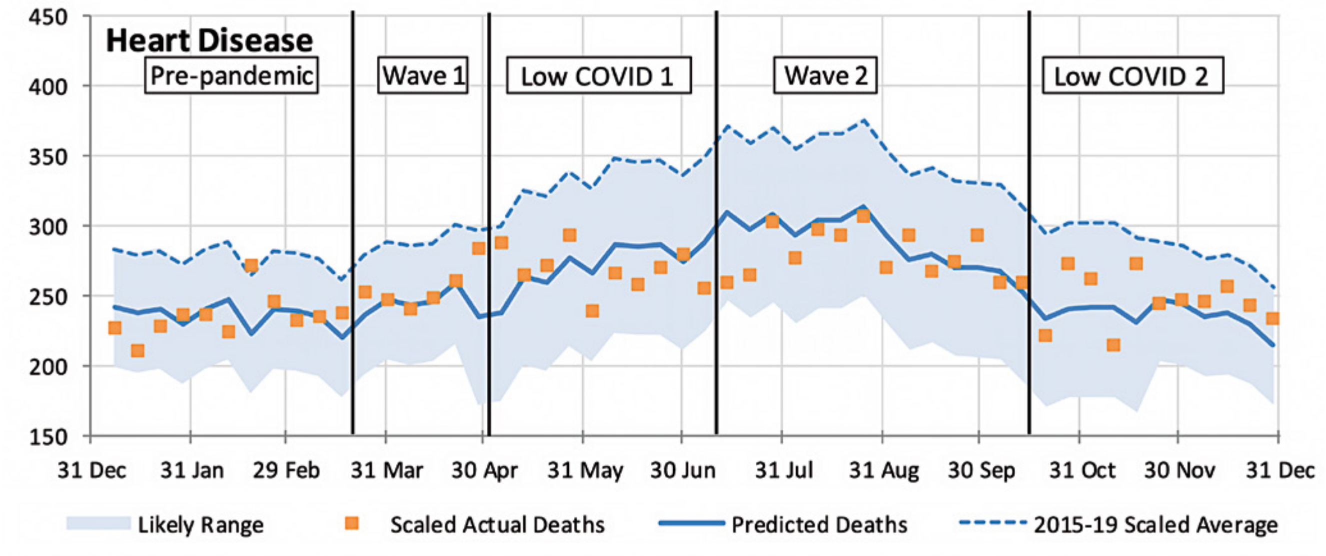
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Cancer deaths do not appear to have been particularly affected by the pandemic, with deaths in 2020 generally within a reasonable range of predicted numbers. There is evidence however that some cancer screening and therapeutic procedures dropped off during the first wave. To the extent that deaths are caused by delayed diagnoses or missed treatments due to people avoiding health care settings in 2020, these are unlikely to show up in the data yet - it is likely that any consequential adverse impact on mortality will take some time to emerge.

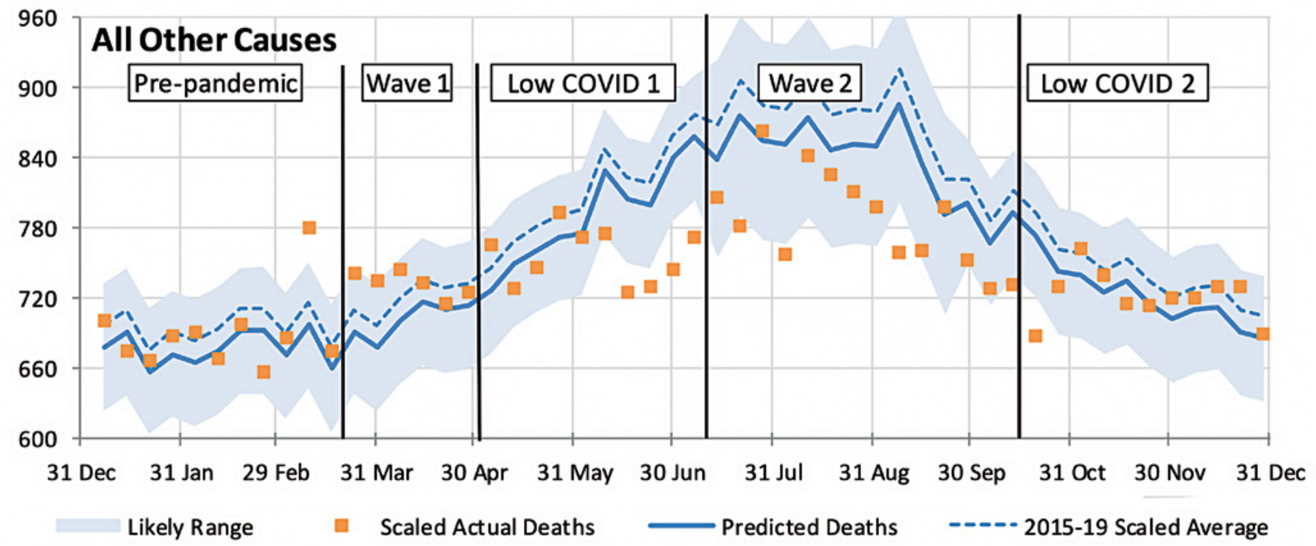
Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Deaths from ischaemic heart disease (primarily heart attack and coronary heart disease) are close to predicted in 2020, continuing the downward trend in mortality from this cause.

Weekly scaled actual and predicted doctor-certified deaths



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting. Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Overall, there were around 3,900 fewer deaths in 2020 than predicted, driven by lower levels of respiratory illness.

All other doctor-certified deaths are similar to predicted levels other than for most of March (relatively high during the first wave) and from mid-June to mid-October (relatively low during the usual winter flu season).

Summary of doctor-certified deaths

Year to 29 December – Actual vs Predicted					
Cause of Death	**Actual**	**Predicted**	**Difference**	**% Diff**	**Contribution**
Respiratory disease					
Lower respiratory	6,656	7,898	(1,241)	-16%	-0.9%
Influenza	42	648	(606)	-94%	-0.4%
Pneumonia	2,085	2,967	(882)	-30%	-0.6%
Other respiratory	3,197	3,689	(492)	-13%	-0.3%
Total	11,980	15,201	(3,221)	-21%	-2.2%
Cancer	47,786	48,154	(368)	-1%	-0.3%
Heart disease	13,442	13,423	19	0%	0.0%
Cerebrovascular disease	8,954	8,911	43	0%	0.0%
Dementia	14,439	15,197	(758)	-5%	-0.5%
Diabetes	4,844	4,516	328	7%	0.2%
Other	38,473	39,215	(742)	-2%	-0.5%
Total	127,938	129,416	(1,478)	-1%	-1.0%
COVID	832	-	832		0.6%
Total	140,750	144,617	(3,867)	-2.7%	-2.7%

Overall, there were around 3,900 (2.7%) fewer deaths in 2020 than predicted.

This is driven by lower numbers of deaths from respiratory illness (around 3,200 fewer than predicted). Higher than expected deaths from pneumonia at the end of March (likely undiagnosed COVID-19) have been more than offset by the much lower numbers of all respiratory deaths since mid-April. While much of the press has focussed on lower levels of influenza deaths, these account for only around 20% of the reduction in respiratory deaths. Pneumonia causes more deaths than influenza, and chronic lower respiratory disease kills more than the other two combined.

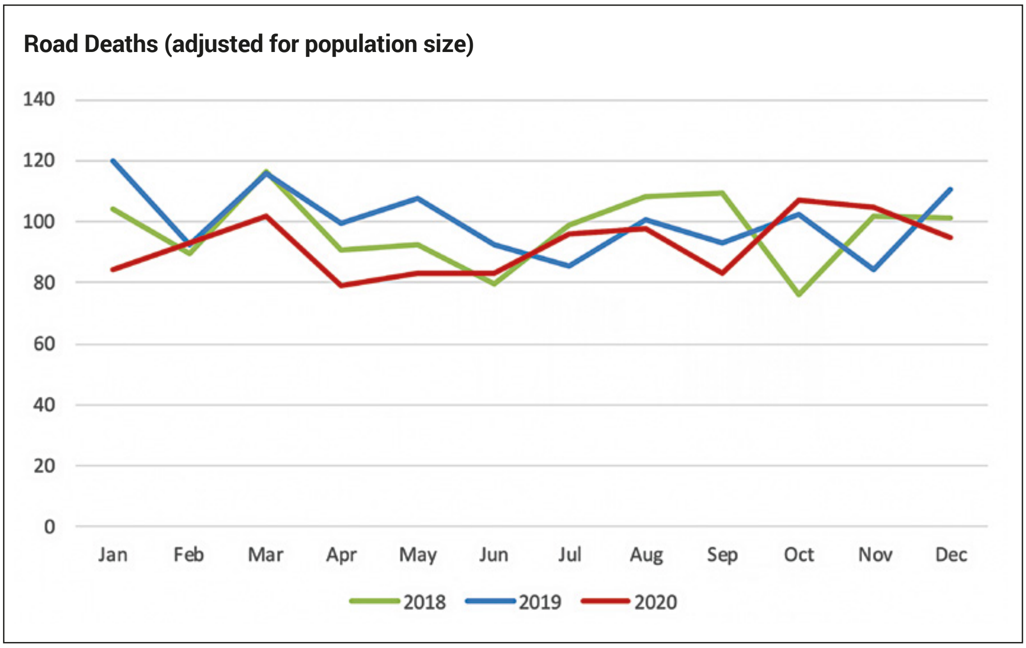
Deaths from non-respiratory causes are also lower than predicted by around 1,500 deaths:

- deaths from cancer are a little lower than predicted;
- deaths from heart disease are the same as predicted, as are deaths from cerebrovascular disease (stroke, etc). For cerebrovascular disease, higher deaths than predicted across Australia in the first wave and in Victoria in the second wave (possibly due to undiagnosed COVID-19 or people delaying treatment) were mostly offset by lower deaths from this cause in the rest of the year;
- deaths from diabetes are higher than expected, driven by higher than expected deaths in the first wave (likely undiagnosed COVID-19)
- deaths from dementia and 'other' are lower than predicted. Higher than predicted numbers of deaths from these causes during the first wave were more than offset by lower than predicted deaths during the winter months as a result of lower levels of respiratory disease.

2.4. Coroner-referred deaths in Australia in 2020

Road deaths

The Australian government publishes monthly road fatalities[4], and for the 2020 year, the number of road deaths reduced by 7.9% per 100,000 population compared with 2019 – from 4.68 per 100,000 (1,186 deaths) to 4.31 per 100,000 (1,106 deaths). This is the lowest per population since records began in Australia, and broadly a continuation of existing trends.



Road deaths were lower from March 2020 to May 2020, coinciding with the Australia-wide lockdown during the first wave. Since then, road deaths in 2020 have been broadly similar to 2018 and 2019.

Road deaths went up in two states compared with previous years – Queensland and Tasmania, but in both cases the five year trend is still down.

4 Road Fatalities Australia Monthly Bulletin December 2020: https://www.bitre.gov.au/sites/default/files/documents/rda_dec2020.pdf

Suicide deaths

In 2020, three states published preliminary suicide statistics:

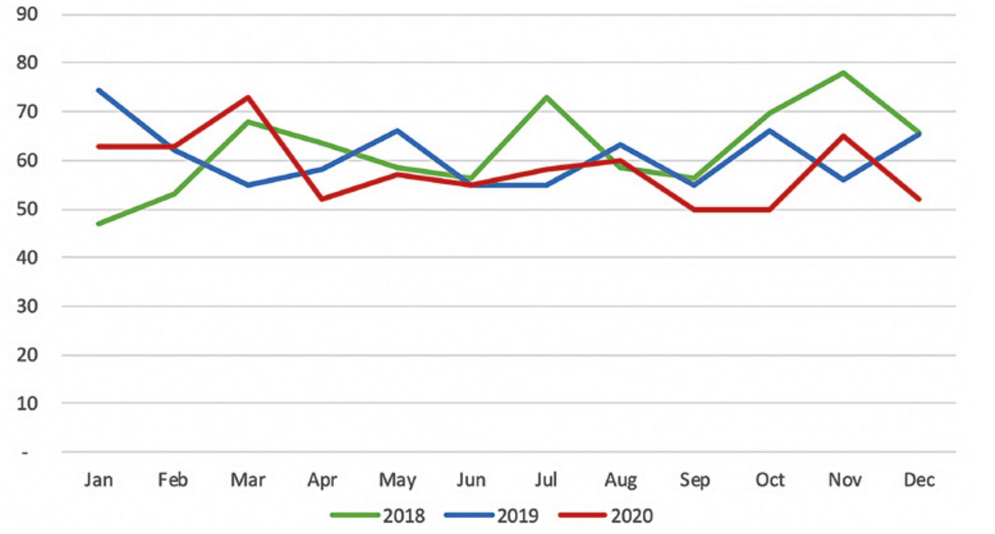
- For NSW,[5] there were 896 suspected or confirmed suicides in 2020, 47 (5%) fewer than in 2019.
- In Victoria[6], there were 698 suspected or confirmed suicides in 2020, 20 (3%) fewer than in 2019.
- In Queensland[7], there were 454 suspected or confirmed suicides in the seven months to 31 July 2020, 9 (2%) fewer than in 2019.

The number of suicide deaths in the two biggest states of Australia appears not to have increased.

Details of how the data is compiled are included in Appendix D.

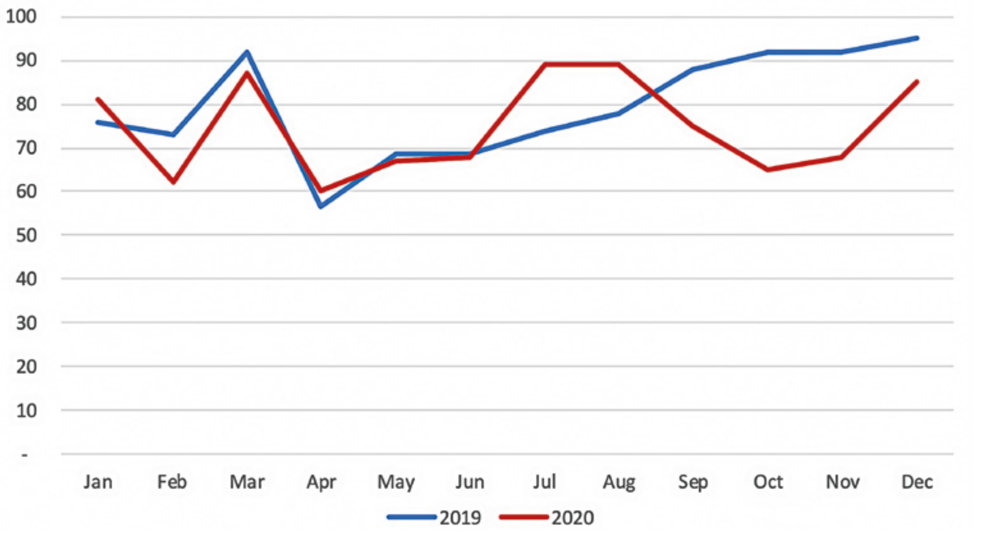
The following charts show the monthly numbers of suicide deaths in each of Victoria and NSW, after adjustment for changes in population size.

Suicide Deaths in Victoria (adjusted for population size)



After adjusting for increases in the size of the Victorian population, suicide deaths in 2020 were 5% lower than in 2019 overall. Reassuringly, there is no evidence of any increase in suicide over the second lockdown period of July through to October. In fact, the months of September and October 2020 have the lowest numbers of suicide deaths of the three years shown. While this does not preclude longer-term mental health impacts, it is good to see that the immediate impacts have not led to increases in suicide rates.

Suicide Deaths in NSW (adjusted for population size)



5 NSW Suicide Monitoring System Report 4 January 202: https://www.health.nsw.gov.au/mentalhealth/resources/Publications/suicide-monitoring-report-jan-21.pdf

6 Coroners Court Monthly Suicide Data Report, December 2020 update, Coroners Court of Victoria: https://www.coronerscourt.vic.gov.au/sites/default/files/2021-01/Coroners%20Court%20Monthly%20Suicide%20Data%20Report%20-%20December%202020.pdf

7 Suicide and Self Harm Monitoring, AIHW website: https://www.aihw.gov.au/suicide-self-harm-monitoring/data/suspected-deaths-by-suicide/data-from-suicide-registers

In NSW, after adjusting for increases in the population, suicide deaths in 2020 were 6% lower than in 2019. While there was no discernible increase in suicide deaths during the first lockdown period (March to May) compared with the previous year, the number of suicides in July and August 2020 were higher than in 2019. However, this was followed by a lower number of suicide deaths in September to December 2020 compared with 2019. As data is unfortunately only available for the two years shown, it is difficult to read much into the monthly data points.

There has been plenty of anecdotal evidence of the impact of lockdowns and other stresses on mental health, so we were pleasantly surprised to see that the number of suicide deaths appears not to have increased, at least not in the two biggest states of Australia. We could speculate on the reasons for this, but we do not consider that we have any special insight. Mathematically, one of two things has happened; either there has been no mortality impact from these stresses or there has been an offsetting reduction in other drivers of suicide.

We are also cognisant of the potential for increases in rates of suicide in the next few years as the longer-term consequences of financial distress can take some time to emerge.

If you or anyone you know needs support call Lifeline on 131 114, or Beyond Blue's coronavirus mental wellbeing support service on 1800 512 348.

Other Coroner-referred Deaths

In respect of other coroner-referred deaths for which no data is currently available, we make the following broad comments:

We have no reason to expect a significant increase or reduction in total coroner-referred deaths.

- Diseases (around 9,400 in a normal year) – we would expect any changes in these deaths to follow a similar trend as the doctor-certified deaths i.e. a general reduction on prior years.
- Accidental deaths (around 5,800 in a normal year) – we may see an increased number of deaths from this cause based on anecdotal reports of an increased number of poisonings associated with hand sanitisers (poisonings usually account for around 1,300 deaths). There may also be an argument for an increase in accidental deaths due to people spending more time at home, which we might expect to be higher risk than the workplace.
- Suicide deaths in other jurisdictions (around 1,000 in a normal year) – there is currently no data available on suicide deaths in other jurisdictions for 2020. However, if the other states follow the experience of Victoria, New South Wales and Queensland (and there is no reason to think otherwise), then suicides are not likely to be a source of increased deaths – they would, in fact, be a further source of mortality reduction in 2020.
- For other causes of death referred to the coroner, we cannot form a view, noting that these deaths make up only a small portion of all deaths (around 600 in a normal year).

On balance, we have no reason to expect a significant increase or reduction in total coroner-referred deaths. Given there have been around 3,900 fewer doctor certified deaths in 2020 than predicted, it is difficult to see how increases in any category of coroner-referred deaths could offset these lower doctor-certified deaths.

3. Long-term consequences of COVID-19

This paper has so far discussed the mortality of COVID-19. However, there are also morbidity impacts from the disease – colloquially known as 'Long COVID'.

These effects are of interest to those interested in public health and disability burdens (including insurers) in countries with significant COVID-19 outbreaks, but also, over time will be of interest to those in countries without outbreaks, as borders gradually open up, and some of those with long-term symptoms move to different countries.

8 Black Flu 1918: The story of New Zealand's worst public health disaster, by Geoffrey W Rice, published by Canterbury University Press

This has been expected from the beginning – the 1918 'Spanish Flu' led to long-term symptoms which included disability.[8]

> *Another collection published around the same time by New Zealand historian Geoffrey Rice is also littered with references to long-term symptoms of that flu—from 'loss of muscular energy' to 'nervous complications.' Some convalescents, recalled a Dr. Jamieson who worked at a hospital in Nelson, on New Zealand's South Island, 'passed through a period of apathy and depression,' or experienced tremor, restlessness, or sleeplessness.*

Now that more than 12 months have passed since the first wave of COVID-19 occurred around the world, what do we know about medium- to long-term morbidity from the disease?

Two major studies have been published recently, looking at different long-term outcomes from COVID-19. While they (unavoidably) only cover the first 6-12 months, they provide strong indications of long-term effects.

The risk of a wide range of illnesses is substantially higher in those who have been ill with COVID-19.

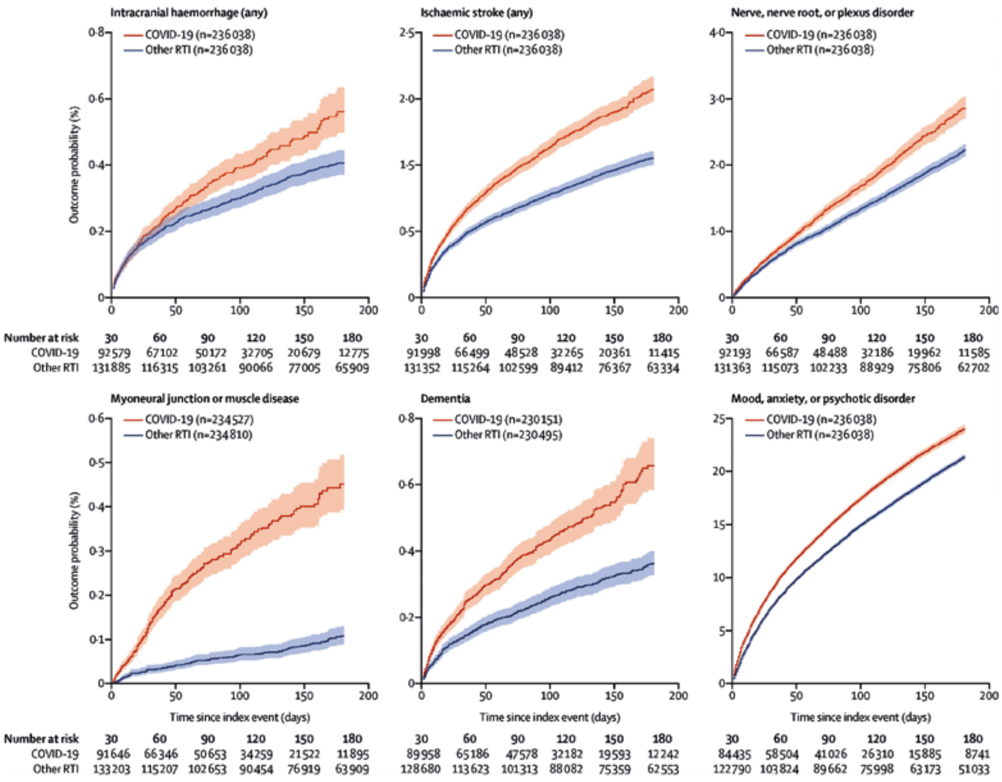
Both studies conclude that the risk of a wide range of illnesses is substantially higher in those who have been ill with COVID-19 than in people in the population with very similar illnesses, such as flu or pneumonia.

In both cases, the more sick a patient was with COVID-19, the more likely they were to experience a subsequent illness.

US Study

The first, published in the Lancet Psychiatry[9], looks specifically at neurological and psychiatric outcomes in the US from more than 200,000 survivors of COVID-19. The study matches (using sex, race, ethnicity and comorbidities) COVID-19 survivors with patients who have suffered from the flu

Kaplan-Meier estimates for the incidence of major outcomes after COVID-19 compared with other RTIs



Shaded areas are 95% CIs. For incidences of first diagnoses, the number in brackets corresponds to all patients who did not have the outcome before the follow-up period. For diagnostic subcategories, see appendix (pp 8–10). RTI=respiratory tract infection.

9 6-month neurological and psychiatric outcomes in 236 379 survivors of COVID-19: a retrospective cohort study using electronic health records, by Maxime Taquet, John R Geddes, Masud Husain, Sierra Luciano, Paul J Harrison, published in the Lancet Psychiatry, May 2021.

or another respiratory disease. The graph below from the paper shows that, for a number of key neurological and psychological outcomes, the risk of COVID-19 was demonstrably more severe than for other respiratory illnesses.

The strength of the study is that it looks at the propensity for these outcomes compared with matched patients.

Among the COVID-19 patients, the estimated incidence of a neurological or psychiatric diagnosis in the following 6 months was 33.62%, with 12.84% receiving their first diagnosis. Most diagnostic categories were more common in patients who had COVID-19 than in those who had influenza – a hazard ratio of 1.44 times as likely for any diagnosis and 1.78 times more likely for any first diagnosis.

HRs for the major outcomes in patients after COVID-19 compared with those after influenza and other RTIs

	COVID-19 vs influenza (N=105 579)*		COVID-19 vs other RTI (N=236 038)*	
	HR (95% CI)	p value	HR (95% CI)	p value
Intracranial haemorrhage (any)	2·44 (1·89–3·16)	<0·0001	1·26 (1·11–1·43)	0·0003
Intracranial haemorrhage (first)	2·53 (1·68–3·79)	<0·0001	1·56 (1·27–1·92)	<0·0001
Ischaemic stroke (any)	1·62 (1·43–1·83)	<0·0001	1·45 (1·36–1·55)	<0·0001
Ischaemic stroke (first)	1·97 (1·57–2·47)	<0·0001	1·63 (1·44–1·85)	<0·0001
Parkinsonism	1·42 (0·75–2·67)	0·19	1·45 (1·05–2·00)	0·020
Guillain-Barré syndrome	1·21 (0·72–2·04)	0·41	2·06 (1·43–2·96)	<0·0001
Nerve, nerve root, or plexus disorders	1·64 (1·50–1·81)	<0·0001	1·27 (1·19–1·35)	<0·0001
Myoneural junction or muscle disease	5·28 (3·71–7·53)	<0·0001	4·52 (3·65–5·59)	<0·0001
Encephalitis	1·70 (1·04–2·78)	0·028	1·41 (1·03–1·92)	0·028
Dementia	2·33 (1·77–3·07)	<0·0001	1·71 (1·50–1·95)	<0·0001
Mood, anxiety, or psychotic disorder (any)	1·46 (1·43–1·50)	<0·0001	1·20 (1·18–1·23)	<0·0001
Mood, anxiety, or psychotic disorder (first)	1·81 (1·69–1·94)	<0·0001	1·48 (1·42–1·55)	<0·0001
Mood disorder (any)	1·47 (1·42–1·53)	<0·0001	1·23 (1·20–1·26)	<0·0001
Mood disorder (first)	1·79 (1·64–1·95)	<0·0001	1·41 (1·33–1·50)	<0·0001
Anxiety disorder (any)	1·45 (1·40–1·49)	<0·0001	1·17 (1·15–1·20)	<0·0001
Anxiety disorder (first)	1·78 (1·66–1·91)	<0·0001	1·48 (1·42–1·55)	<0·0001
Psychotic disorder (any)	2·03 (1·78–2·31)	<0·0001	1·66 (1·53–1·81)	<0·0001
Psychotic disorder (first)	2·16 (1·62–2·88)	<0·0001	1·82 (1·53–2·16)	<0·0001
Substance use disorder (any)	1·27 (1·22–1·33)	<0·0001	1·09 (1·05–1·12)	<0·0001
Substance use disorder (first)	1·22 (1·09–1·37)	0·0006	0·92 (0·86–0·99)	0·033
Insomnia (any)	1·48 (1·38–1·57)	<0·0001	1·15 (1·10–1·20)	<0·0001
Insomnia (first)	1·92 (1·72–2·15)	<0·0001	1·43 (1·34–1·54)	<0·0001
Any outcome	1·44 (1·40–1·47)	<0·0001	1·16 (1·14–1·17)	<0·0001
Any first outcome	1·78 (1·68–1·89)	<0·0001	1·32 (1·27–1·36)	<0·0001

Additional details on cohort characteristics and diagnostic subcategories are presented in the appendix (pp 29–33). HR=hazard ratio. RTI=respiratory tract infection. * Matched cohorts.

Hazard ratios (the ratio of the level of diagnosis compared with matched patients) were higher in patients who had more severe COVID-19 – with a hazard ratio of 1.58 for those admitted to Intensive Care, and 2.87 for any first diagnosis). The table below shows the full outcomes, with many different neurological and psychological diseases displaying increased risk compared with influenza and other respiratory illnesses. Particularly for those who were in intensive care, or ventilated, some of these effects, anecdotally particularly the psychological effects, may be from the treatment as well as from the underlying disease of COVID-19. The study does not differentiate.

UK Study

A team of researchers in the UK used the excellent statistical information from the NHS to study 'post-COVID syndrome' following hospitalisation with coronavirus[10].

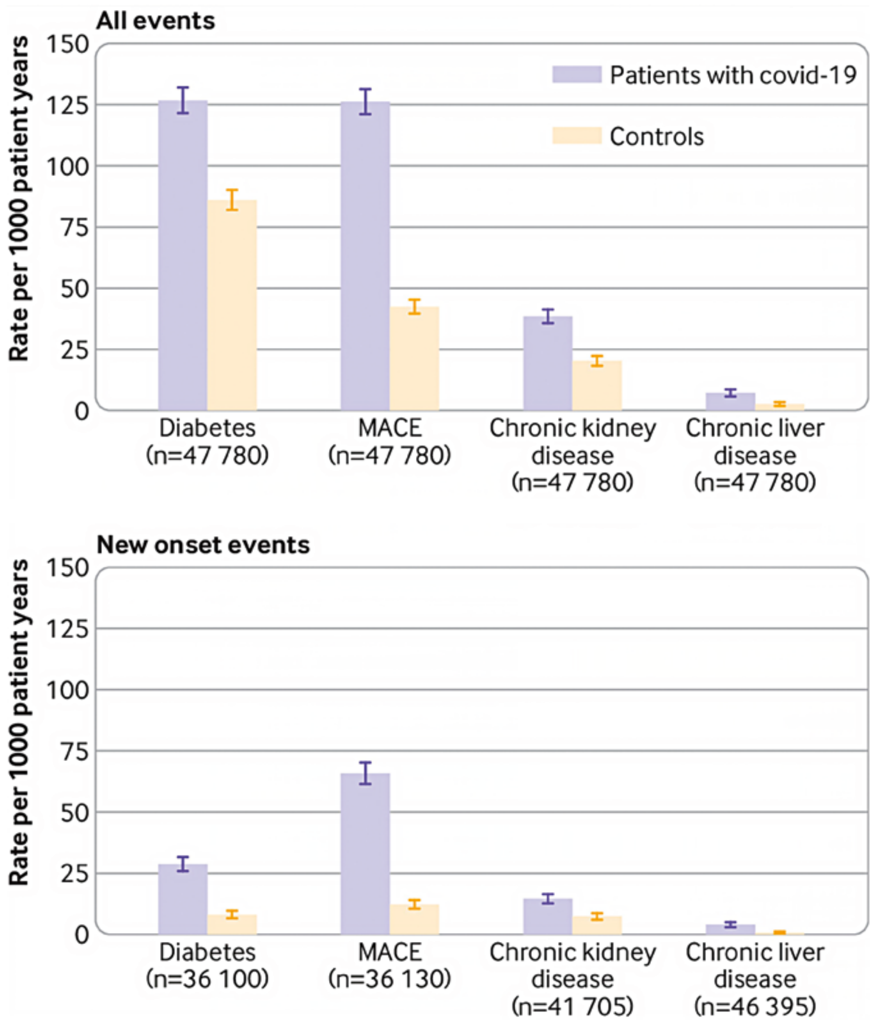
In this study, 47,780 individuals who were hospitalised with COVID-19 and discharged alive were exactly matched to controls of about 50 million people in England for personal and clinical characteristics.

Over a mean follow-up of 140 days, nearly a third of individuals who were discharged from hospital after acute COVID-19 were readmitted (14,060 of 47,780) and more than 1 in 10 (5,875) died after discharge, with these events occurring at rates 3.5 and 7.7 times greater, respectively, than in the matched control group. The authors' conclusion was:

> *Individuals discharged from hospital after COVID-19 had increased rates of multiorgan dysfunction compared with the expected risk in the general population. The increase in risk was not confined to the elderly and was not uniform across ethnicities. The diagnosis, treatment, and prevention of post-COVID syndrome requires integrated rather than organ or disease specific approaches, and urgent research is needed to establish the risk factors.*

The graph below shows this for some major disease types (MACE = Major adverse cardiovascular event).

Major adverse cardiovascular events



10 Epidemiology of post-COVID syndrome following hospitalisation with coronavirus: a retrospective cohort study, by Daniel Ayoubkhani, Kamlesh Khunti, Vahé Nafilyan, Thomas Maddox, Ben Humberstone, Sir Ian Diamond, Amitava Banerjee, published in the British Medical Journal, March 2021.

This study also leads to sobering conclusions about the long-term morbidity implications of COVID-19 illnesses. For those hospitalised with COVID-19, the risk of a wide variety of diseases, some of which can lead to serious disability, is substantially increased.

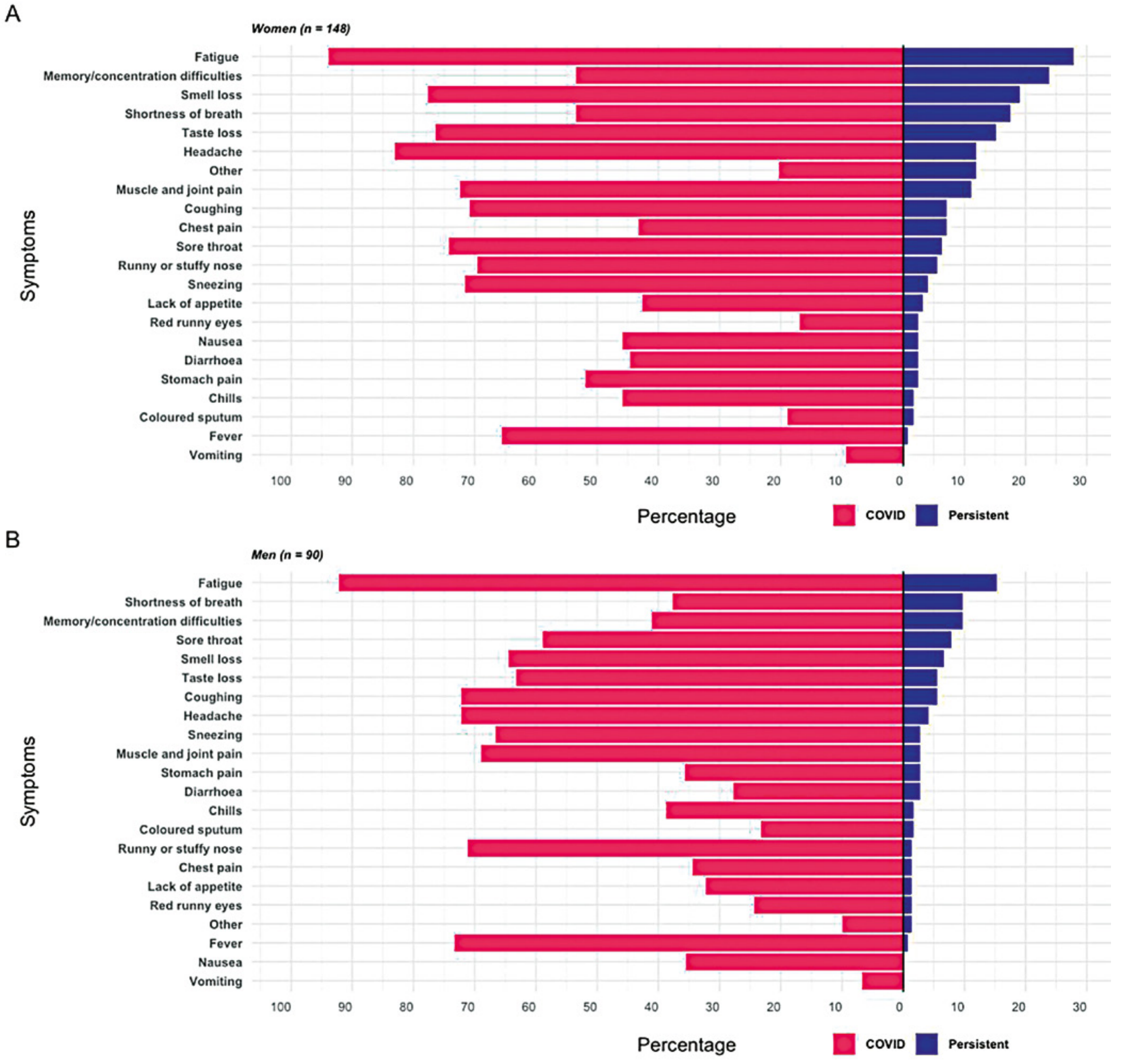
Non-hospitalised COVID-19 patients

Not surprisingly, it is more difficult to find substantial data on the long-term outcome from non-hospitalised COVID-19 patients, as the information about those who were not hospitalised is not as readily available. A Danish study[11] looked at long-term symptoms from those testing positive to COVID-19 who did not attend hospital, although the number of participants in the survey was only 445 non-hospitalised patients, 34% of whom were completely asymptomatic.

The graph below shows the acute and persistent symptoms for men and women with COVID-19 symptoms, showing that persistent (potentially long-term) symptoms were more common in women (nearly 30% having fatigue, for example) and that the four most common symptoms were fatigue, memory/concentration difficulties, 'smell loss' and shortness of breath.

11 Acute and persistent symptoms in non-hospitalized PCR-confirmed COVID-19 patients, by Sofie Bliddal, Karina Banasik, Ole Birger Pedersen, Ioanna Nissen, Lisa Cantwell, Michael Schwinn, Morten Tulstrup, David Westergaard, Henrik Ullum, Søren Brunak, Niels Tommerup, Bjarke Feenstra, Frank Geller, Sisse Rye Ostrowski, Kirsten Grønbæk, Claus Henrik Nielsen, Susanne Dam Nielsen, Ulla Feldt-Rasmussen

COVID-19 – acute and persistent symptoms



The combination of these studies shows both that avoiding COVID-19 illness is very worthwhile even in younger people and that, while the fatality rate is much lower, the risk of long-term illness is significant. And for populations that have been exposed to significant COVID-19 illness, any insurer that covers morbidity or health care costs will need to understand the prevalence of long-term post-COVID-19 illnesses in the population, both from those in their insured population currently (whichever country they are located in) and from those who may become insured in the future.

Insurers (where permitted by legislation) will need to consider the appropriateness of underwriting for previous COVID-19 disease when selecting new customers, noting that in Australia health insurers do not underwrite individual customers due to community rating.

Appendix A – COVID-19 and Excess Deaths in 38 Countries

The following table shows the COVID-19 deaths and total excess mortality for 38 countries/areas. We have constructed this table from OWID data, so it may contain interpretation and calculation errors, in addition to any errors in the data reported by OWID. It is also important to remember that the expected deaths (being the simple average of 2015-19) do not allow for demographic changes or mortality trends. This table shows all countries/areas that were available from OWID at the time of writing.

Region	Country / (Area)	Code	Up To	COVID-19 Deaths	Excess Deaths	Expected Deaths	COVID-19 %	Other Excess %	Total Excess %
ANZ	Australia	AUS	27/12/20	909	(112)	140,472	0.6%	-0.7%	-0.1%
	New Zealand	NZL	4/04/21	26	581	40,769	0.1%	1.4%	1.4%
E Asia	Japan	JPN	28/02/21	7,889	52,970	1,588,369	0.5%	2.8%	3.3%
	Singapore	SGP	31/12/20	29	1,298	20,702	0.1%	6.1%	6.3%
	South Korea	KOR	7/03/21	1,642	16,432	345,998	0.5%	4.3%	4.7%
	(Taiwan)	TWN	27/12/20	7	623	171,204	0.0%	0.4%	0.4%
	Thailand	THA	31/03/21	94	31,046	602,053	0.0%	5.1%	5.2%
W Europe	Belgium	BEL	4/04/21	23,169	15,207	142,983	16.2%	-5.6%	10.6%
	France	FRA	4/04/21	96,808	74,246	767,816	12.6%	-2.9%	9.7%
	Germany	DEU	11/04/21	78,500	58,122	1,230,875	6.4%	-1.7%	4.7%
	Italy	ITA	31/01/21	88,516	100,372	719,068	12.3%	1.6%	14.0%
	Spain	ESP	11/04/21	76,328	84,749	556,532	13.7%	1.5%	15.2%
	United Kingdom	GBR	11/04/21	127,331	112,879	799,853	15.9%	-1.8%	14.1%
N Europe	Denmark	DNK	18/04/21	2,456	369	71,359	3.4%	-2.9%	0.5%
	Finland	FIN	4/04/21	846	454	69,274	1.2%	-0.6%	0.7%
	Latvia	LVA	4/04/21	1,931	1,088	36,901	5.2%	-2.3%	2.9%
	Lithuania	LTU	11/04/21	3,687	4,594	52,909	7.0%	1.7%	8.7%
	Norway	NOR	4/04/21	673	(1,641)	52,766	1.3%	-4.4%	-3.1%
	Sweden	SWE	28/03/21	13,402	6,438	113,509	11.8%	-6.1%	5.7%
Balkans	Bulgaria	BGR	11/04/21	14,418	22,828	143,571	10.0%	5.9%	15.9%
	Croatia	HRV	28/02/21	5,526	4,346	63,227	8.7%	-1.9%	6.9%
	Greece	GRC	28/02/21	6,504	7,329	146,175	4.4%	0.6%	5.0%
	Montenegro	MNE	31/01/21	805	897	7,197	11.2%	1.3%	12.5%
	Romania	ROU	21/02/21	19,847	38,400	306,457	6.5%	6.1%	12.5%
	Slovenia	SVN	21/03/21	3,972	4,186	25,573	15.5%	0.8%	16.4%
N America	Canada	CAN	13/12/20	13,537	27,081	263,184	5.1%	5.1%	10.3%
	Mexico	MEX	7/03/21	190,604	489,210	845,735	22.5%	35.3%	57.8%
	United States	USA	28/02/21	514,943	698,480	3,316,535	15.5%	5.5%	21.1%
S America	Brazil	BRA	31/03/21	321,515	467,567	1,622,855	19.8%	9.0%	28.8%
	Chile	CHL	4/04/21	23,644	28,501	132,410	17.9%	3.7%	21.5%
	Colombia	COL	17/01/21	48,631	73,697	243,680	20.0%	10.3%	30.2%
	Paraguay	PRY	31/12/20	2,262	3,620	30,519	7.4%	4.4%	11.9%
Eurasia	Azerbaijan	AZE	31/12/20	2,641	18,610	57,037	4.6%	28.0%	32.6%
	Georgia	GEO	31/12/20	2,505	2,358	48,179	5.2%	-0.3%	4.9%
	Moldova	MDA	31/12/20	2,985	2,796	37,822	7.9%	-0.5%	7.4%
	Russia	RUS	28/02/21	84,700	343,698	2,173,222	3.9%	11.9%	15.8%
	Ukraine	UKR	28/02/21	27,404	36,225	689,722	4.0%	1.3%	5.3%
	Uzbekistan	UZB	31/03/21	629	22,823	192,413	0.3%	11.5%	11.9%

Note: Percentages shown relate to a base of Expected Deaths. For example, Mexico reported 190,604 COVID-19 deaths from 1/1/20 to 7/3/21. This is 22.5% of the 845,735 expected deaths in this period. 298,606 'other' deaths (489,210 – 190,604) represent 35.3% of expected, with total excess deaths of 489,210 being 57.8% of expected deaths

Appendix B – Doctor-certified versus Coroner-referred Deaths

The following table shows the number of doctor-certified versus coroner-referred deaths for 2015 to 2019.

	Year					Average	Propn
	2015	2016	2017	2018	2019		
Doctor Certified Deaths[1]							
Cancers	44,800	45,200	46,000	46,700	47,700	46,100	29%
Ischaemic heart diseases	15,900	15,700	15,500	14,400	14,000	15,100	9%
Dementia including Alzheimers	12,300	13,000	13,900	13,800	14,600	13,500	8%
Cerebrovascular diseases	10,200	10,000	9,900	9,500	9,100	9,700	6%
Diabetes	4,300	4,400	4,600	4,400	4,500	4,400	3%
Chronic lower respiratory conditions	7,400	7,600	8,000	7,400	7,800	7,600	5%
Pneumonia	2,500	2,600	2,800	2,800	2,800	2,700	2%
Influenza	300	400	1,200	100	1,000	600	0%
Other respiratory diseases	3,100	3,300	3,500	3,400	3,500	3,400	2%
All other	36,400	37,200	38,600	37,100	39,000	37,700	23%
Total	**137,300**	**139,400**	**144,100**	**139,700**	**144,000**	**140,900**	**87%**
Coroner Referred Deaths							
Specified diseases noted above	7,700	6,000	4,300	5,500	8,900	6,500	4%
Other diseases	3,400	2,400	1,600	2,400	4,600	2,900	2%
External causes							
Accidents (falls, poisonings, drownings)	5,400	5,700	5,700	5,900	6,300	5,800	4%
Transport accidents	1,400	1,500	1,400	1,300	1,500	1,400	1%
Suicide	3,100	2,900	3,300	3,100	3,300	3,100	2%
Assault	280	260	200	240	240	200	0.1%
Medical complications	170	70	30	50	60	100	0.1%
Other external causes	300	250	290	350	410	300	0.2%
Total	**21,800**	**19,100**	**16,800**	**18,800**	**25,300**	**20,400**	**13%**
% of all deaths	14%	12%	10%	12%	15%	13%	
All Deaths[2]	**159,100**	**158,500**	**160,900**	**158,500**	**169,300**	**161,300**	**100%**

[1] based on date of occurrence of death
[2] based on date of registration of death

Note that the ABS did not report coroner-referred deaths in Provisional Mortality Statistics, Australia 2020, so we have deduced them as the difference between total deaths and doctor-certified deaths. This is not strictly correct, because doctor-certified deaths are compiled based on the date the death occurred, and total deaths are based on the date the death was registered. However, 95% of doctor-certified deaths are registered within three months of occurrence, and almost all doctor-certified deaths are registered within five months of death, so we do not expect that any error will be significant.

For the specified diseases included in the ABS 2020 data, the following table shows the proportion of total deaths that doctor-certified deaths represent.

	Proportion of Total Deaths per Year					
	2015	2016	2017	2018	2019	Average
Doctor Certified Deaths						
Cancers	97%	99%	100%	99%	96%	98%
Ischaemic heart diseases	80%	82%	82%	82%	77%	81%
Dementia including Alzheimers	97%	99%	101%	99%	97%	99%
Cerebrovascular diseases	94%	95%	97%	96%	92%	95%
Diabetes	92%	93%	95%	93%	91%	93%
Chronic lower respiratory conditions	93%	94%	96%	94%	93%	94%
Pneumonia	92%	91%	94%	94%	92%	93%
Influenza	92%	93%	95%	90%	93%	94%
Other respiratory diseases	94%	95%	98%	96%	94%	96%
All other	91%	94%	96%	94%	89%	93%
Total	**86%**	**88%**	**90%**	**88%**	**85%**	**88%**

Appendix C – Methodology and Adjustments for Doctor-Certified Deaths

The following table shows the weekly doctor-certified deaths for each year 2015 to 2020. The figures shown include deaths up until 30 December or 29 December for leap years i.e. each year shown includes deaths in the first 364 days of the year.

To examine underlying trends in the data, we have adjusted deaths from prior years to allow for both population growth and the ageing of the population. Also, the ABS 2020 data is provisional and subject to change, with recent weeks expected to increase as more deaths are registered; allowance has been made for this delayed reporting. These adjustments are shown in the following tables.

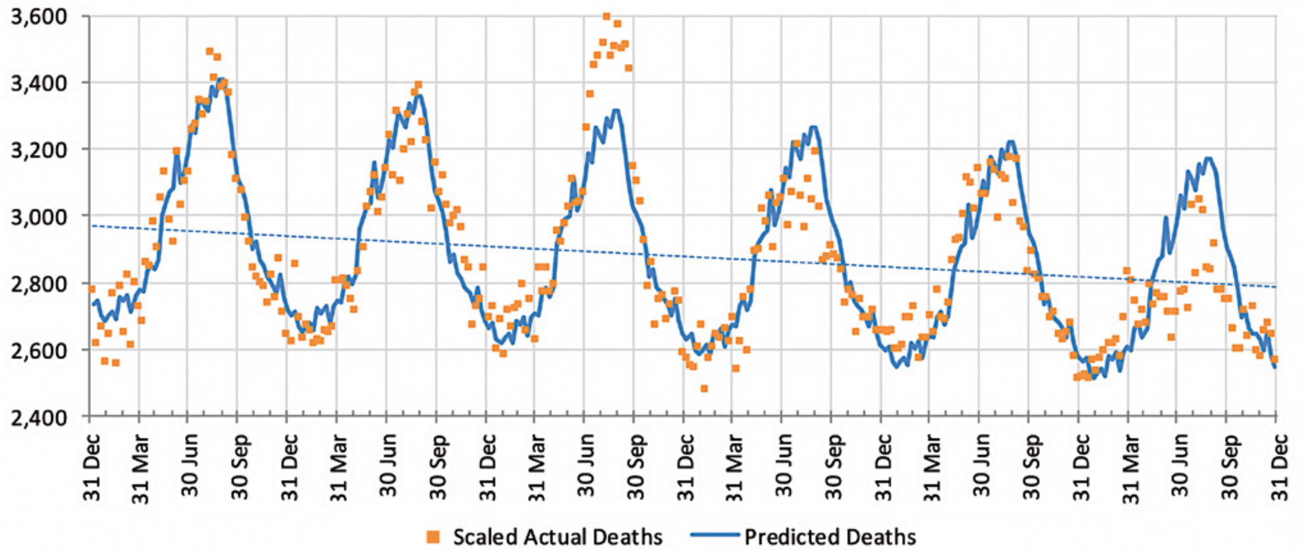
Year	Doctor Certified Deaths to 29 Dec	Population (m)	Population Adjusted Deaths	Age Mix Adjustment	Age Mix Adjusted Deaths	Delayed Reporting Allowance	Total Adjusted Deaths
2015	136,894	23.6	147,872	1.041	153,871	0	153,871
2016	138,685	24.0	147,656	1.033	152,558	0	152,558
2017	143,790	24.4	150,549	1.025	154,318	0	154,318
2018	139,324	24.8	143,614	1.017	146,055	0	146,055
2019	143,674	25.2	145,756	1.008	146,990	0	146,990
2020	140,363	25.5	140,363	1.000	140,363	387	140,750

Week ending	Registered Deaths	Late Reporting Allowance	Percent Loading	Adopted Deaths
Prior	103,506	91	0%	103,597
29-Sep-20	2,741	10	0%	2,751
6-Oct-20	2,738	10	0%	2,748
13-Oct-20	2,652	10	0%	2,662
20-Oct-20	2,587	11	0%	2,598
27-Oct-20	2,587	13	1%	2,600
3-Nov-20	2,702	14	1%	2,716
10-Nov-20	2,624	15	1%	2,639
17-Nov-20	2,707	17	1%	2,724
24-Nov-20	2,572	22	1%	2,594
1-Dec-20	2,558	22	1%	2,580
8-Dec-20	2,625	28	1%	2,653
15-Dec-20	2,644	33	1%	2,677
22-Dec-20	2,599	42	2%	2,641
29-Dec-20	2,521	47	2%	2,568
Total	**140,363**	**387**	**0%**	**140,750**

We have predicted doctor-certified deaths in 2020 by fitting multivariate linear regression models to the 2015 to 2019 weekly deaths (after adjustments) for each cause of death. The explanatory variables are year and month, and the death data has been normalised to allow for the shape and heteroskedasticity of the weekly deaths. We have also derived 5th and 95th percentiles around these predicted numbers, to indicate the range of reasonable variation. One week in 20 is expected to show deaths above this range and one week in 20 should be below the range.

While unadjusted deaths are rising (as shown in the doctor-certified deaths column above), after adjusting for population and age mix, we can see a trend of mortality improvement since 2015. This is consistent with our expectations and general experience and is demonstrated in this chart:

Weekly scaled actual and predicted doctor-certified deaths – All Causes



Actual deaths are scaled to 2020 allowing for population growth and change in age profile; 2020 deaths include allowance for late reporting.
Predicted deaths come from the linear trend in each week's scaled deaths in 2015 to 2019.

Focusing on 2020, we can see that Australia is predicted to have fewer doctor-certified deaths than 2015-2019, scaled for population and age changes. This reflects the overall decreasing trend in mortality in Australia. Actual deaths have been well below predicted.

Limitations

Our analysis of doctor-certified deaths is based on the ABS mortality statistics up to 29 December. We have made actuarial adjustments to allow for changes in population numbers and age profile and to reflect the likely emergence of more reported deaths for the period as time passes. These adjustments are quite simple. In particular:

- the same allowance for late reported deaths was applied to each cause of death. Examination of late reporting by cause of death indicates that there is no discernible difference, however for some causes of death the number of deaths is small hence variable;
- we used total death rates to make the age mix adjustments (not doctor-certified deaths only). The available data on doctor-certified deaths is not supplied in granular enough age bands to allow the age mix adjustment to be carried out on these deaths only;
- the same age mix adjustment was applied to each cause of death due to limitations in the available data; and
- only limited data is available showing both cause of death and state. This information is available for Victoria only, and it has been compiled by the ABS using different weeks to the Australia-wide data hence comparisons are difficult.

Appendix D – Suicide Data

Victoria

The Coroners Court of Victoria reviews newly-referred deaths each day to identify those that are consistent with suicide and adds these to the Victorian Suicide Register (VSR). Deaths included in the VSR are regularly reviewed as coroners' investigations progress. Deaths may be removed if investigations establish that they are likely not to be suicides, and deaths may be added if new evidence consistent with suicide is gathered. As such, data may change over time. The Victorian Coroner has stated that these changes are usually quite minor and that the VSR coding team are consistently better than 95% accurate in identifying suicide deaths.

New South Wales

All suicides or suspected suicides in New South Wales are reported to the Coroner. Data on these Police notifications of suspected suicides are obtained from the 'JusticeLink' information system managed by the New South Wales Department of Communities and Justice. As well as the initial Police advice, records are searched for potential indicators of suicide in other data fields. These include the manner or place of death, and whether the person communicated their intention to family and friends. Each potential suicide death record is then screened manually by the Department of Communities and Justice to confirm the classification of suspected or confirmed suicide. The data about suspected suicides are an estimate. A final determination of the manner of death can only be made by the Coroner after detailed enquiry. This will mean that there may be small differences in the number of suicides between reports for the same reporting period. The numbers reported for the most recent month may be underestimated due to time taken to record a report of a death. Evidence from Suicide Registers in other states shows that initial Police advice is usually accurate. However, once all facts are known some suspected suicide deaths are found to be due to other causes, and some deaths initially thought to be accidental are found to be due to suicide.

Queensland

Each suspected suicide is entered in two stages, resulting in the interim Queensland Suicide Register (iQSR) and the Queensland Suicide Register (QSR). In the first stage, information from the police report for all suspected suicides enters the iQSR. The iQSR is updated weekly from police communications containing forms on suspected suicides, allowing real-time monitoring of suspected suicides in Queensland. The iQSR includes administrative, demographic, geocoding and circumstantial information on suspected suicides. In the second stage, as investigations on suspected suicides close, they move from the iQSR to the QSR. All available information from the NCIS is downloaded, entered, reviewed and added to the QSR.

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