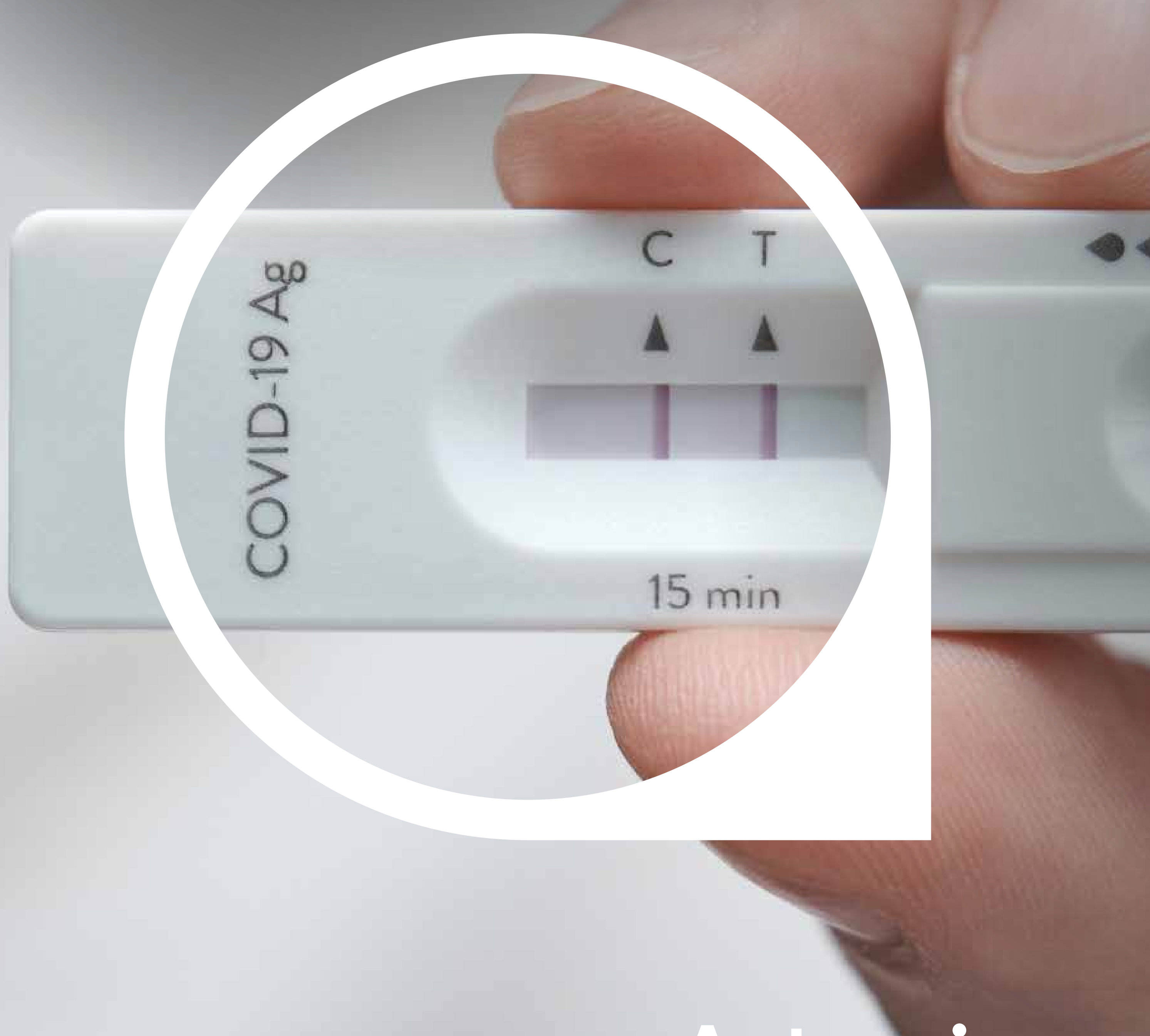
Research Paper - July 2023

How COVID-19 has affected mortality in 2020 to 2022



Actuaries Institute.

How COVID-19 has affected Mortality in 2020 to 2022

July 2023

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Executive Summary

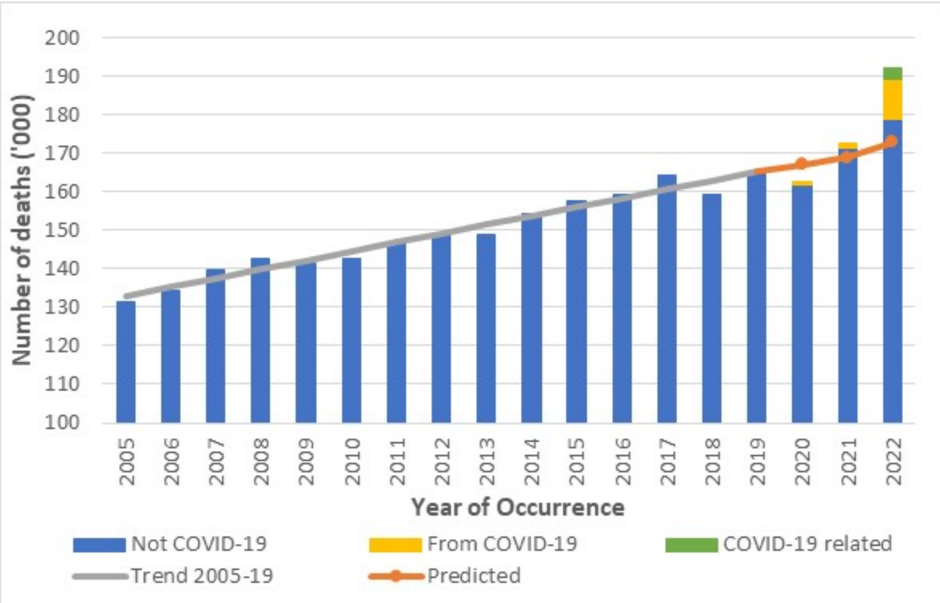
Australian experience

We estimate that there were almost 20,000 (11%; 95% confidence interval of 9%-13%) more deaths in Australia in 2022 than we would have expected if there had been no pandemic. Excess mortality is widely regarded as the best measure of the overall impact of a pandemic, since it includes deaths both directly and indirectly due to the disease.

Of the 19,200 excess deaths in 2022, we estimate that:

- 10,300 deaths (54%) were *from* COVID-19;
- 3,000 deaths (15%) were COVID-19 *related*, meaning that COVID-19 contributed to the death; and
- 5,900 deaths (31%) had no mention of COVID-19 on the death certificate.

Figure 1 – Annual deaths In Australia[1]



Deaths *from* COVID-19 are those where COVID-19 is given as the underlying cause of death on the death certificate. Deaths *from* COVID-19 were the third leading cause of death in Australia in 2022. COVID-19 *related* deaths are those where COVID-19 was a contributing factor mentioned on the death certificate.

The main reason why the numbers do not match those derived from surveillance reports[2] is that the latter include almost all cases[3] where people had COVID-19 when they died. Reported surveillance deaths will include deaths *from* COVID-19, deaths that were COVID-19 *related* and other deaths where the doctor/coroner has determined that COVID-19 was *incidental* and had no role in the death of the person.

It is unclear how close we are to reaching an endemic state, when the impact of COVID-19 on mortality will become (more) predictable. Figure 2 shows that the December 2022/January 2023 wave of COVID-19 deaths had ended by February 2023 (similar to the lowest month of 2022 at around 350 deaths), and a new wave of COVID-19 deaths was apparent in April/May 2023.

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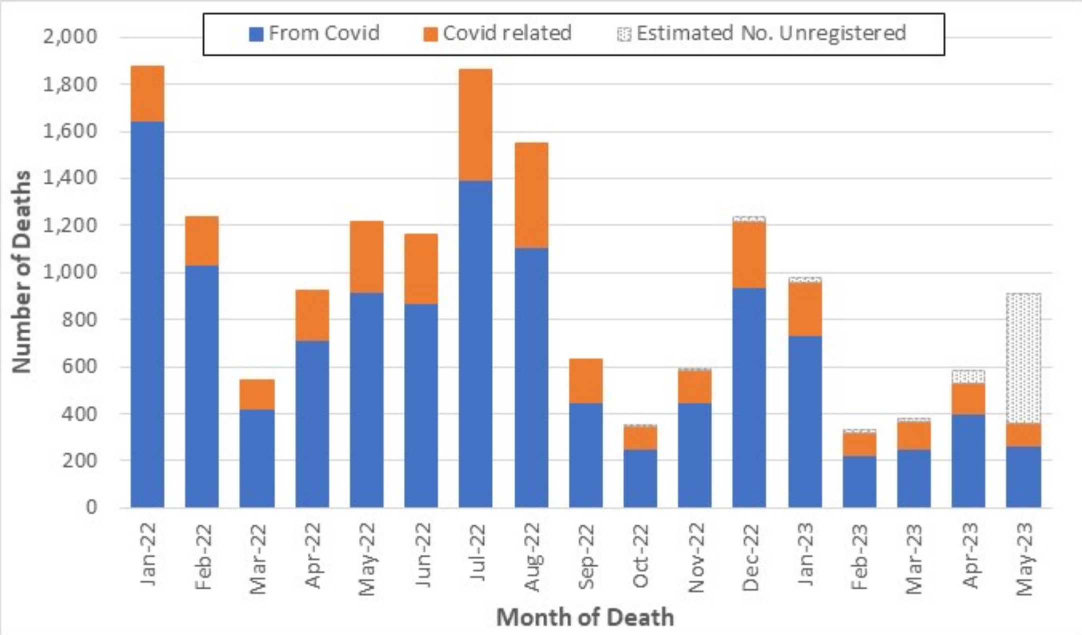
[1] The trendline included here is for illustrative purposes only. Our predicted values are derived from a much more complex approach as discussed in Section 2.2

[2] Surveillance reporting refers to the weekly (previously daily) figures reported by the state/territory health authorities

[3] Deaths are only excluded where COVID-19 is clearly not the cause, such as death by trauma

Figure 2 – COVID-19 deaths in 2022 and the first five months of 2023[4]



The death certificates of about one-third of excess deaths in 2022 had no mention of COVID-19. These non-COVID-19 deaths represent excess mortality of 4%, which is extraordinarily high in itself, particularly given that the 2022 influenza season was representative of an "average" year and that the severity (or not) of the flu season usually dictates any significant variation from trend. Non-COVID-19 excess deaths are particularly apparent in those aged over 75 for both genders, and those aged under 65 for females only. We consider that the most likely reasons for these excess deaths are:

- the impact of COVID-19 on subsequent mortality risk, particularly heart disease, stroke, diabetes and dementia, which have all been identified in studies[5];
- delays in emergency care, particularly at times of high prevalence of COVID-19 and/or influenza; and
- delays in routine care, which refers to missed opportunities to diagnose or treat non-COVID-19 diseases and the likelihood of consequent higher mortality from those conditions in future. From discussions with medical professionals, we understand that disrupted prescription of medications may be particularly likely to be a major risk factor for those with chronic heart disease.

Other possible reasons, which (in our opinion) have had less impact in 2022, include:

- mortality displacement, which refers to the proposition that many lives that were saved by the reduced spread of respiratory disease in 2020 and 2021 represent vulnerable people who would soon die of their underlying conditions;
- undiagnosed COVID-19, which clearly happened early in the pandemic, but seems far less likely in 2022, given awareness and testing protocols;

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[4] Note that this data comes from the latest ABS COVID-19 article, based on death certificates. While the ABS data is less timely than surveillance reports, deaths are allocated to the month of occurrence rather than the month of (sometimes quite late) reporting.

[5] A small selection of numerous research studies includes:

Davis, H.E., McCorkell, L., Vogel, J.M. et al. Long COVID: major findings, mechanisms and recommendations. Nat Rev Microbiol 21, 133–146 (2023).

Xie Y, Xu E, Bowe B, Al-Aly Z. Long-term cardiovascular outcomes of COVID-19. Nature Medicine. 2022;28(3):583-590.

Douaud G, Lee S, Alfaro-Almagro F, et al. SARS-CoV-2 is associated with changes in brain structure in UK Biobank. Nature. 2022;604(7907):697-707.

Xu E, Xie Y, Al-Aly Z. Long-term neurologic outcomes of COVID-19. Nature Medicine. 2022;28(11):2406-2415.

- mental health issues, widely understood to have arisen from stress associated with the pandemic, but not (or not yet) showing up in any significant way in suicide mortality data; and
- road deaths, which were up a little in 2022 but are not of the magnitude required to significantly impact excess mortality.

In this context, we note that vaccination is **highly unlikely** to be a cause of excess mortality in 2022. Indeed, given the well-documented reduction in COVID-19 mortality risk conferred by vaccination, the 14 confirmed vaccine-caused deaths that had occurred by June 2023 are a fraction of the lives saved by vaccination.

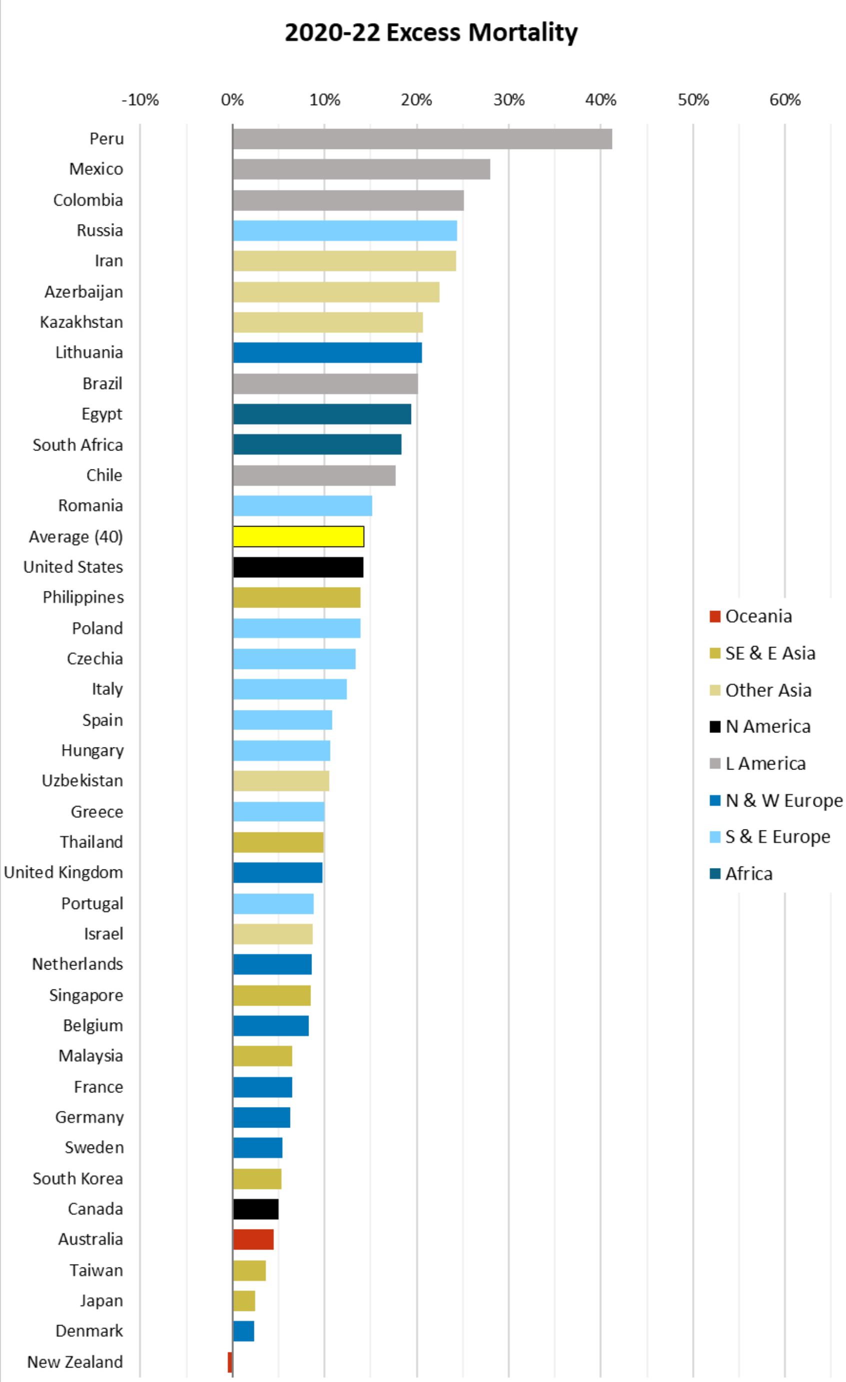
World-wide experience

Figure 3 sets Australia in its global context, showing that almost all countries had positive total excess mortality across the three years 2020-22, with a weighted average[6] of 14%. New Zealand (-0.5%) was the only exception among the 40 countries[7] shown here.

[6] The average shown is (total actual) / (total expected) – 1 for the 40 selected countries; the unweighted average is 13%

[7] See Section 4 and Appendix G for a discussion of the selection of the 40 countries in Figure 3, including the unavailability of data for four of the five largest countries by population (China, India, Indonesia and Pakistan)

Figure 3 – Excess mortality for 40 countries over three years ending 31/12/22, as a percentage of expected deaths



Source: Our World in Data (OWID) and analysis. Excess mortality relative to projected deaths.

Excess mortality has been very high in Latin America, averaging about 24% over the three years.

South-East and East Asia have generally fared much better than Other Asia. Similarly, Northern and Western Europe has generally had lower excess mortality than Southern and Eastern Europe.

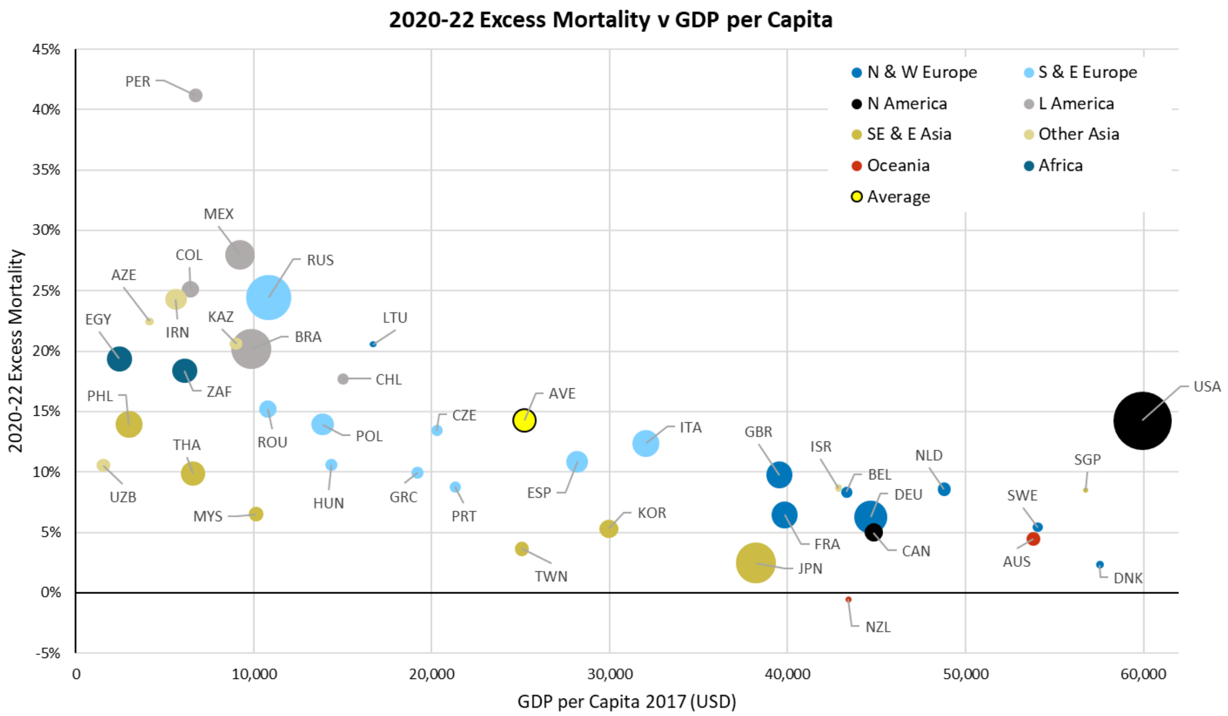
The United States has experienced 14% excess mortality across the three years, far higher than Canada (5%). The difference is mostly due to COVID-19, with excess mortality from other causes at 2% in the United States and -1% in Canada, although there is evidence[8] that deaths from opioid poisoning, road deaths and firearms deaths have continued to increase in the United States.

[8] See, for example, https://marypatcampbell.substack.com/p/us-mortality-trends-through-the-pandemic

Despite high excess mortality in 2022, average Australian excess mortality over the three years (4%) is among the lowest of the countries included in our selection. In general, we note that those countries with higher excess mortality in 2020 and 2021 appear to have lower excess mortality in 2022, and vice versa, but that the overall level of excess mortality across the three years is lower the later the occurrence of the peaks.

Figure 4 shows that there appears to be an overall negative correlation between GDP per person and excess mortality – richer countries generally had lower excess mortality than poorer countries (although the USA is a notable exception).

Figure 4 – Comparison of 2020-22 excess mortality of 40 countries with per capita GDP, showing a clear inverse relationship



Sources: Our World in Data (OWID), Worldometer and analysis. Excess mortality relative to projected deaths. Bubble size is projected deaths.

The information available for the world also enables a high-level look at the differences in excess mortality by age.

Table 1 – Simple unweighted average of excess mortality (as a percentage of expected) of 18 countries by age group and year

Age Group	2020	2021	2022	All Years
0-14	-7.4%	-2.6%	-0.7%	**-3.6%**
15-64	5.5%	12.3%	6.5%	**8.1%**
65-74	9.0%	13.9%	7.4%	**10.1%**
75-84	11.9%	14.2%	14.6%	**13.5%**
85+	8.4%	6.2%	8.8%	**7.8%**

Table 1 shows a simple, unweighted average of excess mortality by age group across all 18 countries where relevant data was available. It confirms the observation that excess mortality (as a percentage) has been highest in the 75-84 age group, but that excess mortality appears to have been material in all age groups above age 15 for the last three years.

Mortality outlook

Finally, we look at what information might be used to project future excess mortality in Australia, compared with what mortality might have been in the absence of a pandemic.

In our view, the "new normal" level of mortality is likely to be higher than it would have been in the absence of a pandemic. 2022 had 11% higher than predicted mortality. Our analysis[9] of the latest ABS *Provisional Mortality Statistics* shows 6% excess mortality in 2023 Q1, with a likely upward trend for April and May. It is likely that 2023's excess will be lower than 11%, but probably at least 5%. Looking further ahead, we think that excess mortality (relative to no pandemic) will gradually decline over time.

While we think that the level of excess mortality will decline, COVID-19 is likely to continue to cause **some** excess mortality for some years to come, directly as a cause of death and, less directly, as a contributor to other causes such as heart disease. There will also be an indirect impact, with the largest contributor likely to be the ongoing consequences of disruption to usual healthcare practices in the last three years. Counter to this, to the extent that mask-wearing and other defence measures persist in vulnerable settings, this will likely lead to lower deaths from respiratory disease.

[9] https://www.actuaries.digital/2023/07/06/excess-mortality-running-at-6-for-the-first-three-months-of-2023/

1 Introduction

This section discusses why we measure excess mortality and introduces terminology used throughout the Research Note.

1.1 Why measure excess mortality?

It is generally accepted[10] that the best way to measure the mortality impact of a pandemic is to measure excess deaths. In the context of COVID-19, the reasons for this include:

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

While the official global death toll from COVID-19 is now (June 2023) close to 7 million, estimates of the actual impact of COVID-19 are far higher. For example, The Economist estimates that there have been 23.8 million excess deaths, with a 95% confidence interval of 17.1 million to 30.6 million[11].

In some countries and/or at certain high-stress times during the pandemic, many COVID-19 deaths will not have been recorded as such, simply because the infrastructure did not cope. Even under more "normal" conditions, COVID-19 deaths may be misclassified where the deceased has not experienced noticeable symptoms.

On the other hand, necessary differences in criteria between surveillance reporting (which sacrifices accuracy for speed) and official death certificates mean that there may be systemic over- or under-reporting of COVID-19 deaths in the surveillance reports. This is the "death with-not-from COVID" issue.

The impact of COVID-19 on mortality from other causes may have been positive or negative. For example, lockdowns, border closures and other measures appear to have reduced the spread of respiratory disease, with several countries benefiting from milder flu seasons[12]. But the same behavioural changes have led to a reduction in the rate of screenings and diagnostic tests and to mental stress – which, in turn, could lead to higher mortality, albeit potentially with a time lag.

1.2 Terminology

Throughout this Research Note we separate COVID-19 deaths into:

- deaths "*from* COVID-19", namely deaths where COVID-19 is listed as the primary/underlying cause of death; and
- deaths that were "COVID-19 *related*", namely deaths where the underlying cause of death has been determined as something other than COVID-19, but COVID-19 was a contributing factor mentioned on the death certificate.

The COVID-19 deaths covered in this Research Note are distinct from "incidental COVID-19" deaths, namely deaths where the person was COVID-19 positive at the time of death, but COVID-19 was not recorded on the death certificate. These deaths are generally included in surveillance reporting where identified (other than where there is a clear alternative cause of death, such as trauma) but are not separately identified in the ABS statistics.

We have used the same definition of a week/year as the ABS, namely that weeks are based on the ISO (International Organization for Standardisation) week date system. This results in the 2020 "year" including exactly 53 weeks and the 2021 and 2022 "years" including exactly 52 weeks.

[10] See, for example, Measuring Australia's excess mortality during the COVID-19 pandemic | Australian Bureau of Statistics (abs.gov.au) and Excess mortality during the Coronavirus pandemic (COVID-19) - Our World in Data

[11] The pandemic's true death toll | The Economist (extracted 14 June 2023)

[12] This is a common shorthand for the seasonal impact of respiratory disease on mortality, whether directly from conditions such as pneumonia or flu or indirectly from other conditions (such as dementia) that leave the sufferer more vulnerable

1.3 Content warning

This Research Note includes discussion of suicide deaths in several places, notably in section 3.6.

2 Excess deaths in Australia

This section includes analysis of excess deaths in Australia since the start of the pandemic. Our previous Research Notes *Impact of COVID-19 on Mortality and Morbidity in 2020* and *Impact of COVID-19 on Mortality and Morbidity in 2020 and 2021* included detailed analysis of mortality experience in 2020 and 2021. This paper concentrates on 2022, although information is also shown for 2020 and 2021. This section covers:

- the available data;
- our approach;
- excess deaths in total; and
- excess deaths broken down by cause of death, by age band/gender, and by state/territory.

Section 3 discusses the possible causes of excess mortality in Australia, concentrating on 2022.

2.1 Available data

There have traditionally been significant delays in releasing information on deaths in Australia given the sometimes lengthy delays between the time of death and the time the death is registered, with these delays further exacerbated if a death is referred to the coroner. Given the heightened interest in death statistics due to the pandemic, the ABS has been releasing a subset of the death statistics each month since June 2020[13] in order to provide more timely information to the public.

The information used in this section in respect of Australian deaths includes:

- From the ABS *Provisional Mortality Statistics*[14] publication: deaths occurring in each week from the start of 2015 until end-February 2023, provided that the death had been registered by 30 April 2023. Due to delays in registration of deaths, most weeks of 2022 will be missing a small number of deaths (around 0.5% for the earliest weeks of 2022 increasing to around 2.0% for the last week of the year). Deaths are available broken down by:
    - cause of death for doctor-certified deaths, for eleven selected causes (including COVID-19), plus coroner-referred deaths for all causes combined. The ABS has worked around the significant delays introduced by coronial investigations by including deaths once they have been reported to the coroner, but not waiting for the outcome of cause of death. As such, the coroner-referred deaths are not broken down by cause;
    - age band and gender, summarised into five age bands for each gender; and
    - state/territory.

      Note that due to confidentiality restrictions on the data the ABS is able to release, combinations of cause/age band/state are not available, so for example, we are unable to examine cancer mortality for older females in NSW only.

  Standardised death rates are also provided in this publication; weekly figures are available for all-cause mortality and broken down by cause of death (but not by age band/gender or state/territory).

  The ABS made some changes to the Provisional Mortality Statistics publication in April 2023, separately reporting on "other cardiac conditions" and making some small changes to the classifications included in the "dementia" category. Both of these changes acted to reduce the number of deaths included in our "other unspecified causes" category relative to the figures included in previous Research Notes.
- From the ABS *COVID-19 Mortality in Australia*[15] articles: the number of deaths registered and received by the ABS by 30 April 2023 that included COVID-19 on the death certificate. This publication includes monthly data on whether deaths were from COVID-19 or were COVID-19 related deaths, associated causes of death (i.e. pre-existing conditions and the chain of

[13] The first release covered mortality from January to March 2020

[14] https://www.abs.gov.au/statistics/health/causes-death/provisional-mortality-statistics/jan-feb-2023

[15] https://www.abs.gov.au/articles/covid-19-mortality-australia-deaths-registered-until-30-april-2023

events leading to death), breakdowns by age/gender, state/territory, country of birth, socio-economic status, and the underlying causes of COVID-19 related deaths.

We have also been provided with additional data by the ABS in a customised report in relation to COVID-19 deaths registered by 30 April 2023, namely the total number of deaths each week (doctor-certified and coroner-referred) both from COVID-19 and COVID-19 related.

2.2 Measuring excess deaths – approach

Measuring excess deaths is not straightforward. In its simplest form, excess deaths are calculated as the difference between actual deaths occurring in a particular period less a "baseline" level of deaths. But what to use for the baseline?

Early in the pandemic, most measures of excess deaths compared 2020 actual deaths to a simple average of deaths in 2015 to 2019. However, this approach does not allow for changes in either the size or the age structure of the population, or for the continuation of any trends in mortality that may have been expected in the absence of the pandemic.

In their June 2021 paper[16], Karlinsky and Kobak took a different approach, fitting a trend to the 2015 to 2019 years to get their baseline. This approach, while allowing for past changes in size of population, age structure of the population and mortality trends, intermingles these three effects and assumes that their aggregate impact will continue on the same trend into 2020 to 2022.

Unlike Karlinsky and Kobak, who were projecting a baseline for each of 84 countries, we are focusing on Australia only, so we have taken the opportunity to apply a more detailed approach. We have explicitly allowed for changes in population size and age structure. Any modelled trends are the residual, being the improvement in the overall mortality rate over time[17].

As we do not have the data in three-way breakdowns (i.e. cause x age band/gender x state) we have built a separate model for each of the three breakdowns that are available. We have the most information for the breakdown by cause due to the ABS provision of standardised death rates (SDRs) by cause. We have necessarily used a more approximate approach to allow for changes in population size and age demographic for the models by age band/gender and by state/territory. As a result, our models of excess deaths broken down by cause of death are our primary models. Our approach for each model is discussed further below.

2.2.1 Deaths broken down by cause

In preparing this Research Note, we have decided that it remains appropriate to continue to estimate our baseline **in the absence of a pandemic**. This makes the measurement and analysis of excess mortality more meaningful.

In previous Research Notes, we have used the 2015-19 years as the basis for our projections and have been able to attribute excess deaths to the impacts of the pandemic. However, as time marches on, this approach becomes more problematic; the 2015-19 years are getting old.

While it is completely reasonable to project mortality out for one year (2020), and still justifiable to project mortality out for a second year (2021), projecting out for a third year (2022) is approaching the limit of what is reasonable. We would also prefer not to ignore the latest two years of mortality data in forming projections for 2022.

[16] Karlinsky & Kobak, 2021, *Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset*

[17] We identified this trend for each separate cause of death, age/gender and state/territory combination for which we have data

Nevertheless, as we have decided to continue to measure excess deaths relative to no pandemic, we cannot simply use the 2020 and 2021 experience without adjustment. At the same time, it is hard – if not impossible – to determine how much of the experience is due to the pandemic and how much is random.

Accordingly, for our cause of death model we:

- fitted linear regression models to the SDRs. We trained the regression models on different years of data, depending on the cause of death:
  - For the 2020 and 2021 projection years, we have used the 2015-19 experience to train the model for all causes.
  - For the 2022 projection year, we have:
    - used 2015-19 experience to train the model for deaths from respiratory disease, dementia, diabetes and other cardiac conditions, on the basis that 2020 and 2021 experience for these causes was materially affected by the pandemic; and
    - used 2015-21 experience to train the model for deaths from all other causes and for coroner-referred deaths, on the basis that it is likely that 2020 and 2021 experience more closely reflects a slow-down in underlying mortality improvement than the impacts of the pandemic.

  (We have included a sensitivity analysis in Section 2.4.2 that shows our estimate of excess mortality had we only used the 2015-19 experience to train the models for all causes of death.)
- extrapolated the linear regression model to arrive at a predicted SDRs for each week in 2020 to 2022;
- converted predicted SDRs to predicted numbers of deaths for ease of communication;
- compared predicted deaths to the actual deaths in 2020 to 2022 (after including a small allowance for late reported deaths).

The baselines for our estimates of excess deaths are "predicted deaths in the absence of the pandemic, allowing for a continuation of pre-pandemic mortality improvement" for each of the years 2020 to 2022. We have not included any COVID-19 deaths in the baselines, as these would not exist in the absence of the pandemic.

It is important to note that predicted death *numbers* are increasing faster from demographic changes (ageing and population size) than they are reducing due to mortality improvement, even though age-standardised death *rates* are reducing. Therefore, our model predicts higher baseline numbers of deaths in each successive year.

2.2.2 Deaths broken down by age/gender and by state/territory

Our models of excess deaths broken down by age band/gender and state/territory are supplementary to our cause of death models. As SDRs are not available by age band/gender or state/territory, we use a modified version of the above approach by cause of death. For each age band/gender combination and for each state/territory we:

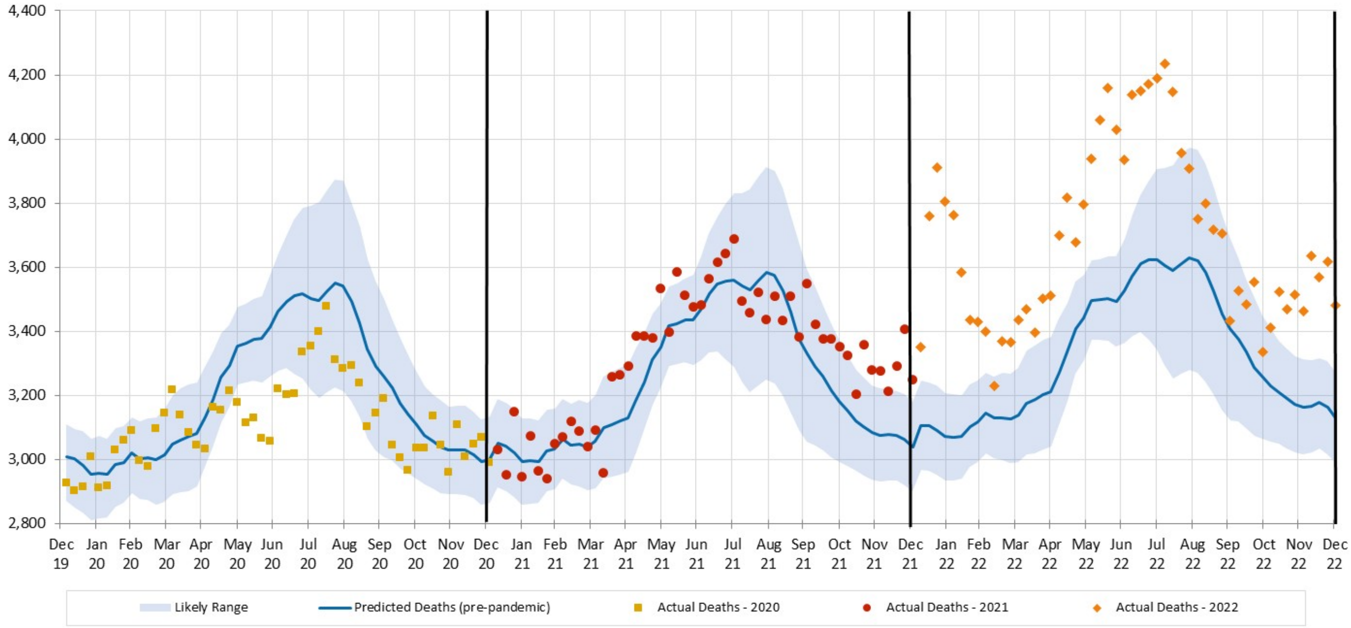
- scaled actual weekly deaths from 2015 to 2021 so that they are representative of the number of deaths in those years if they had the 2022 population size and age mix;
- fitted a linear regression model to the scaled deaths from 2015 to 2019. As we know that some causes of death were more impacted by the pandemic than others, but have no information by cause AND age/gender or by cause AND state/territory, we are unable to use any data other than the 2015-19 years to obtain baselines representative of pre-pandemic expectations;
- extrapolated the linear regression model to arrive at a predicted number of deaths for each week in 2020 to 2022 (implicitly assuming that the same per annum mortality improvement over 2015-19 continues, and ignoring the impact of the pandemic); and
- compared predicted deaths to the actual deaths in 2020 to 2022 (after a small allowance for late reported deaths).

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

2.3 Excess deaths in total

Figure 5 shows the results of our analysis, comparing actual deaths each week to our predicted values and the 95% prediction interval.

Figure 5 – Weekly actual and predicted deaths – All Causes

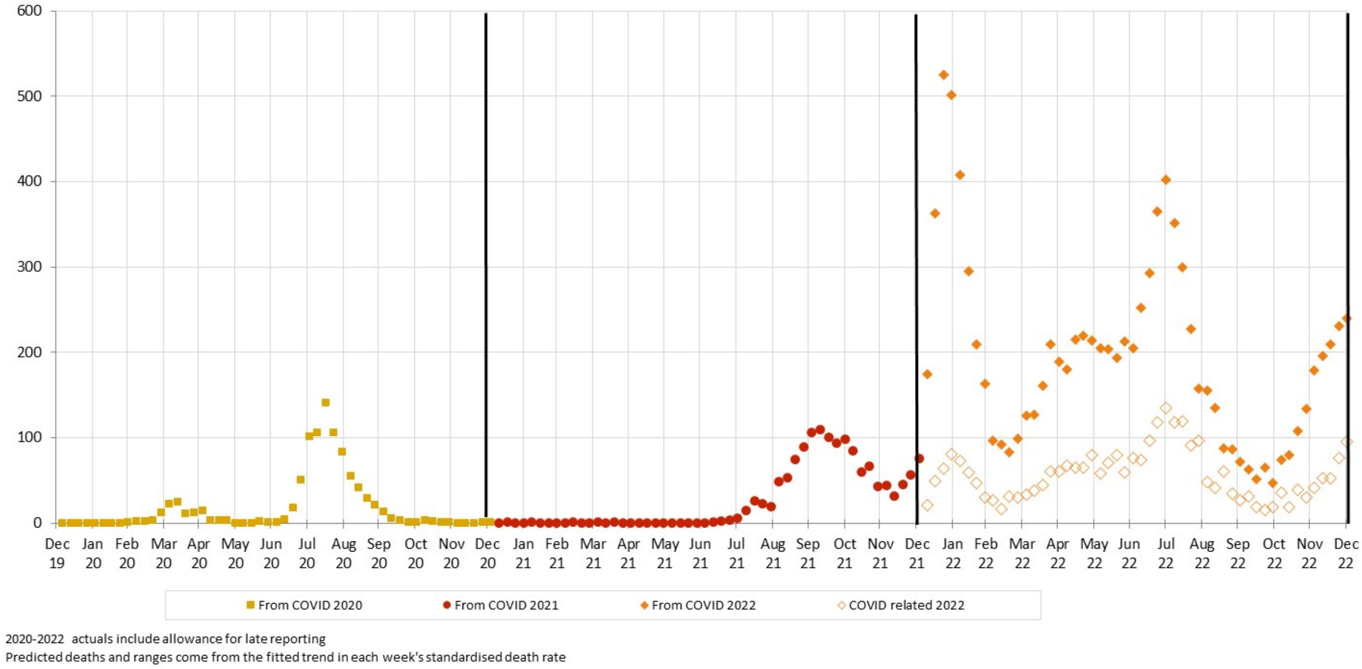


2020-2022 actuals include allowance for late reporting
Predicted deaths and ranges come from the fitted trend in each week's standardised death rate

For the majority of 2022, most weeks had actual deaths that were well above the upper end of the 95% prediction interval. The only period where deaths were not outside the prediction interval was from around mid-August to end-October, when COVID-19 prevalence in Australia was relatively low.

Figure 6 shows deaths *from* COVID-19 and COVID-19 *related* deaths, noting that, given small numbers, weekly data for COVID-19 *related* deaths is not available for 2020 or 2021.

*Figure 6 – Weekly deaths – from COVID-19 and COVID-19 related**



* *COVID-19 data from ABS customised report 2023*

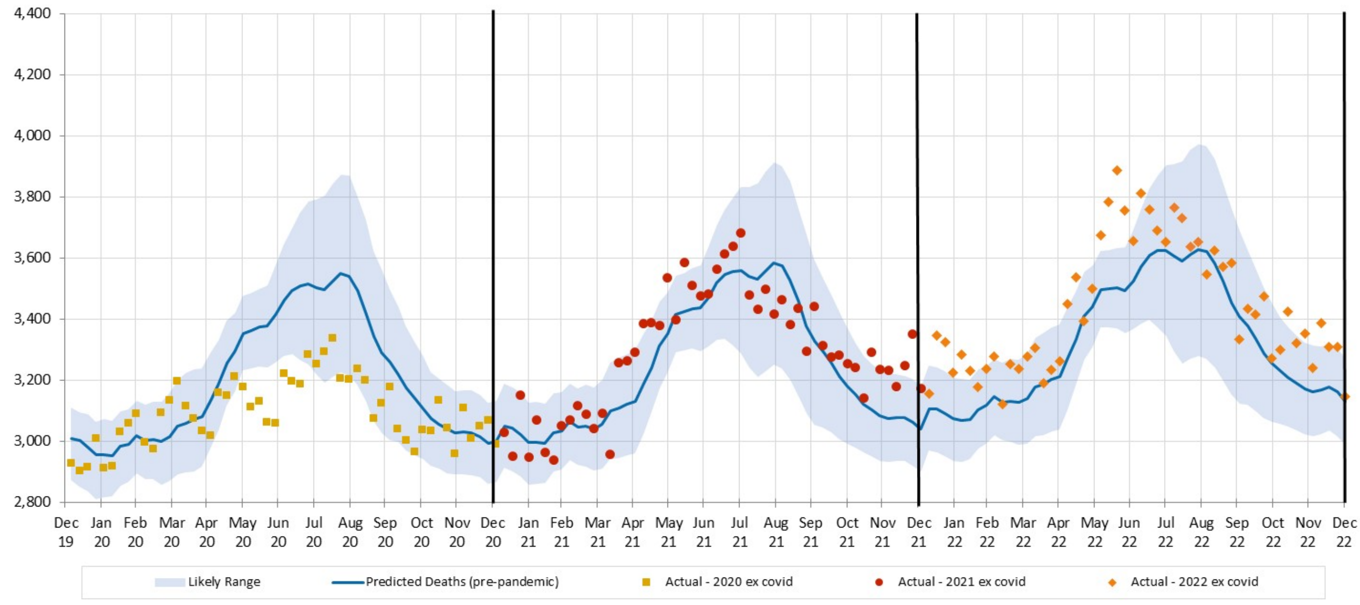
In 2022, there were 10,305 deaths from COVID-19 and 2,956 COVID-19 related deaths, significantly higher than the numbers of COVID-19 deaths in 2020 (915) and 2021 (1,413). Deaths *from* COVID-19 and COVID-19 *related* deaths follow the same pattern of peak and troughs.

It is unclear how many people whose deaths were COVID-19 *related* would have died during this period anyway, and how many may have had their death hastened by COVID-19. Given that COVID-19 is considered to have contributed to the death, and that these deaths follow the same peaks and troughs as *from* COVID-19 deaths, it seems that COVID-19 is a catalyst in these deaths, rather than being merely coincidental. We note that the same has traditionally happened with the winter peak of respiratory disease deaths.

There may be instances where it is difficult to determine whether a death is due to COVID-19 versus COVID-19 being a contributing cause, and an element of professional judgment by the certifier will necessarily need to be exercised. It is unclear to us how often such decisions may need to be made, and how much "blurring" there may be between deaths *from* COVID-19 and COVID-19 *related* deaths.

Figure 7 shows the comparison of actual deaths to predicted after removing deaths *from* COVID-19 and COVID-19 *related* deaths.

Figure 7 – Weekly actual and predicted deaths – All Causes excluding deaths from COVID-19 and COVID-19 related deaths



2020-2022 actuals include allowance for late reporting
Predicted deaths and ranges come from the fitted trend in each week's standardised death rate

Even after removing all deaths *from* COVID-19 and those that were COVID-19 *related*, significant excess mortality remains for 2022, with:

- a spike around the time of the January peak in COVID-19 deaths;
- another spike coinciding with the peak of the flu season (which in 2022 came in late June, just before another peak of COVID-19 deaths); and
- another smaller spike in November/December when COVID-19 deaths were again high.

Only a very small number of weeks since late 2021 have had actual deaths below the predicted level.

The next section discusses the causes of death driving this trend.

2.4 Excess deaths by cause of death

Table 2 shows our estimate of excess deaths broken down by cause. We have shown the 2022 year in detail, plus summary findings for 2020 and 2021. Figure 8 shows the 95% confidence interval around the estimates for the 2022 year, both including and excluding deaths from COVID-19 and COVID-19 related deaths.

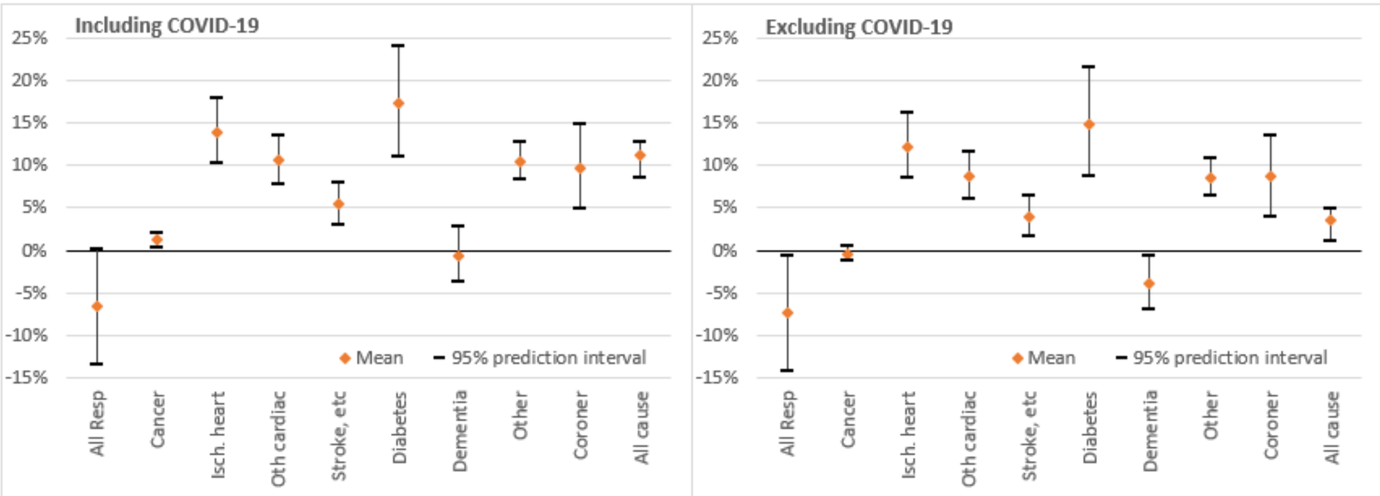
Note that we have formed an estimate of the number of coroner-referred deaths that were from COVID-19 as discussed in Section 2.4.1 below. If our estimate of coroner-referred COVID-19 deaths is too high (or low), this will not affect the total level of excess deaths measured; it will just mean that our estimate of non-COVID-19 coroner-referred deaths will be too low (or high) by the same amount.

Table 2 – Excess deaths by cause – 2020 to 2022

Cause of Death	2022 (52 weeks)						2021 (52 weeks)		2020 (53 weeks)	
	Actual			Predicted	Excess	% Excess	Excess	% Excess	Excess	% Excess
	Non-Covid	Covid	Total							
From COVID-19										
Doctor-certified	-	9,818	9,818	-	9,818	100%	1,249	100%	856	100%
Coroner-referred	-	487	487	-	487	100%	130	100%	51	100%
All From COVID-19	**-**	**10,305**	**10,305**	**-**	**10,305**	**100%**	**1,379**	**100%**	**907**	**100%**
Doctor-certified other respiratory disease										
Influenza	283	6	289	680	(390)	-57%	(660)	-100%	(600)	-93%
Pneumonia	2,350	-	2,350	2,770	(420)	-15%	(780)	-28%	(750)	-28%
Lower respiratory	7,990	66	8,050	8,350	(290)	-4%	(810)	-10%	(1,280)	-16%
Other respiratory	3,750	29	3,780	3,710	80	2%	(20)	0%	(440)	-12%
All doctor-certified respiratory	**14,370**	**102**	**14,470**	**15,500**	**(1,030)**	**-7%**	**(2,260)**	**-15%**	**(3,070)**	**-20%**
Doctor-certified other diseases										
Cancer	49,820	780	50,600	50,030	580	1%	130	0%	(700)	-1%
Ischaemic heart disease	14,770	236	15,000	13,160	1,840	14%	840	6%	(120)	-1%
Other cardiac conditions	10,130	175	10,310	9,320	980	11%	470	5%	(490)	-5%
Cerebrovascular disease	9,210	132	9,350	8,860	480	5%	360	4%	(100)	-1%
Diabetes	5,510	118	5,630	4,800	830	17%	350	7%	350	8%
Dementia	17,110	581	17,690	17,820	(120)	-1%	(550)	-3%	(990)	-6%
Other unspecified diseases	34,960	611	35,570	32,210	3,360	10%	2,380	8%	(120)	0%
All other doctor-certified disease	**141,520**	**2,632**	**144,150**	**136,200**	**7,950**	**6%**	**3,980**	**3%**	**(2,150)**	**-2%**
Coroner-referred excl. From COVID-19	**22,560**	**222**	**22,780**	**20,760**	**2,010**	**10%**	**740**	**4%**	**(100)**	**0%**
Total	**178,400**	**13,261**	**191,700**	**172,500**	**19,200**	**11%**	**3,900**	**2%**	**(4,400)**	**-3%**

* Figures shaded green indicate that the observed values are below the 95% prediction interval while figures shaded red are above the 95% prediction interval

Figure 8 – Excess deaths by cause in 2022 – 95% prediction intervals



When broken down by cause of death, in 2022:

- total deaths were 11% (or +19,200) higher than predicted, compared with excess deaths of -4,400 for 2020 and +3,900 for 2021;
- there were 10,305 deaths *from* COVID-19, representing 54% of the excess deaths and including 172 deaths reported as due to Long Covid;
- 2,956 COVID-19 *related* deaths are included among the other causes of death (13,261 less 10,305), representing a further 15% of the excess deaths
- the remaining 31% of excess deaths (c. 6,000) have no mention of COVID-19 on the death certificate;
- despite influenza circulating in Australia again in 2022, doctor-certified deaths from respiratory disease were again lower than expected (7% lower) although not as low as we saw earlier in the pandemic;

- while doctor-certified deaths from cancer were close to predicted in percentage terms (1% higher), this difference is statistically significant. When COVID-19 related deaths are excluded, deaths from cancer are not statistically significantly different from predicted;
- doctor-certified deaths from ischaemic heart disease, other cardiac conditions, cerebrovascular disease and diabetes were all significantly higher than predicted (by between 5% and 17%) and remain so after COVID-19 related deaths are excluded;
- doctor-certified deaths from dementia were close to predicted overall and significantly lower than predicted once COVID-19 related deaths are excluded;
- doctor-certified deaths from other unspecified diseases were significantly higher than predicted (by 10%), continuing a trend observed since April 2021. Note that this is a large "catch-all" category and it is difficult to infer the reason for this large increase; and
- coroner-referred deaths excluding those from COVID-19 were 10% higher than predicted. Note that in the years immediately preceding the pandemic, around 11,500 coroner-referred deaths were those from "external causes" (being accidents, assaults, suicides, poisonings, etc) with the remaining approximately 9,000 deaths being deaths from disease that are referred to the coroner for various reasons. Of these disease deaths, around 4,500 (about half) are from ischaemic heart disease and other cardiac conditions and are thus likely to be a significant contributor to much of the excess mortality for this cohort.

Figure 9 and Figure 10 show weekly excess deaths by underlying cause (thus including COVID-19 *related* deaths) since the start of the pandemic, compared with the 95% prediction interval. All graphs are shown using the same y-axis to give a sense of the contribution of each cause. The 9-week centred average is also shown, to highlight any trends.

Figure 9 – Weekly excess deaths in 2020-22 for cancer, ischaemic heart, other cardiac, stroke, and diabetes

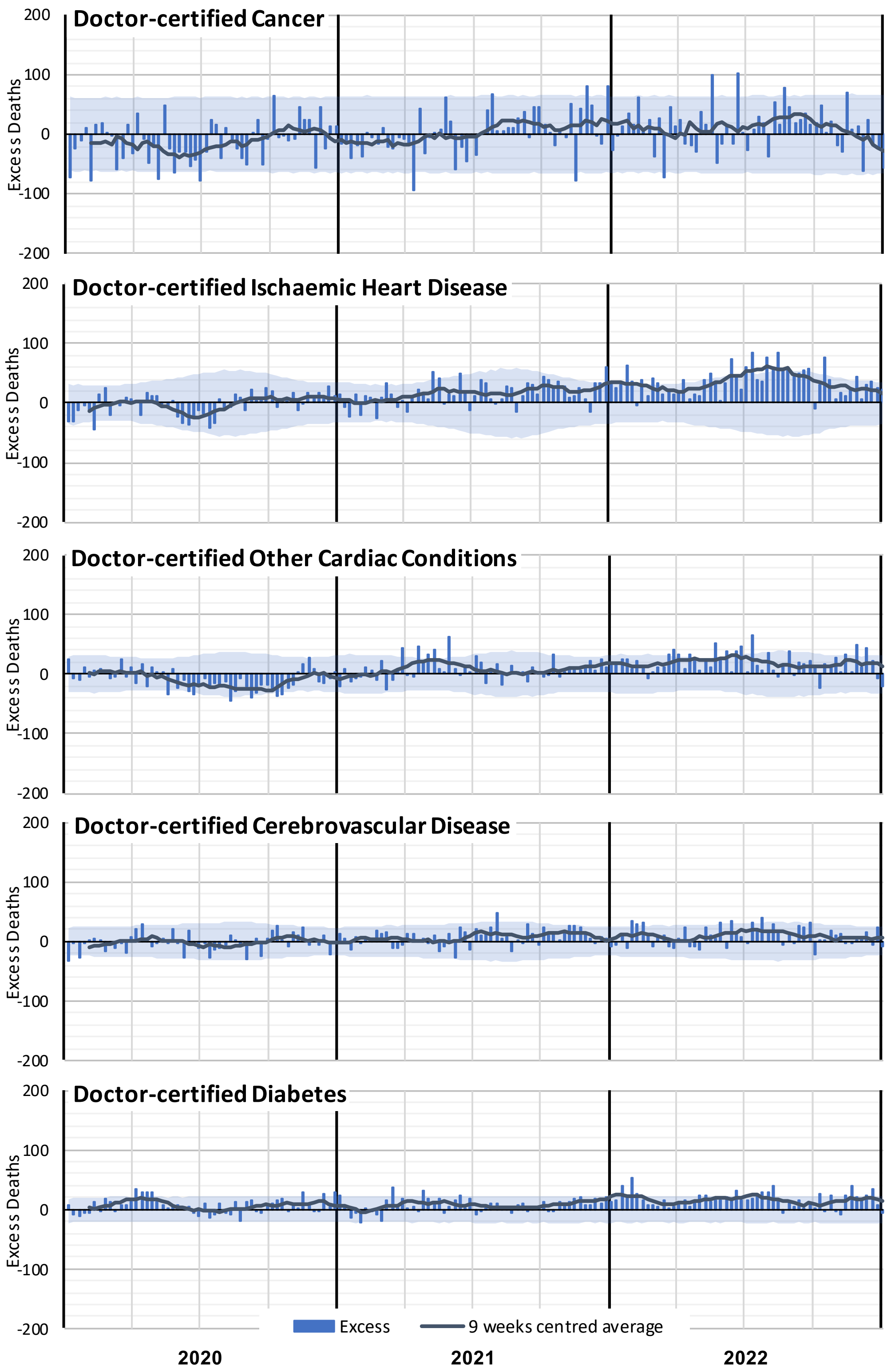


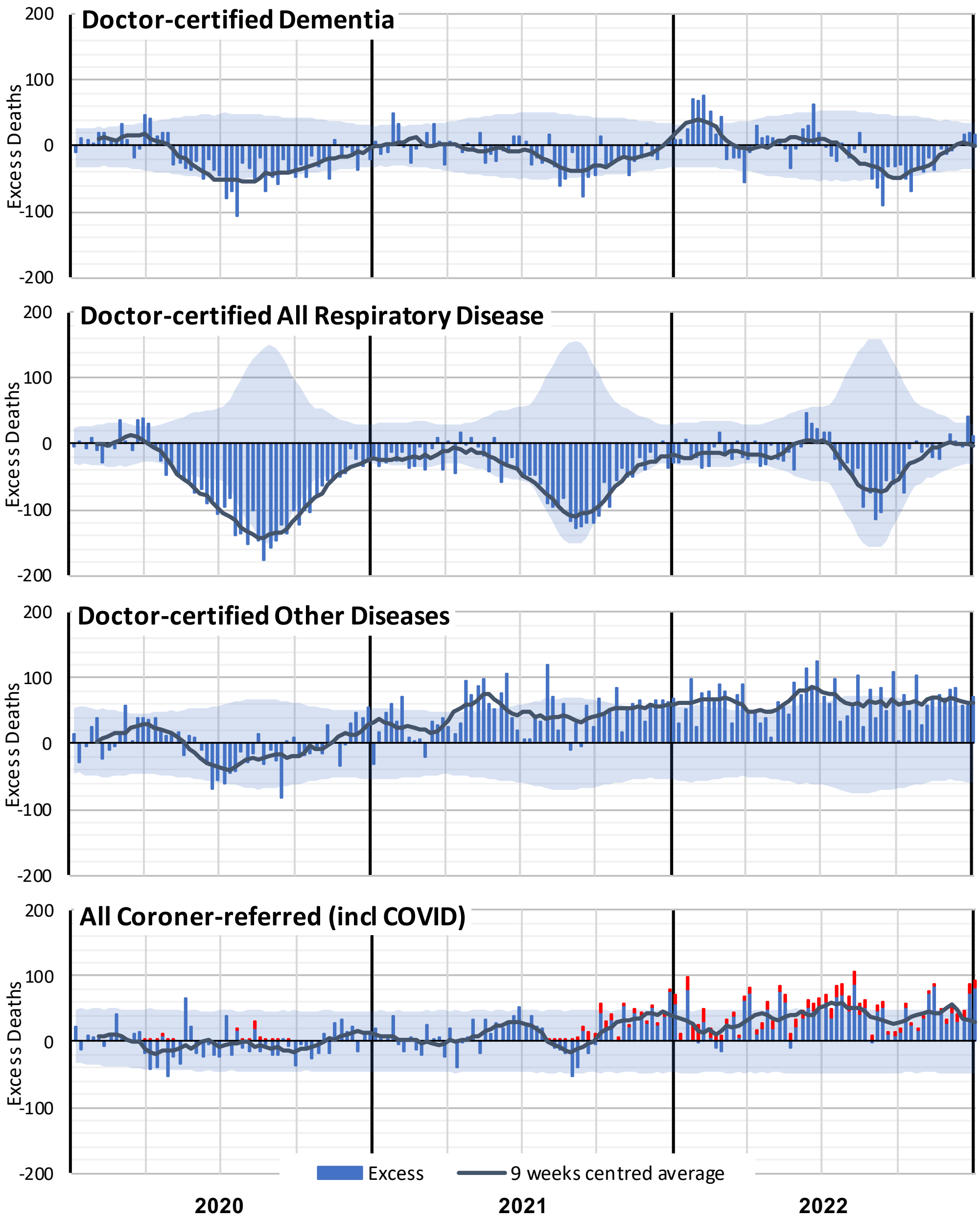
Figure 9 shows:

- a clear increase in excess deaths due to ischaemic heart disease from around March 2021 until around August 2022, with the peaks and troughs following the same timing as deaths *from* COVID-19 (noting that each chart includes COVID-19 *related* deaths from that cause);
- deaths due to other cardiac conditions have been consistently higher than predicted since late 2021;

- there has been a consistent, albeit volatile, excess for deaths from both cancer and cerebrovascular disease since around July 2021; and
- diabetes deaths have generally been higher than expected throughout the pandemic, and again the peaks and troughs have followed the same patterns as deaths *from* COVID-19.

Of these five causes, ischaemic heart disease is the biggest contributor to excess deaths in 2022, followed by other cardiac conditions.

Figure 10 – Weekly excess deaths in 2020-22 for other causes



In Figure 10:

- there were negative excess deaths for dementia in 2020, 2021 and September/October 2022 (with the timing closely aligned with lower prevalence of respiratory disease), and higher excess deaths in the first half of 2022 (with the timing closely aligned with COVID-19 and flu waves).

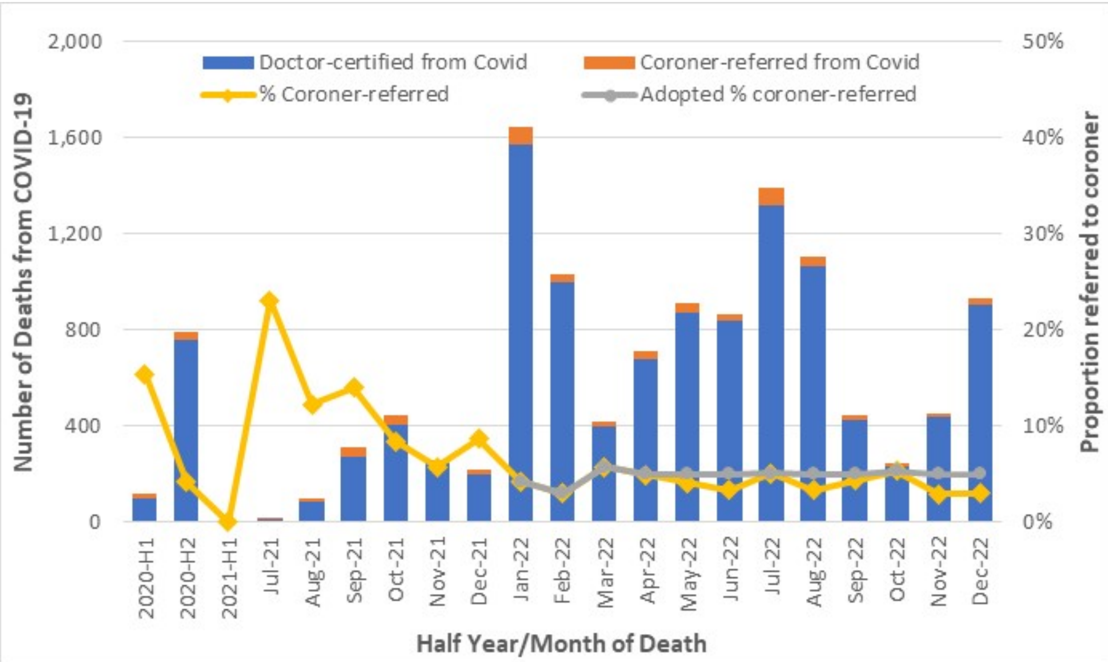
- deaths from respiratory disease have been significantly lower than expected throughout the pandemic, except for the short (and early) flu season which peaked in late June 2022. This coincides with the second 2022 peak in excess non-COVID-19 deaths that we saw in Figure 7.
- deaths from other diseases (where available ABS data does not specify the cause) were also lower than predicted in 2020 (correlated with lower respiratory disease) but have been, as a group, the largest contributor to non-COVID-19 excess deaths in 2021 and 2022. It is not clear what might be driving this, although we expect that at least part of the excess will be in respect of people who otherwise may have succumbed to respiratory disease in 2020 and 2021.
- coroner-referred deaths include deaths *from* COVID-19 that have been referred. In Figure 10, we have separately shown these (in red), using actual coroner-referred COVID-19 deaths for 2020 and 2021, and estimates for 2022 based on our assumption that 5% of all COVID-19 deaths are referred to the coroner. The residual non-COVID-19 coroner-referred deaths are well above expected levels in the second half of 2021 and throughout 2022. We note, however, that suicide monitoring reports for NSW and Victoria show a slight increase in 2022, but not large enough to account for the level of excess seen in those states (see Section 3.6). Similarly, Australia-wide road death statistics show a small increase in 2022, but not large enough to account for the overall increase (see Section 3.7).

2.4.1 Coroner-referred deaths from COVID-19

The *Provisional Mortality Statistics* publication includes the number of deaths from COVID-19 that were doctor-certified, while the *COVID-19 Mortality in Australia* article includes total deaths from COVID-19. Taking the difference between the two gives the number of coroner-referred deaths from COVID-19.

Figure 11 shows the number of deaths from COVID-19 split between doctor-certified and coroner-referred, plus the proportion that are coroner-referred.

Figure 11 – Doctor-certified versus Coroner-referred deaths from COVID-19



In 2020 and early 2021, Australia experienced relatively small numbers of deaths from COVID-19 and the proportion that were coroner-referred varied quite significantly given the low numbers. We have assumed that coroner-referred deaths from COVID-19 will be 5% of all deaths from COVID-19 for all months after March 2022, based on the experience of late 2021 and the first quarter of 2022. We have deducted these estimated coroner-referred deaths from COVID-19 from other coroner-referred deaths.

2.4.2 Sensitivity analysis

Table 3 below provides a sensitivity analysis, comparing our predicted deaths presented above (and the resulting excess) to those that would have resulted from using only the pre-pandemic data of 2015-19 to train our prediction models for all causes of death.

Table 3 – Predicted deaths in Australia –Sensitivity analysis

Cause of Death	Predicted deaths			Measured Excess		
	Adopted Models	2015-19 Models	Difference	Adopted Models	2015-19 Models	Difference
From COVID-19	**-**	**-**	**-**	**100%**	**100%**	**0%**
Doctor-certified other respiratory disease						
Influenza	680	680	-	-57%	-57%	0%
Pneumonia	2,770	2,770	-	-15%	-15%	0%
Lower respiratory	8,350	8,350	-	-4%	-4%	0%
Other respiratory	3,710	3,710	-	2%	2%	0%
All doctor-certified respiratory	**15,500**	**15,500**	**-**	**-7%**	**-7%**	**0%**
Doctor-certified other diseases						
Cancer	50,030	50,340	(310)	1%	1%	1%
Ischaemic heart disease	13,160	12,730	430	14%	18%	-4%
Other cardiac conditions	9,320	9,320	-	11%	10%	0%
Cerebrovascular disease	8,860	8,700	160	5%	7%	-2%
Diabetes	4,800	4,800	-	17%	17%	0%
Dementia	17,820	17,820	-	-1%	-1%	0%
Other unspecified diseases	32,210	30,890	1,320	10%	15%	-5%
All other doctor-certified disease	**136,200**	**134,610**	**1,590**	**6%**	**7%**	**-1%**
Coroner-referred excl. From COVID-19	**20,760**	**20,320**	**440**	**10%**	**12%**	**-2%**
Total	**172,500**	**170,400**	**2,100**	**11%**	**12%**	**-1%**

If we had adopted models based on the pre-pandemic years of 2015-19 only, our predicted number of deaths would have been around 2,100 lower. This would have resulted in measured excess mortality of 12% for 2022 rather than 11%, which is not a particularly large difference.

2.5 Excess deaths by age and gender

Unfortunately, there are no breakdowns of the age/gender data by cause of death. However, we do have a breakdown of COVID-19 deaths by age/gender through the customised report we have sought from the ABS.

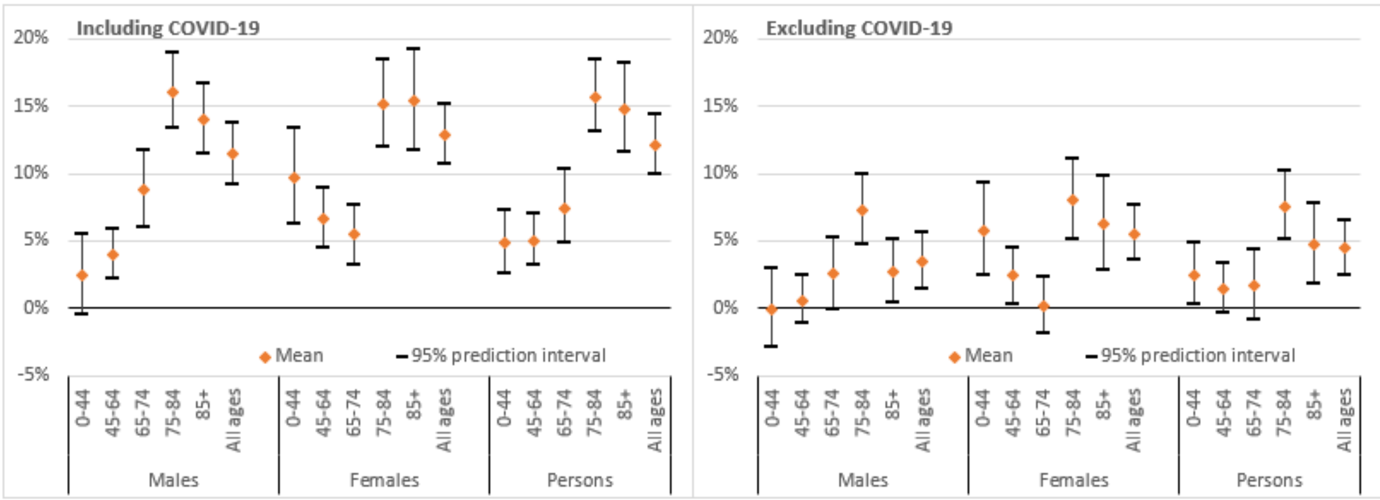
Table 4 summarises the results of the analysis by age band and gender, for each of 2020 to 2022 (noting that the totals are not quite the same as the totals in Table 2 due to the more approximate approach to setting our baseline by age/gender). We have shown the excess including all deaths, and then again after deducting *from* COVID-19 and COVID-19 *related* deaths. Figure 12 shows the 95% confidence interval around the estimates for the 2022 year, both including and excluding COVID-19 deaths.

Table 4 – Excess doctor-certified deaths by age and gender – 2020 to 2022

Age Band and Gender	2022 Year to Date (52 weeks)							2021				2020			
	Actual	Predicted	Excess	% Excess	Covid-19	% Covid	% Net	Excess	% Excess	Covid-19	% Net	Excess	% Excess	Covid-19	% Net
Males, 0-44	5,190	5,070	120	2%	126	2%	0%	-80	-2%	25	-2%	-120	-2%	2	-2%
Males, 45-64	13,940	13,410	530	4%	454	3%	1%	-90	-1%	143	-2%	-350	-3%	23	-3%
Males, 65-74	17,930	16,480	1,450	9%	1,035	6%	3%	380	2%	182	1%	-200	-1%	60	-2%
Males, 75-84	29,300	25,240	4,060	16%	2,222	9%	7%	990	4%	246	3%	-560	-2%	132	-3%
Males, 85 and over	33,780	29,640	4,140	14%	3,337	11%	3%	550	2%	215	1%	-800	-3%	224	-4%
Males, All ages	**100,100**	**89,800**	**10,300**	**11%**	**7,193**	**8%**	**3%**	**1,800**	**2%**	**811**	**1%**	**-2,000**	**-2%**	**441**	**-3%**
Females, 0-44	2,850	2,600	250	10%	102	4%	6%	100	4%	16	3%	10	0%	0	0%
Females, 45-64	8,790	8,240	550	7%	350	4%	2%	-50	-1%	79	-2%	-150	-2%	14	-2%
Females, 65-74	11,640	11,040	600	5%	578	5%	0%	250	2%	104	1%	-410	-4%	27	-4%
Females, 75-84	22,330	19,400	2,930	15%	1,374	7%	8%	760	4%	144	3%	-380	-2%	118	-3%
Females, 85 and over	45,720	39,640	6,080	15%	3,611	9%	6%	1,290	3%	220	3%	-1,350	-3%	307	-4%
Females, All ages	**91,300**	**80,900**	**10,400**	**13%**	**5,931**	**7%**	**6%**	**2,400**	**3%**	**563**	**2%**	**-2,300**	**-3%**	**466**	**-3%**
Person, 0-44	8,040	7,660	380	5%	182	2%	3%	20	0%	41	0%	-110	-1%	2	-1%
Person, 45-64	22,730	21,650	1,080	5%	776	4%	1%	-130	-1%	222	-2%	-500	-2%	37	-2%
Person, 65-74	29,570	27,510	2,060	7%	1,594	6%	2%	630	2%	286	1%	-610	-2%	87	-3%
Person, 75-84	51,630	44,640	6,990	16%	3,612	8%	8%	1,750	4%	390	3%	-940	-2%	250	-3%
Person, 85 and over	79,500	69,280	10,220	15%	6,953	10%	5%	1,840	3%	435	2%	-2,160	-3%	531	-4%
Person, All ages	**191,500**	**170,700**	**20,700**	**12%**	**13,123**	**8%**	**4%**	**4,100**	**2%**	**1,374**	**2%**	**-4,300**	**-3%**	**907**	**-3%**

* Figures shaded green indicate that the observed values are below the 95% prediction interval while figures shaded red are above the 95% prediction interval

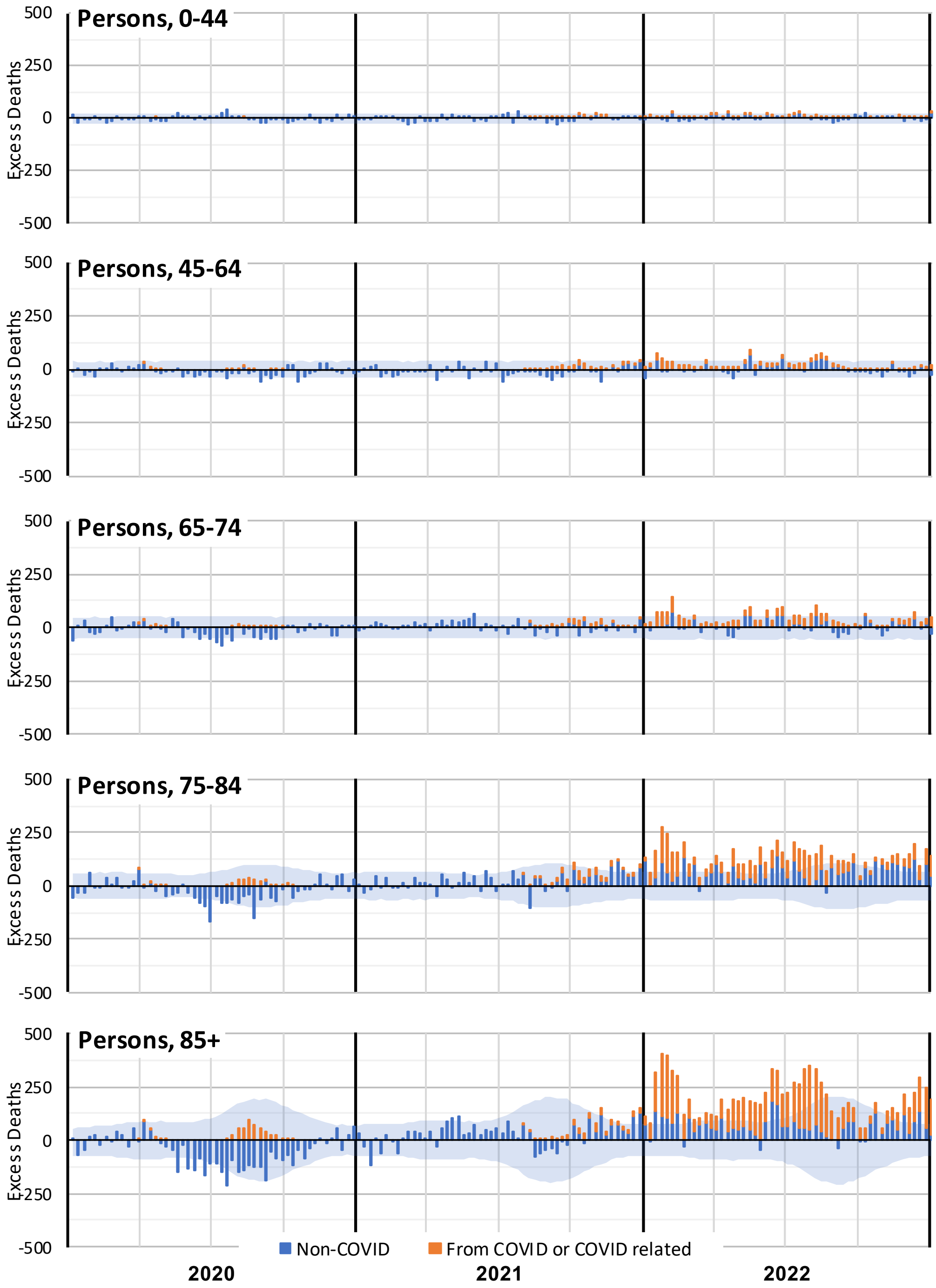
Figure 12 – Excess deaths by age and gender in 2022 – 95% prediction intervals



All age bands show excess deaths in 2022 (which is not all that surprising given the excess deaths for the whole population), but the number and percentage of excess deaths is higher in older age bands. The risk of mortality from COVID-19 is steeper than the underlying age mortality curve, so this result is somewhat expected.

However, it is notable that excess deaths in each age band are generally significant, even after removing COVID-19 deaths. To look at this further, we have shown these results similarly to the graphs by cause, showing weekly excess deaths by age band since the start of the pandemic. For these charts, we have been able to show the contribution of deaths *from* COVID-19 and COVID-19 *related* deaths (in orange) separately to non-COVID-19 deaths. The 95% prediction interval is also shown. All age bands are shown using the same y-axis to give a sense of contribution of each age band.

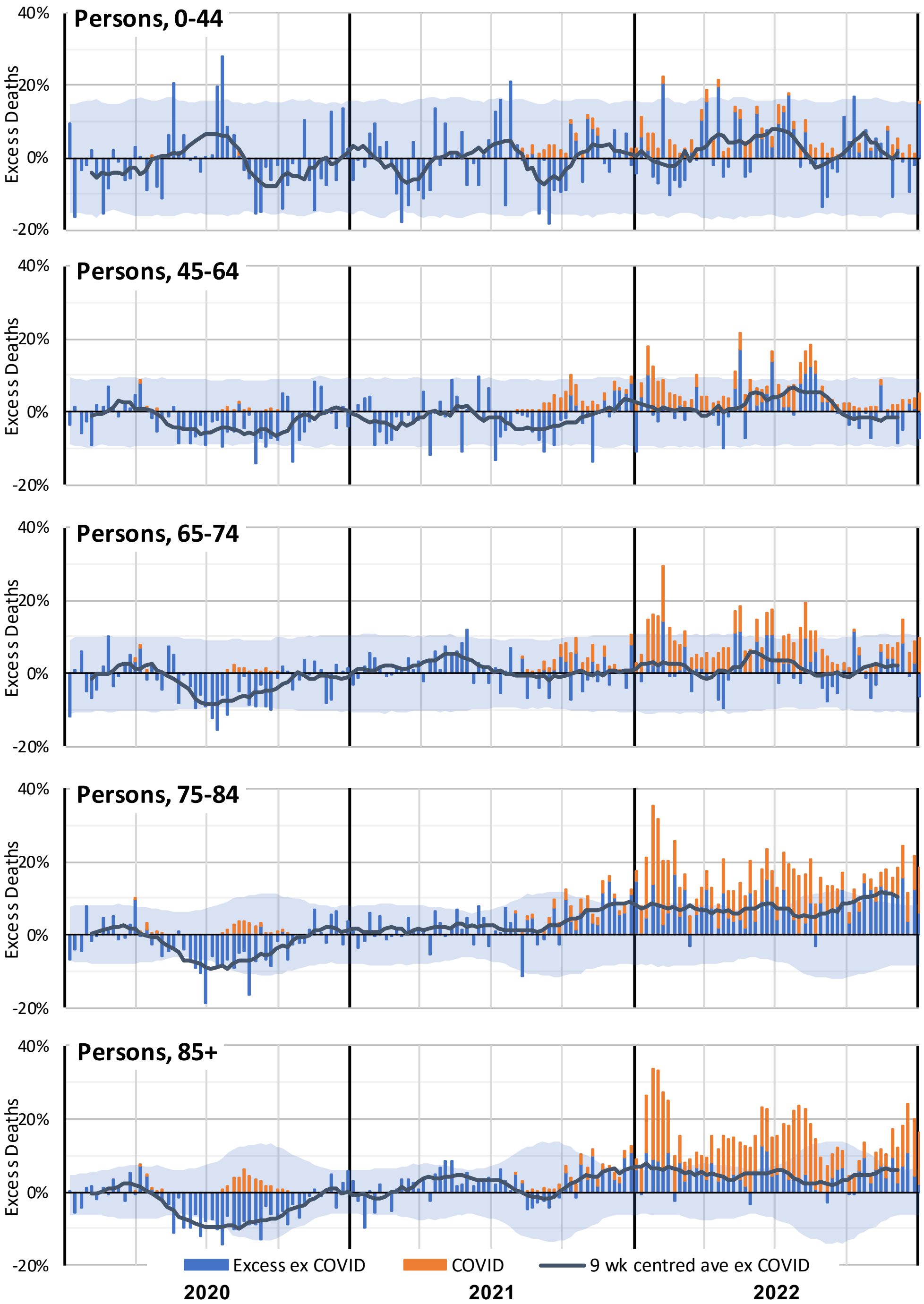
*Figure 13 – Weekly excess deaths in 2020-22 by age band (all persons)**



* *COVID-19 data from ABS customised report 2023*

Figure 13 shows that excess deaths in 2022 are dominated by the older age groups. However, we already expect many more deaths in these age groups. It is instructive to consider the same information with the excess deaths expressed as a percentage of predicted deaths.

*Figure 14 – Weekly excess deaths as a % of predicted in 2020-22 by age band (all persons)**

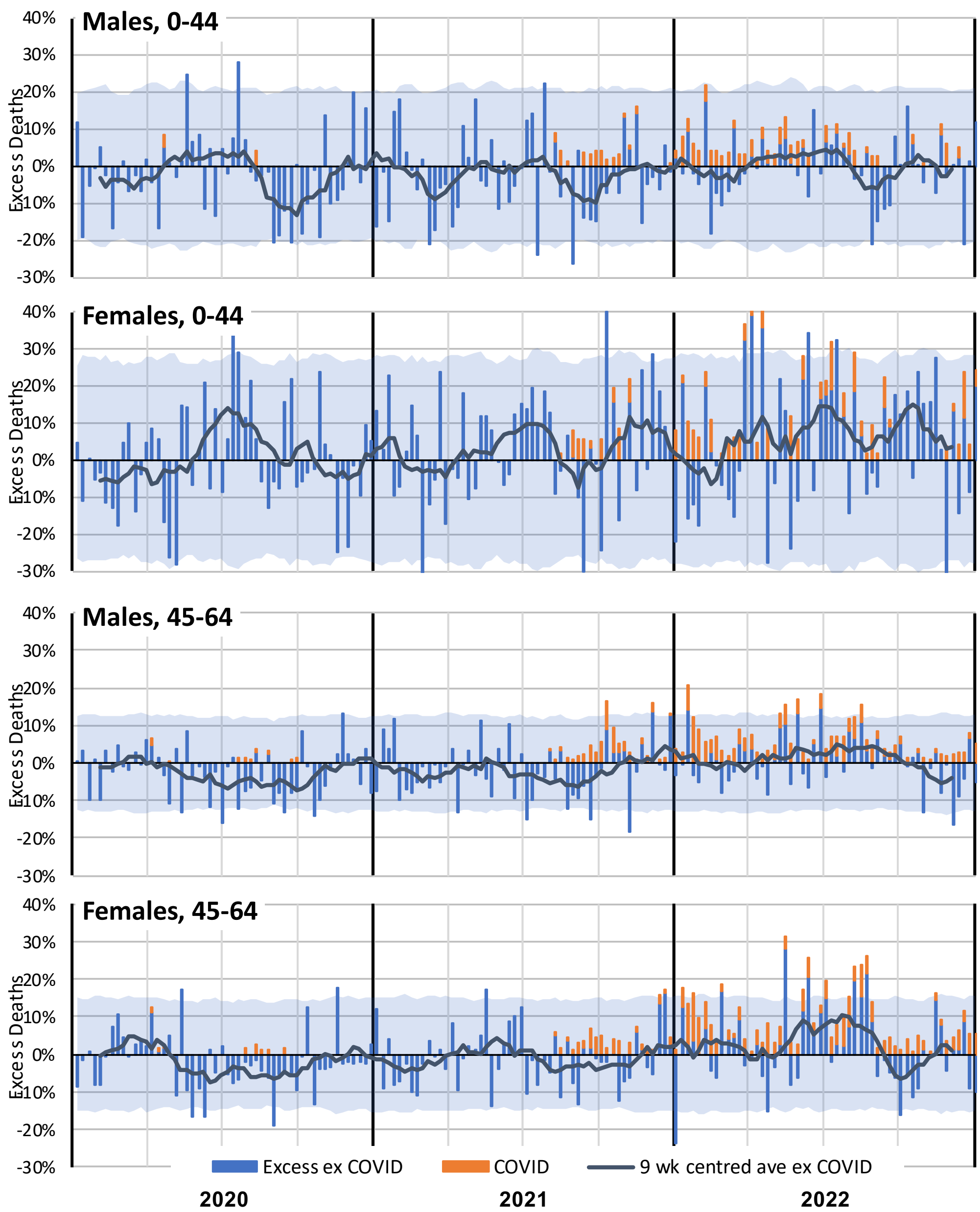


* *COVID-19 data from ABS customised report 2023*

Figure 14 shows that the older age groups still experienced the most significant increase in excess deaths when expressed as a percentage of predicted deaths. Indeed, deaths of people over the age of 75 are significantly higher than expected in almost every week of 2022.

While the numbers of deaths in the 0-44 and 45-64 age bands are small and hence subject to considerable natural variation, we saw in Table 4 that year-to-date excess deaths in 2022 are materially higher than expected. That table also showed that the percentage excess was higher for females than for males. We have shown the graphs for younger males and females in Figure 15.

*Figure 15 – Weekly excess deaths as a % of predicted in 2020-22 for ages 0-44 and 45-64 by gender**



* *COVID-19 data from ABS customised report 2023*

Figure 15 shows that female non-COVID-19 mortality experience in 2021 and 2022 is noticeably worse than male, especially in the 0-44 age band.

2.6 Excess doctor-certified deaths by state/territory

Table 5 shows our estimate of excess deaths by state/territory, before and after deducting *from* COVID-19 and COVID-19 *related* deaths (noting that the totals are not quite the same as the totals in Table 2 due to the more approximate approach to setting our baseline by state/territory).

Figure 16 shows the 95% confidence interval around the estimates for the 2022 year, both including and excluding COVID-19 deaths.

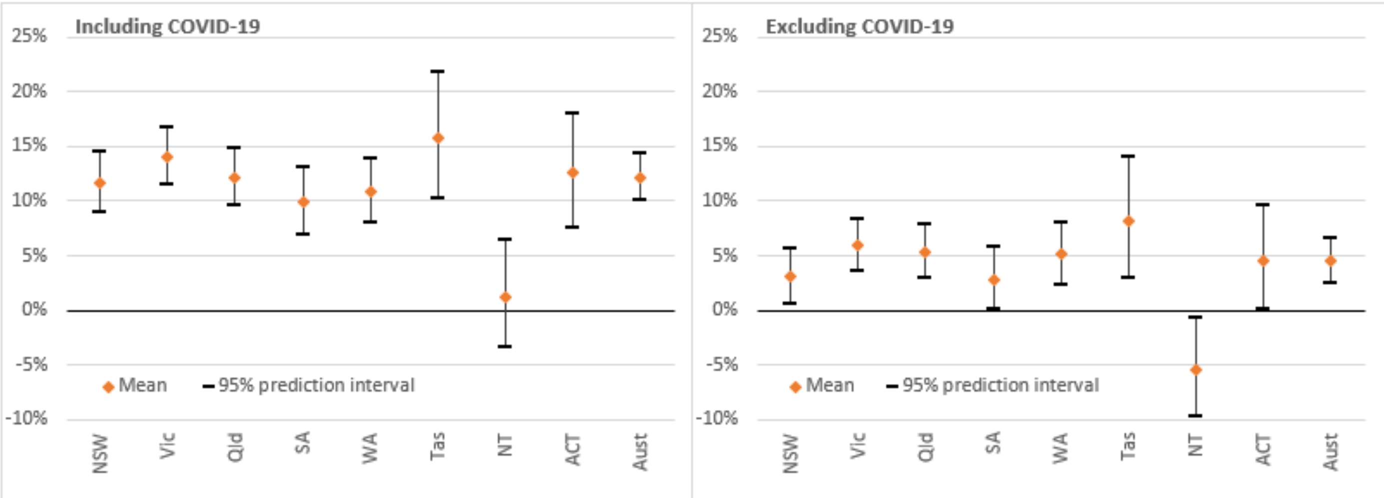
*Table 5 - Excess deaths in Australia – By State/Territory**

State/Territory	2022 Year to Date (52 weeks)						2021 (52 weeks)				2020 (53 weeks)			
	Actual	Predicted	Excess	% Excess	Covid-19	% Net	Excess	% Excess	Covid-19	% Net	Excess	% Excess	Covid-19	% Net
NSW	62,500	55,900	6,600	12%	4,791	3%	600	1%	639	0%	-2,100	-4%	63	-4%
Victoria	47,600	41,700	5,900	14%	3,420	6%	1,800	4%	716	2%	-300	-1%	806	-3%
Queensland	38,700	34,500	4,200	12%	2,339	5%	700	2%	4	2%	-1,200	-4%	4	-4%
South Australia	16,000	14,500	1,500	10%	1,023	3%	200	1%	4	1%	-400	-3%	3	-3%
Western Australia	17,400	15,700	1,700	11%	909	5%	700	4%	0	4%	-200	-2%	11	-2%
Tasmania	5,200	4,500	700	16%	334	8%	300	8%	0	8%	-100	-3%	17	-3%
Northern Territory	1,220	1,200	20	1%	81	-5%	20	2%	2	2%	-20	-2%	0	-2%
ACT	2,900	2,600	300	13%	204	5%	0	-2%	12	-2%	-100	-2%	2	-2%
Australia	**191,500**	**170,700**	**20,800**	**12%**	**13,123**	**4%**	**4,100**	**2%**	**1,374**	**2%**	**-4,400**	**-3%**	**907**	**-3%**

* Figures shaded green indicate that the observed values are below the 95% prediction interval while figures shaded red are above the 95% prediction interval

* *COVID-19 data from ABS customised report 2023*

Figure 16 – Excess deaths by state/territory in 2022 – 95% prediction intervals

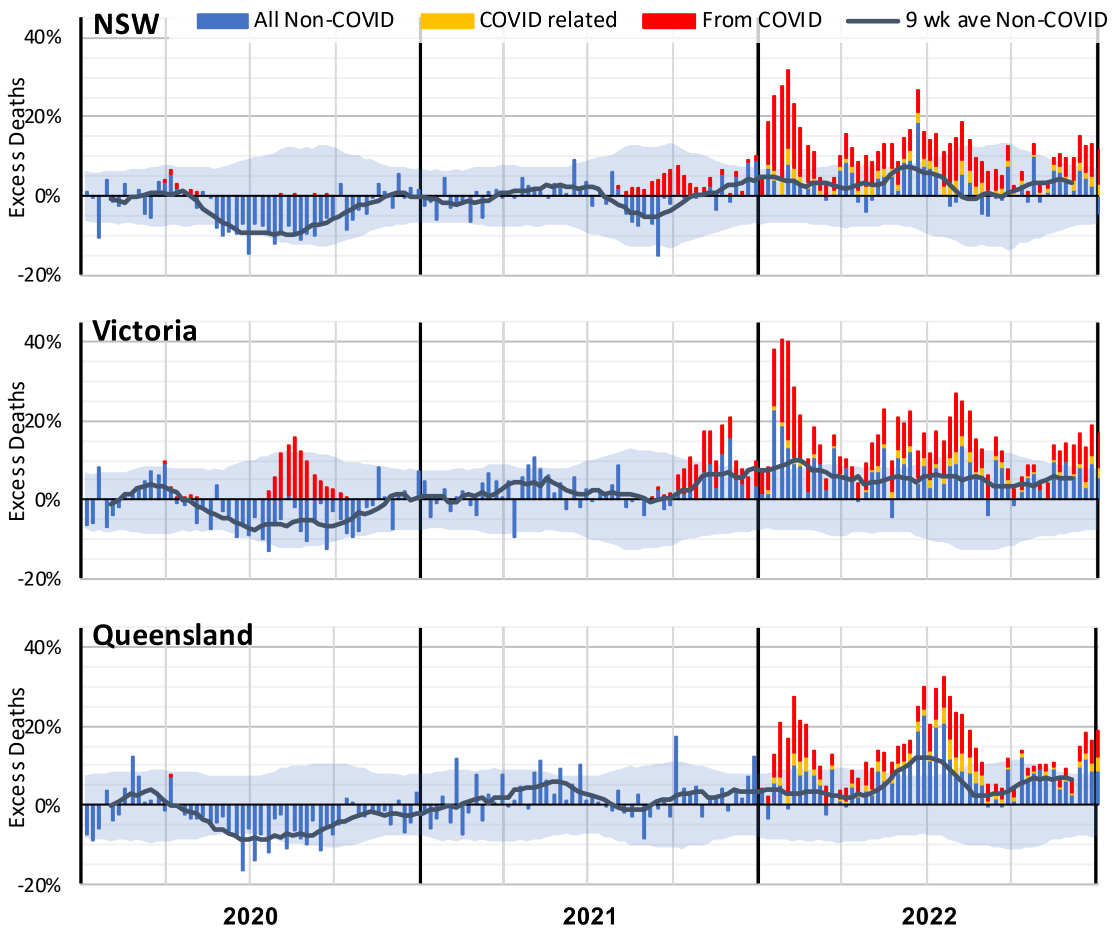


In 2022, all states/territories apart from NT had significant levels of excess mortality ranging from 10% to 16% of predicted. Generally, about half of this is due to deaths *from* COVID-19, with another 1-2% due to COVID-19 *related* deaths. Notably, the differences in the measured excess mortality between states are not statistically significant (the 95% prediction intervals overlap), other than for the NT which is clearly lower than the other states/territories.

The graphs below show these results week-by-week (with the excess shown as a percentage of the predicted value) for:

a. the three largest states (NSW, Victoria and Queensland) where we have weekly information on both deaths *from* COVID-19 deaths and COVID-19 *related* deaths;
b. SA and WA where we have weekly information on deaths *from* COVID-19 only; and
c. the smaller states/territories (Tasmania, NT and ACT) where weekly information on COVID-19 deaths is not available.

*Figure 17 – Weekly excess deaths as a % of predicted in 2020-22 for NSW, Victoria, Queensland**



** COVID-19 data from ABS customised report 2023*

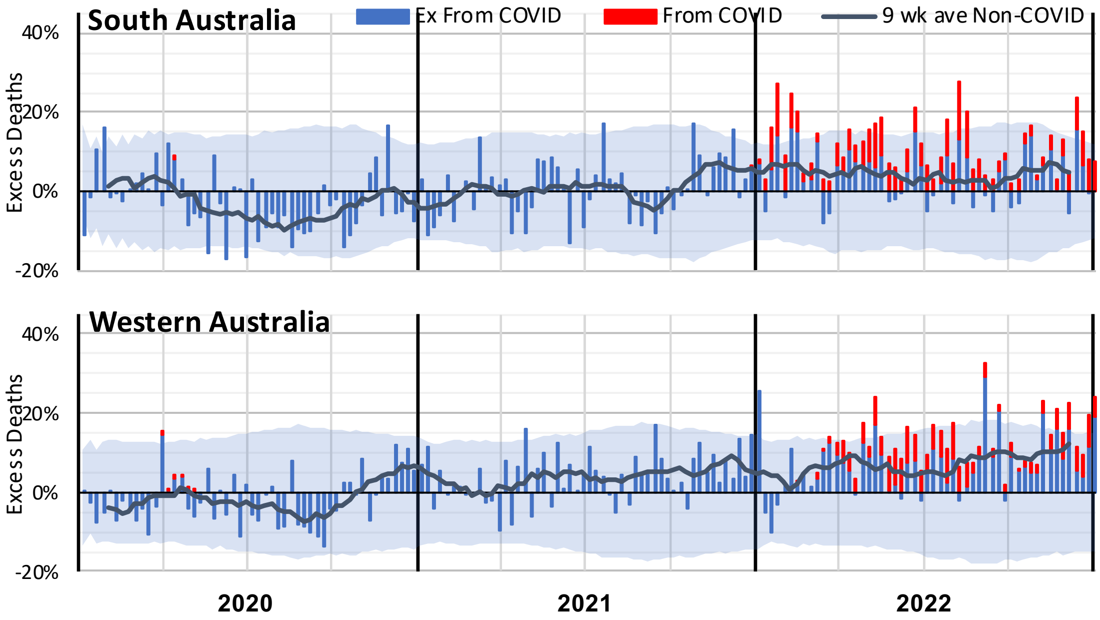
Figure 17 shows that these larger states all had better-than-expected mortality in 2020. It also shows the impact of the second COVID-19 wave in Victoria.

In 2021, Victoria shows a much higher level of excess deaths in the Delta wave – in the last quarter of the year – than either NSW or Queensland. A large share of these deaths do not have COVID-19 on the death certificate.

In 2022:

- Queensland had a large peak in non-COVID excess deaths in the middle of the year (at the time of flu and COVID-19 waves). NSW had a smaller peak of non-COVID deaths at this time, but Victoria did not have a similar peak; and
- barring the winter peaks for NSW and Queensland, Victoria's non-COVID-19 excess has tended to be higher than the other two large states.

*Figure 18 – Weekly excess deaths as a % of predicted in 2020-22 for WA and SA**



** COVID-19 data from ABS customised report 2023*

The SA experience is similar to the three largest states, although somewhat more volatile given its smaller size.

Western Australia, while mostly having excess deaths within the 95% prediction interval, had many more weeks with positive excess deaths than with negative excess deaths. There is no large COVID-19 spike in January/February, thanks to the later opening of WA's borders.

Figure 19 – Weekly excess deaths as a % of predicted in 2020-22 for Tasmania, ACT and NT

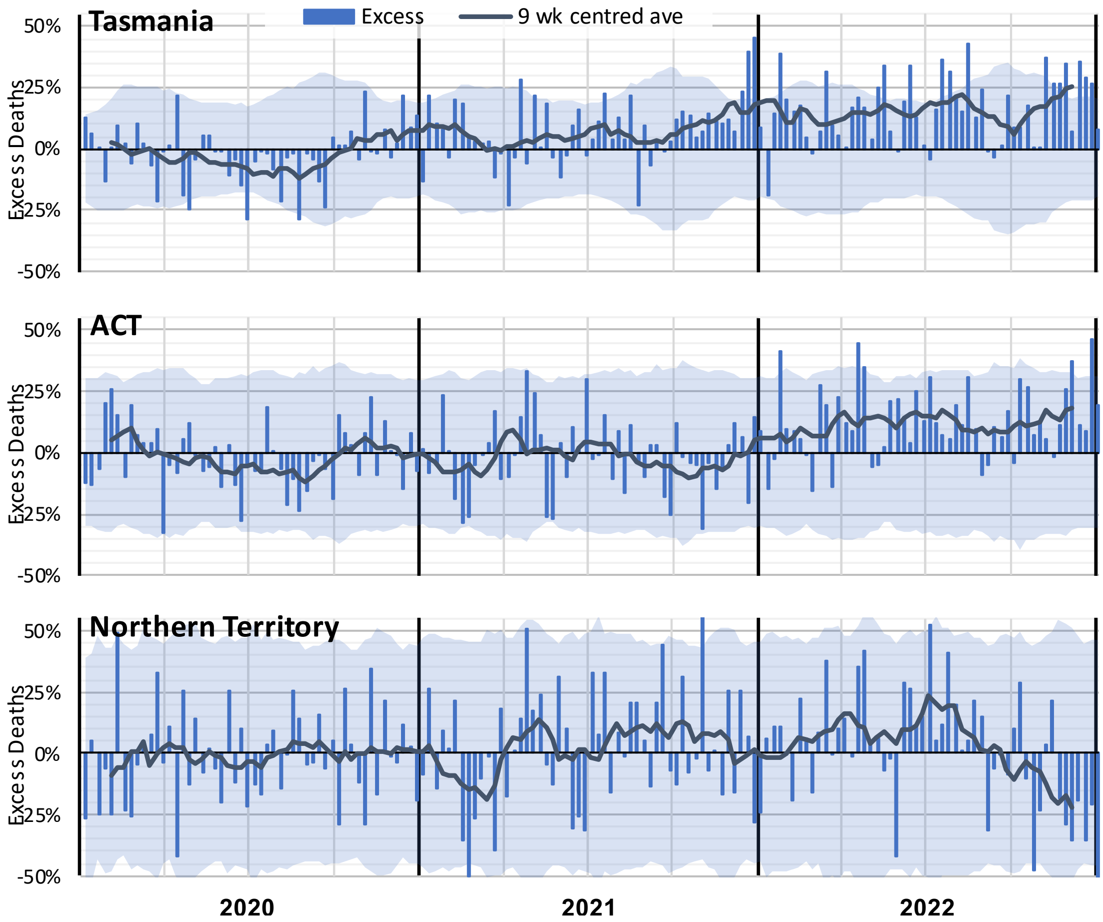


Figure 19 shows the higher volatility of excess mortality experienced by the smallest state and the two territories. Allowing for that volatility, Tasmania had broadly the same experience of excess mortality as the larger states, but with a high level of excess deaths during the Delta wave late in 2021.

With its relatively young and affluent population[18], the ACT has experienced lower excess mortality than the larger states.

The Northern Territory has a very young population, which might explain the low net impact of the pandemic after allowing for the high volatility caused by a very small weekly expected death count. There is no apparent general trend in the excess mortality, although it does appear to have been declining since the middle of 2022. (Note that we have used the same loadings for late-registered deaths for each state. If, as is plausible, registration delays are longer in the NT compared with larger, more populous states, the reducing trend in excess mortality in the most recent 1-2 months may be a function of our simplified modelling approach rather than a real feature.)

2.7 Leading causes of death

The ABS reports on the top 20 leading causes of death by grouping deaths based on their International Classification of Diseases, version 10 (ICD-10) code. Unlike the *Provisional Mortality Statistics*, cancers are grouped based on the region of the body rather than being classed as a single cause of death.

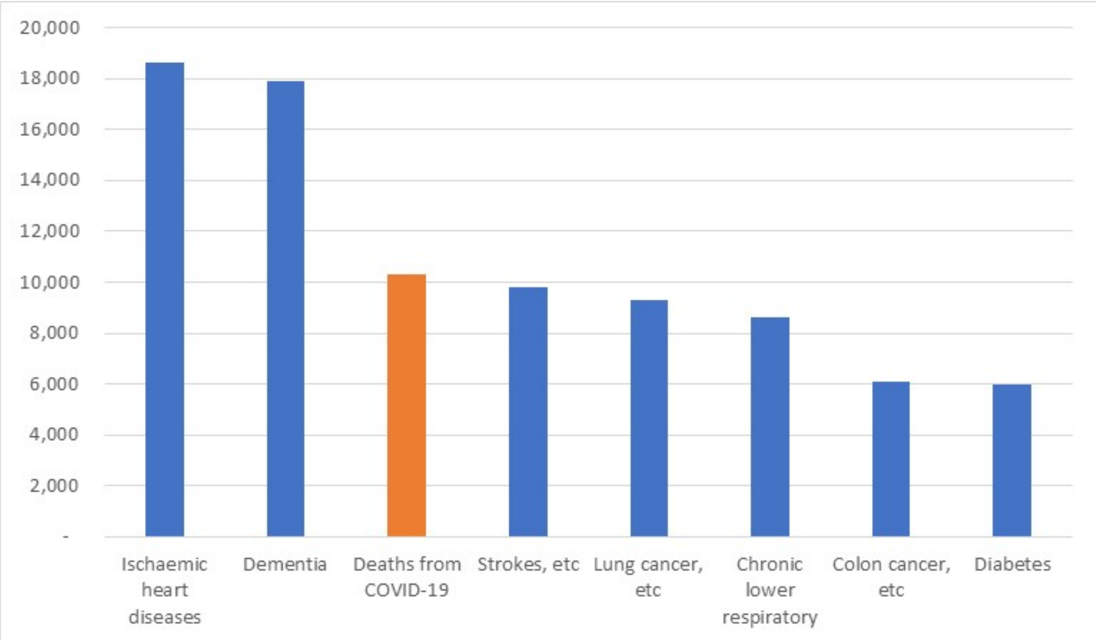
[18] ABS statistics included in the *COVID-19 Mortality in Australia* article shows that those with in the lowest SEIFA quintile have been impacted more heavily than those in the highest SEIFA quintile

In this section, we assess where COVID-19 sits in terms of leading causes of death in Australia in 2022 and have followed the ABS classification system.

We have estimated deaths for the leading causes for 2022 by:

- taking doctor-certified deaths by cause to 31 December 2022 as shown in Table 2;
- including an allowance for coroner-referred deaths (using the historical ratio of doctor-certified to coroner-referred deaths)[19]; and
- for the leading cancer causes, estimating deaths from all cancers and then assuming that lung cancers and colon cancers make up 18% and 12% respectively of all cancer deaths, in line with the stable proportions seen over the recent past.

Figure 20 – Leading causes of death – Australia 2022



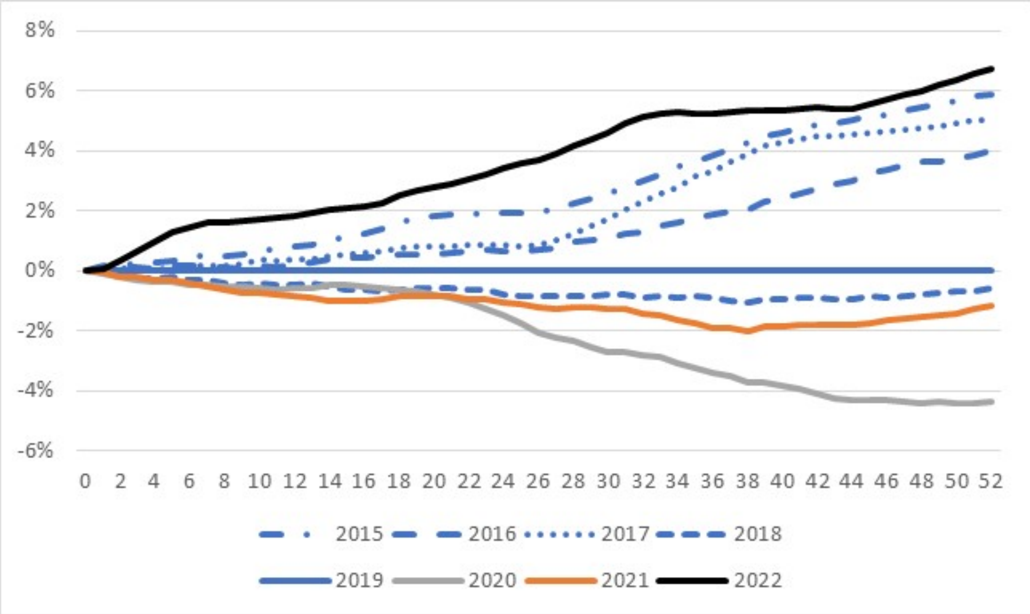
With around 10,300 deaths from COVID-19, this puts COVID-19 as the third leading cause of death in Australia in 2022.

2.8 Standardised mortality rates

Figure 21 shows the cumulative weekly standardised mortality rates (SDRs) for 2015 to 2022, expressed relative to the equivalent rate for 2019. The SDRs are from the *Provisional Mortality Statistics*, plus allowance for late-reported deaths.

[19] We have taken all deaths from the ABS *Cause of Death*, and doctor-certified deaths from the ABS *Provisional Mortality Statistics*, with the difference assumed to be coroner-referred deaths. For almost all causes of death shown, around 95% or more deaths have historically been doctor-certified. The exception to this is ischaemic heart disease where around 80% of deaths have historically been doctor-certified. With significantly higher numbers of deaths in Australia in 2022, particularly for doctor-certified ischaemic heart disease deaths, there is uncertainty over these assumptions.

Figure 21 - Cumulative standardised mortality rate relative to 2019



The graph shows that:

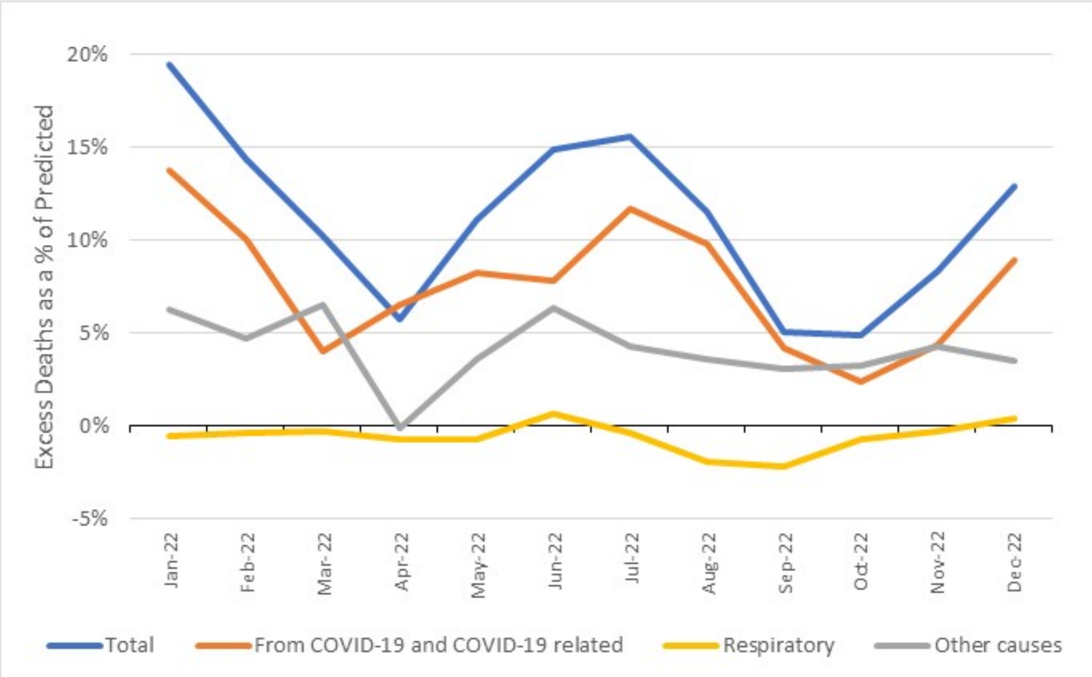
- mortality rates improved over the 2015 to 2019 pre-pandemic years, noting that both 2017 and 2019 were "bad" influenza years, resulting in higher than usual deaths both from and related to influenza;
- the 2020 year is considerably lower than 2019, a result of the lower number of respiratory and respiratory-related deaths in that year due to measures introduced to curb COVID-19;
- 2021 is higher than 2020, a combination of both deaths from COVID-19 during the Delta wave and excess mortality from other causes of death (other than from respiratory disease); and
- for 2022, after being well above all other years shown until mid-August, experience from mid-August to end-October moved the 2022 year much closer to the 2015 year. At the end of the year, 2022 is almost 1% higher than the 2015 year and 7% higher than 2019 (noting that if pre-pandemic mortality trends had continued, we would expect 2022 to be around 5% below 2019).

3 Possible causes of non-COVID-19 excess deaths in 2022

Taking the figures from Section 2.2.1, Figure 22 shows excess deaths (as a % of predicted) for each month of 2022. We have shown the total excess (blue) and the contributions of:

- deaths from COVID-19 and COVID-19 related deaths (orange), noting that Figure 6 showed that deaths from these two sources move in the same pattern;
- deaths from respiratory disease (yellow); and
- deaths from all other causes (grey).

Figure 22 – Excess deaths (% of predicted) by month in 2022



Deaths *from* COVID-19 and COVID-19 *related* deaths are the clear drivers of the majority of the excess mortality.

Deaths from respiratory disease have mostly been a negative contributor to excess mortality. We can see the impact of the early, lighter than average, influenza season in 2022 with a small contribution to excess mortality in June 2022, more than offset by high negative contributions in August and September 2022 (the months where influenza deaths usually peaked before the pandemic).

Excess deaths from other causes (i.e., non-COVID-19, non-respiratory), somewhat follows the pattern of COVID-19 mortality; it tends to be higher when COVID-19 (and respiratory) deaths are high and tends to be low when COVID-19 deaths are low. However, the relationship is not 100% correlated – e.g., there was substantial non-COVID-19, non-respiratory excess mortality in September and October 2022 when both COVID-19 and respiratory deaths were relatively low.

The measurement of higher numbers of deaths than predicted does not tell us why this is occurring. It isn't possible to identify from death counts alone what is causing the non-COVID-19 excess deaths. Multiple factors are likely in play, and different factors may be more or less pronounced at various times. There are several reasons hypothesised around the world (where this effect is occurring to a greater or lesser extent) including, but not limited to:

- post-COVID-19 sequelae or interactions with other causes of death;
- delays in emergency care;
- mortality displacement;
- delays in routine care;
- undiagnosed COVID-19;

- mental health issues;
- increases in road accident deaths; and
- vaccine-related deaths.

In this section, we explore these factors in the Australian context, with a particular focus on the impact on excess mortality in 2022.

3.1 Post-COVID-19 sequelae or interactions with other causes of death

Studies have shown that COVID-19 is associated with higher subsequent mortality risk from heart disease and other causes[20], but certifying doctors would generally not be able to medically identify a **causative** link several months after recovery from COVID-19 (for example, we understand that medical science cannot currently distinguish between a heart attack that was caused by the after-effects of COVID-19 versus any other heart attack). Therefore, it seems likely that there would be more of these deaths than identified. The age-based analysis in Section 2.5 supports this hypothesis, with non-COVID-19 excess deaths occurring in 2022 even in those under 45, noting that this age group has had low levels of COVID-19 deaths. The absence of excess deaths in WA in January as shown in Section 2.6 also supports this explanation i.e. the fact that WA did not have a January 2022 COVID-19 spike, and also no non-COVID-19 excess, supports the hypothesis that there are post-COVID-19 sequelae deaths.

Likely impact in Australia in 2022: High

3.2 Delays in emergency care

Pressure on the health, hospital and aged care systems, including ambulance ramping[21] and bed block[22], could lead to people not getting the care they require, either as they avoid seeking help, or their care is not as timely as it might have been in pre-pandemic times. The peaks in non-COVID-19 excess deaths at times of high COVID-19 and/or influenza deaths supports this hypothesis.

Ambulance statistics: during 2022, there were over 1.3 million ambulance responses in NSW[23], of which more than half (about 694,000, or 52%) were "emergency priority 1 (P1)" activities. A small cohort of P1, just under 45,000, were highest priority (P1A) responses to patients with life-threatening conditions. Figure 23 shows that the percentage of P1A responses reached within 10 minutes decreased steadily over the pandemic, and P1 responses reached within 15 minutes decreased more significantly. Of all P1A responses in 2022, 60% were reached within 10 minutes, compared with 71% in 2019. For P1 responses in 2022, only 38% were reached within 15 minutes, well below earlier years.

Figure 23 also shows for Victoria[24] the percentage of Code 1 responses that were reached within 15 minutes (Code 1 patients are those that require urgent paramedic and hospital care and receive a "lights and sirens" response). This metric has declined steady since late 2020, with only around 64% of Code 1 responses reached within 15 minutes in 2022, down from around 84% pre-pandemic.

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[20] A small selection of numerous research studies includes:
Davis, H.E., McCorkell, L., Vogel, J.M. et al. Long COVID: major findings, mechanisms and recommendations. Nat Rev Microbiol 21, 133–146 (2023).
Xie Y, Xu E, Bowe B, Al-Aly Z. Long-term cardiovascular outcomes of COVID-19. Nature Medicine. 2022;28(3):583-590.
Douaud G, Lee S, Alfaro-Almagro F, et al. SARS-CoV-2 is associated with changes in brain structure in UK Biobank. Nature. 2022;604(7907):697-707.
Xu E, Xie Y, Al-Aly Z. Long-term neurologic outcomes of COVID-19. Nature Medicine. 2022;28(11):2406-2415.

[21] refers to the inability of ambulances to transfer their patients to hospital emergency departments on arrival due to the emergency department itself having reached patient capacity

[22] used to describe the situation when patients admitted from emergency departments cannot be moved to hospital beds because they are occupied

[23] Source: Bureau of Health Information, *Tracking public hospital and ambulance service activity and performance in NSW, January to March 2023*

[24] Source: Ambulance Victoria, quarterly *Response Times* report

Note that the metrics shown for NSW and Victoria are not directly comparable due to different definitions used.

Figure 23 – Percentage of ambulance responses within time in NSW and Victoria – 2018-22

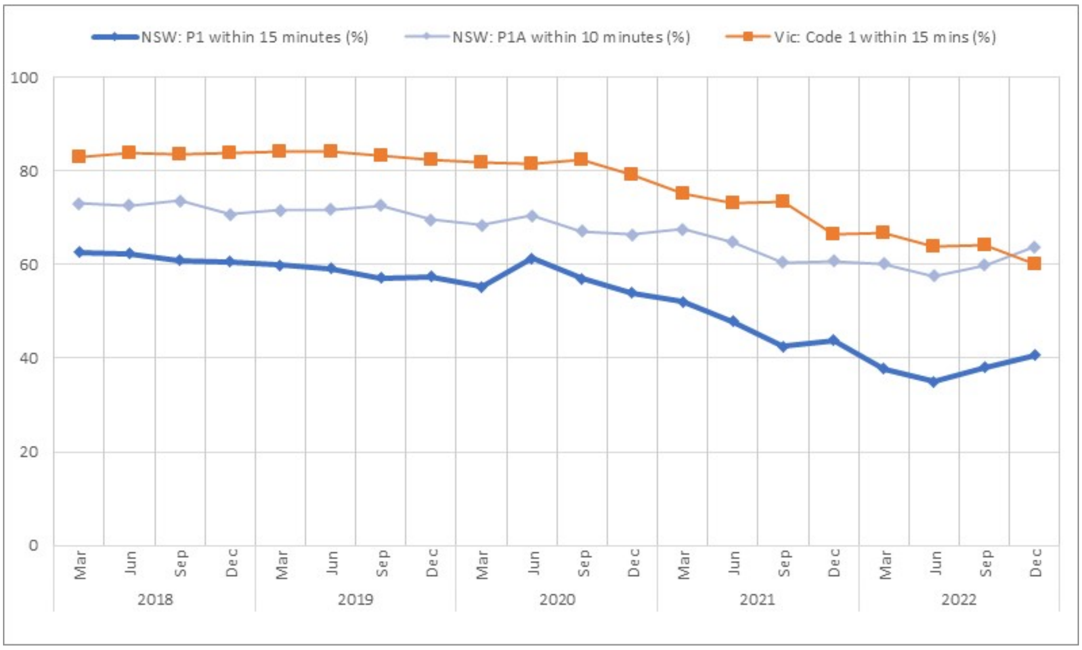
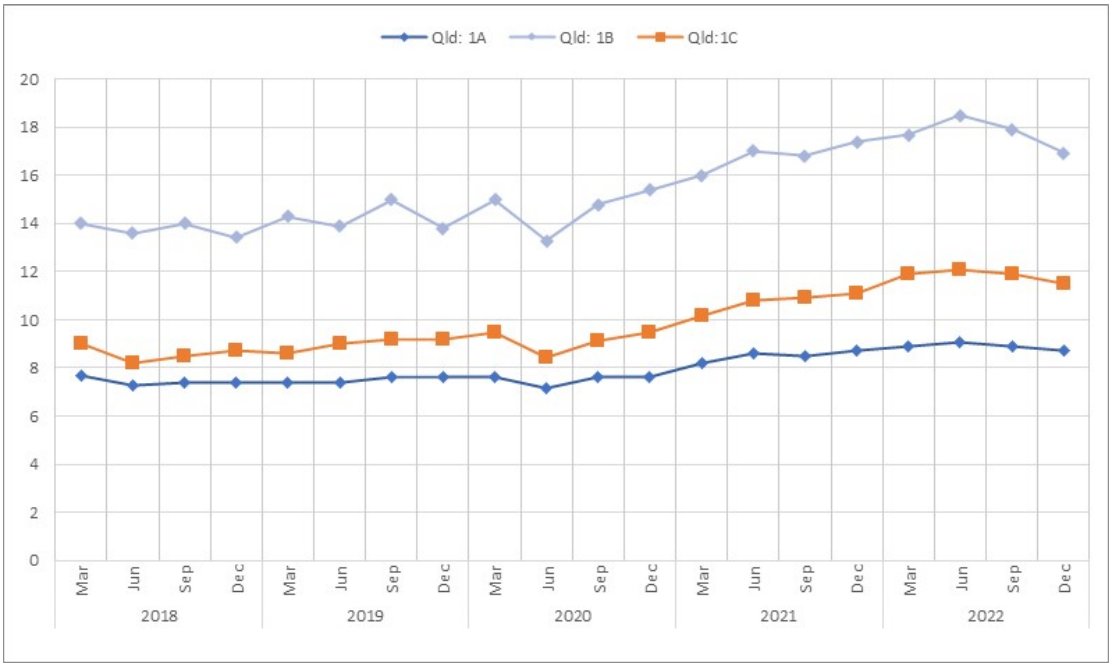


Figure 24 shows the median ambulance response times for Queensland[25] for responses designated 1A (actual time critical), 1B (emergent time critical) and 1C (potential time critical). As for NSW and Victoria, the metrics have deteriorated over the course of the pandemic. Median response times for 1A responses in 2022 were around 20% worse than in 2020; for 1B this increased to around 30% while for 1C response times were around 40% worse.

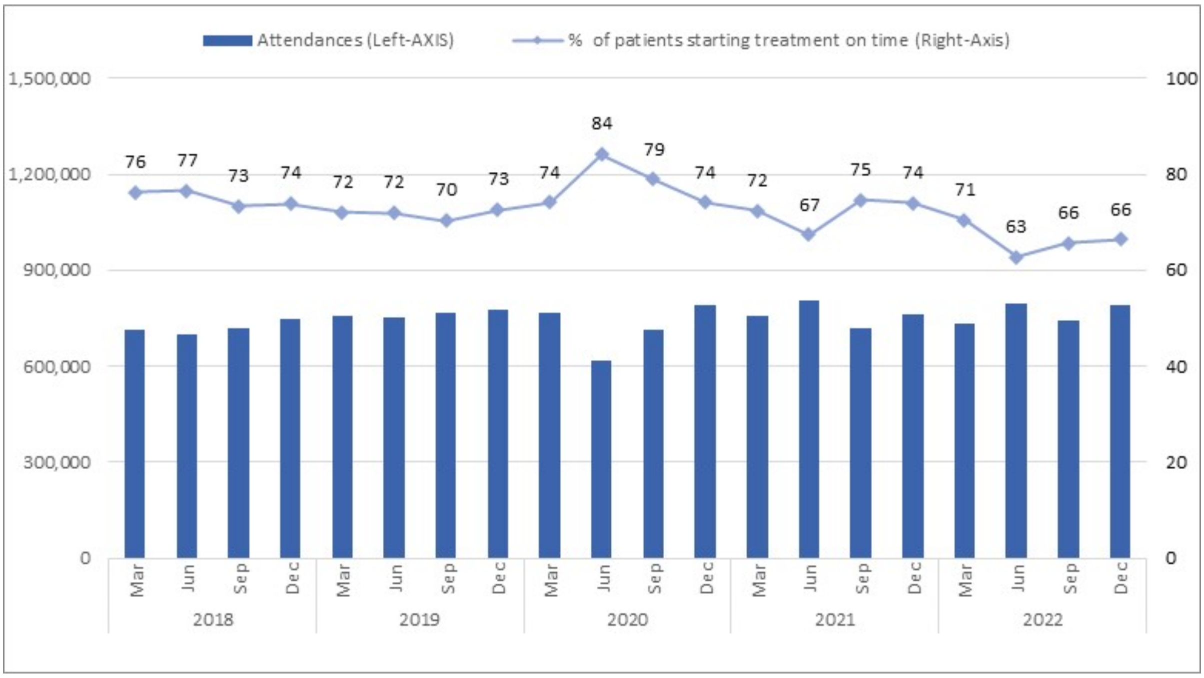
Figure 24 – Median ambulance response time for Queensland – 2018-22



[25] Source: Queensland Ambulance Service, quarterly *Public Performance Indicators*. The reports show year-to-date figures each quarter, and we have derived the quarterly performance figure based on the number of daily emergency incidents also included in the reports.

Emergency Department (ED) statistics: there were over 3 million ED attendances in NSW[26] public hospitals in 2022, a similar level to 2021 but higher than just under 2.9 million in 2020. As a result of the March 2020 stay-at-home orders, the June 2020 quarter saw the lowest quarterly number of attendances for at least five years. However, this proved to be temporary, with attendances returning to pre-pandemic levels by December 2020. Since then, ED attendances have fluctuated more than they did pre-pandemic. Figure 25 shows that the percentage of ED patients treated on time has been substantially lower in 2022 compared with all prior periods shown.

Figure 25 – Proportion of NSW public hospital Emergency Department patients whose treatment started on time – 2018-22



This information from NSW, Victoria and Queensland does suggest that ambulance wait times have increased, as have hospital emergency department wait times in NSW, in 2022 compared with pre-pandemic years. Unfortunately, the statistics are only available quarterly (rather than monthly), so it is difficult to compare the figures directly to our excess non-COVID-19 deaths and to be conclusive about their impact on non-COVID-19 mortality.

Likely impact in Australia in 2022: High during COVID-19 and influenza peaks

3.3 Mortality displacement

Australia had negative mortality displacement (i.e., fewer deaths than expected) in the first year or so of the pandemic, resulting from the absence of many respiratory diseases. The lower-than-expected mortality from respiratory disease was again apparent in 2021. As such, some of the excess we have seen in some causes in 2021 and 2022 may be the reversing of this effect. People who otherwise may have died earlier had their systems been stressed by respiratory disease may now be succumbing to their underlying illnesses. Conversely, the earlier-than-usual flu season in 2022 appears to have resulted in some forward mortality displacement.

Likely impact in Australia in 2022: Moderate

[26] Source: Bureau of Health Information, *Tracking public hospital and ambulance service activity and performance in NSW, January to March 2023*

3.4 Delays in routine care

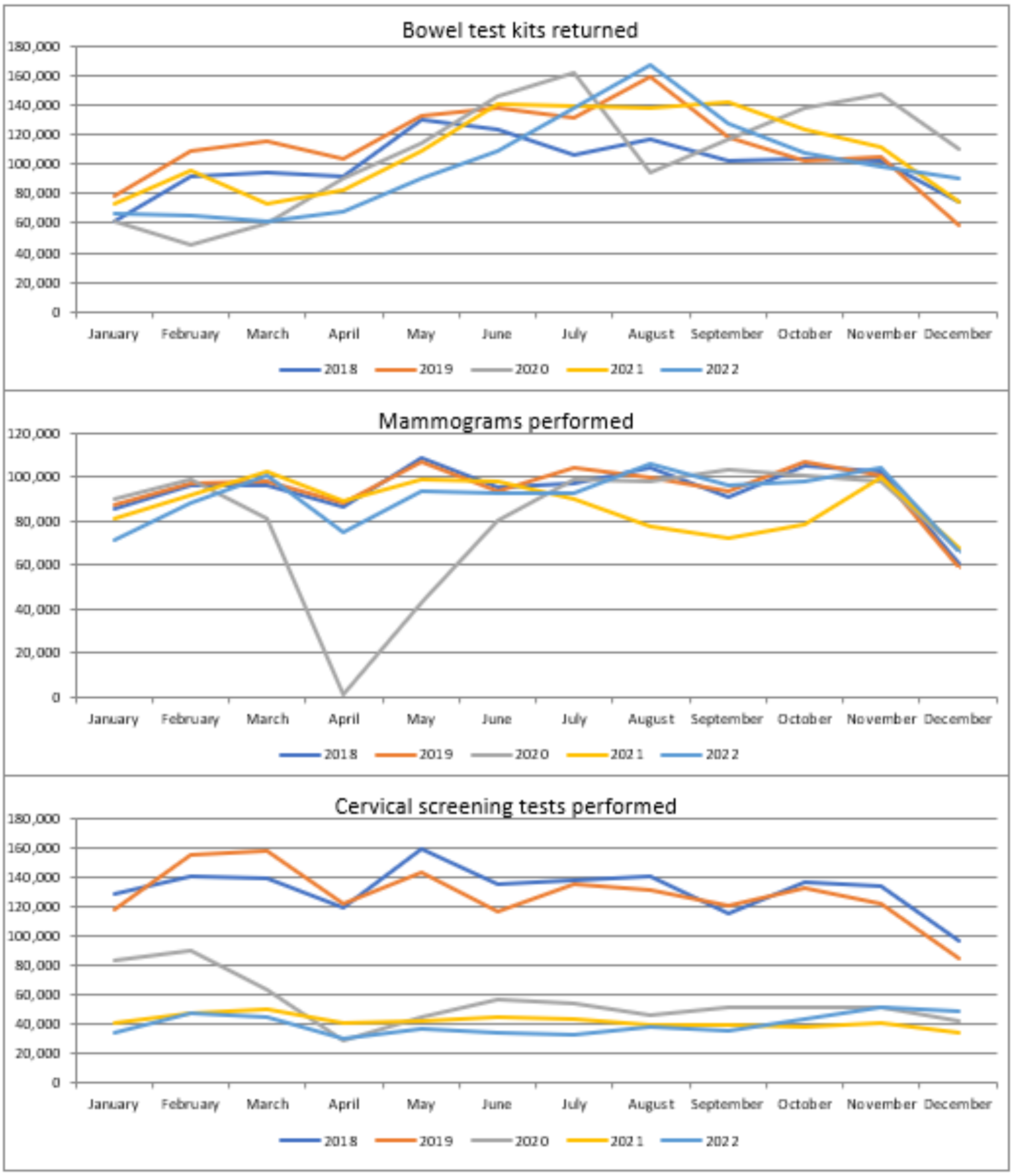
Opportunities to diagnose or treat non-COVID-19 diseases have been missed for various reasons including fear and lack of opportunity. There is some evidence that this may be affecting cancer deaths, and that disruptions to prescribing heart medications may be impacting on chronic ischaemic heart disease deaths. It may also be a factor in higher deaths from other causes, such as diabetes, and the large "other" category.

Screening program statistics: Figure 26 shows the numbers of tests conducted under our three national cancer screening programmes for Bowel Cancer, Breast Cancer, and Cervical Cancer in 2018 to 2022, using AIHW data[27]. Other than the seasonal summer dip in testing across the board, experience has been different by cancer type, including during the initial lockdown period in Mar-Apr 2020:

- There was no obvious lockdown impact on Bowel Cancer screening, which is not surprising, given that this is a home-based test.
- Breast Cancer test numbers dropped sharply to zero during the national lockdown of March/April 2020 but immediately recovered to pre-pandemic levels. There was a dip in screening numbers in the latter half of 2021 when a large portion of the population was in lockdown to try to halt the spread of the Delta variant. Screening levels had mostly returned to normal by early 2022.
- There was a clear dip in Cervical Cancer test numbers during the 2020 lockdown. Test numbers in 2021 and 2022 are much lower than in 2018 and 2019, but we suggest that this is largely due to a change in the recommended screening interval from 2 years to 5 years, a change that was introduced in December 2017 and will have taken some time to work through the system.

[27] Source: AIHW Cancer screening programs: quarterly data

Figure 26 – Numbers of tests for Bowel, Breast and Cervical Cancer – 2018-22, per AIHW

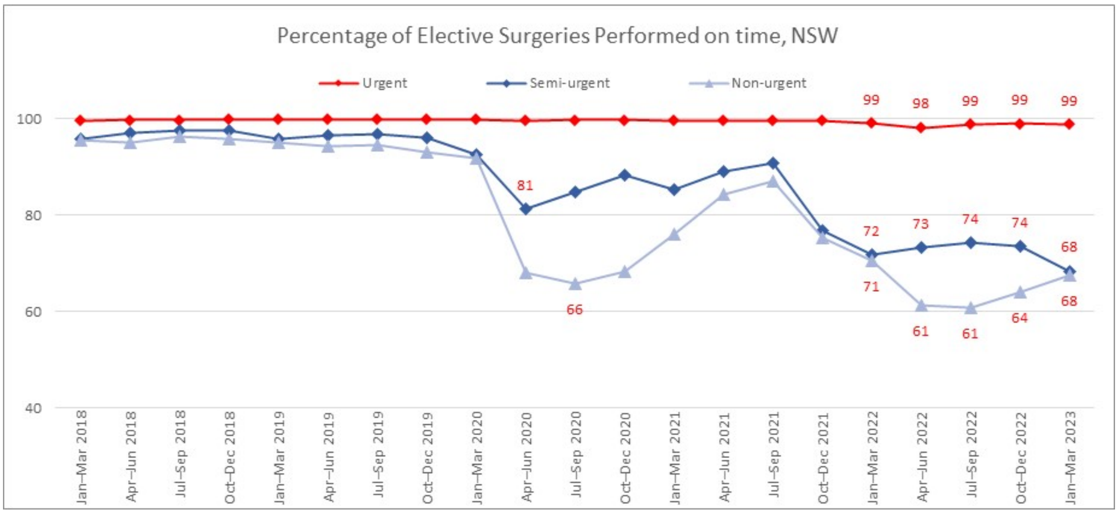


So, while there does appear to have been a reduction in cancer screening during the lockdown period, this was quite short lived and is not expected to be a material driver of any non-COVID-19 excess mortality.

Elective surgery statistics: during the pandemic NSW[28] experienced successive suspensions in non-urgent and semi-urgent elective surgeries, resulting in sharp quarterly drops in the number of elective surgeries performed in the first half of 2020, late 2021 and early 2022. Figure 27 shows that, while the percentage of surgeries performed on time was close to 100% for the urgent category, it decreased significantly for semi-urgent and non-urgent categories.

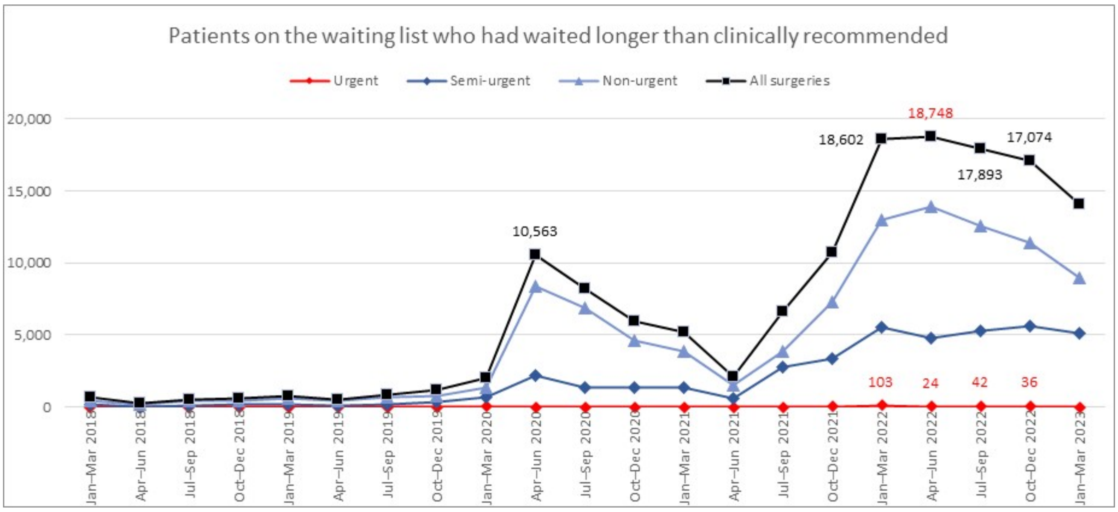
[28] Source: Bureau of Health Information, *Tracking public hospital and ambulance service activity and performance in NSW, January to March 2023*

Figure 27 – Percentage of elective surgeries performed on time in NSW – 2018-22



In NSW, as Figure 28 shows, the number of patients on the waiting list who had waited longer than clinically recommended increased significantly to a peak in early 2020, declined over the rest of 2020 and the first half of 2021 before reaching a higher peak in early 2022 (18,748). Subsequently, the waiting list reduced to 17,074 by the end of 2022, but this is still far higher than pre-pandemic numbers (generally less than 1,000). For the "Urgent" category, the number peaked at 103 patients by the end of March 2022. This was significantly higher than quarters in 2018 to 2021, where only 2 out of the 16 quarters saw more than 10 patients on the waiting list. The number of semi-urgent patients who have waited longer than the recommended time has been around 5,000 across all of 2022 and into 2023.

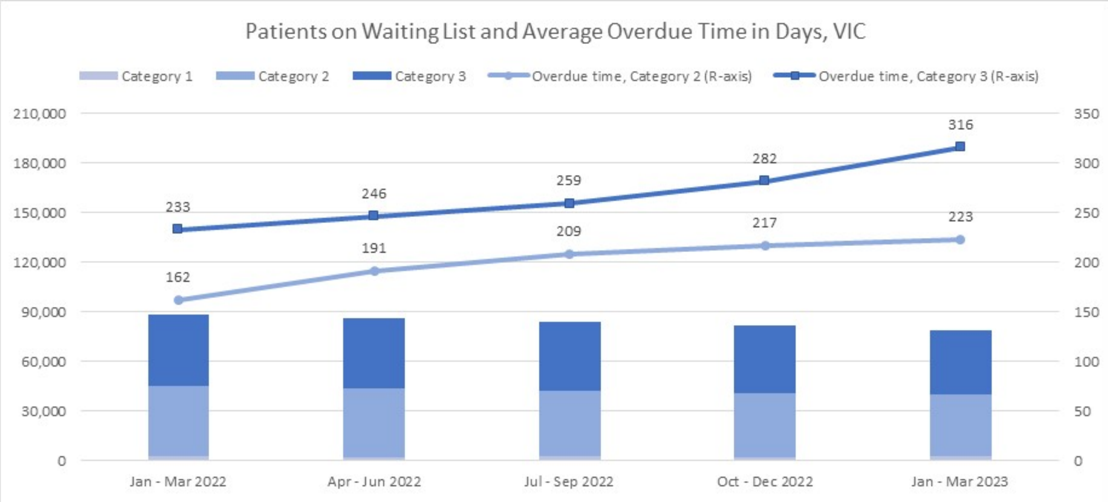
Figure 28 – Numbers of patients on the waiting list for surgery in NSW beyond clinically recommended times – 2018-22



While we have been unable to source figures for pre-2022 years, data[29] shows that at the end of December 2022 there were almost 82,000 patients on the elective surgery waiting list in Victoria. Figure 29 shows that over the 2022 year, the average overdue wait time increased significantly; Category 2 increased from 162 days in the March quarter to 217 days in the December quarter, while Category 3 increased from 233 days to 282 days.

[29] Source: Victorian Agency for Health Information, *Victorian Health Services Performance*

Figure 29 – Patients on the Waiting List and Average Overdue time (in days), Vic



So while it appears that the impact of the pandemic on Australia's cancer screening programs was quite short-lived, the impact on elective surgeries has been, and continues to be, quite dramatic.

Likely impact in Australia in 2022: Low to Moderate

3.5 Undiagnosed COVID-19

Some of the excess deaths could be from unidentified COVID-19. This effect happened early in the pandemic, but it seems less likely in 2022, as testing is much more available, particularly for those who are seriously ill (although for mild illness, testing is clearly reduced). While for any deaths where COVID-19 may be suspected, post-mortem testing is occurring in Australia, it is possible that some deaths caused by COVID-19 with unusual symptoms (e.g. some sudden cardiovascular deaths) may not be identified as caused by COVID-19. The timing of the higher levels of non-COVID-19 excess deaths (once COVID-19 *related* deaths are also removed) coinciding with high levels of COVID-19 deaths suggests that there may be some undiagnosed COVID-19 deaths.

Likely impact in Australia in 2022: Low, perhaps higher during COVID-19 peaks

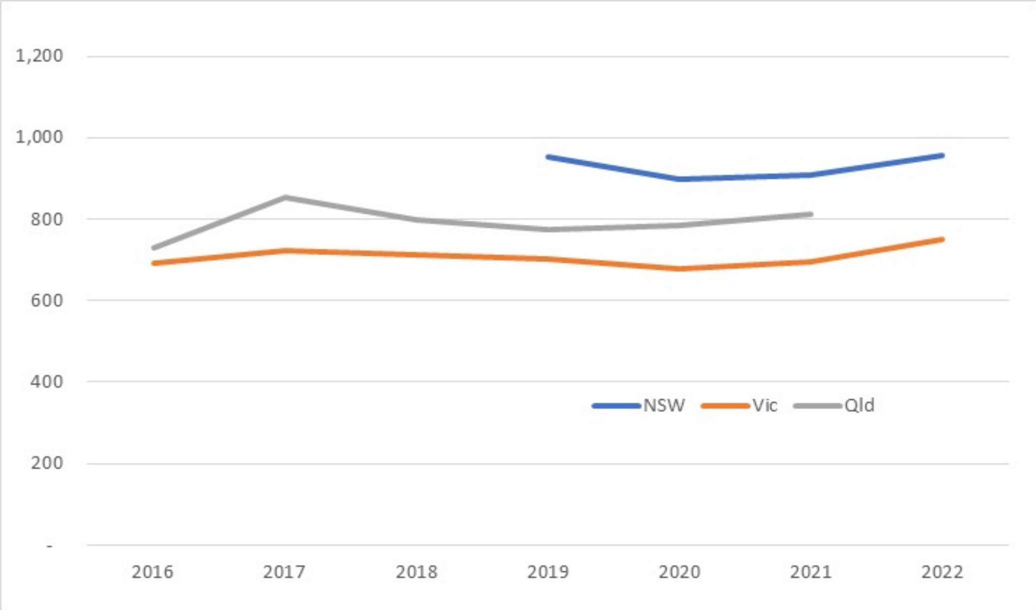
3.6 Mental health issues

There has been much discussion throughout the pandemic about the impacts on mental health, including commentary that lockdowns and other measures are causing an increase in suicide deaths. Data from the 2021 ABS Causes of Death, Australia publication shows that age-standardised suicides rates for both males and females were lower in 2020 and 2021 compared with the preceding three years, noting that the 2020 and 2021 data is preliminary. The publication also shows that 3.2% of suicide deaths in 2020 (0.06% of all deaths) and 2.6% in 2021 (0.05% of all deaths) had the pandemic mentioned as a risk factor. Even where the pandemic was a risk factor, there were, on average, five other risk factors.

Three states (NSW[30], Victoria[31], and Queensland[32]) publish preliminary suicide statistics. For NSW and Victoria, data is available up to and including 2022, but for Queensland the data is only available to 31 December 2021. Figure 30 shows the number of suicide deaths in each year for Victoria, NSW and Queensland, after adjustment for changes in population size.

30 *NSW Suicide Monitoring System, Report 31, Data to March 2023*, NSW Health
31 *Coroners Court Monthly Suicide Data Report*, May 2023 update, Coroners Court of Victoria
32 *Suicide in Queensland: Annual Reports 2018-2022*, Griffith University

Figure 30 – Yearly suicide deaths, adjusted for 2021 population size – NSW, Victoria and Queensland



After adjusting for changes in the size of the population, suicide deaths in 2020 and 2021 for the three states shown are largely unchanged from pre-pandemic levels. However, both NSW and Victoria show an increase in the number of suicides in 2022:

- in NSW, suicide deaths in 2020 were 6% lower than in 2019, but then increased by 1% in 2021 and a further 5% in 2022;
- suicide deaths in Victoria in 2020 were 3% lower than 2019, but then increased by 2% in 2021 and 8% in 2022; and
- in Queensland, suicide deaths in 2020 were 1% higher than in 2019, and then a further 4% higher in 2021.

There has been plenty of anecdotal evidence of the impact of lockdowns and other stresses on mental health, but the statistics show that the number of suicide deaths appears to be largely unchanged in 2020 and 2021, at least in the three biggest states of Australia.

We are cognisant of the potential for increases in rates of suicide in the next few years as the longer-term consequences of financial and other distress can take some time to emerge, and we may be seeing some of this impact in the higher 2022 figures. Note, however, that while the number of suicides does appear to have increased in the two largest states in 2022, the absolute numbers of such deaths remain a very small proportion of all deaths and are not a major driver of excess mortality.

If you or anyone you know needs support call Lifeline on 131 114.

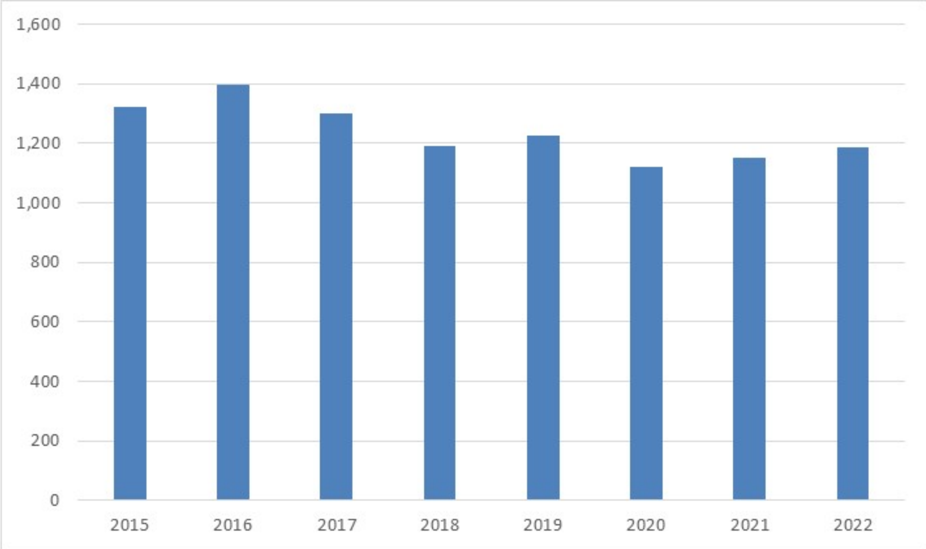
Likely impact in Australia in 2022: Low

3.7 Road deaths

The Australian Government via the Bureau of Infrastructure and Transport Research Economics (BITRE) publishes statistics on road accident deaths[33], including month of death and breakdowns by state/territory, age, gender, and road user type. Figure 31 shows the number of road deaths in each year, after adjustment for changes in population size.

[33] https://www.bitre.gov.au/publications/ongoing/road_deaths_australia_monthly_bulletins

Figure 31 – Yearly road deaths, adjusted to 2021 population size



For the 2020 year, the number of road deaths (after adjustment for changes in population size) was 9% lower than 2019, with most of the lower road toll occurring during the nation-wide lockdown of late-March 2020 to June 2020. Road deaths in 2021 were 3% higher than 2020, and then 2022 was a further 3% higher. The figures for 2020 to 2022 are the lowest per capita since records began in Australia, and they are broadly a continuation of existing trends.

Likely impact in Australia in 2022: Negligible.

3.8 Vaccine-related deaths

While there have been deaths in Australia caused by the administration of COVID-19 vaccines, the number of such deaths has been small. Australia's vaccine approval and safety monitoring processes are administered by the Therapeutic Goods Administration (TGA).

We note that the TGA is not a de facto coroner. The TGA does not make formal determination of the cause of death for an individual, as it is the role of treating medical practitioners, hospitals and coroners to determine the medical conditions that caused death. The TGA reviews reported individual deaths following COVID-19 vaccination to assess whether the information provided suggests a possible link between vaccination and the cause of death, with a view to taking public health action if necessary. The case reviews consider the strength of the available evidence to determine whether the medical conditions that led to a fatal outcome represent an emerging safety signal for the vaccine.

From the TGA website:

> *"Vaccines can lead to death in extremely rare instances. However, most deaths that occur after vaccination are not caused by the vaccine. In large populations in which a new vaccine is given, there are people with underlying diseases who may die from these diseases. When a vaccine is given in that same population, the link between the vaccine and death is usually coincidental – not caused by the vaccine. These deaths are carefully reviewed to assess whether vaccines could be the cause and for the vast majority that is not the case."*

The TGA's latest COVID-19 vaccine safety report (to 15 June 2023) shows that, of the 991 reports of death following vaccination, only 14 were found to have been linked to the vaccine. The TGA has not found a link between vaccination and death for the remaining reports. This may be due to either there being insufficient information to assess any potential link, or that available information indicates that the death was due to other, unrelated causes.

The next two graphs show a comparison of the vaccine rollout in Australia compared with excess deaths. Figure 32 compares the administration of first doses against non-respiratory, non-COVID-19 excess deaths, while Figure 33 compares the administration of all doses to the same excess deaths.

Figure 32 – Vaccine rollout versus excess deaths – First vaccine doses

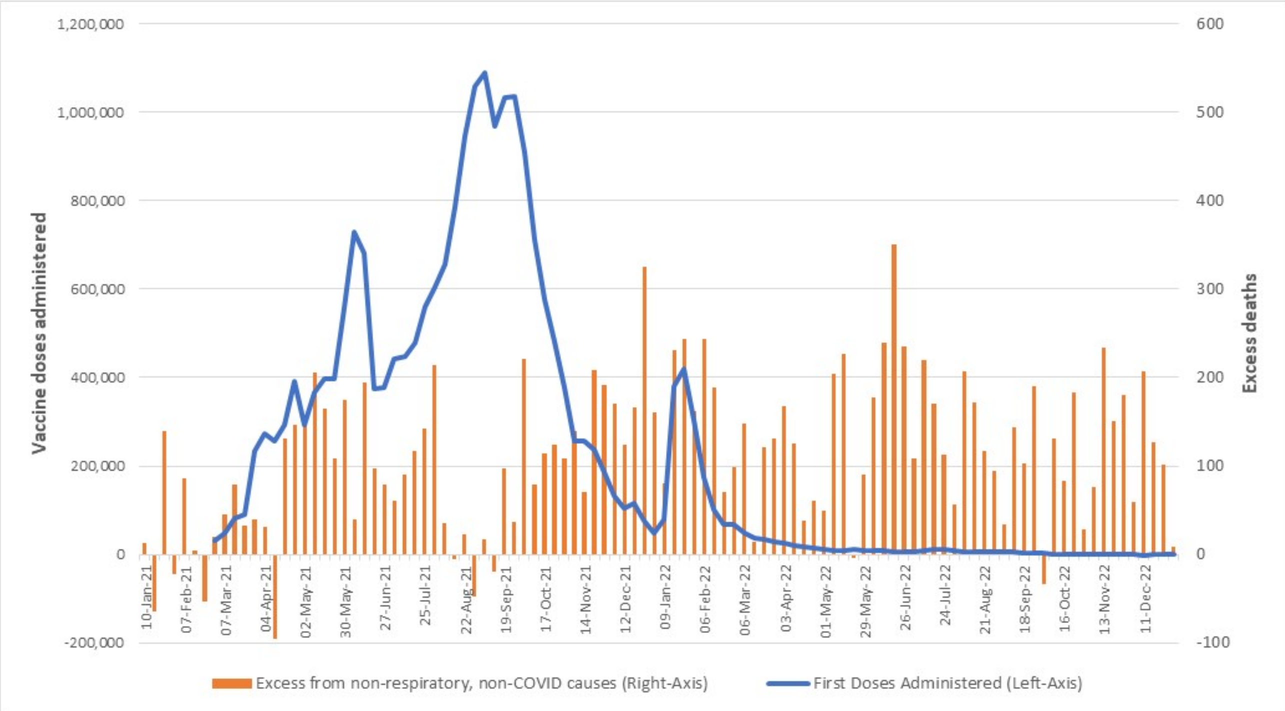
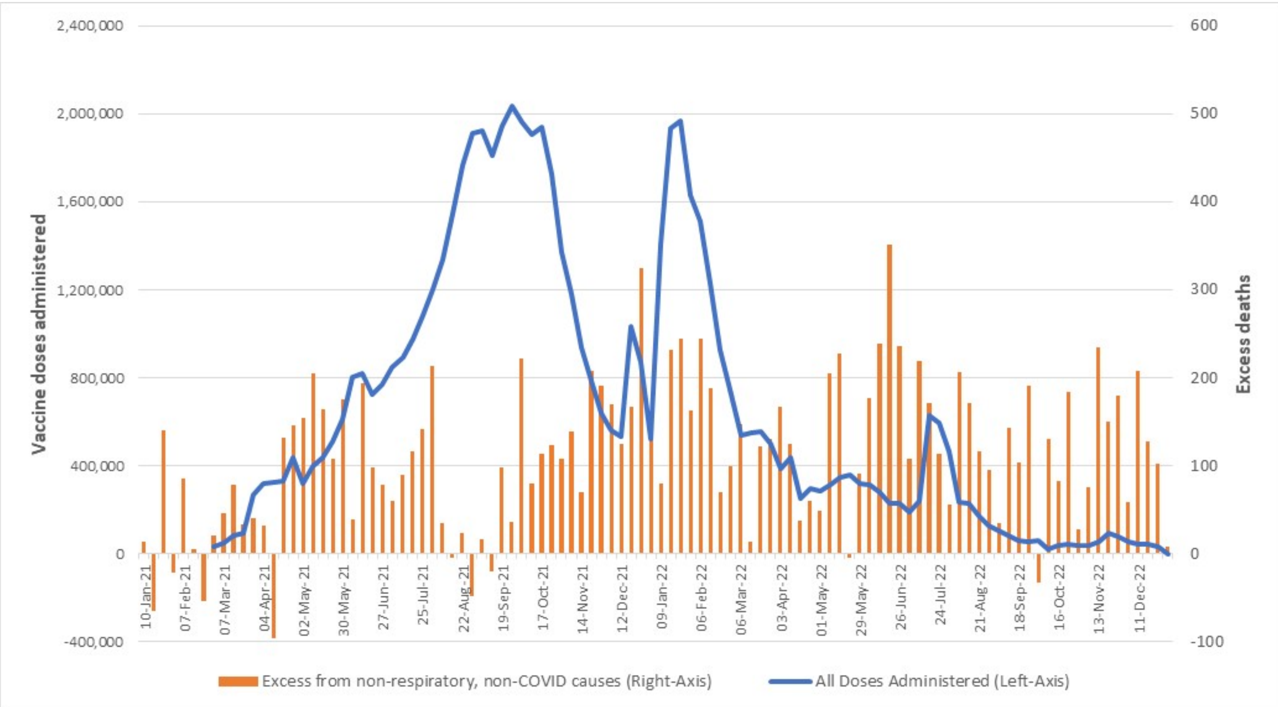


Figure 33 - Vaccine rollout versus excess deaths – All vaccine doses



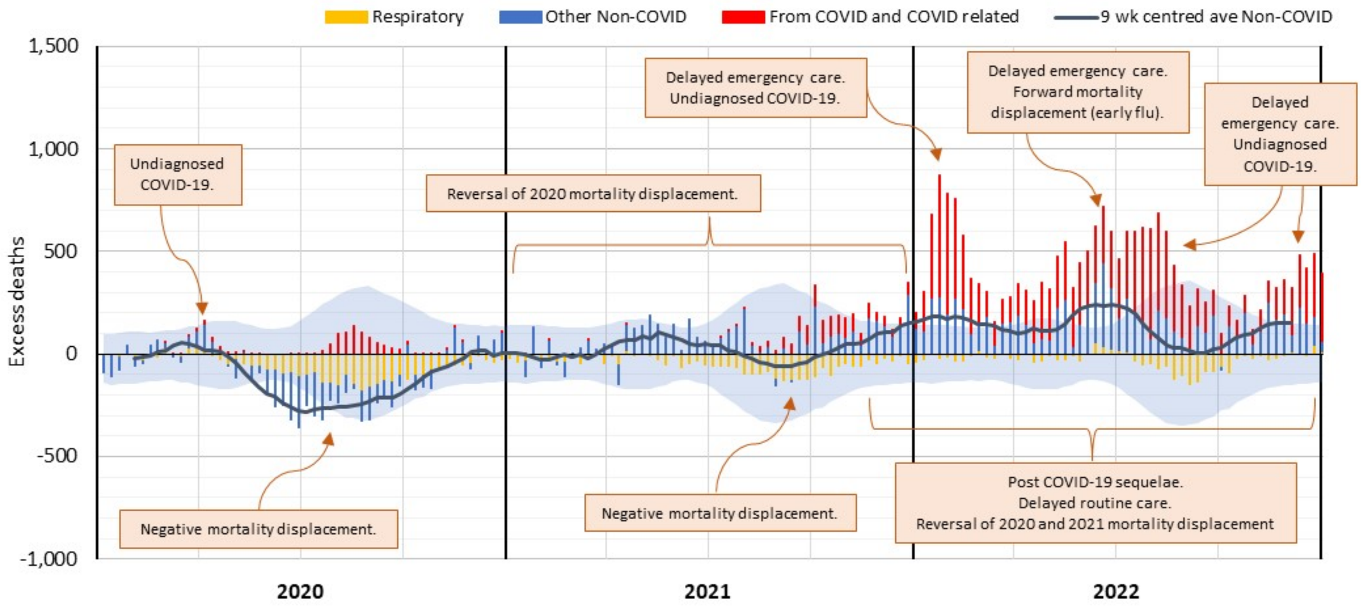
The vaccine rollout ramped up slowly from February 2021, with high rates of vaccination in August to October 2021 and again in January 2022, but has been low for most of 2022. This does not fit with the timing or shape of the excess mortality.

Likely impact in Australia in 2022: Negligible.

3.9 Summary of possible impacts

Figure 34, which shows excess deaths from doctor-certified respiratory disease, other non-COVID causes and those *from* COVID-19 and that were COVID-19 *related*, puts the above into context, across the pandemic.

*Figure 34 - Possible causes of non-COVID-19 excess mortality from time to time during the pandemic**



* *COVID-19 data from ABS customised report 2023*

4 Australian excess mortality in context: what happened in the rest of the world?

4.1 Methodology

As discussed earlier, the impact of COVID-19 on global and national mortality can best be seen by considering excess mortality. It is, therefore, interesting to consider how excess mortality differs between 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.

Our analysis of excess mortality in different countries revolves around two measures of mortality as a percentage of expected deaths:

- **total excess mortality**, which we have taken directly from OWID data, interpolating where required; and
- **COVID-19 mortality**, which we have calculated by dividing COVID-19 deaths by the expected deaths for the relevant period.

This has required us to derive expected deaths for each period, data that is not directly available in the OWID database[34]. We have done so by dividing actual deaths by (1 + excess mortality). Because of rounding, this will have introduced a small error that is unlikely to have had a material impact on our analysis.

4.2 Handle with care

We note that the approach used by OWID to calculate excess mortality is to compare reported deaths for each week or month with projected deaths[35] for that period based on the experience in 2015 to 2019. In turn, this generally uses estimates of expected deaths produced by Ariel Karlinsky and Dmitry Kobak as part of their World Mortality Dataset (WMD)[36].

This is subject to general uncertainty, to the extent that there may be reporting delays or errors. Also, there may be issues relating to the interpretation of data in some countries. For example, our own analysis gives slightly different rates of excess mortality in Australia. However, the WMD analysis is objective, and we do not expect any material differences in the context of our analysis.

In relation to COVID-19 deaths from surveillance reports, it is important to understand that the criteria vary between countries. For example:

- in Australia, it is a death following a positive test without a subsequent recovery, unless there is a clear alternative cause of death that cannot be related to COVID-19 (e.g. trauma); but
- in the UK, it is a death within 28 days of being identified as a COVID-19 case by a positive test, no matter what the cause of death or whether the person had recovered.

The likelihood that a person dying with COVID-19 has even had a positive test will also vary between countries, so our assessment of the contribution of COVID-19 to excess mortality in different countries is subject to considerable uncertainty.

[34] Note that OWID uses different expected values for each of 2020, 2021 and 2022, but the data item included in OWID called projected_deaths_2020_2022_all_ages is not a sum of these values hence cannot be used
[35] This is theoretically more accurate than OWID's previous use of the simple average of 2015-19 deaths
[36] GitHub - akarlinsky/world_mortality: World Mortality Dataset: international data on all-cause mortality.

4.3 Selected countries[37]

Appendix F contains tables, derived from OWID data, showing COVID-19 deaths and total excess deaths for 40 countries, in 2020, 2021, 2022 and all three years combined.

There are 90 countries for which, at the time of collecting our data (May 2023), OWID had produced excess death data covering the whole of 2020 and 2021 and most of 2022. We have selected the largest 33 of these (including Australia) by expected deaths, plus a further seven (Sweden, Azerbaijan, Denmark, Israel, Lithuania, New Zealand and Singapore) for their relevance. The reasons for selecting these additional countries are set out in Appendix G .

These 40 countries represent about 93% of the 90 by population[38] and by expected and actual deaths. They had 14.3% combined excess mortality across 2020-2022, with reported COVID-19 deaths representing 11.3% of expected deaths.

Adopting the criterion of "most of 2022" enabled us to include:

- The Philippines (9 months of data in 2022);
- South Africa (11.3 months);
- Iran (9.0 months);
- South Korea (7.0 months);
- Canada (10.9 months); and
- Peru (9.2 months).

Nevertheless, notable omissions[39] from the list include:

- four of the top five countries by population (China, India, Indonesia and Pakistan) and parts of Africa[40] – for which OWID has no data on excess mortality; and
- Ukraine, Türkiye, Argentina and Algeria – which are in the OWID top-30 for expected deaths but for which OWID has little or no excess mortality data for 2022.

The latter four countries are included in individual country charts in Appendix F .

We have been able to use a larger set of 121 countries for regional analysis. These are countries that we had excluded from detailed analysis on the grounds of size or the incompleteness of data. They include the four countries listed above.

Our 40 selected countries represent about 82% of the expanded set by population and 84% by expected annual deaths.

In our analysis, we have grouped countries in accordance with the UN geoscheme[41] to provide an objective basis for comparison at a regional level. For this purpose, we have combined some regions to give a total of eight, being:

- Oceania;
- South-East & East Asia;
- Other Asia;
- North America;
- Latin America (including the Caribbean);
- Northern & Western Europe;
- Southern & Eastern Europe; and
- Africa.

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[37] We use "country" as a shorthand, given that the list includes Taiwan on the basis that it is in the top 30 territories by expected deaths in the available OWID data

[38] Total population of the 40 countries is over 2.2 billion

[39] Countries that would have made the top 40

[40] Egypt and South Africa are included in our 40 countries, and there are only two others of reasonable size (Algeria and Tunisia) for which OWID has any excess mortality data at all

[41] Found at https://en.wikipedia.org/wiki/List_of_countries_by_United_Nations_geoscheme

4.4 Excess mortality by region in 2020-22

Figure 35 – Excess mortality by region in 2020-22, showing differences in regional trends

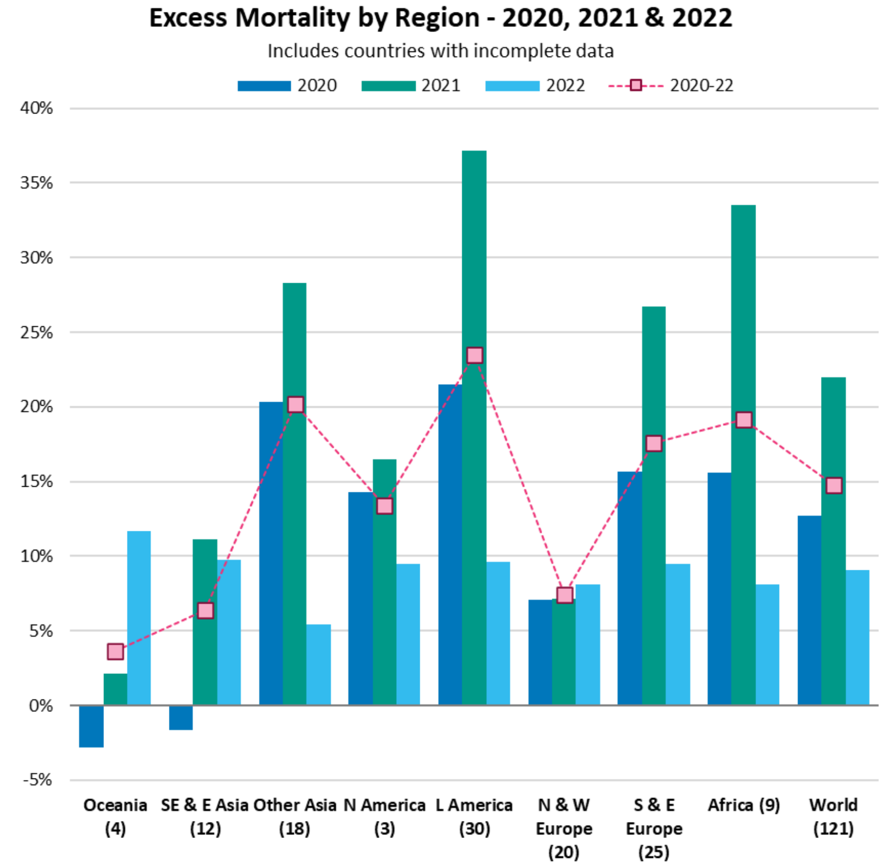


Figure 35 shows that there are significant regional differences in mortality experience.

Oceania (dominated by Australia) had negative excess mortality in 2020 and a low positive excess in 2021, but it had the highest excess mortality in 2022.

SE & E Asia also had negative excess mortality in 2020. Excess mortality was over 10% in 2021 (still only half the world average), falling back below 10% in 2022, to a level just above the world average.

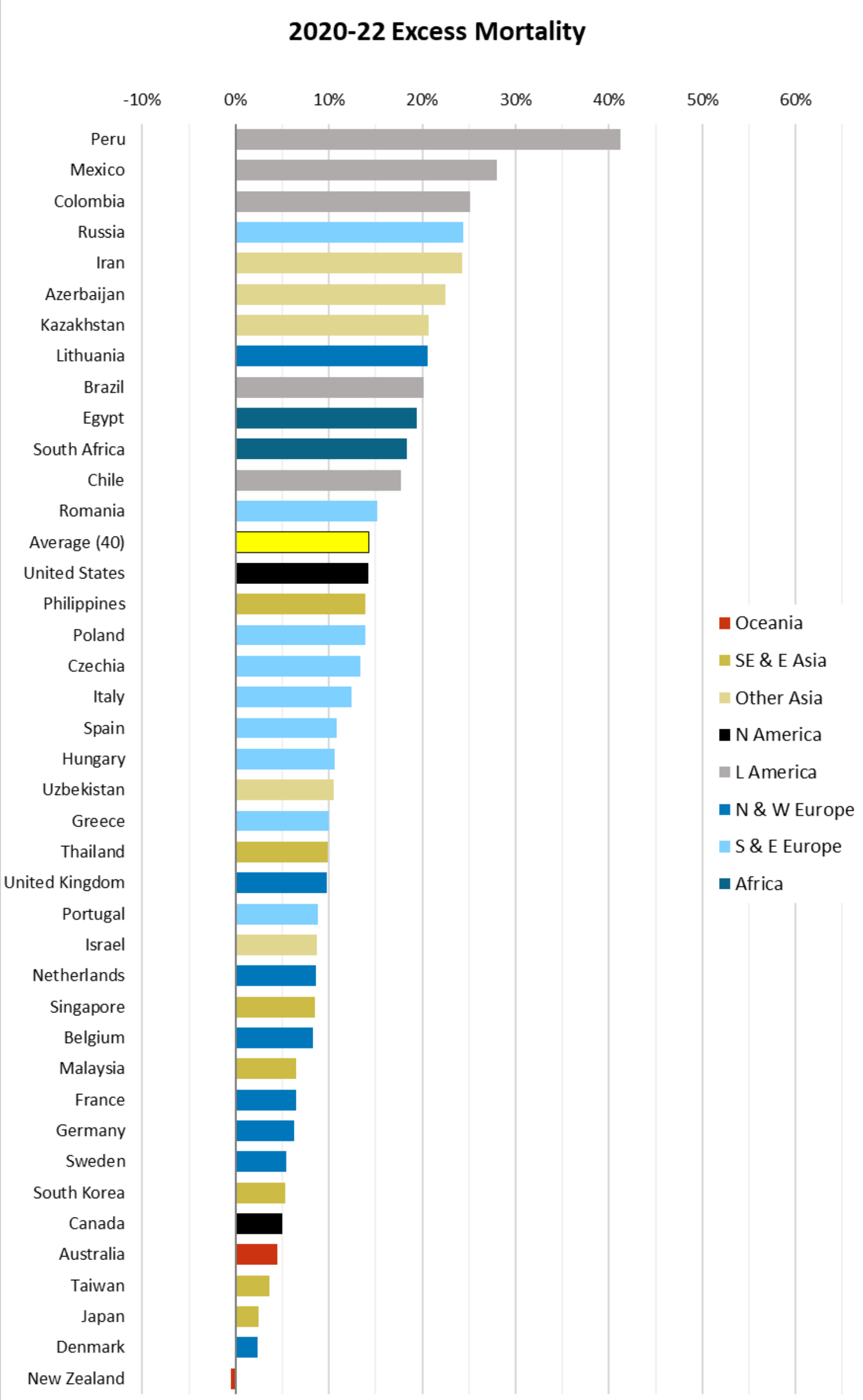
N & W Europe, which is generally quite wealthy, has seen excess mortality below the world average every year, but the rate is increasing.

North America (dominated by the USA) had excess mortality above the world average in 2020, with an increase in 2021 and a drop in 2022.

All other regions had excess mortality that was high in 2020 and very high in 2021, dropping to relatively low levels (around or below the world average) in 2022. There are few wealthy countries in these regions.

4.5 Overall excess mortality by country in 2020-22

Figure 36 – Excess mortality for three years ending 31/12/22, as a percentage of expected deaths



Source: Our World in Data (OWID) and analysis. Excess mortality relative to projected deaths.

Figure 36 shows that almost all our 40 selected countries had positive total excess mortality across the three years, with an average of 14%. New Zealand (-0.5%) was the only exception.

Excess mortality has been very high in Latin America, averaging about 24% over the three years.

South-East and East Asia have generally had lower excess mortality than Other Asia (especially Iran, Azerbaijan and Kazakhstan, which are near neighbours, all bordering the Caspian Sea). Similarly, Northern and Western Europe has generally lower excess mortality than Southern and Eastern Europe.

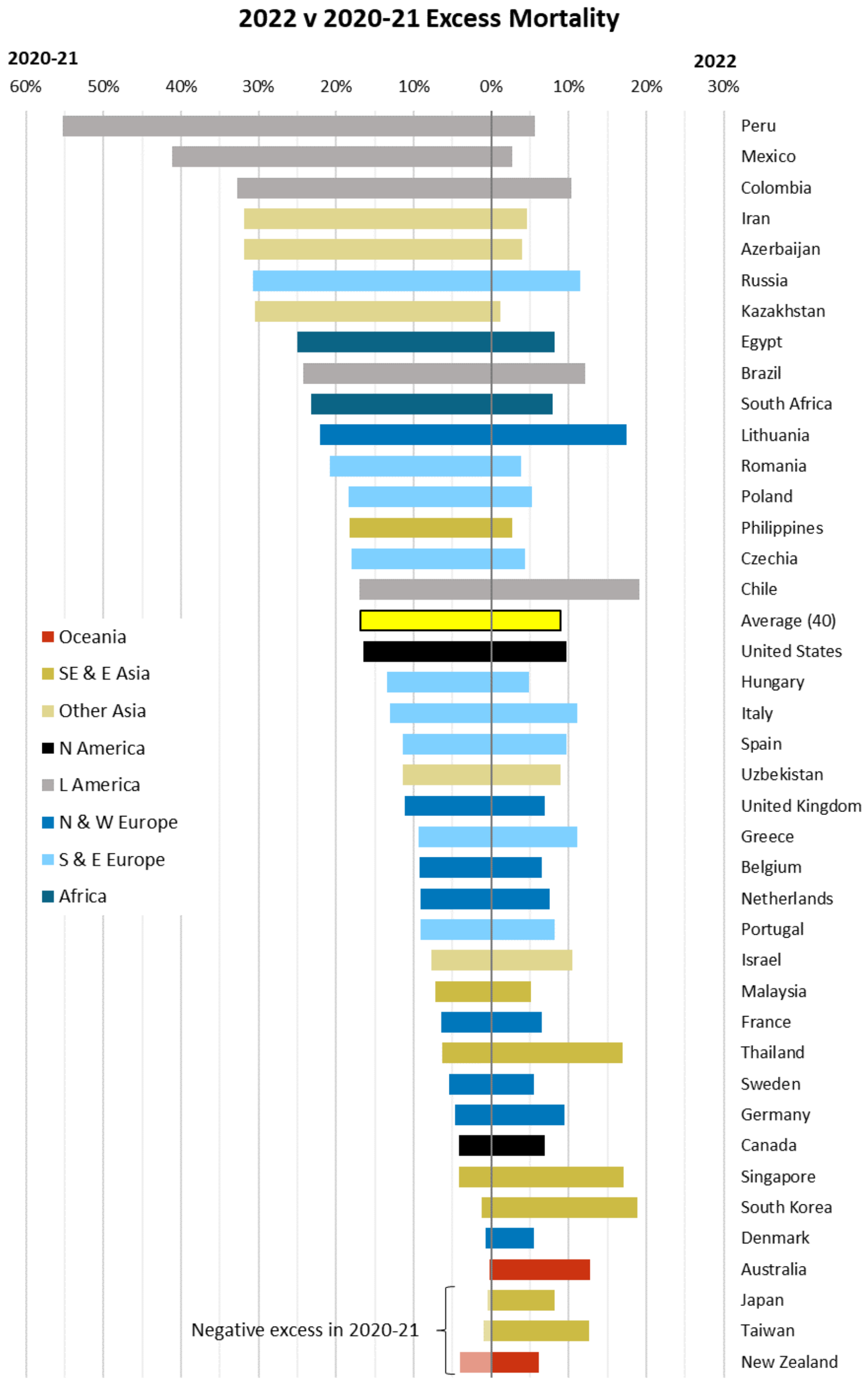
The United States has experienced 14% excess mortality across the three years, far higher than Canada (5%). The difference is mostly due to COVID-19, with excess mortality from other causes at 2% in the United States and -1% in Canada, although there is evidence[42] that deaths from accidents (which include opioid poisoning, road deaths and firearms deaths) have continued to climb in the United States.

Despite high excess mortality in 2022, average Australian excess mortality (4%) is among the lowest of the countries included in our selection.

In our regional analysis above (Figure 35), we have seen several examples of high 2020-21 excess mortality followed by quite low 2022 excess mortality, and vice versa. It is interesting to consider the comparison between 2020-21 and 2022 for all our selected countries. Figure 37 shows the excess mortality for the 2020-21 years (LHS) versus the 2022 year (RHS), with the countries ordered from highest 2020-21 excess mortality to lowest. Note that three countries had negative excess mortality in 2020-21. For ease of comparison, the 2020-21 excess mortality for these countries is shown as if it were positive, but in a lighter shade.

[42] See, for example, https://marypatcampbell.substack.com/p/us-mortality-trends-through-the-pandemic

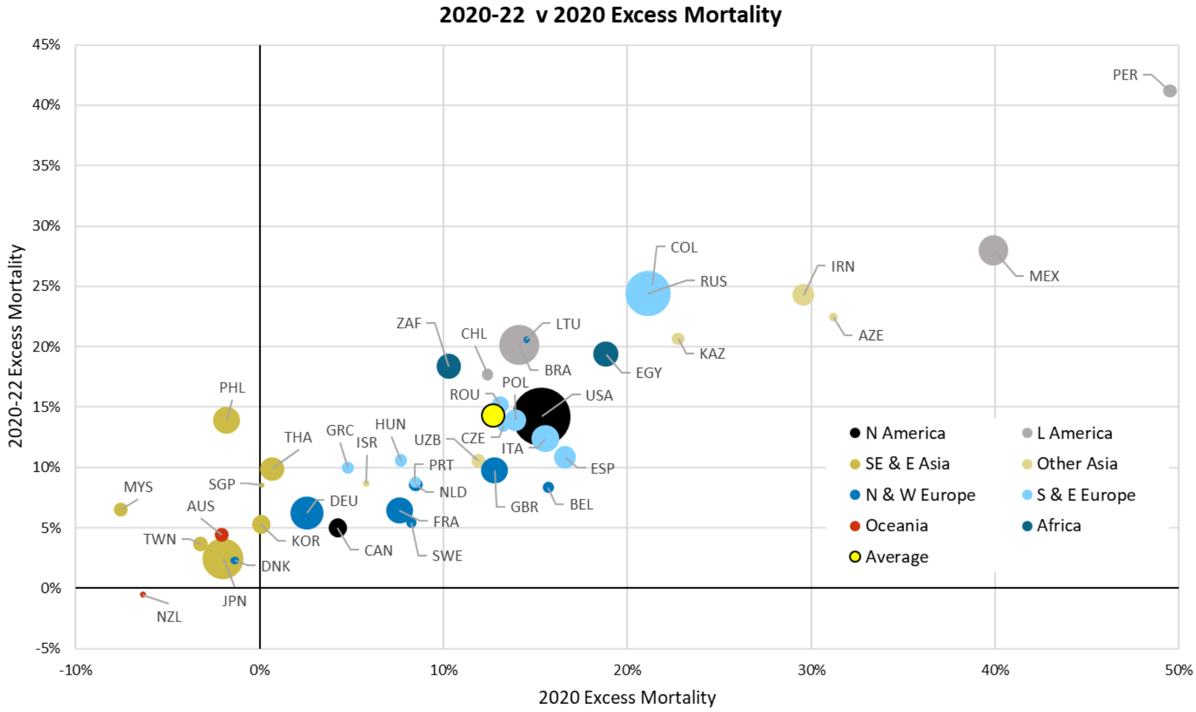
Figure 37 – A comparison of 2020-21 and 2022 excess mortality, showing a general inverse relationship



Source: Our World in Data (OWID) and analysis. Excess mortality relative to projected deaths.

Figure 37 confirms that there is something of an inverse relationship between excess mortality in 2020-21 and that in 2022. It is encouraging that most countries with high excess mortality in 2020-21 have relatively low excess mortality in 2022. Perhaps this reflects a degree of mortality displacement. This relates to the fact that there are many people whose age and health unfortunately mean that they are expected to die within one or two years – a period that can be cut short by respiratory disease such as flu. Contracting COVID-19 hastened death for some, while defence measures protected others from both COVID-19 and other respiratory diseases, gaining them an extra year or two of extra life.

Figure 38 – Comparison of excess mortality in 2020-22 with excess mortality in 2020, showing that overall excess mortality is highly correlated with performance in the first year of the pandemic



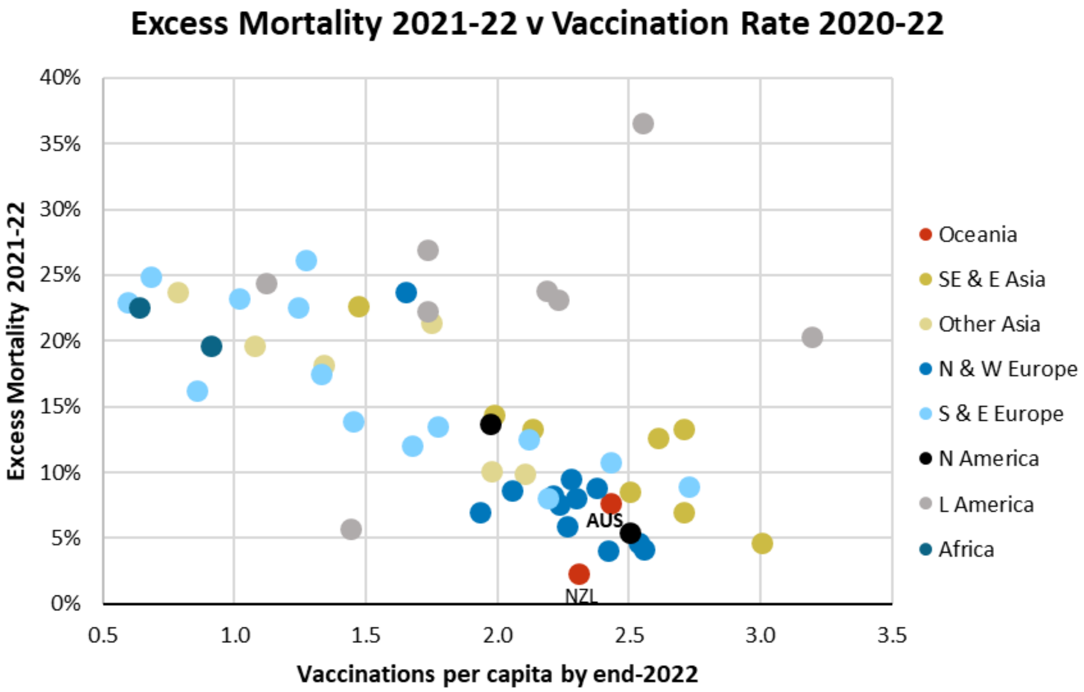
Sources: Our World in Data (OWID), Worldometer and analysis. Excess mortality relative to projected deaths. Bubble size is projected deaths.

Despite the comment above, Figure 38 shows that there is a very strong correlation between 2020 excess mortality and the total excess over 2020-22 for our 40 countries. There has not been a relative catch-up of lives saved in 2020 by lockdowns and other defence measures.

4.6 Comparing excess mortality with reported vaccination rates

It is also likely that the level of vaccination (defined as the number of vaccinations per capita at the end of 2022) affects the level of excess mortality.

Figure 39 – Comparison of excess mortality with vaccination rates for 54 countries, showing an inverse relationship



Source: Our World in Data (OWID) and analysis. Excess mortality relative to projected deaths.

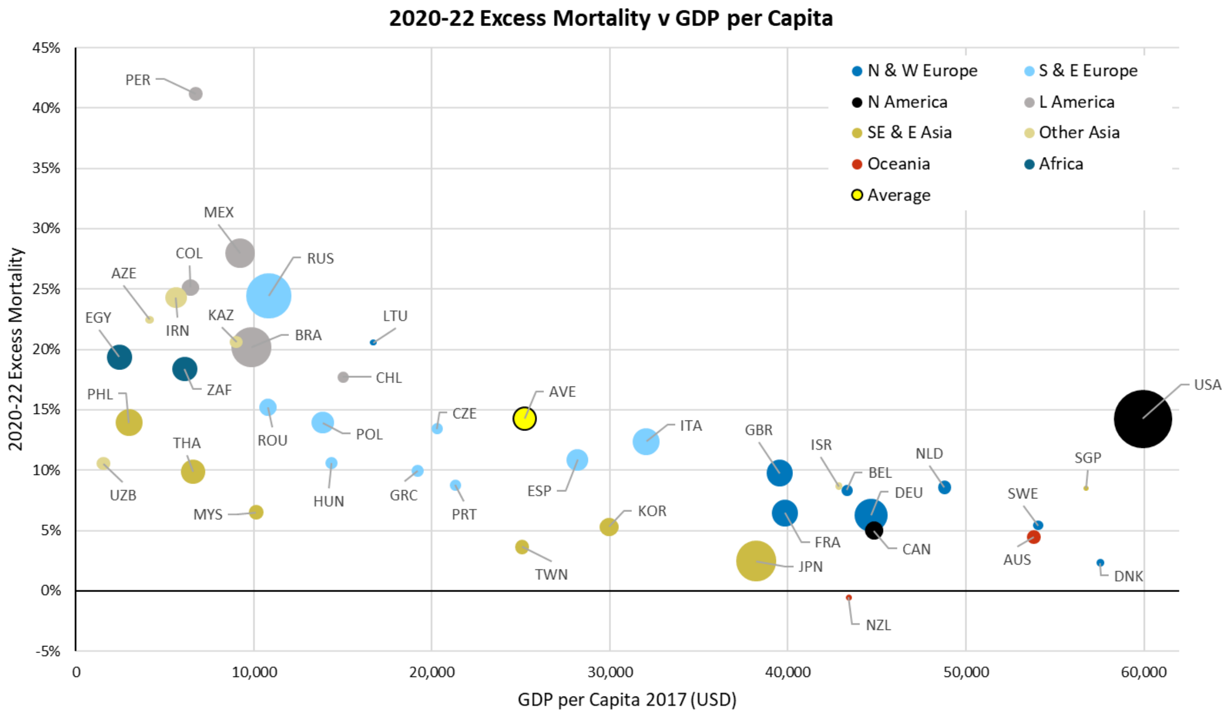
Figure 39 covers our 40 selected countries plus 14 smaller ones for which sufficient data is available. It shows that higher rates of vaccination per capita are associated with lower excess mortality across the two years when vaccines were widely available: 2021 and 2022. However, there are clear outliers, including most of the Latin American countries (top right of the chart).

Note that there are several limitations in this relationship, including the different speeds of take-up of vaccines between countries and the fact that a broad measure of vaccination rates tells us nothing about the extent to which the most vulnerable (due to age and/or health) have been protected.

4.7 Comparing excess mortality with GDP

It is also worth considering the impact of wealth (measured by GDP per capita) on excess mortality.

Figure 40 – Comparison of 2020-22 excess mortality with per capita GDP, showing a clear inverse relationship



Sources: Our World in Data (OWID), Worldometer and analysis. Excess mortality relative to projected deaths. Bubble size is projected deaths.

The inverse relationship between per capita GDP and excess mortality for our 40 selected countries can be seen in Figure 40. Interestingly, the USA is an outlier. Given its wealth, it would be expected to have achieved a much lower level of excess mortality. Singapore, too, appears to be above the trend, while other countries in the SE & E Asia region appear to have done better than might have been expected based solely on per capita GDP.

Among the poorer countries in the chart, the Latin American countries are generally perhaps also above the trend, as are Russia and Lithuania.

Overall, we consider that this chart demonstrates the significant advantage of wealth in the face of a pandemic.

An alternative perspective is the impact of excess mortality on GDP. To assess this, we have measured excess real GDP in 2023 Q1 by comparing actual real GDP with what it would have been if pre-pandemic trend growth had continued since 2019 Q4[43]. Comparing this with cumulative excess mortality since 2020 gives an indication of whether lower excess mortality has come at a significant economic cost.

[43] To do this, we used the series *LNBQRSA: National currency, chained volume estimates, national reference year, quarterly levels, seasonally adjusted* from OECD.stat

Figure 41 – A comparison of 2023 Q1 excess real GDP (compared with pre-pandemic trend) with cumulative excess mortality, showing a weak positive correlation (countries identified by two-digit ISO 3166-1 codes)

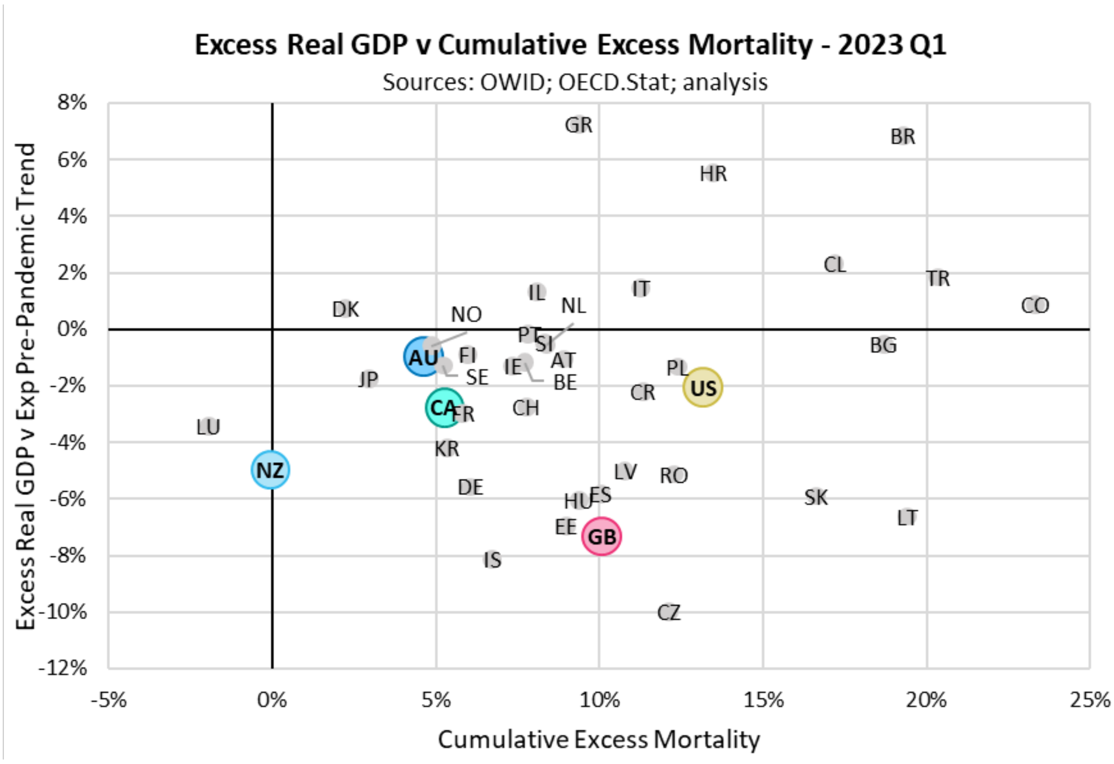


Figure 41 shows this comparison for the 41 countries for which there was relevant data. Higher excess mortality since 2020 shows a weak positive correlation (R^2 = 4.5%) with real GDP, relative to pre-pandemic GDP growth trends. In other words, there may be an economic cost of implementing policies to reduce deaths directly related to the pandemic.

However, this data covers countries of differing wealth and in different regions. Perhaps these differences introduce too much noise?

In an attempt to answer this question, we now consider a region that is well represented in the data, where most of the countries are quite wealthy – namely, Northern & Western Europe. If we focus on the largest countries in this region, we get a different picture:

Figure 42 – A comparison of 2023 Q1 excess real GDP (compared with pre-pandemic trend) with cumulative excess mortality, for 12 countries in N & W Europe, showing a clear negative correlation

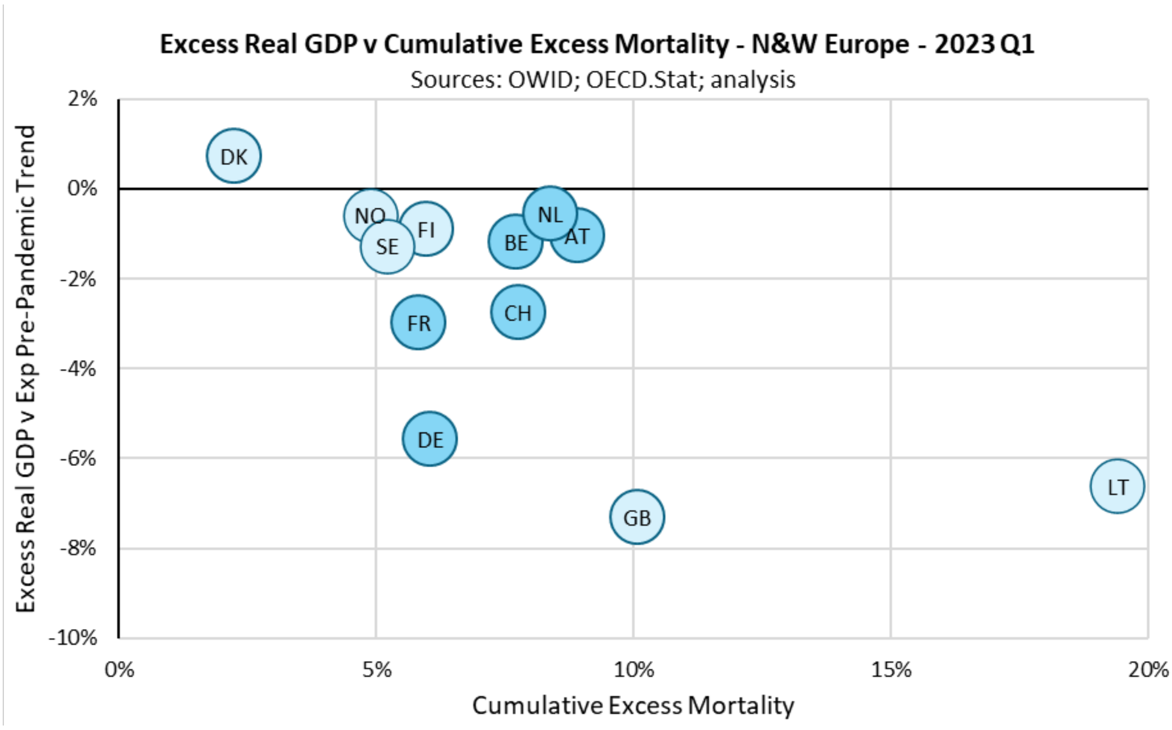


Figure 42 is the same as Figure 41, except that it only shows the 12 largest countries in Northern and Western Europe by expected annual deaths.

Now, there is a clear negative correlation (R^2 = 42%) between excess real GDP and excess mortality. In other words, those countries that have had lower excess mortality have also experienced a better economic outcome.

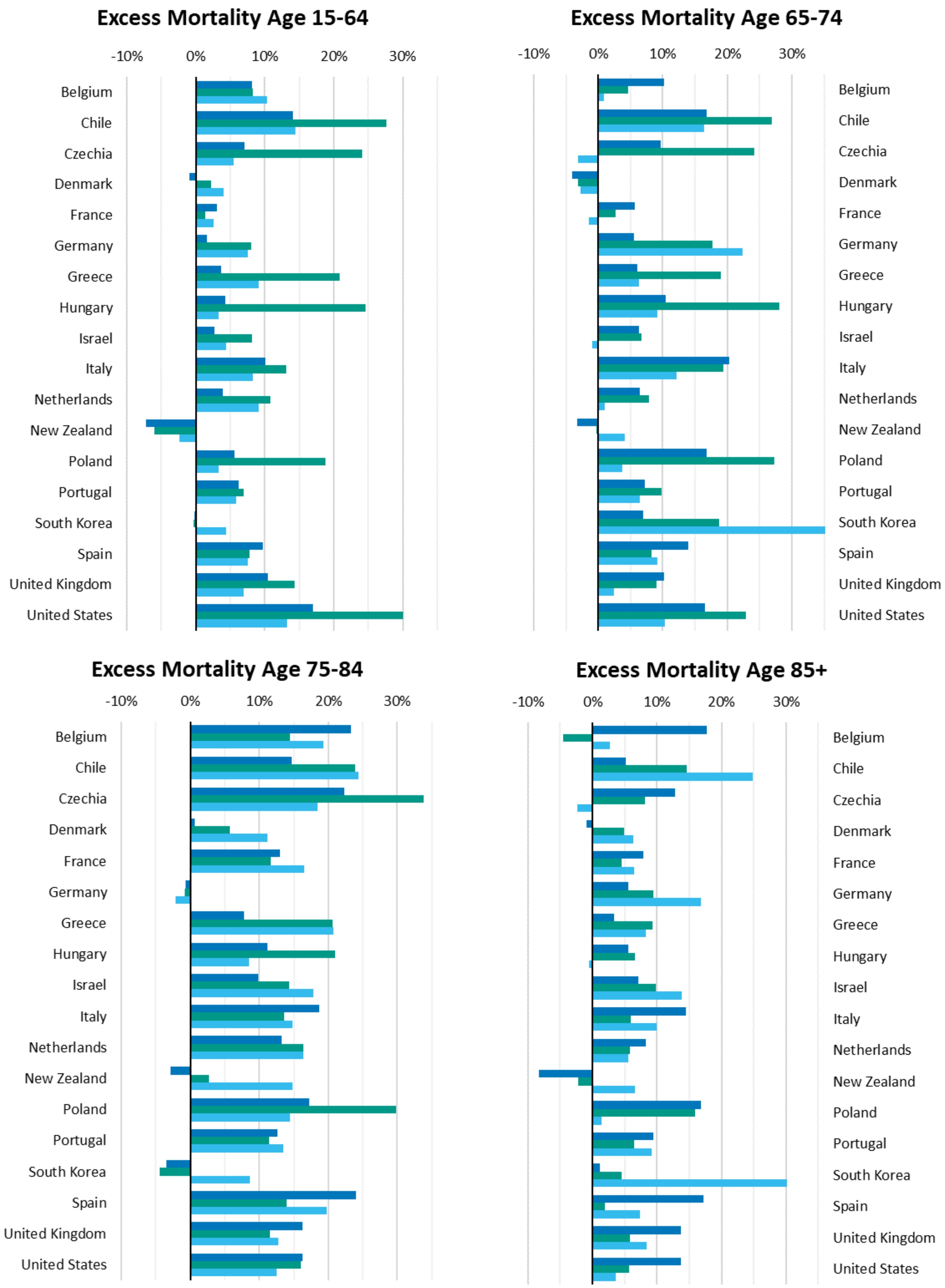
It is still possible that there are confounding sub-trends. In the top left of the chart, the four Nordic nations (Denmark, Norway, Sweden and Finland) support the negative correlation, as do their fellow Northern European countries, the United Kingdom (GB) and Lithuania. However, the trend among the more darkly shaded Western European countries (France, Germany, Switzerland, Belgium, Netherlands and Austria) appears strongly positive.

4.8 Excess mortality by age

OWID data allows us to drill into excess mortality by age group for some countries. The data gives weekly excess mortality rates, as a percentage of projected deaths. We derived annual excess mortality rates as a simple average of weekly rates. This will introduce a small error, because projected deaths are cyclical, but we think that the results are still meaningful.

This OWID data does not include Australia, but we do have data for New Zealand, which had broadly similar experience.

Figure 43 – Excess mortality by age group and year for 18 countries, ages 15+, on a consistent scale



Source: Our World in Data (OWID) and analysis.
Excess mortality relative to projected deaths.

Figure 43 shows that excess mortality (as a percentage) has generally been highest in the 75-84 age group, although the highest individual annual reading (37.2%) was in 2022 for South Koreans aged 65-74. We note that 2021 saw the highest excess mortality rates in many countries in the younger age groups, but this rarely happened in the 85+ age group, and does not appear to vary depending on whether 2020 had been bad (e.g. Spain, Poland, Belgium, UK or USA) or good (e.g. NZ, Denmark or South Korea). This suggests that the elderly generally were vaccinated sooner, as one would expect given what we know about the staging of the vaccination rollout in most countries.

Figure 44 – Excess mortality by year for 18 countries, persons aged 0 to 14

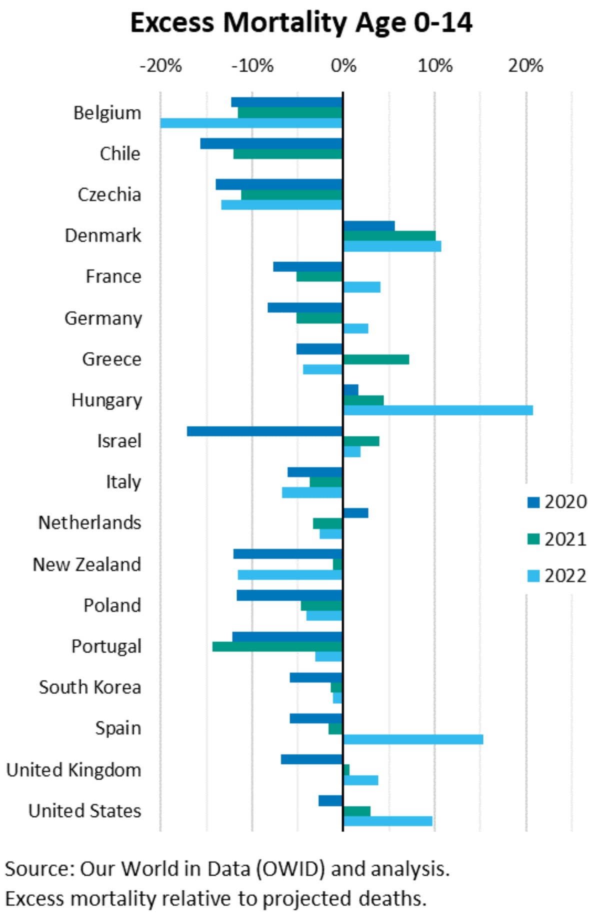


Figure 44 shows the youngest age group on a different scale from Figure 43, reflecting the generally lower (often negative) excess mortality in this age group. Note that Belgium recorded -34.8% excess mortality in 2022 – and OWID data suggests that year-to-date 2023 mortality in this age group is almost as low. It is not immediately obvious why this should be so.

Almost all countries had negative excess mortality in this age group in 2020, but almost half had positive excess mortality in 2022. Indeed, 2022 excess mortality exceeded 2020 in almost all age groups, as can be seen in Table 6.

Table 6 – Simple unweighted average of excess mortality of 18 countries by age group and year

Age Group	2020	2021	2022	All Years
0-14	-7.4%	-2.6%	-0.7%	**-3.6%**
15-64	5.5%	12.3%	6.5%	**8.1%**
65-74	9.0%	13.9%	7.4%	**10.1%**
75-84	11.9%	14.2%	14.6%	**13.5%**
85+	8.4%	6.2%	8.8%	**7.8%**

Table 6 shows a simple, unweighted average of excess mortality by age group across all 18 countries for each year and for all three years combined. It confirms the observation that excess mortality (as a percentage) has been highest in the 75-84 age group. This may relate to the fact that this age group is more independent (and therefore less protected) than the 85+ but is still highly vulnerable to COVID-19 and its complications.

5 What does the future hold?

Prediction is very difficult, especially if it's about the future![44]

We include this quote from Niels Bohr, as we did in our previous Research Note, because it has been hard enough to form a view about what has already happened, and yet we will now attempt to predict (or at least sketch) the future.

Prophecy is a good line of business, but it is full of risks.

Mark Twain said this, and it is a good reminder that even understanding the present is difficult enough, but prediction is much harder.

5.1 Mortality

How do we predict mortality in the future after these three years of COVID-19 experience? There are a number of contributors to future mortality, which we have briefly covered in the likely causes of the current excess mortality.

To some degree, we can also look to other countries where COVID-19 has been circulating in the population for longer than in Australia to understand what might happen.

Overall, in the authors' view, excess mortality is likely to be remain above zero for some years for two main reasons:

1. COVID-19 is likely to remain a significant (perhaps top 10) cause of death, which increases total deaths in the population, and
2. a population which has experienced COVID-19 infection, particularly multiple times, is likely to be sicker than it would have been without COVID-19 infections.

Working against these two forces that increase mortality, some population behaviour (staying home, staying away from vulnerable people, masking while sick, increased awareness of the importance of ventilation) seems to have reduced the incidence of a number of respiratory diseases in Australia, which will probably improve mortality longer term.

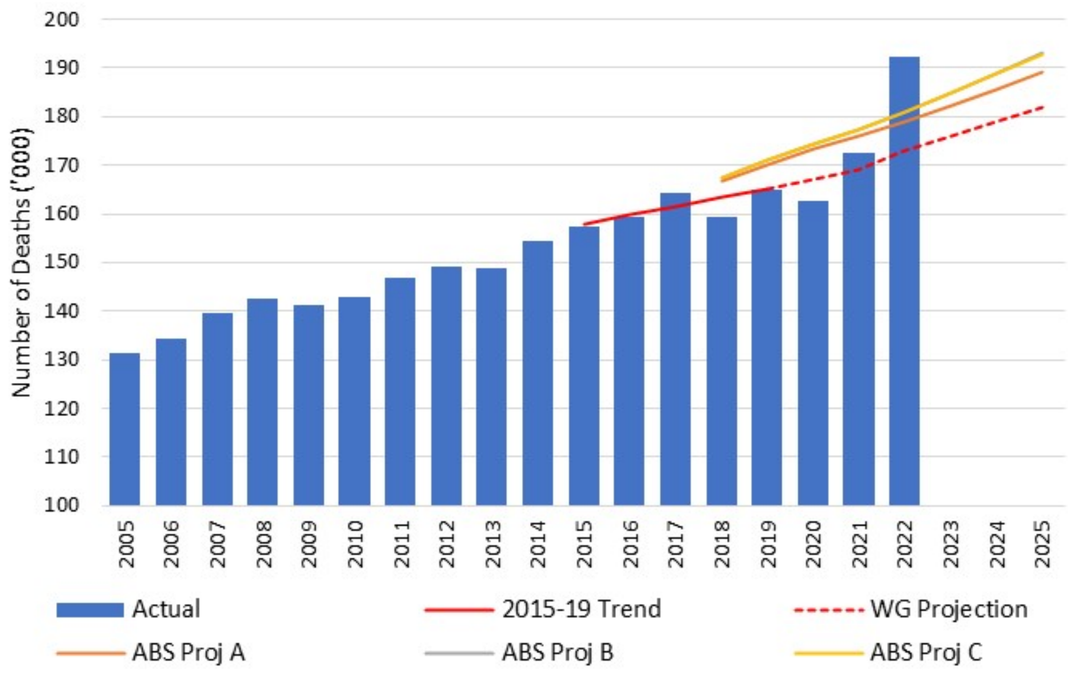
5.1.1 Projected deaths

In Section 2 of this paper we have used our own very specific model of mortality for Australia, which allows for actual population growth and demographic changes, and uses current trends in mortality from specific causes of death to project into the future.

The ABS, periodically, projects the total population of Australia for the next 50 years, an exercise which includes an overall projection of deaths. This projection was most recently performed in 2018 (released 22 November 2018) using the 2017 population as a base. There were three different projection scenarios (A, B and C). Figure 45, which is an extension of Figure 1, shows that these scenarios all had higher expected deaths than our projections (shown as "WG projections"), noting of course that we have had the benefit of two years of additional mortality on which to base our models.

[44] Niels Bohr, atomic physicist

Figure 45 – ABS projected number of deaths compared with 2015-19 trend and our projected deaths



Comparing the ABS projections with the 2015-19 trend in Figure 45, we can see that mortality projections can quickly become outdated, even without a pandemic. The ABS projections are about 6,000-8,000 (4-5%) higher than ours in 2022. As it happens, it does not seem unreasonable to project mortality at about 5% above the pre-pandemic trend, at least for the next few years.

We await the next series of ABS projections with great interest.

5.1.2 Evidence from overseas

We have seen (Sections 2 and 4) that Australia's excess mortality was 11% in 2022 and 4% for the three years 2020-22. Looking at the selected 40 countries in Section 4, we see that average excess mortality was 14% over the last three years, and just under 10% in 2022.

Section 4 shows a broad pattern that higher excess mortality in 2020 and 2021 tends to be correlated with lower excess mortality in 2022 – i.e., those countries that had more excess deaths earlier in the pandemic tended to have a lower excess mortality experience in 2022 than countries like Australia.

This suggests (but without a strong causal framework) that the direct contribution of COVID-19 to excess mortality is likely to reduce over time. However, as there are very few countries where excess mortality has reduced to zero, it seems unlikely to disappear entirely.

It seems likely that COVID-19, directly or indirectly, will continue to increase mortality in Australia.

5.1.3 Contribution of other (not directly COVID-19) issues to excess mortality

In section 3 we discussed a number of possible reasons for the high (non-COVID-19) excess deaths in Australia in 2022. These issues will continue into the future to various extents, and we have briefly reviewed their likely impact on future deaths here. In this section, when we talk about "the future impact" we are generally referring to impact in the next 1-5 years.

Post-COVID-19 sequelae or interactions with other causes of death

As noted in section 3, studies have shown that COVID-19 is associated with higher subsequent mortality risk from heart disease and other causes. Given the strongly increased deaths from heart disease that we have seen in the mortality statistics to date, it seems likely that this will continue for some time into the future.

Likely future impact in Australia: ***High***

Delay in emergency care

The contribution of delays in emergency care to future mortality will be largely dependent on how well the health system functions. Strain from COVID-19 (and influenza) infections is likely to still exist into the future, but the strain will depend on both the size of future COVID-19/influenza waves and the long term resourcing of the health sector.

Likely future impact in Australia: ***Reducing***

Mortality displacement

From looking at mortality around the world, it seems plausible that while mortality displacement has almost certainly occurred over the last three years, it is unlikely to continue (other than potentially short-term fluctuations with influenza seasons occurring outside of their longer-term seasonal pattern).

Likely future impact in Australia: ***Low***

Delay in routine care

Opportunities to diagnose or treat non-COVID-19 diseases have been missed over the last few years for various reasons, and we expect that the full impact on mortality of these delays have not yet been fully realised, given the long latency of some conditions such as cancer and chronic heart disease. However, in the current environment in Australia, it is likely that services have, or are, returning to normal. The notable exception to this is the longer-than-usual waiting lists for elective surgeries (see section 3.4), but various state governments are putting in place mechanisms to aim to address this[45].

Likely future impact in Australia: ***Increasing over the medium term (1-2 years), reducing over the long term as the health system catches up.***

Undiagnosed COVID-19

Undiagnosed COVID-19 will increasingly be the case as fewer people are tested for the disease. However, the overall contribution of COVID-19 to future mortality will remain whether diagnosed or not.

Likely future impact in Australia: ***Included in COVID-19 impact***

Mental health issues and road deaths

To date there has been little to no direct evidence of mental health issues or road accidents increasing death rates in the population, with the available statistics not showing a material increase at a population level.

Likely future impact in Australia: ***Low***

Vaccine-related deaths

While there have been deaths in Australia caused by the administration of COVID-19 vaccines, the number of such deaths has been small. While vaccinations continue regularly, the total vaccinations per member of the population are lower than they were in 2021, thus reducing the risk of death from vaccines further.

Likely future impact in Australia: ***Negligible***

[45] As an example, the Victorian state government announced in May 2023 their "planned surgery recovery and reform program", aimed at providing better and more timely health outcomes.

Non-pharmaceutical interventions (NPIs)

All of the above factors have been considered in the context of possible causes of **increased** mortality, but we have also seen that some of the non-pharmaceutical interventions introduced in Australia have acted to **reduce** mortality. To the extent that mask-wearing and other defence measures persist in vulnerable settings, this will likely lead to lower deaths from respiratory disease.

Likely future impact in Australia: ***Moderate to high negative contribution***

5.2 What is the new normal?

In our view, the "new normal" level of mortality is likely to be higher than it would have been in the absence of a pandemic. 2022 had 11% higher than predicted mortality. Our analysis[46] of the latest ABS *Provisional Mortality Statistics* report shows 6% excess mortality in 2023 Q1, with a likely upward trend for April and May. It is likely that 2023's excess will be lower than 11%, but probably at least 5%. Looking further ahead, we think that excess mortality (relative to no pandemic) will gradually decline over time.

While we think the level of excess mortality will decline, COVID-19 is likely to continue to cause **some** excess mortality for some years to come, directly as a cause of death and less directly, as a contributor to other causes such as heart disease. There will also be an indirect impact, with the largest contributor likely to be the ongoing consequences of disruption to usual healthcare practices in the last three years. Counter to this, to the extent that mask-wearing and other defence measures persist in vulnerable settings, this will likely lead to lower deaths from respiratory disease.

[46] https://www.actuaries.digital/2023/07/06/excess-mortality-running-at-6-for-the-first-three-months-of-2023/

Appendix A IBNR factors and scaling of deaths

This appendix sets out the allowances we have made for late reported deaths (IBNR factors) and also the factors used to scale past deaths to 2022 values for the age band/gender and state/territory calculations. These scaling factors are used as a proxy as standardised death rates are not available by age band/gender or by state/territory.

A.1 IBNR Factors

Table 7 shows the adjustments made for late reported deaths for 2022.

Table 7 – Adjustments for late-reported deaths

	Doctor certified deaths				Coroner referred deaths			
Week ending	Registered	Late Reporting	Percent Loading	Adopted deaths	Registered	Late Reporting	Percent Loading	Adopted deaths
3-Jan to 3-Jul	83,011	462	0.6%	83,473	11,298	56	0.5%	11,354
10-Jul-22	3,641	23	0.6%	3,664	471	2	0.5%	473
17-Jul-22	3,611	23	0.6%	3,634	513	3	0.5%	516
24-Jul-22	3,639	23	0.6%	3,662	508	3	0.5%	511
31-Jul-22	3,676	23	0.6%	3,699	487	2	0.5%	489
07-Aug-22	3,689	24	0.7%	3,713	519	3	0.5%	522
14-Aug-22	3,647	24	0.7%	3,671	475	2	0.5%	477
21-Aug-22	3,445	23	0.7%	3,468	485	2	0.5%	487
28-Aug-22	3,455	23	0.7%	3,478	427	2	0.5%	429
04-Sep-22	3,246	22	0.7%	3,268	478	2	0.5%	480
11-Sep-22	3,299	23	0.7%	3,322	475	3	0.6%	478
18-Sep-22	3,266	23	0.7%	3,289	426	3	0.7%	429
25-Sep-22	3,262	23	0.7%	3,285	416	3	0.7%	419
02-Oct-22	2,991	22	0.7%	3,013	416	3	0.7%	419
09-Oct-22	3,055	24	0.8%	3,079	444	3	0.8%	447
16-Oct-22	3,043	24	0.8%	3,067	414	4	1.0%	418
23-Oct-22	3,118	24	0.8%	3,142	406	4	1.1%	410
30-Oct-22	2,887	23	0.8%	2,910	421	5	1.1%	426
06-Nov-22	2,925	25	0.9%	2,950	453	6	1.4%	459
13-Nov-22	3,024	27	0.9%	3,051	464	8	1.7%	472
20-Nov-22	3,009	28	0.9%	3,037	424	8	1.8%	432
27-Nov-22	3,065	30	1.0%	3,095	413	7	1.8%	420
04-Dec-22	2,991	31	1.0%	3,022	429	11	2.5%	440
11-Dec-22	3,165	41	1.3%	3,206	417	12	3.0%	429
18-Dec-22	3,088	41	1.3%	3,129	425	16	3.8%	441
25-Dec-22	3,088	42	1.4%	3,130	469	18	3.8%	487
01-Jan-23	2,940	42	1.4%	2,982	477	22	4.6%	499

A.2 Scaling factors – by age band/gender

Table 8 – Population and other adjustments applied to actual deaths for each age band/gender

	Gender/Age Group										
Year	M, 0-44	M, 45-64	M, 65-74	M, 75-84	M, >85	F, 0-44	F, 45-64	F, 65-74	F, 75-84	F, >85	Total
Reported deaths											
2015	5,339	13,280	15,027	22,659	25,552	2,869	8,160	9,552	18,547	38,930	159,915
2016	5,180	12,910	15,252	22,657	25,892	2,856	7,980	9,572	17,932	38,219	158,450
2017	5,323	13,077	15,919	23,201	27,088	2,832	8,138	10,196	18,581	39,569	163,924
2018	5,057	12,996	15,629	22,632	26,485	2,666	8,200	9,985	17,855	37,574	159,079
2019	5,247	13,321	15,880	23,607	27,423	2,750	8,101	10,394	18,532	39,128	164,383
2020	5,153	13,196	16,291	24,004	27,695	2,748	8,224	10,425	18,771	38,247	164,754
2021	4,989	13,156	16,545	25,519	29,403	2,718	8,084	10,973	19,735	40,532	171,654
2022	5,149	13,832	17,784	29,066	33,512	2,824	8,715	11,547	22,151	45,356	189,936
Population (m)											
2015	7.29	2.88	0.99	0.50	0.17	7.12	2.97	1.02	0.58	0.30	23.82
2016	7.38	2.91	1.03	0.51	0.18	7.21	3.02	1.06	0.60	0.30	24.19
2017	7.48	2.96	1.06	0.53	0.18	7.30	3.07	1.10	0.61	0.31	24.59
2018	7.57	2.99	1.09	0.55	0.19	7.39	3.11	1.14	0.63	0.31	24.97
2019	7.67	3.03	1.12	0.58	0.19	7.47	3.14	1.18	0.66	0.31	25.34
2020	7.70	3.07	1.15	0.61	0.20	7.51	3.19	1.22	0.69	0.32	25.66
2021	7.65	3.09	1.17	0.64	0.21	7.45	3.19	1.25	0.71	0.33	25.69
2022	7.69	3.13	1.21	0.67	0.22	7.49	3.24	1.30	0.75	0.33	26.03
Population adjusted deaths											
2015	5,596	14,246	17,802	29,143	31,043	3,004	8,760	11,782	22,749	42,649	172,485
2016	5,368	13,688	17,427	28,298	30,165	2,953	8,422	11,359	21,519	40,990	168,256
2017	5,443	13,653	17,661	27,862	30,730	2,890	8,453	11,672	21,654	42,013	171,215
2018	5,107	13,402	16,826	26,202	29,312	2,689	8,419	11,008	20,235	39,492	163,676
2019	5,233	13,573	16,691	26,099	29,546	2,743	8,225	11,088	20,199	40,640	166,640
2020	5,114	13,268	16,602	25,196	28,894	2,727	8,232	10,696	19,562	39,081	164,965
2021	4,989	13,156	16,545	25,519	29,403	2,718	8,084	10,973	19,735	40,532	171,654
2022	5,120	13,645	17,241	27,596	32,438	2,808	8,588	11,104	21,178	44,606	187,459
Age Mix adjustments											
2015	99.1%	100.9%	102.2%	99.2%	103.6%	99.2%	101.3%	102.1%	98.6%	104.7%	110.2%
2016	99.5%	100.9%	102.0%	99.4%	102.7%	99.7%	101.3%	102.0%	99.0%	103.8%	108.7%
2017	99.9%	100.9%	101.2%	99.6%	102.1%	100.3%	101.3%	101.2%	99.2%	102.8%	107.6%
2018	100.2%	100.9%	100.6%	99.6%	101.5%	100.7%	101.1%	100.7%	99.3%	102.1%	106.4%
2019	100.3%	100.6%	100.3%	99.7%	101.0%	100.8%	100.8%	100.5%	99.4%	101.4%	105.0%
2020	100.2%	100.3%	100.1%	99.8%	100.6%	100.6%	100.3%	100.2%	99.6%	100.8%	103.0%
2021	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
2022	99.9%	99.6%	99.8%	100.0%	99.5%	99.7%	99.5%	99.7%	100.2%	99.3%	98.0%
Age mix adjusted deaths											
2015	5,545	14,374	18,201	28,919	32,162	2,979	8,876	12,026	22,428	44,646	190,155
2016	5,340	13,811	17,781	28,135	30,969	2,945	8,535	11,587	21,303	42,528	182,934
2017	5,436	13,781	17,868	27,752	31,374	2,899	8,562	11,814	21,483	43,193	184,160
2018	5,116	13,519	16,926	26,101	29,751	2,707	8,513	11,087	20,085	40,310	174,115
2019	5,251	13,656	16,743	26,028	29,850	2,764	8,290	11,139	20,078	41,214	175,013
2020	5,126	13,304	16,622	25,147	29,057	2,742	8,258	10,722	19,493	39,394	169,864
2021	4,989	13,156	16,545	25,519	29,403	2,718	8,084	10,973	19,735	40,532	171,655
2022	5,113	13,594	17,200	27,606	32,273	2,801	8,546	11,074	21,221	44,300	183,729
Delayed reporting allowance											
2021	20	53	67	105	122	11	33	45	81	168	704
2022	42	110	139	223	261	23	69	89	172	357	1,485
Total scaled deaths											
2015	5,545	14,374	18,201	28,919	32,162	2,979	8,876	12,026	22,428	44,646	190,155
2016	5,340	13,811	17,781	28,135	30,969	2,945	8,535	11,587	21,303	42,528	182,934
2017	5,436	13,781	17,868	27,752	31,374	2,899	8,562	11,814	21,483	43,193	184,160
2018	5,116	13,519	16,926	26,101	29,751	2,707	8,513	11,087	20,085	40,310	174,115
2019	5,251	13,656	16,743	26,028	29,850	2,764	8,290	11,139	20,078	41,214	175,013
2020	5,126	13,304	16,622	25,147	29,057	2,742	8,258	10,722	19,493	39,394	169,864
2021	5,009	13,209	16,612	25,624	29,525	2,729	8,117	11,018	19,816	40,700	172,359
2022	5,155	13,704	17,339	27,830	32,534	2,824	8,614	11,163	21,393	44,658	185,214

A.3 Scaling factors – by state/territory

Table 9 – Population and other adjustments applied to actual deaths for each age band/gender

				State/Territory					
Year	NSW	Vic	Qld	SA	WA	Tas	NT	ACT	Total
Reported deaths									
2015	53,307	39,667	30,518	13,761	14,710	4,681	1,156	2,116	159,916
2016	52,536	39,722	30,032	13,353	14,879	4,557	1,056	2,318	158,453
2017	54,695	40,785	31,686	14,023	14,507	4,761	1,102	2,369	163,928
2018	52,221	39,669	31,194	13,581	14,629	4,243	1,178	2,366	159,081
2019	54,228	40,896	32,274	13,948	15,031	4,611	1,116	2,281	164,385
2020	53,547	41,602	32,322	13,963	15,272	4,462	1,159	2,431	164,758
2021	55,565	42,893	34,299	14,404	16,053	4,801	1,189	2,451	171,655
2022	61,968	47,237	38,382	15,850	17,298	5,120	1,208	2,876	189,939
Population (m)									
2015	7.62	6.02	4.78	1.70	2.54	0.52	0.24	0.40	23.81
2016	7.73	6.17	4.85	1.71	2.56	0.52	0.25	0.40	24.19
2017	7.85	6.30	4.93	1.73	2.59	0.53	0.25	0.42	24.59
2018	7.95	6.42	5.01	1.75	2.62	0.54	0.25	0.43	24.96
2019	8.03	6.53	5.09	1.77	2.66	0.55	0.25	0.44	25.34
2020	8.09	6.61	5.18	1.79	2.72	0.56	0.25	0.45	25.65
2021	8.09	6.55	5.22	1.80	2.75	0.57	0.25	0.45	25.68
2022	8.16	6.63	5.30	1.83	2.81	0.58	0.25	0.46	26.03
Population adjusted deaths									
2015	56,650	43,130	33,328	14,591	15,921	5,161	1,177	2,425	172,474
2016	54,988	42,134	32,341	14,057	16,008	5,001	1,071	2,608	168,260
2017	56,388	42,392	33,546	14,620	15,417	5,118	1,107	2,578	171,219
2018	53,195	40,472	32,484	14,010	15,348	4,461	1,182	2,495	163,678
2019	54,630	41,004	33,053	14,209	15,517	4,741	1,121	2,344	166,641
2020	53,544	41,236	32,588	14,038	15,449	4,497	1,160	2,447	164,968
2021	55,565	42,893	34,299	14,404	16,053	4,801	1,189	2,451	171,655
2022	61,461	46,654	37,759	15,632	16,937	5,012	1,203	2,813	187,444
Age Mix adjustments									
2015	109.2%	108.5%	112.3%	109.6%	115.9%	108.2%	118.0%	109.3%	110.2%
2016	108.2%	107.4%	110.0%	107.7%	113.5%	106.3%	115.2%	107.0%	108.7%
2017	107.3%	106.7%	108.4%	106.4%	111.2%	105.3%	112.8%	106.7%	107.6%
2018	106.3%	105.9%	106.9%	105.1%	108.3%	104.8%	109.9%	106.6%	106.4%
2019	105.0%	105.1%	105.1%	103.9%	106.0%	103.8%	107.3%	105.5%	105.0%
2020	102.8%	103.3%	103.0%	102.5%	103.1%	102.4%	103.4%	103.5%	103.0%
2021	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
2022	97.9%	98.4%	97.9%	98.5%	97.3%	98.7%	95.7%	98.2%	98.0%
Age mix adjusted deaths									
2015	61,846	46,799	37,442	15,990	18,449	5,583	1,390	2,649	190,148
2016	59,495	45,234	35,563	15,143	18,166	5,316	1,234	2,792	182,944
2017	60,509	45,218	36,365	15,551	17,138	5,389	1,248	2,750	184,167
2018	56,542	42,875	34,722	14,723	16,625	4,676	1,299	2,658	174,120
2019	57,373	43,077	34,755	14,770	16,442	4,923	1,202	2,474	175,016
2020	55,064	42,595	33,552	14,383	15,933	4,606	1,200	2,534	169,866
2021	55,565	42,893	34,299	14,404	16,053	4,801	1,189	2,451	171,655
2022	60,175	45,893	36,972	15,404	16,481	4,946	1,151	2,761	183,783
Delayed reporting allowance									
2021	228	177	140	59	65	20	5	10	704
2022	483	371	300	125	135	40	9	23	1,485
Total scaled deaths									
2015	61,846	46,799	37,442	15,990	18,449	5,583	1,390	2,649	190,148
2016	59,495	45,234	35,563	15,143	18,166	5,316	1,234	2,792	182,944
2017	60,509	45,218	36,365	15,551	17,138	5,389	1,248	2,750	184,167
2018	56,542	42,875	34,722	14,723	16,625	4,676	1,299	2,658	174,120
2019	57,373	43,077	34,755	14,770	16,442	4,923	1,202	2,474	175,016
2020	55,064	42,595	33,552	14,383	15,933	4,606	1,200	2,534	169,866
2021	55,793	43,070	34,439	14,463	16,118	4,821	1,194	2,461	172,359
2022	60,659	46,264	37,271	15,529	16,615	4,986	1,160	2,784	185,268

Appendix B Predicting deaths using a linear model

We perform simple linear regression on standardised SDRs or death counts to predict weekly expected SDRs for each cause of death (11 causes) plus coroner-certified deaths, as well as weekly expected number of deaths for each age/gender combination (10 combinations) and each state/territory (6 states and 2 territories).

The standardisation procedure and the linear regression are described in SectionB.1and SectionB.2, respectively. These sections describe the approach used for setting the predicted values for the 2020 and 2021 years (which are based on the 2015-19 years' actual data). The same approach is adopted in setting the predicted values for 2022, although for some causes of death (respiratory diseases, dementia, other cardiac conditions and diabetes) we use the 2015-21 years' data (see Section 2.2.1).

B.1 Standardisation and smoothing

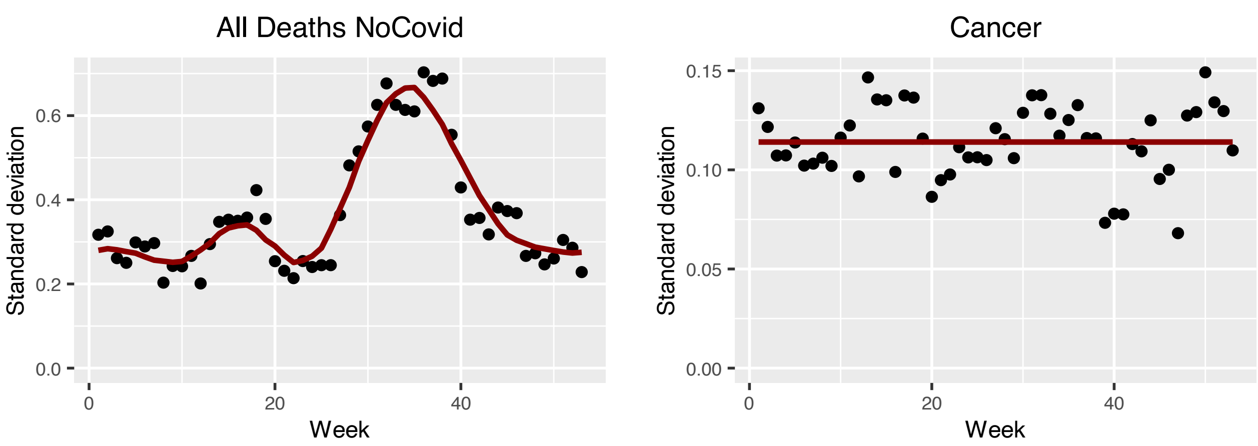
The standardised SDRs or death counts are obtained by subtracting the means from the original series and then dividing by the smoothed standard deviations.

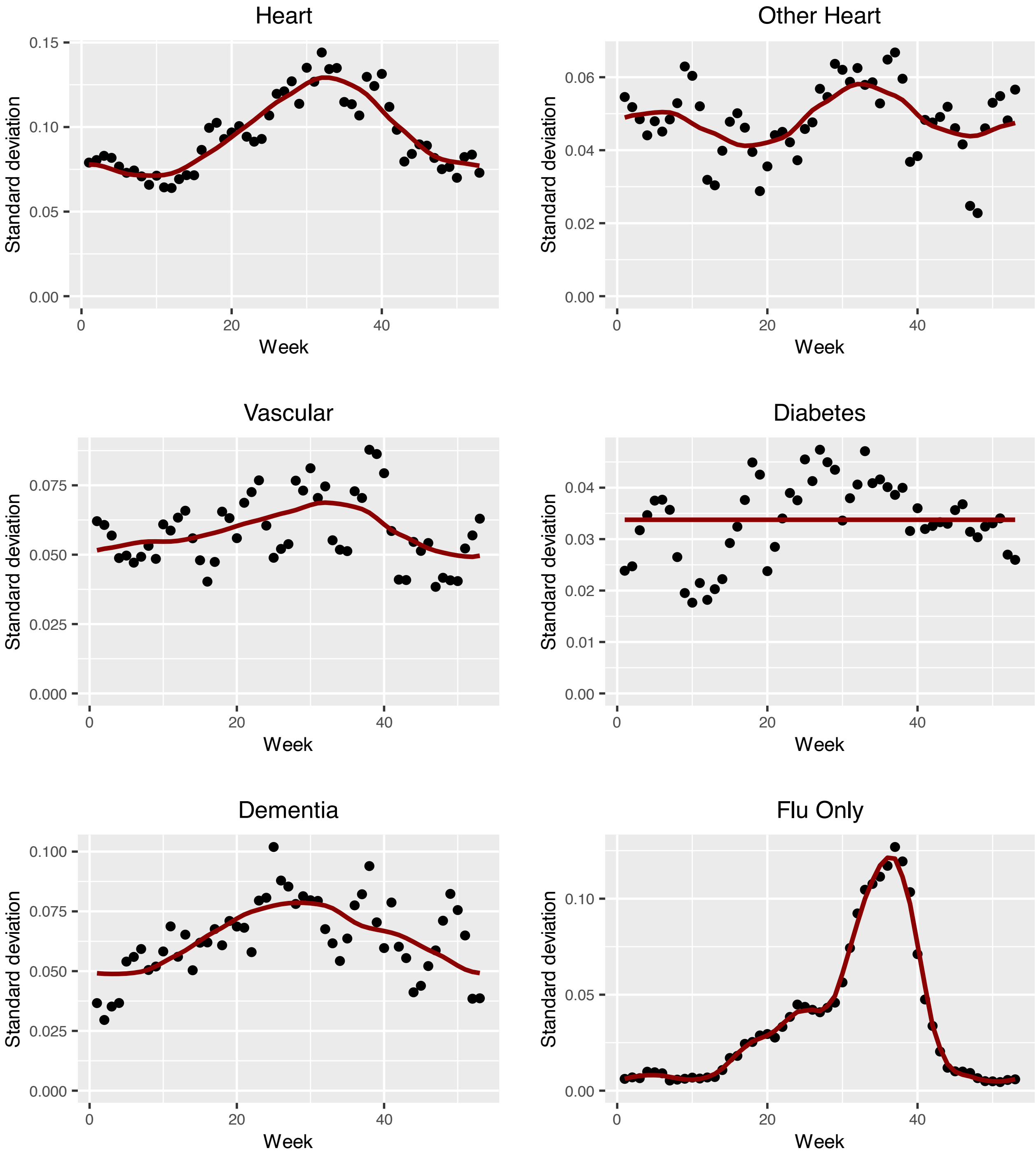
The mean (standard deviation) in Week x is calculated by taking the average (sample standard deviation) of SDRs/deaths in Weeks $x-1$, x, and $x+1$ between 2015 and 2019. For the first week in each year, Week $x-1$ refers to the last week of the previous year; for the last week in each year, Week $x+1$ refers to the first week of the following year.

The standard deviation series are volatile, so we perform a local regression, namely LOESS (locally estimated scatterplot smoothing) to reduce the noise. When performing the LOESS, we also ensure a smooth transition from Week 52/53 to Week 1. For cancer and cardiovascular disease and the three age groups under age 75, the standard deviations are noisy and lack clear seasonality, so we have adopted the average over all weeks as the smoothed standard deviations.

Figure 46 shows the actual (black dots) and adopted (red line) standard deviations for each cause of death, while Figure 47 shows the same information for each age/gender combination and Figure 48 for each state/territory.

Figure 46 – Actual and adopted standard deviations by cause of death





Heart
Other Heart
Vascular
Diabetes
Dementia
Flu Only
Standard deviation
Week
0.15
0.10
0.05
0.00
0.06
0.04
0.02
0.075
0.050
0.025
0.000
0.03
0.01
0.100
0
20
40

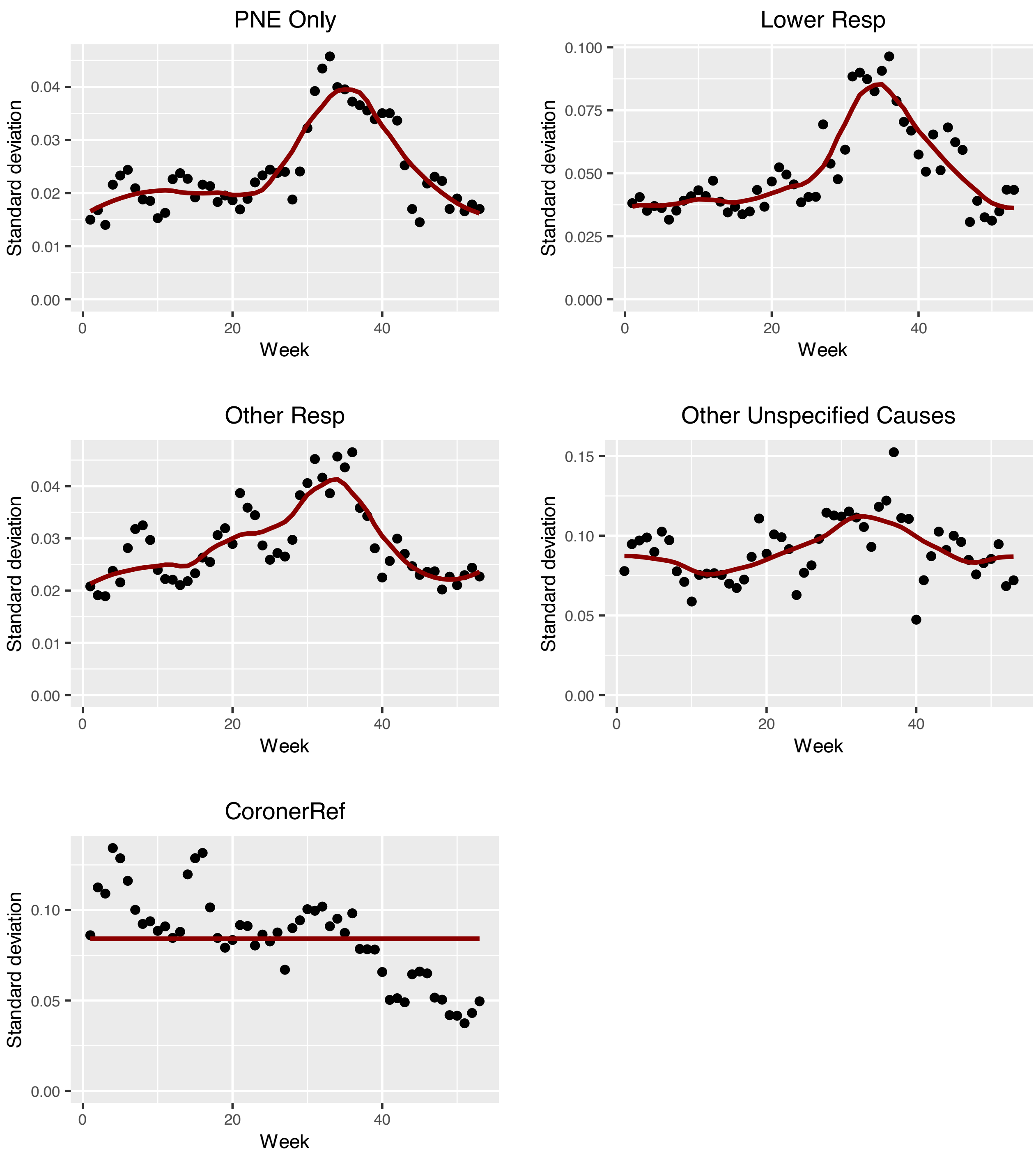
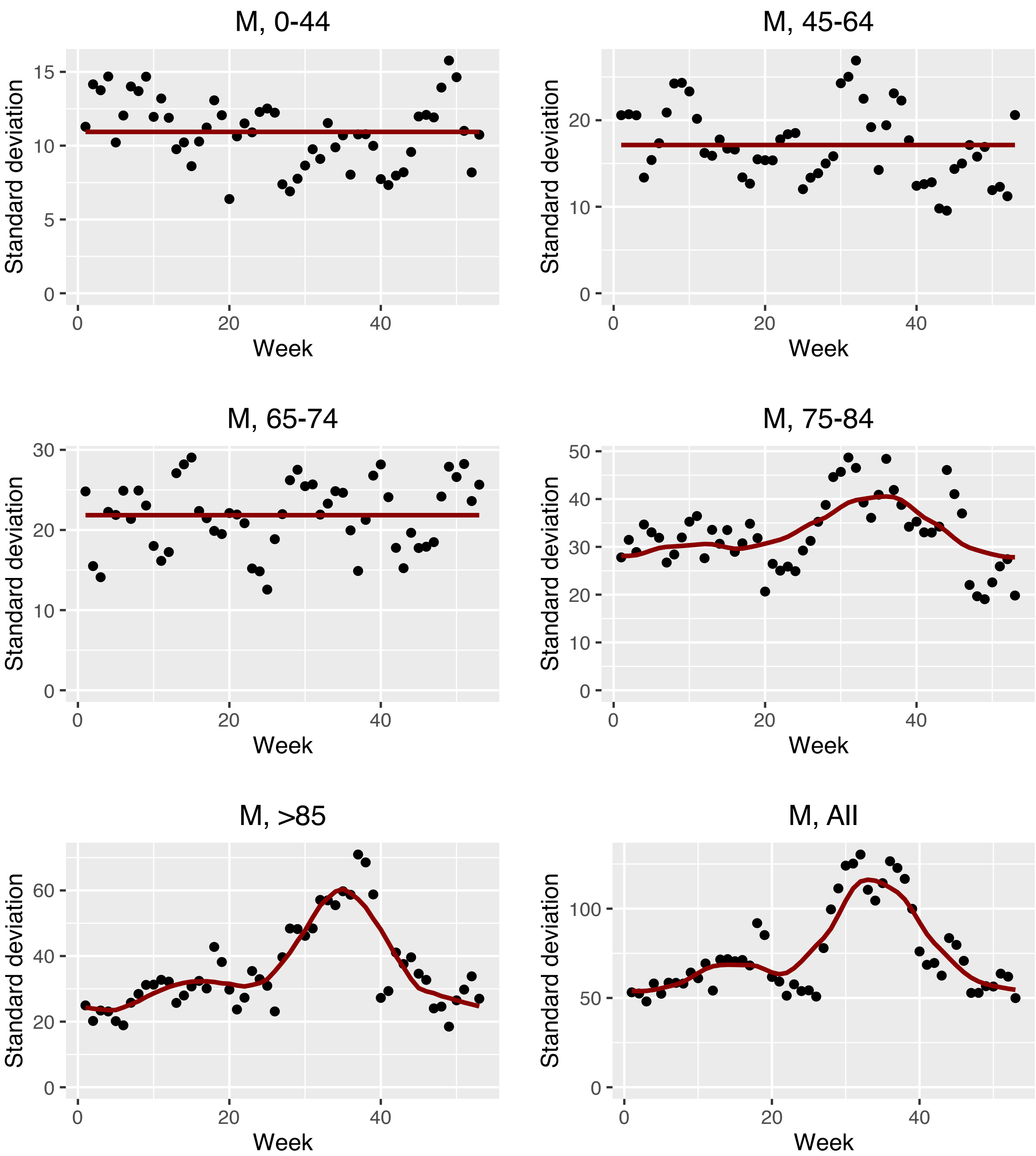

PNE Only
Lower Resp
Other Resp
Other Unspecified Causes
CoronerRef
Standard deviation
Week
0.00
0.01
0.02
0.03
0.04
0.000
0.025
0.050
0.075
0.100
0.05
0.10
0.15
0
20
40

Figure 47 – Actual and adopted standard deviations by age/gender



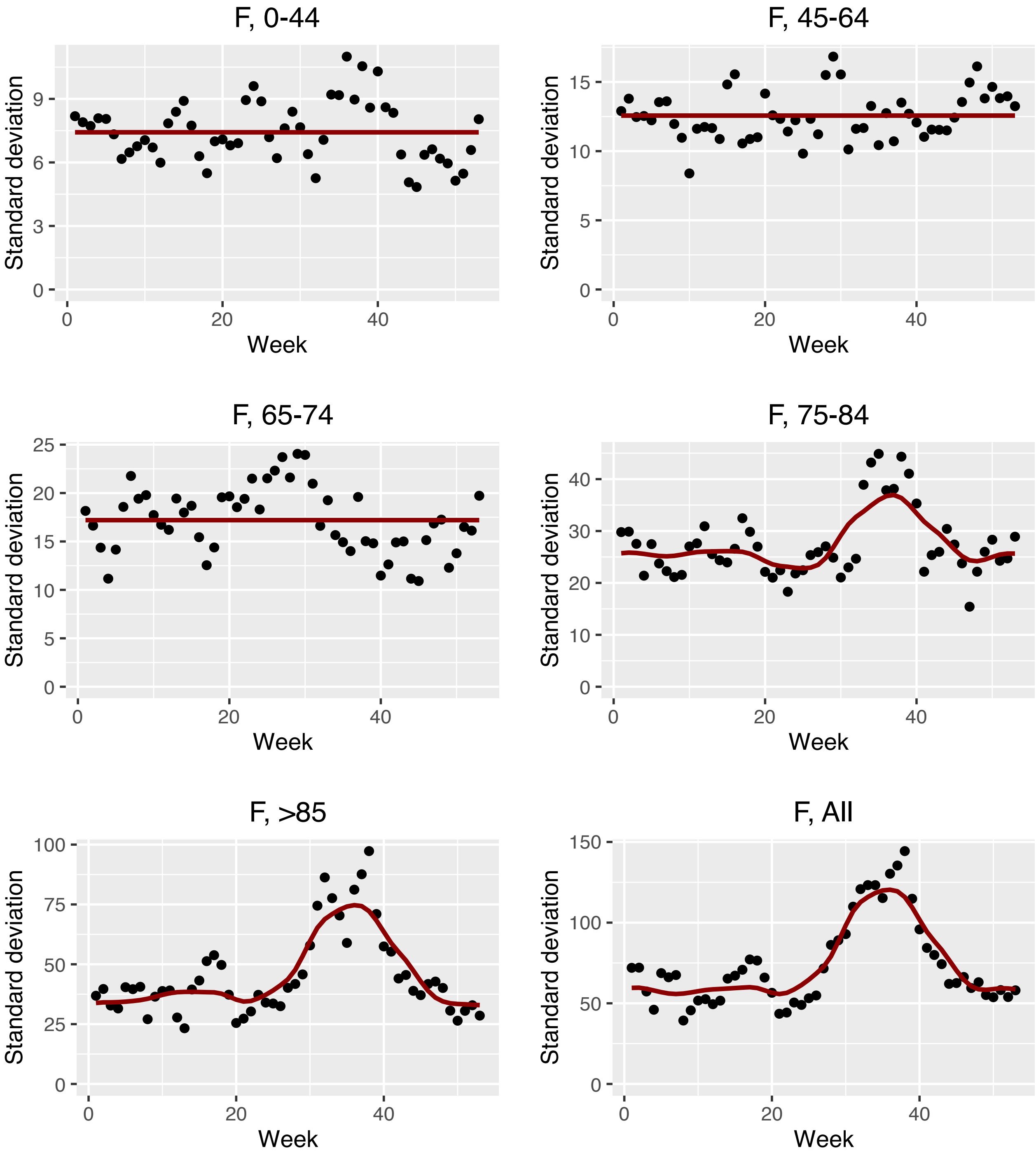
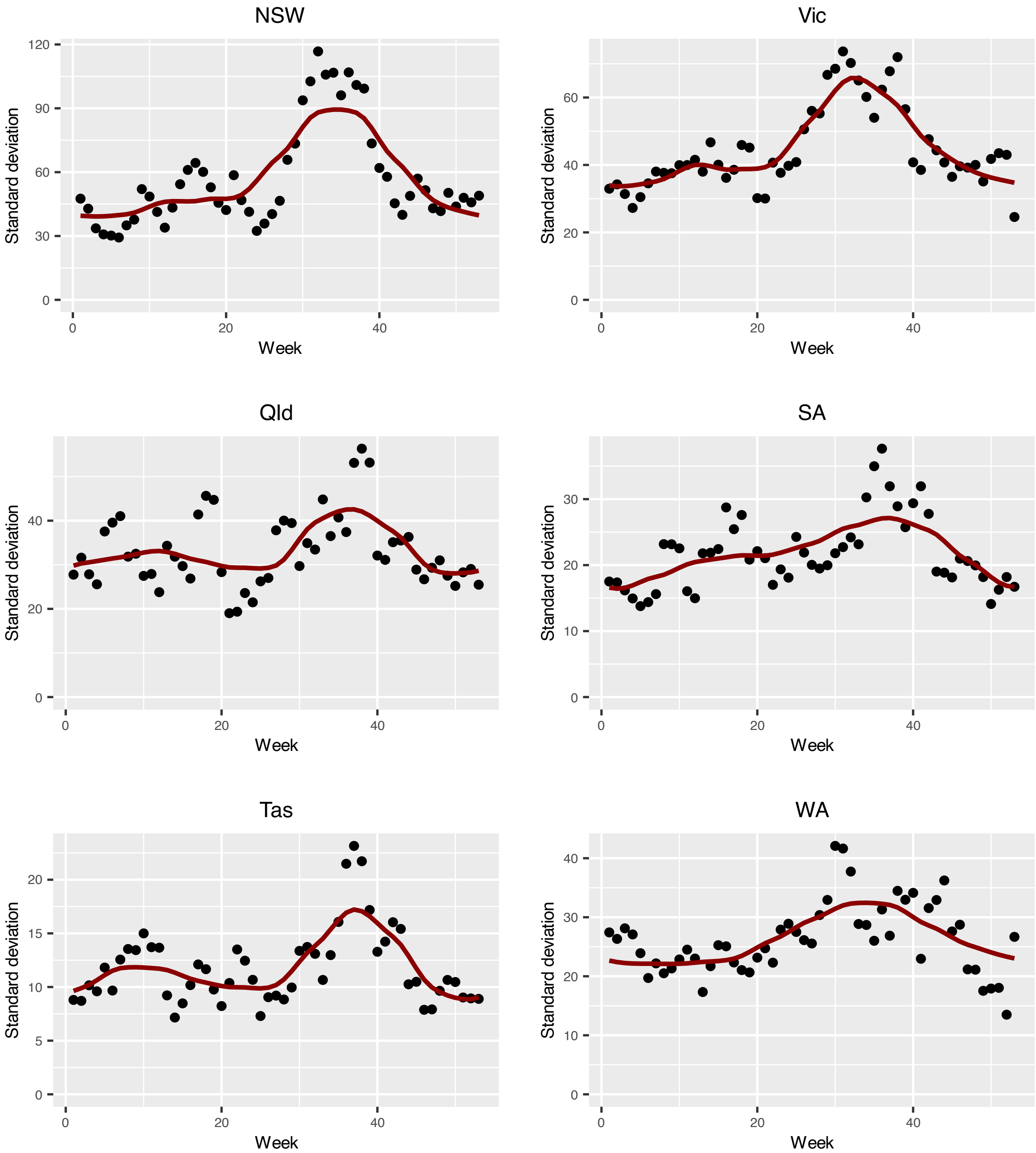
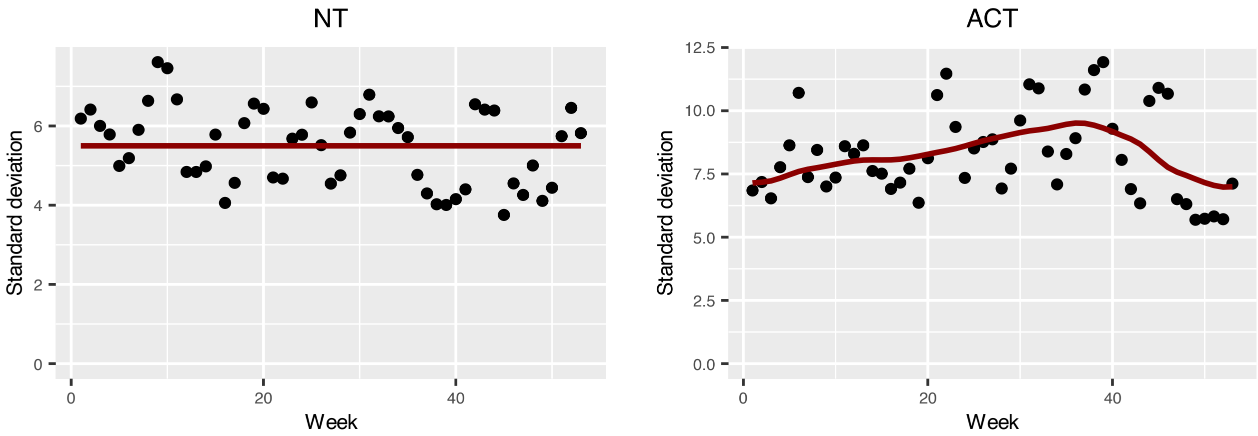

F, 0-44
Standard deviation
Week
F, 45-64
Standard deviation
Week
F, 65-74
Standard deviation
Week
F, 75-84
Standard deviation
Week
F, >85
Standard deviation
Week
F, All
Standard deviation
Week

Figure 48 – Actual and adopted standard deviations by state/territory





B.2 Simple linear regression

For the 2020 and 2021 prediction years, the linear model is fitted to the weekly SDRs/deaths data (after scaling adjustments) from the first week of 2015 to the last week of 2019. We then use the estimated parameters to predict the expected number of deaths from the first week of 2020 to the last week of 2021.

For the 2022 prediction year, the linear model is fitted to data from:

- the first week of 2015 to the last week of 2019 in the case of deaths from respiratory diseases, dementia, other cardiac conditions and diabetes
- the first week of 2015 to the last week of 2021 for all other causes and coroner referred deaths.

We then use the estimated parameters to predict the expected number of deaths from the first week of 2022 onwards.

The explanatory variable in the regression is a time index that takes the value based on both year and week [47]. The response variable in the regression is the standardised death count where seasonality has been removed from the series.

Table 10 - The value of time index in the simple linear regression

Year	Week	Time index
2015	1	1
2015	2	2
⋮	⋮	⋮
2015	53	53
2016	1	54
⋮	⋮	⋮
2016	52	105
2017	1	106
⋮	⋮	⋮

[47] We fit a horizontal line with no time trend to the deaths due to influenza because the number of influenza deaths are volatile from year-to-year, and Australia experienced a severe flu seasons in 2017 and 2019. Fitting a linear model to the five years 2015-2019 leads to an upward trend that predicts unrealistically high figures in later years.

B.3 Prediction intervals

We generate the prediction intervals for the weekly expected SDRs/deaths using the simulation method. The residuals of the simple linear regression show strong serial correlation, so we fit a time series model to the residuals of each linear regression. We then simulate 100,000 paths based on the fitted time series model. Each of the 100,000 paths is then added to the weekly expected SDRs/number of deaths, and the sum becomes one simulated path of weekly SDRs/number of deaths. We use the 2.5% and 97.5% quantiles of the simulated weekly SDRs/number of deaths as our prediction intervals. One week in 40 is expected to show deaths above this range and one week in 40 should be below the range.

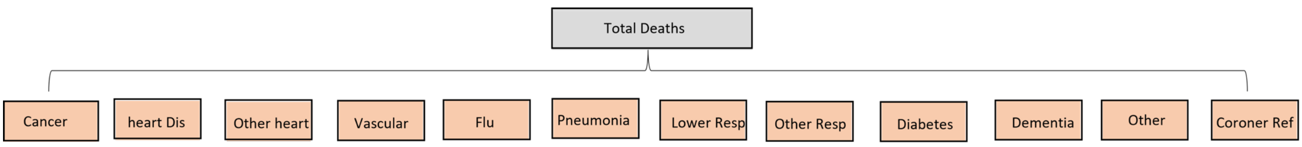
In addition to the weekly figures, we are also interested in the cumulative number of deaths in a year. The cumulative expected number of deaths is the sum of the weekly expected number of deaths. To generate the prediction intervals, we first calculate the cumulative SDRs/number of deaths in each simulated path of weekly SDRs/number of deaths, and then use the 2.5% and 97.5% quantiles as our prediction intervals.

B.4 Forecast Reconciliation

Once predictions on SDRs or death counts are generated via the linear models described in Section B.2, we implement a forecast reconciliation approach to ensure coherence of forecasts across different causes.[48] Forecast reconciliation is a useful tool that eliminates the discrepancy resulting from conflicting forecasts. Essentially, this technique ensures that the individual predictions for each cause or age/gender combination or state/territory add up to the total. By incorporating information from all levels, reconciliation methods also improve overall forecast accuracy.

The cause-specific SDRs follow a hierarchical setting illustrated in Figure 49. For each time series in the hierarchy, we model and forecast the SDR using separate models. However, it is very unlikely that these forecasts will add up in the same way as specified in the underlying hierarchy structure. Therefore, we need to reconcile these forecasts so that they fulfil certain aggregation constraints.

Figure 49 – Hierarchy of causes of death



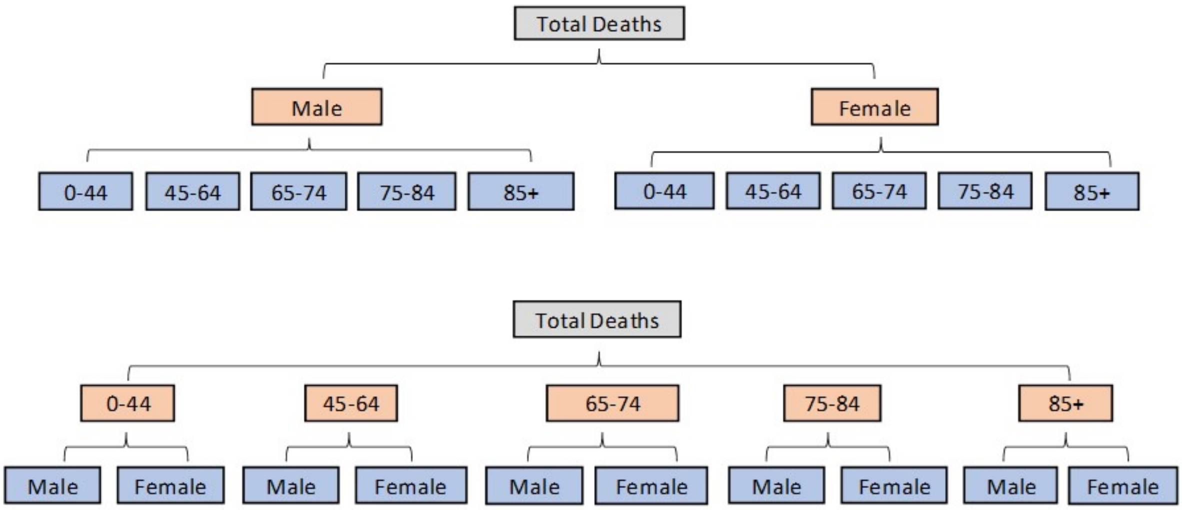
For the hierarchical structure of SDRs, we need to ensure that forecast of deaths from individual causes add up to forecast of total SDR.

For the age/gender combinations, there are two hierarchies as shown in Figure 50. We perform forecast reconciliation on the two hierarchies simultaneously.

[48] For more details of this approach, please refer to:

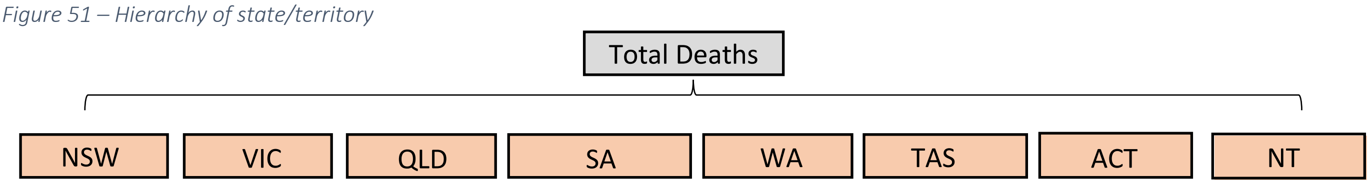
1. Li, H., Li, H., Lu, Y., and Panagiotelis, A. (2019). A forecast reconciliation approach to cause-of-death mortality modeling. *Insurance: Mathematics and Economics*, 86, 122-133; and
2. Wickramasuriya, S. L., Athanasopoulos, G., and Hyndman, R. J. (2019). Optimal forecast reconciliation for hierarchical and grouped time series through trace minimization. *Journal of the American Statistical Association*, 114(526), 804-819.

Figure 50 – Hierarchies of age/gender



For the state/territory death counts, the hierarchy is shown in Figure 51.

Figure 51 – Hierarchy of state/territory



The following sets out how the forecast reconciliation process is implemented for the cause of death models. A similar process is followed for the age/gender models and state/territory models. Following the trace minimization (MinT) reconciliation method proposed by Wickramasuriya et al. (2019), we define the following notation

- Let $y = (Total\ deaths, Cancer, Diabetes, Dementia, Flu, Pne,\ Lower\ Resp, Other\ Resp,$ $Vascular, HeartDis, OtherHeart, Other, Coroner\ Ref)$ be a vector that contains observations of all series in the hierarchy.
- Let $x = (Cancer, Diabetes, Dementia, Flu, Pne,\ Lower\ Resp, Other\ Resp,$
- $Vascular, HeartDis, OtherHeart, Other, Coroner\ Ref)$ be a vector that contains observations at the bottom level only.

We can then link these two vectors by the equation

$y = Sx,$

where S is a summing matrix of dimension 13 (representing all series, including the overall total) ×12 (representing the bottom level only), which aggregates cause-specific death counts to the total level, and it is given by

$$S = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ & & & & & & & & & & & \\ & & & & & I_{12} & & & & & & \\ & & & & & & & & & & & \end{pmatrix},$$

where I_{12} denotes a 12×12 identity matrix. The aggregation constraints in the hierarchy are reflected by the first two rows of the matrix.

Let $\hat{y}_h$ be a vector of independently obtained *h*-step-ahead forecasts of all series in the hierarchy, and $\hat{b}_h$ be a vector of independently obtained *h*-step-ahead forecasts of bottom-level series only. According to Wickramasuriya et al. (2019), the MinT reconciliation methods can be expressed as

$\tilde{y}_h = SP\hat{y}_h$.

$\tilde{y}_h$ is the reconciled forecasts, and P is a matrix of dimension 12×13, and it is given by

$P = (S'W_h^{-1}S)^{-1}S'W_h^{-1}$,

where W_h is a variance-covariance matrix of the *h*-step-ahead in-sample forecast errors.

As proved by Wickramasuriya et al. (2019) and the references therein, the linear reconciliation produces unbiased forecasts and leads to improved overall forecast accuracy.

B.5 Limitations

Our analysis is based on the ABS mortality statistics registered by 30 April 2023. 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, with the exception of coroner-referred deaths which has a larger allowance. 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. For each age/gender combination and state/territory, we have used the same overall allowance for late reported deaths; and
- the same age mix adjustment was applied to each cause of death due to limitations in the available data.

Appendix C Excess deaths by Cause

This appendix includes graphs for each cause of death, showing:

- The actual standardised death rates (SDRs)
- The modelled SDRs (for the 2015-2019 years) and predicted SDRs (2020-2022 years)
- The 95th percentile prediction interval for the 2020 to 2022 years.

Figure 52 – Deaths from all causes

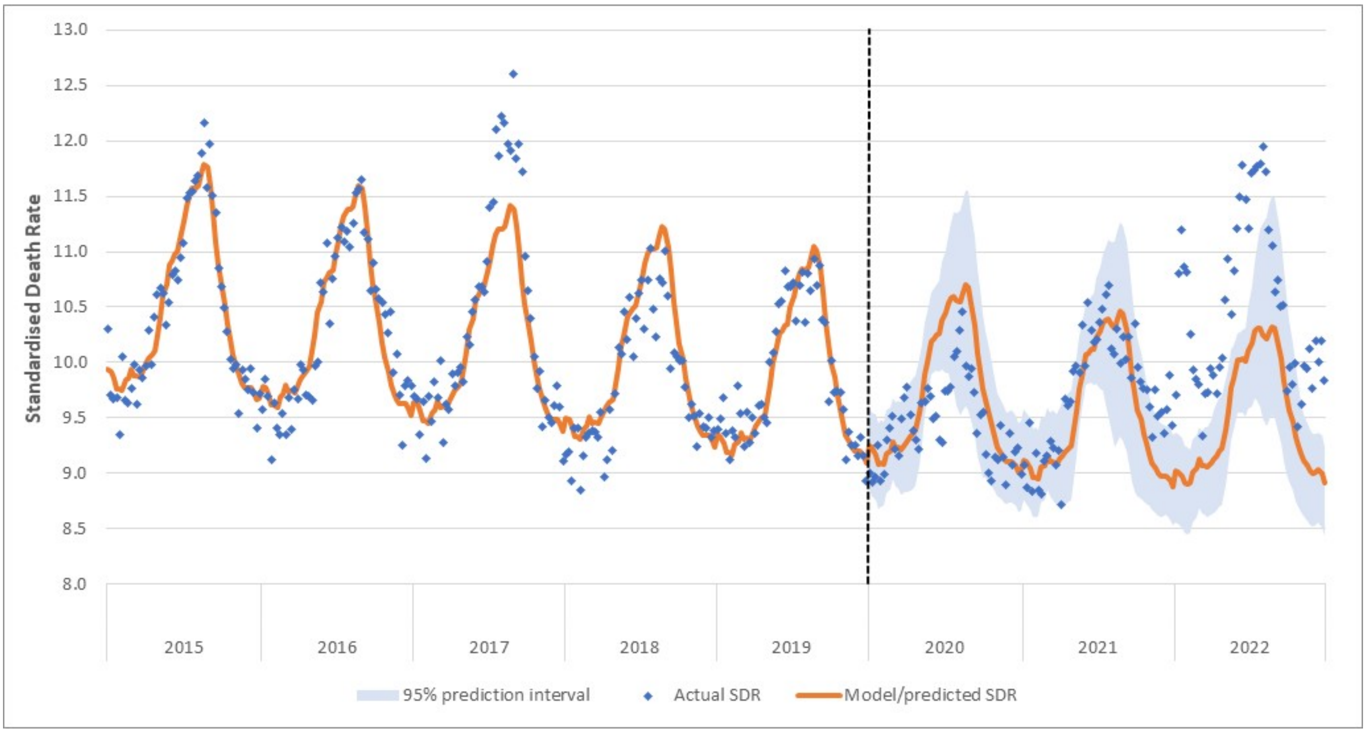


Figure 53 – Doctor-certified influenza deaths

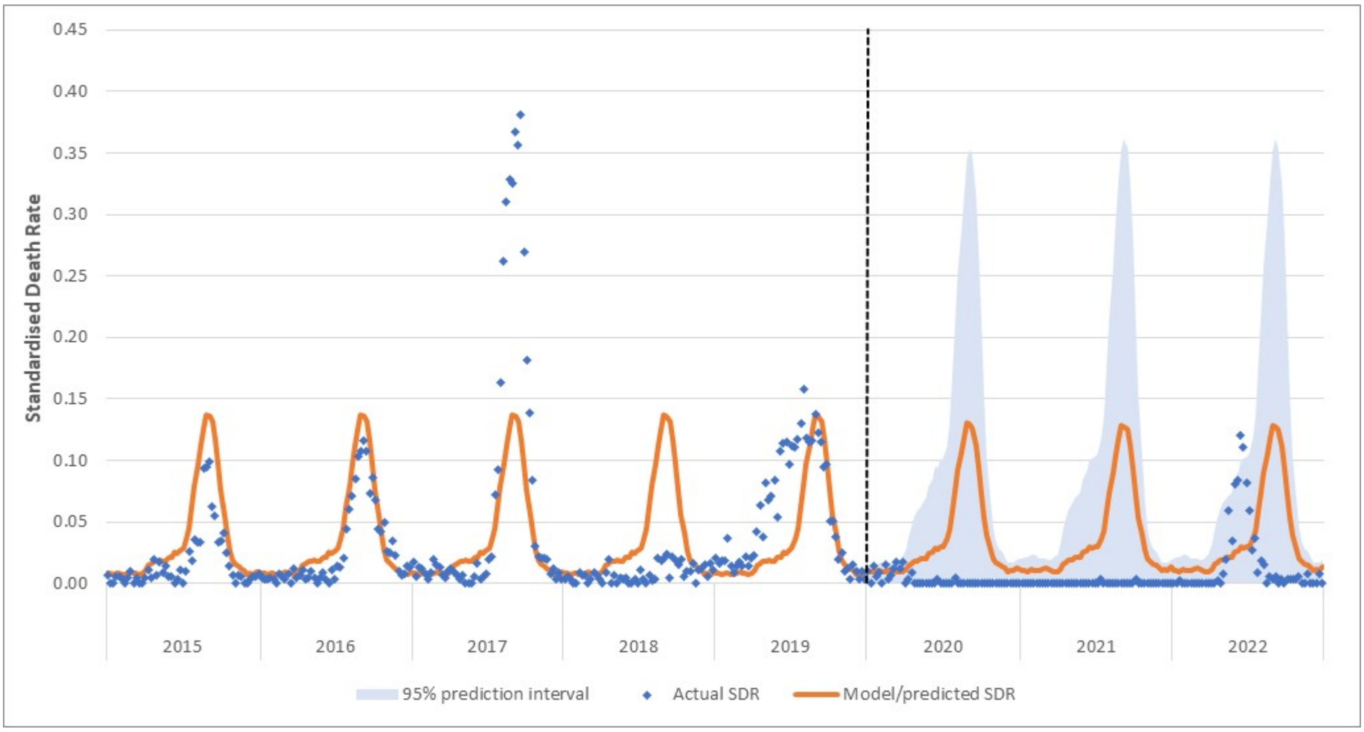


Figure 54 – Doctor-certified pneumonia deaths

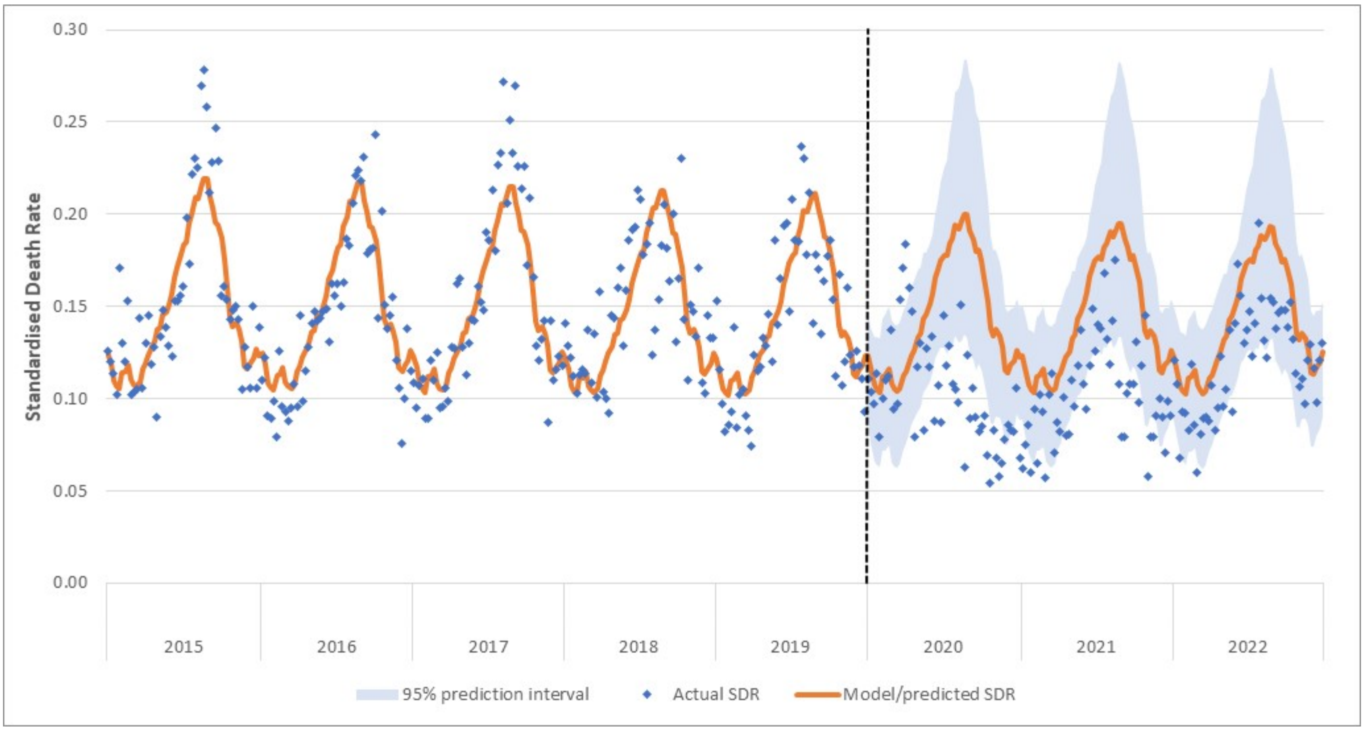


Figure 55 – Doctor-certified lower respiratory disease deaths

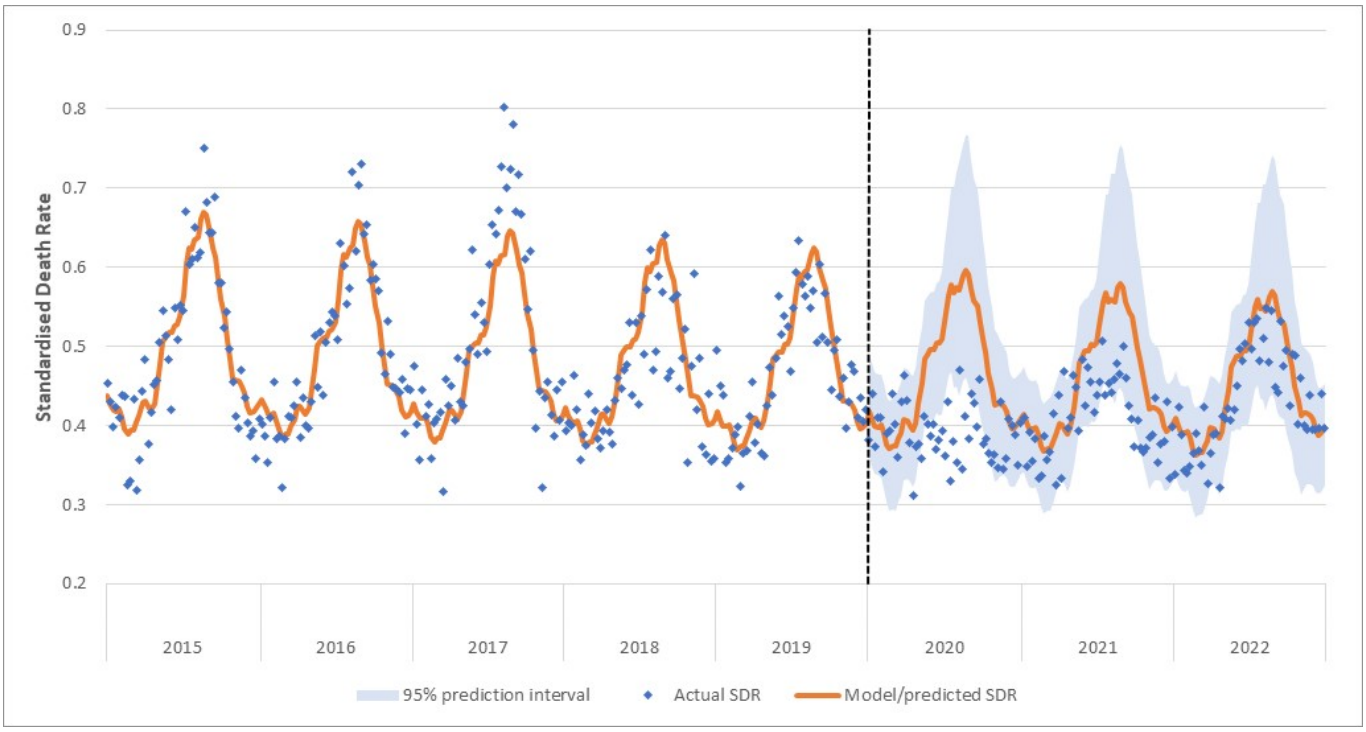


Figure 56 – Doctor-certified deaths from other respiratory diseases

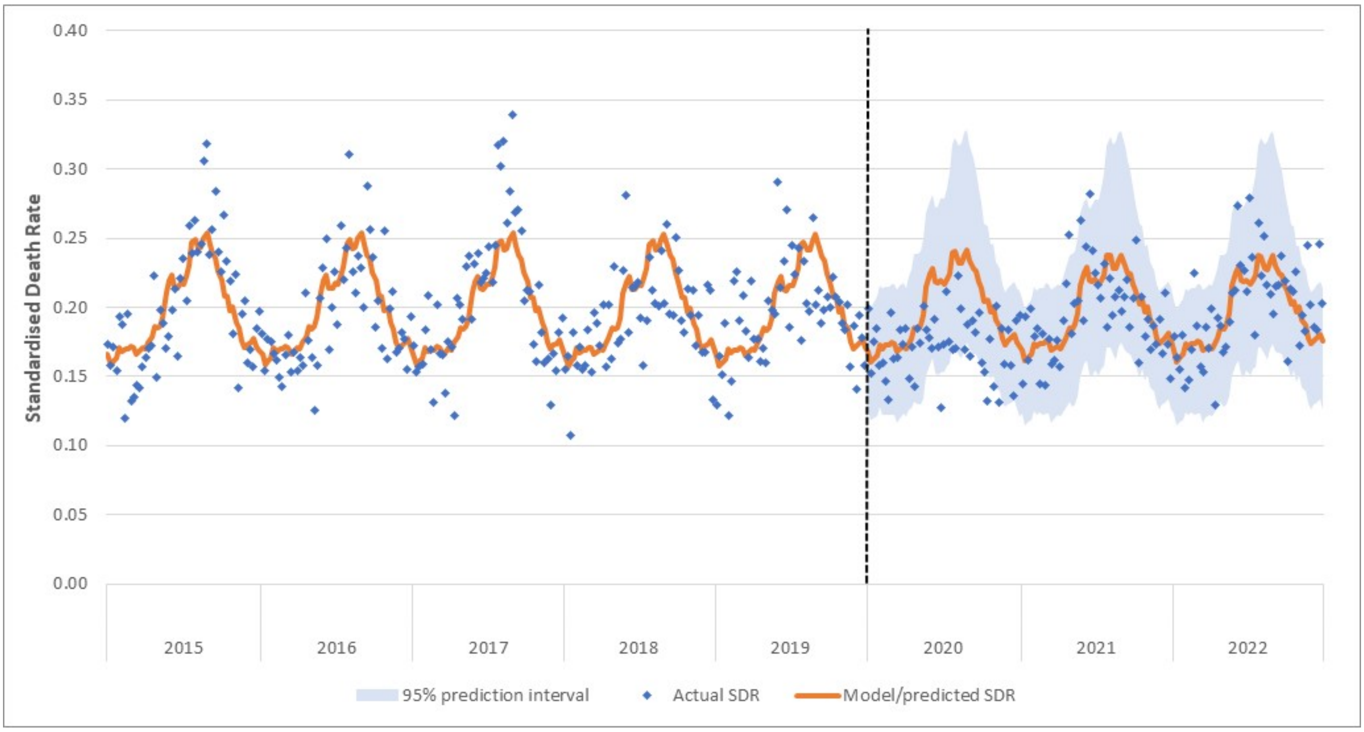


Figure 57 – Doctor-certified cancer deaths

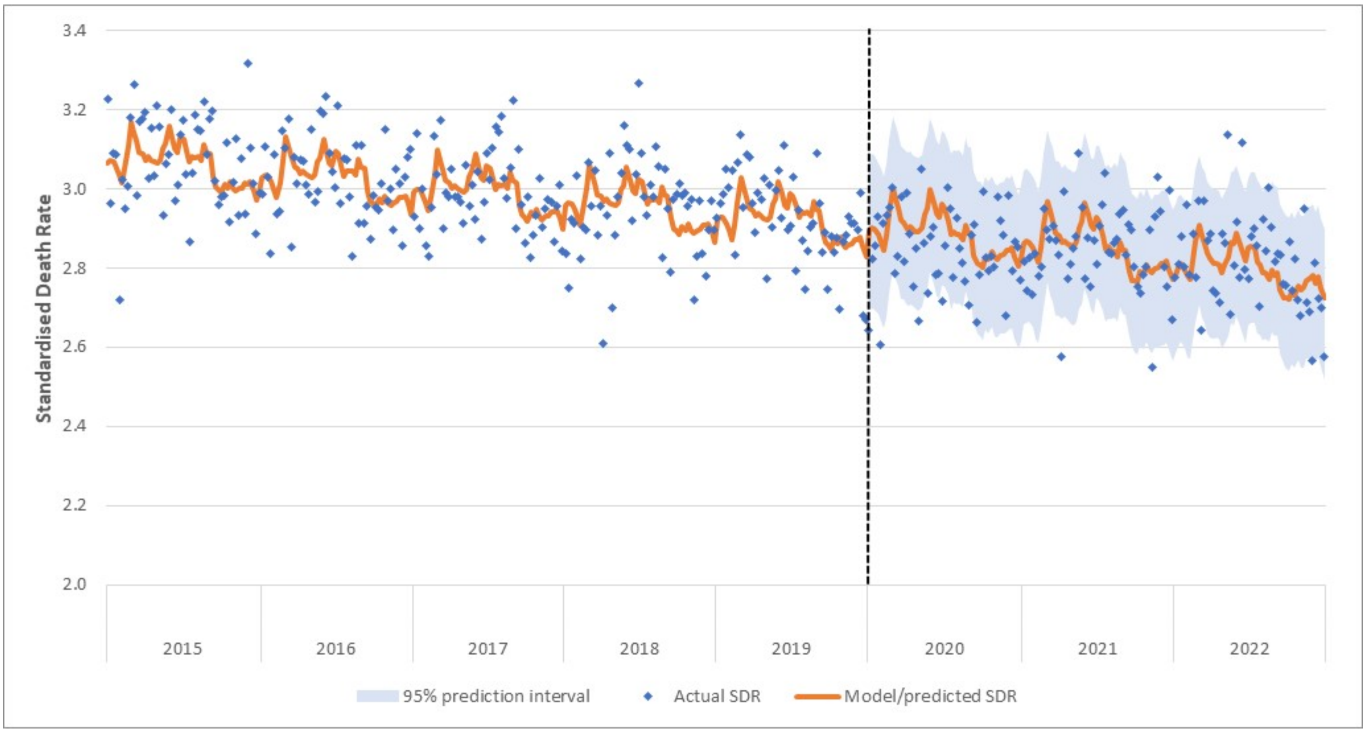


Figure 58 – Doctor-certified deaths from ischaemic heart disease

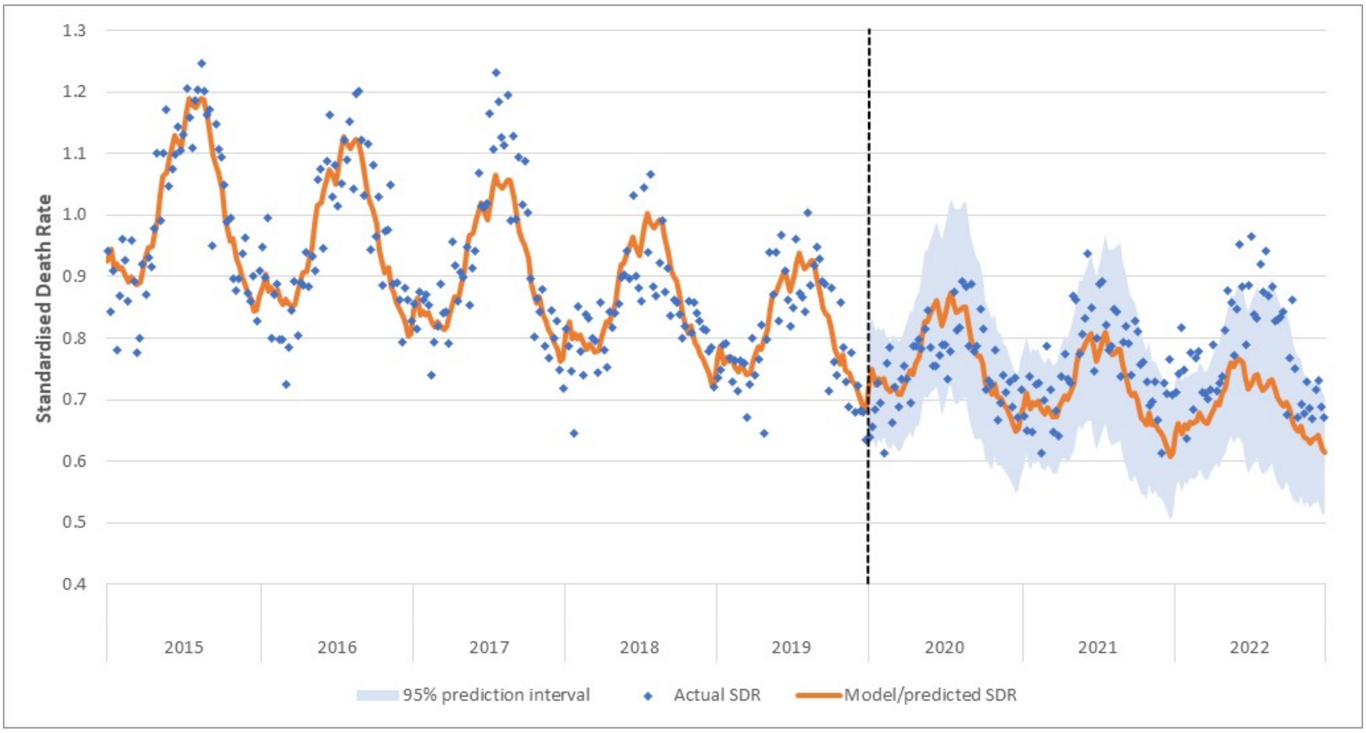


Figure 59 – Doctor-certified deaths from other cardiac conditions

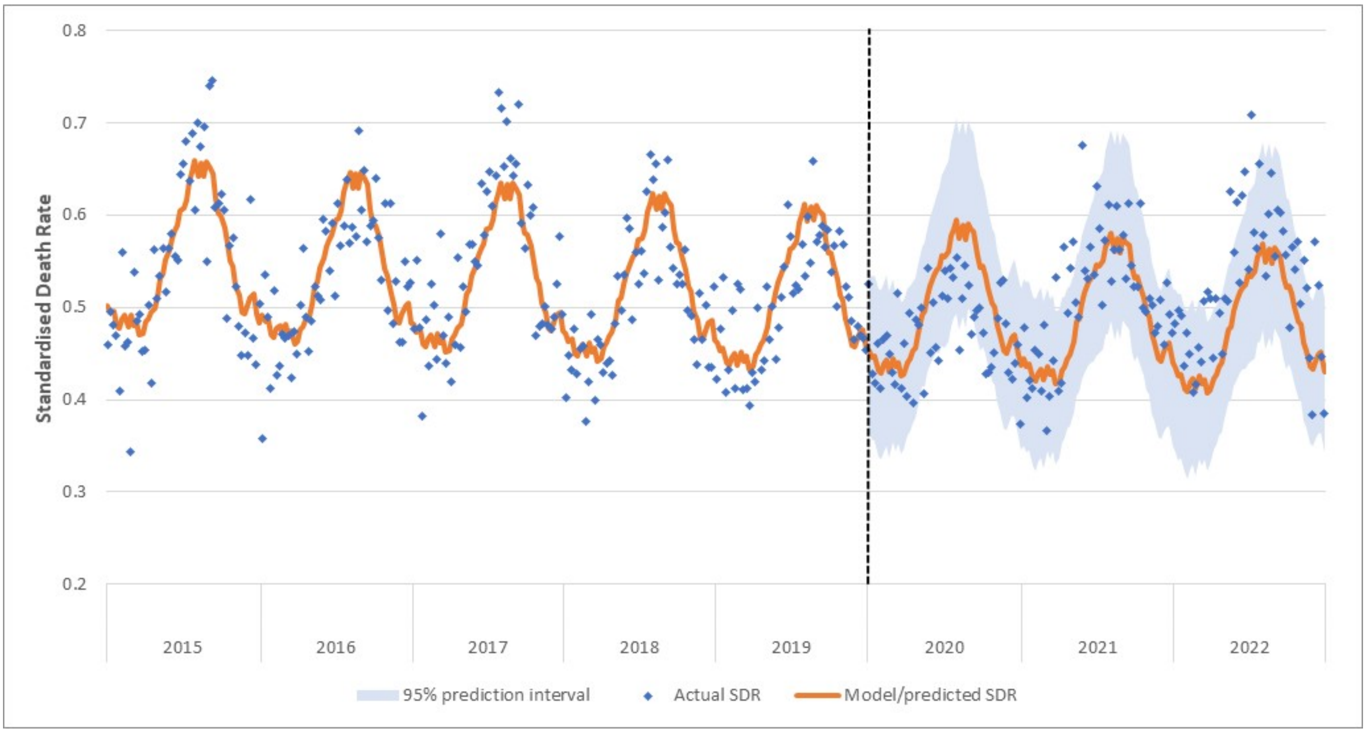


Figure 60 – Doctor-certified deaths from cerebrovascular disease (stroke, etc)

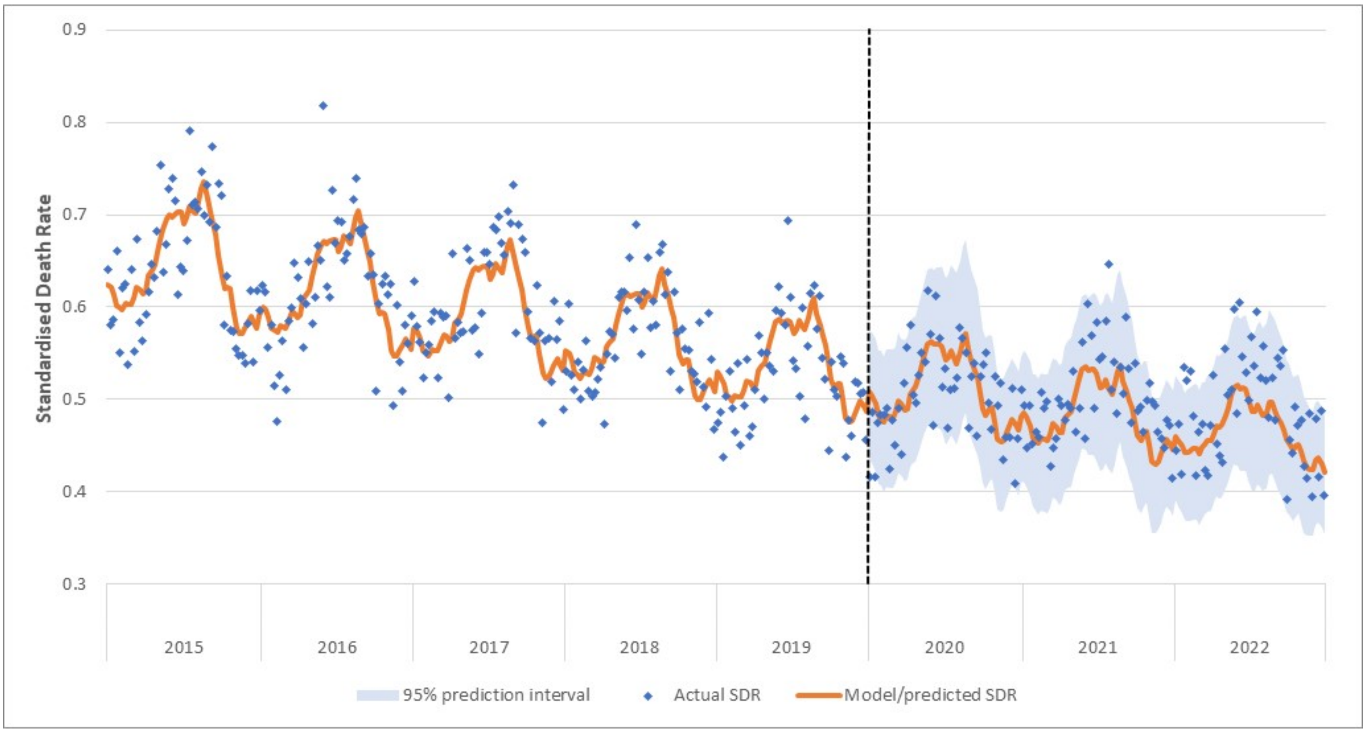


Figure 61 – Doctor-certified diabetes deaths

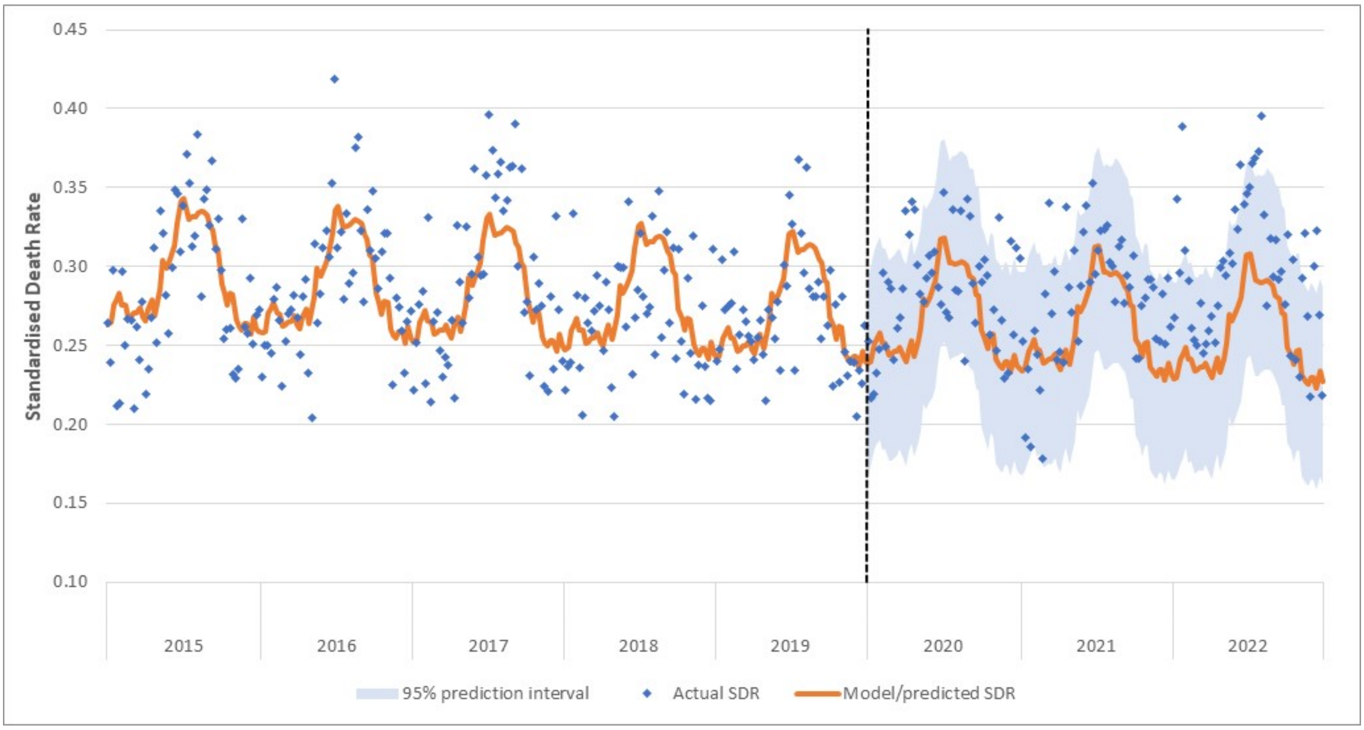


Figure 62 – Doctor-certified dementia deaths

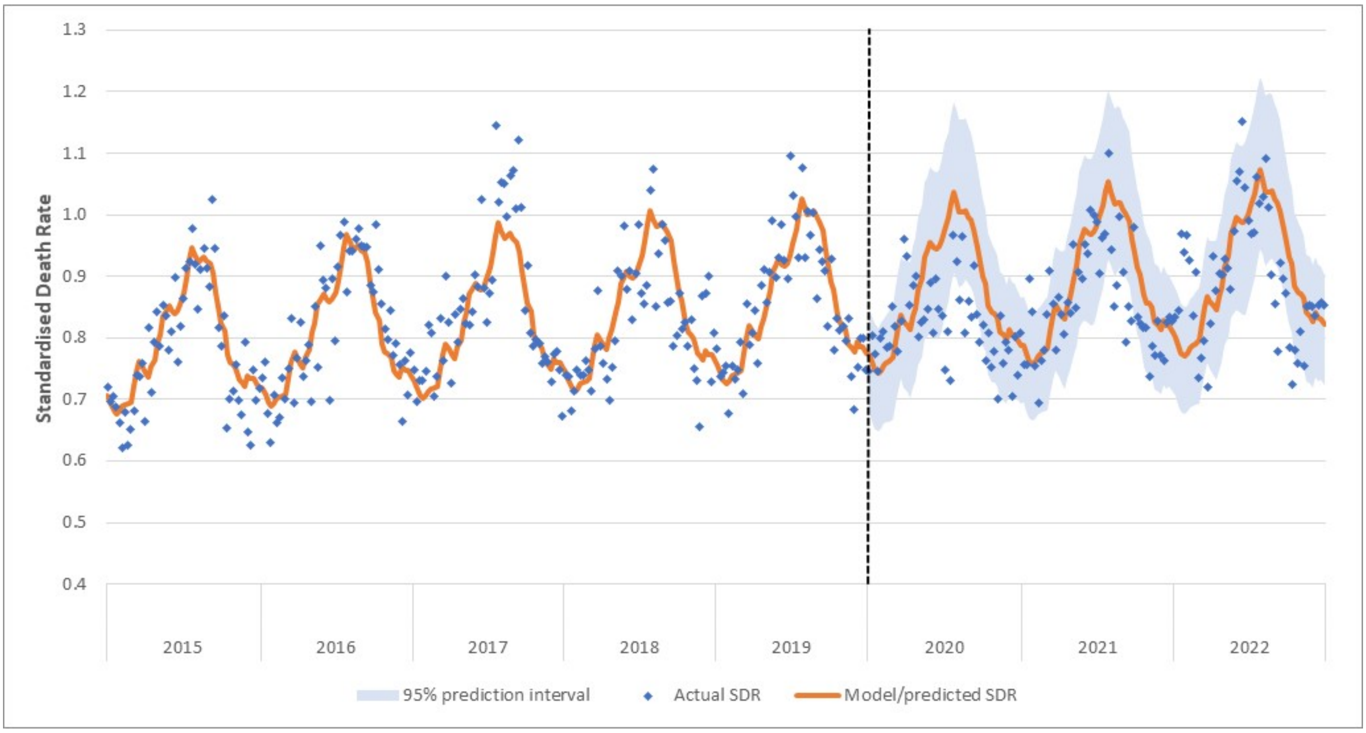


Figure 63 – Doctor-certified deaths from other causes, not explicitly identified in the ABS report

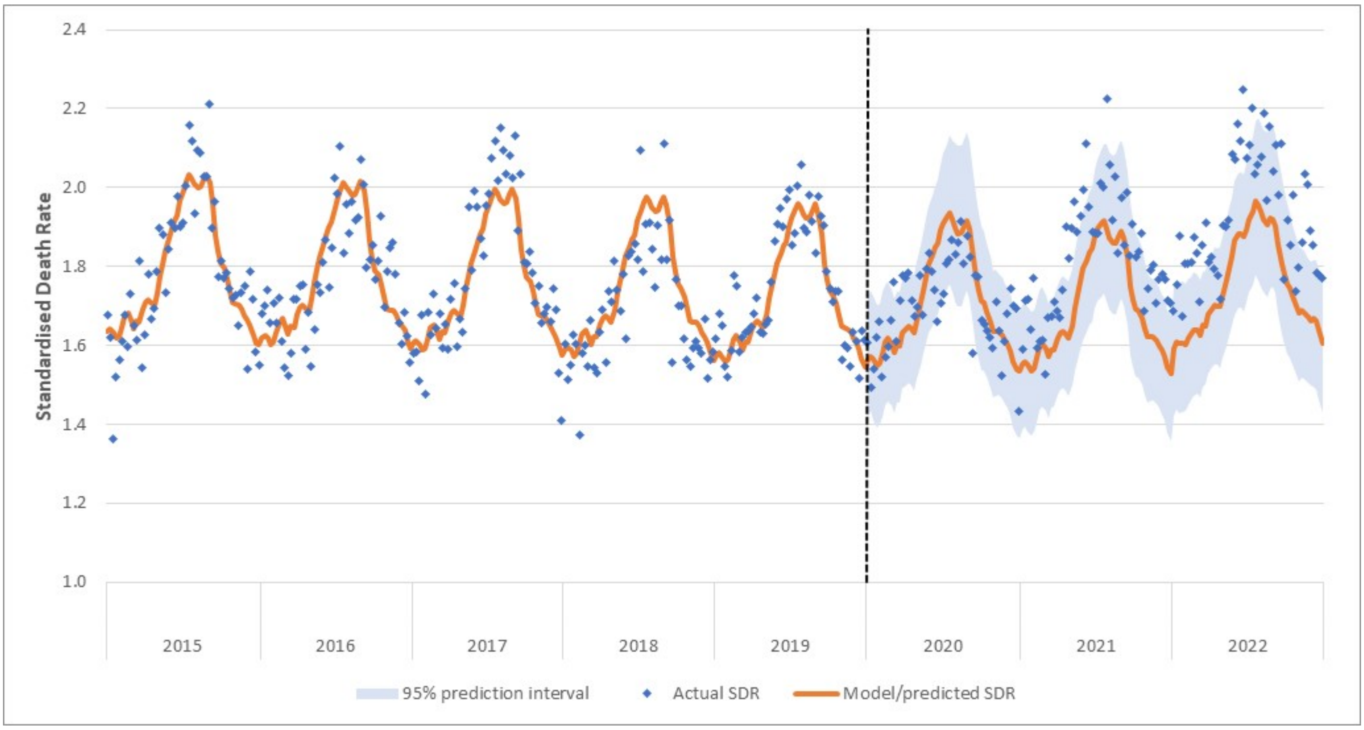
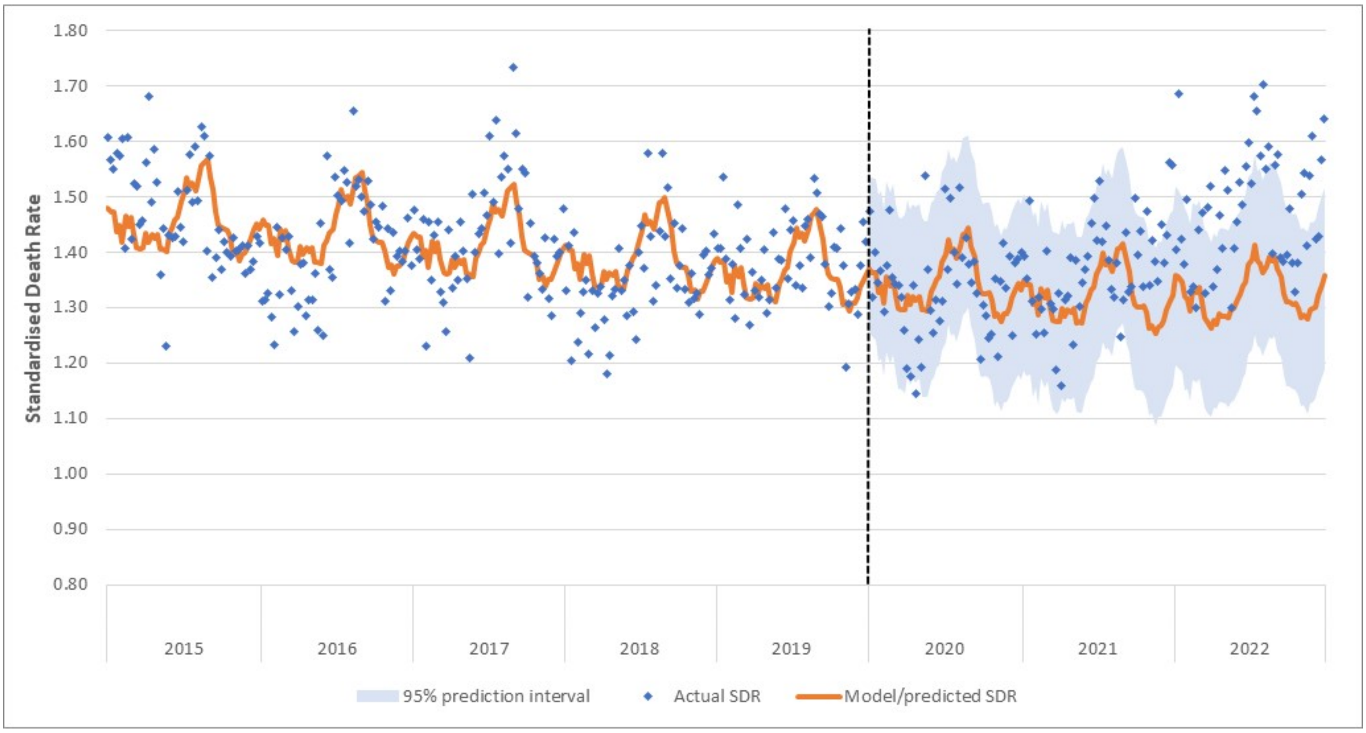


Figure 64 – Coroner-referred deaths from all causes



Appendix D Excess deaths by Gender and Age Band

This appendix includes graphs for each age band and gender combination, showing:

- The actual scaled deaths (scaled to reflect the 2022 population size and age mix)
- The modelled scaled deaths (for the 2015-2019 years) and predicted scaled deaths (2020-2022 years)
- The 95th percentile prediction interval for the 2020 to 2022 years.

D.1 Deaths for Males by Age Band

Figure 65 – Deaths of males aged 0-44

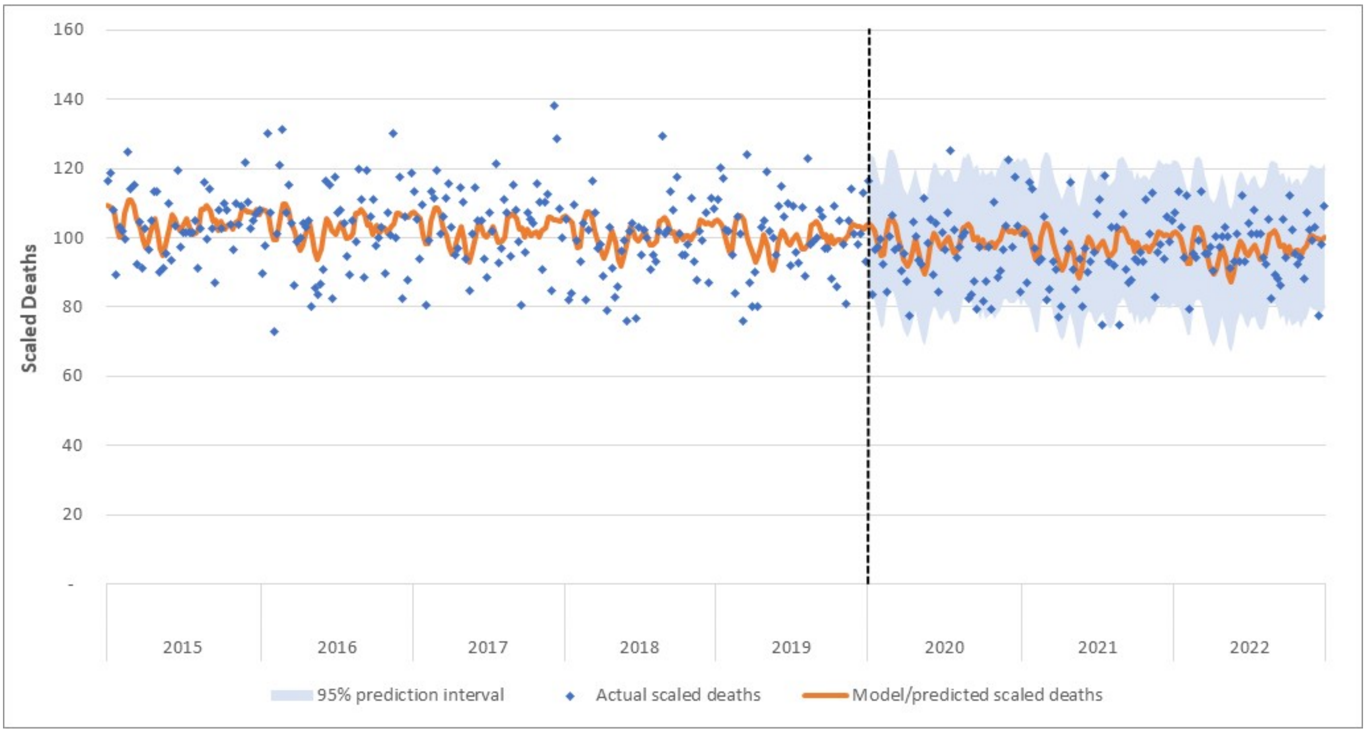


Figure 66 – Deaths of males aged 45-64

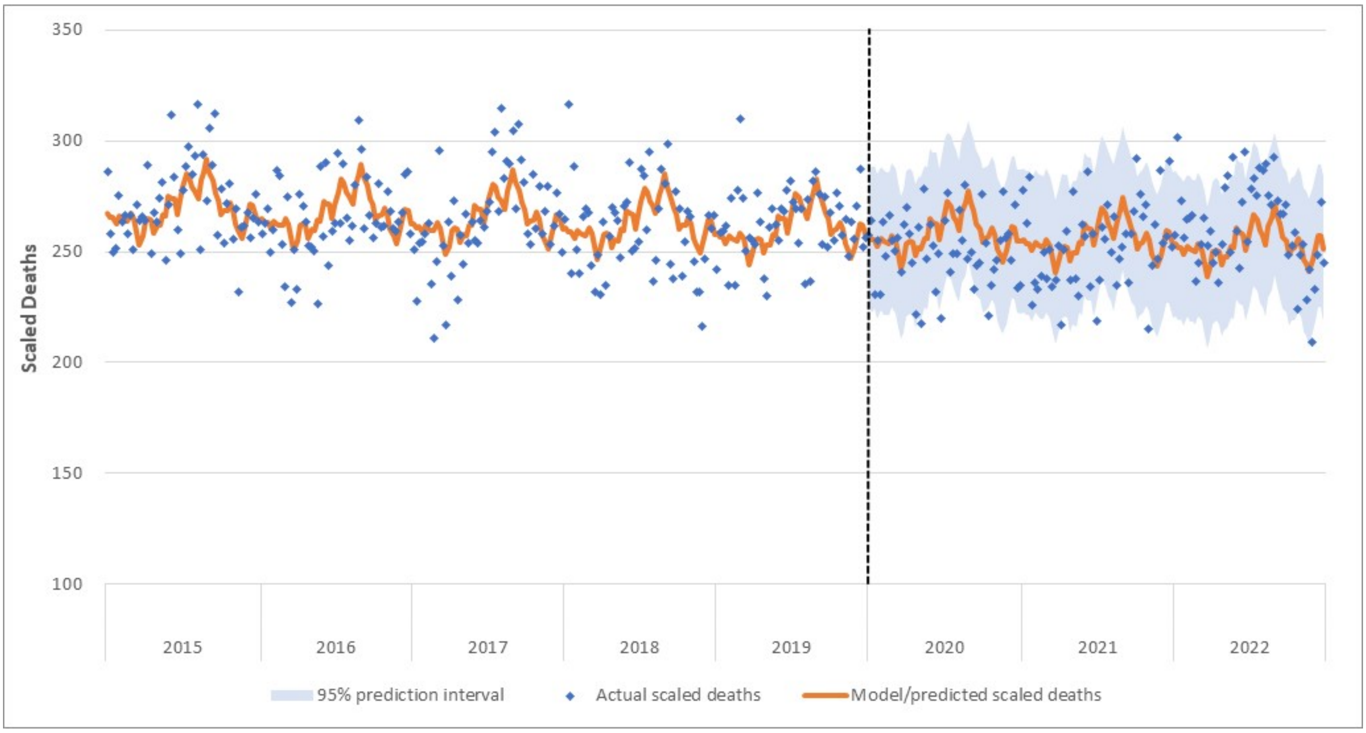


Figure 67 – Deaths of males aged 65-74

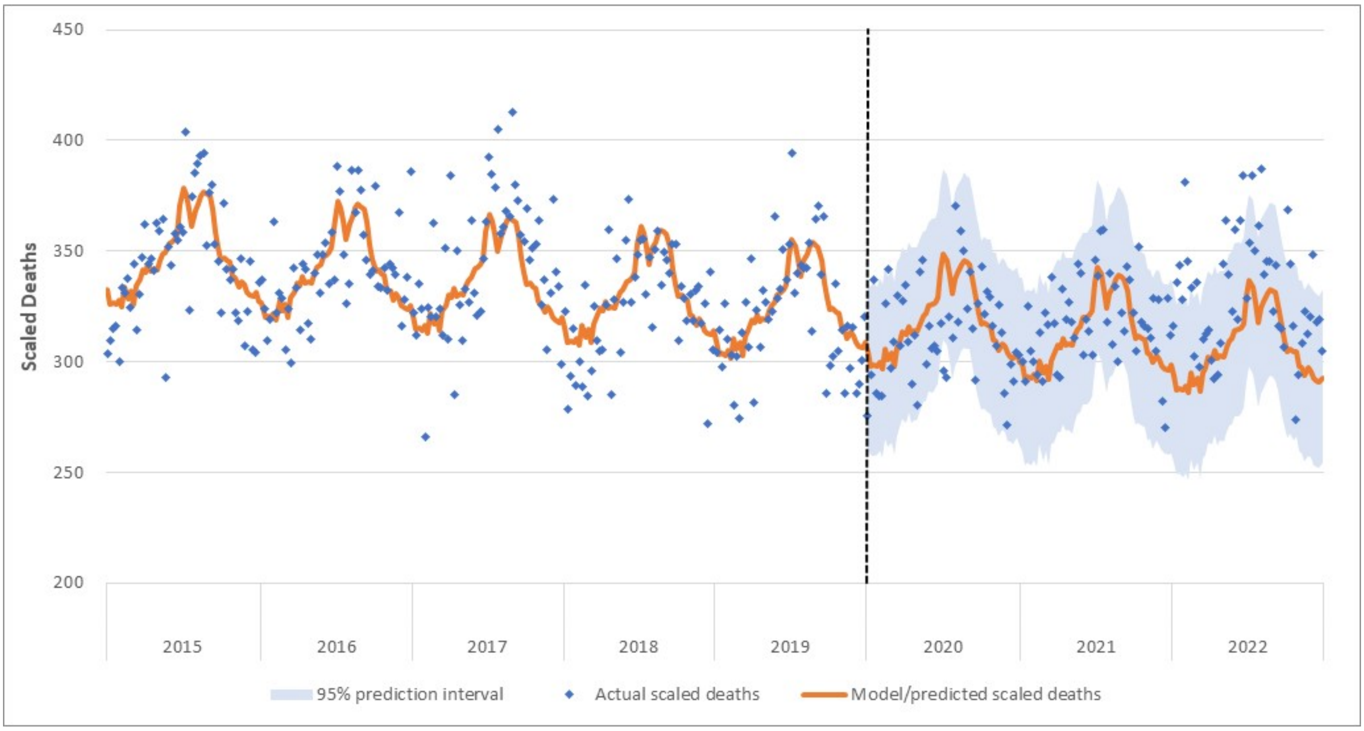


Figure 68 – Deaths of males aged 75-84

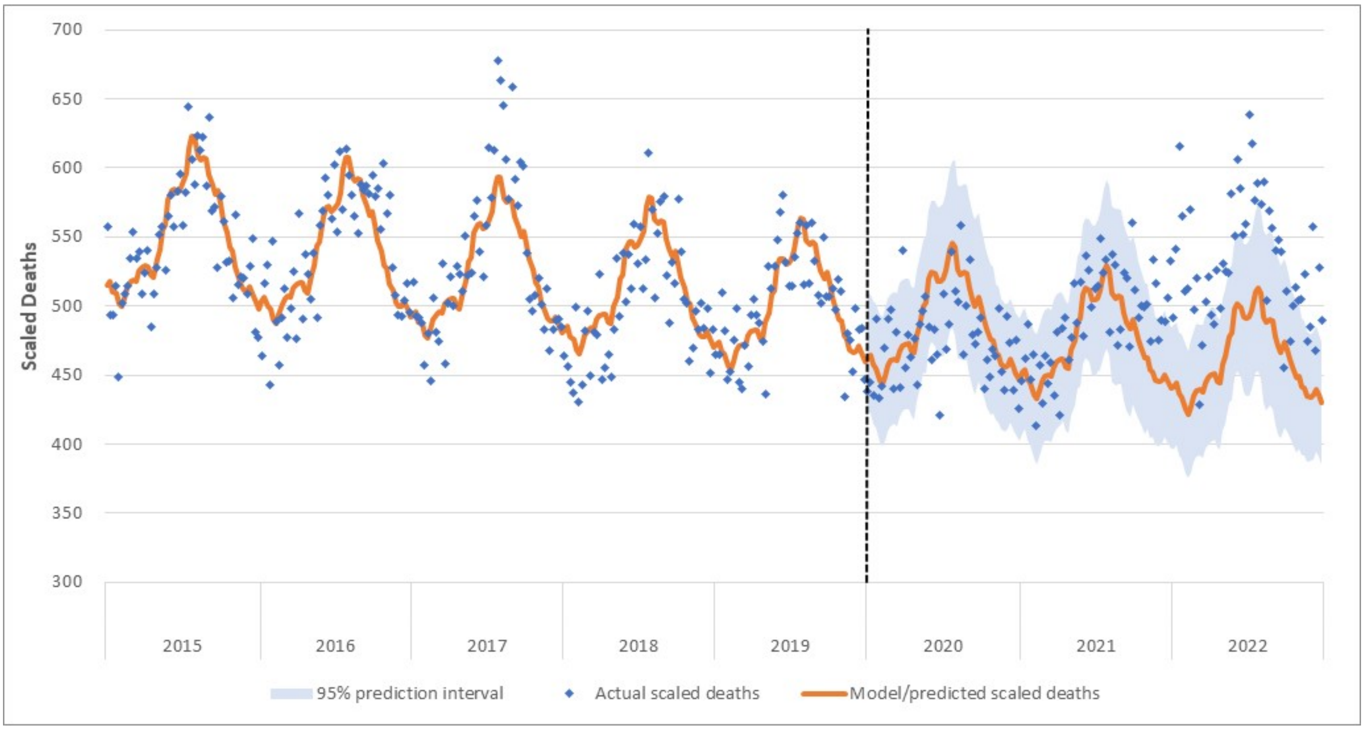


Figure 69 – Deaths of males aged 85+

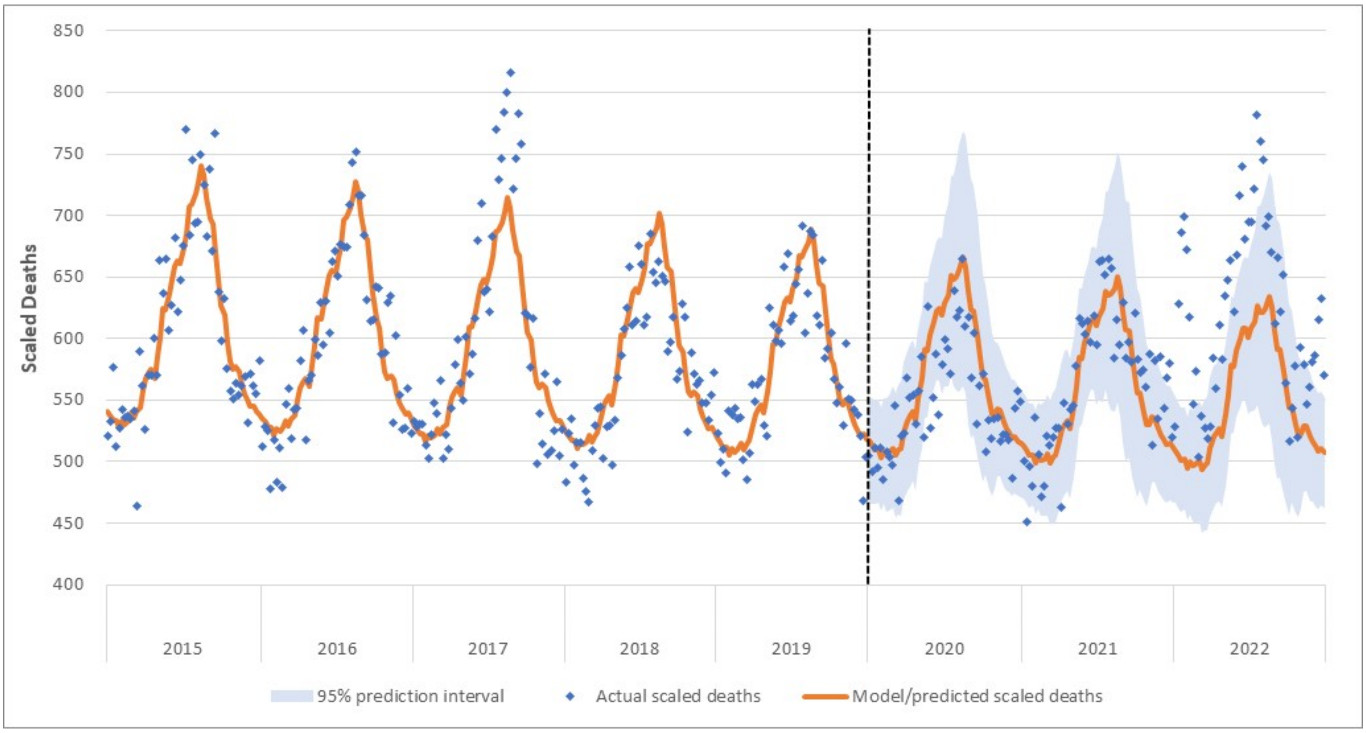
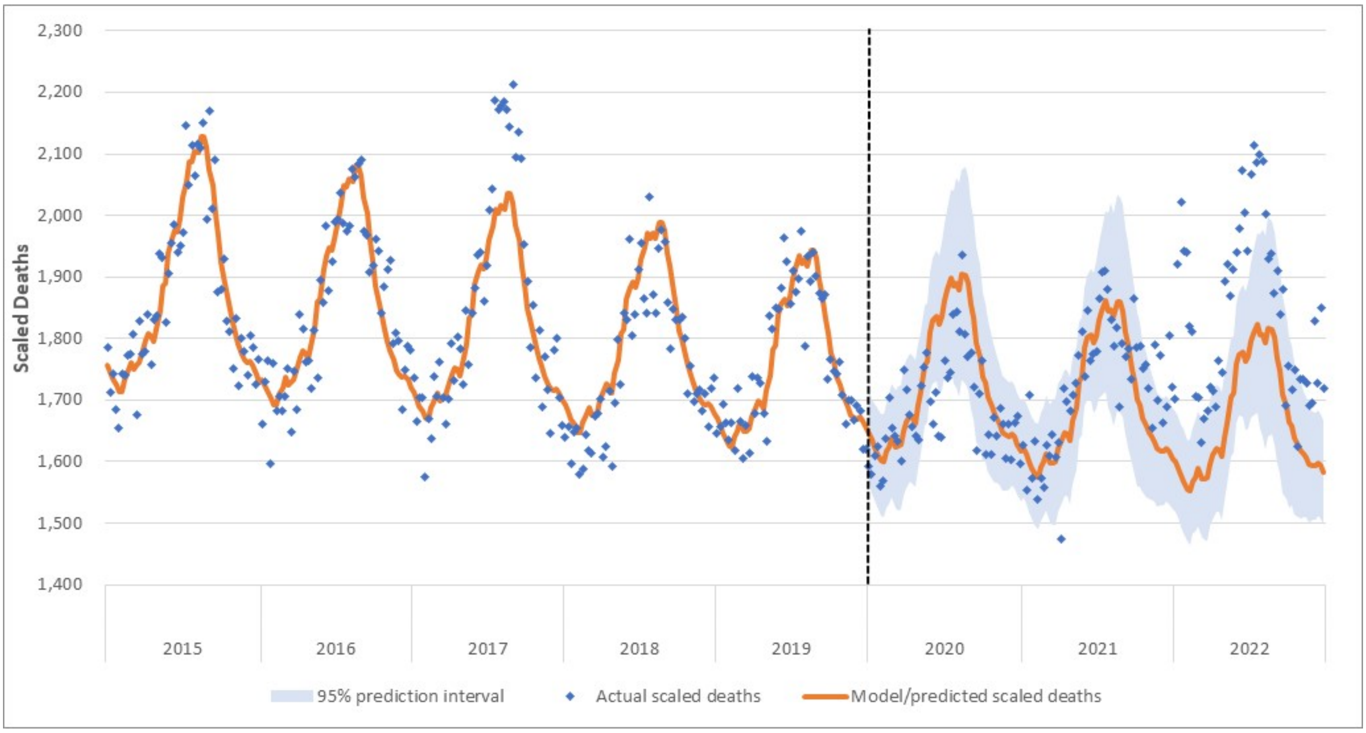


Figure 70 – Deaths of all males



D.2 Deaths for Females by Age Band

Figure 71 – Deaths of females aged 0-44

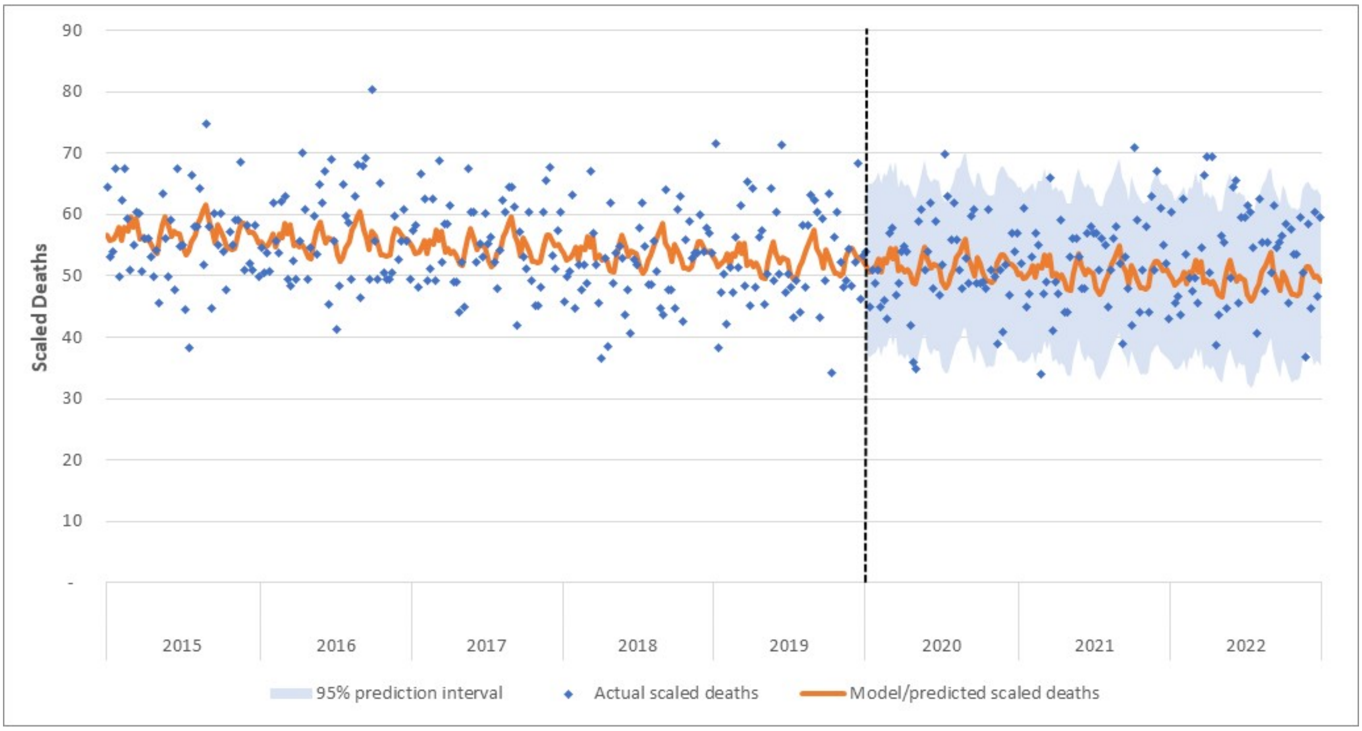


Figure 72 – Deaths of females aged 45-64

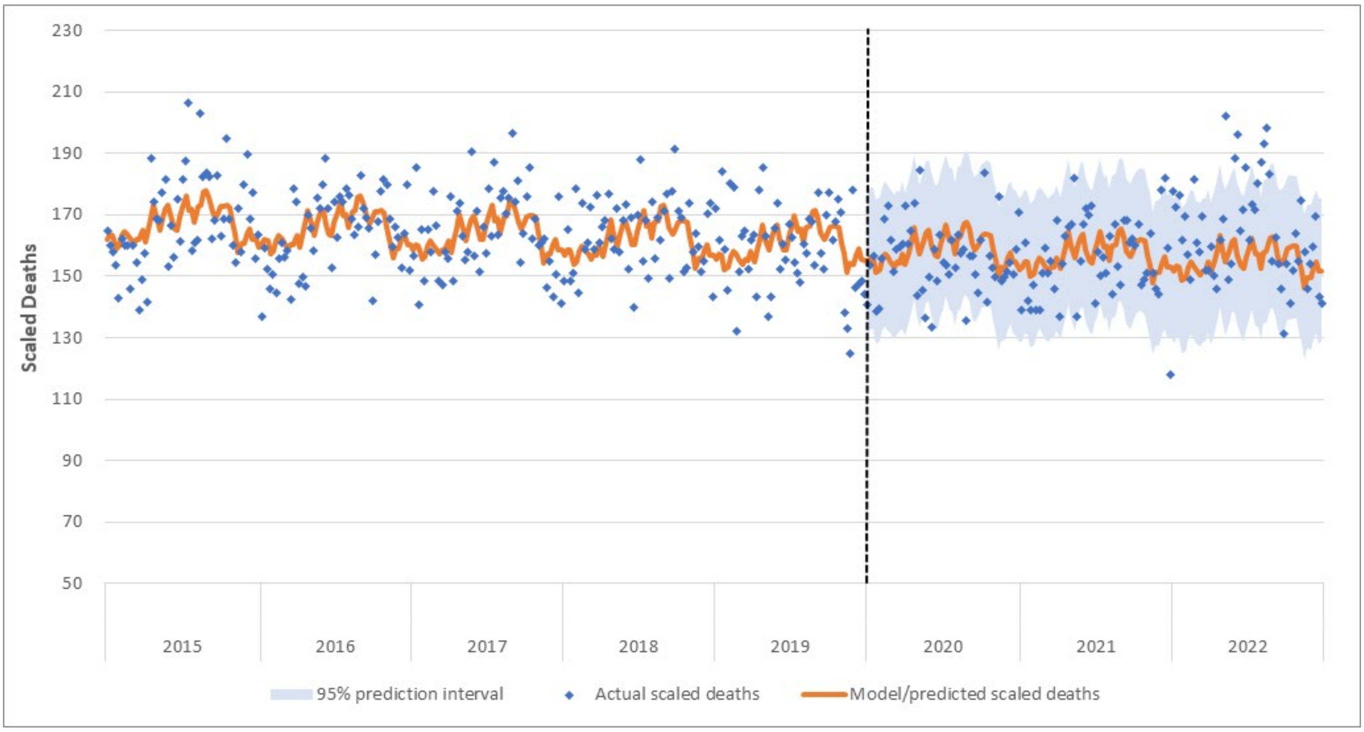


Figure 73 – Deaths of females aged 65-74

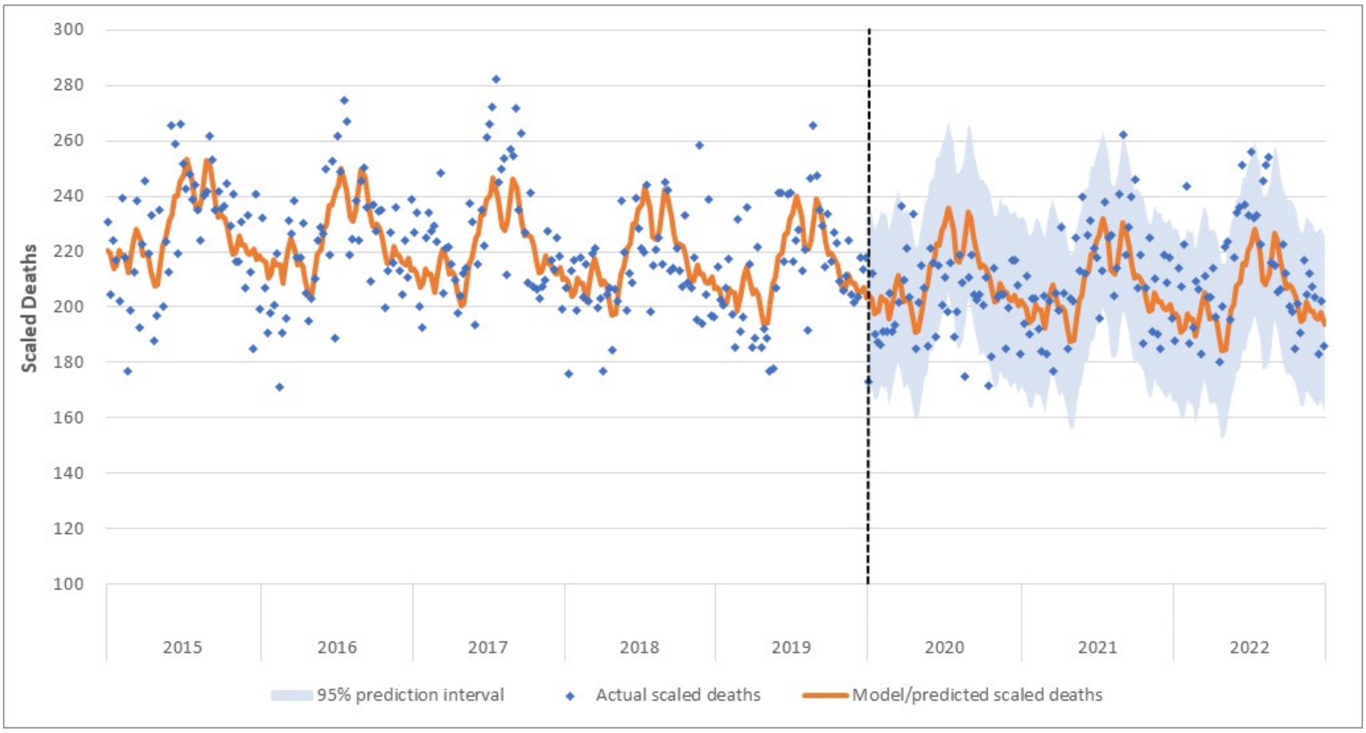


Figure 74 – Deaths of females aged 75-84

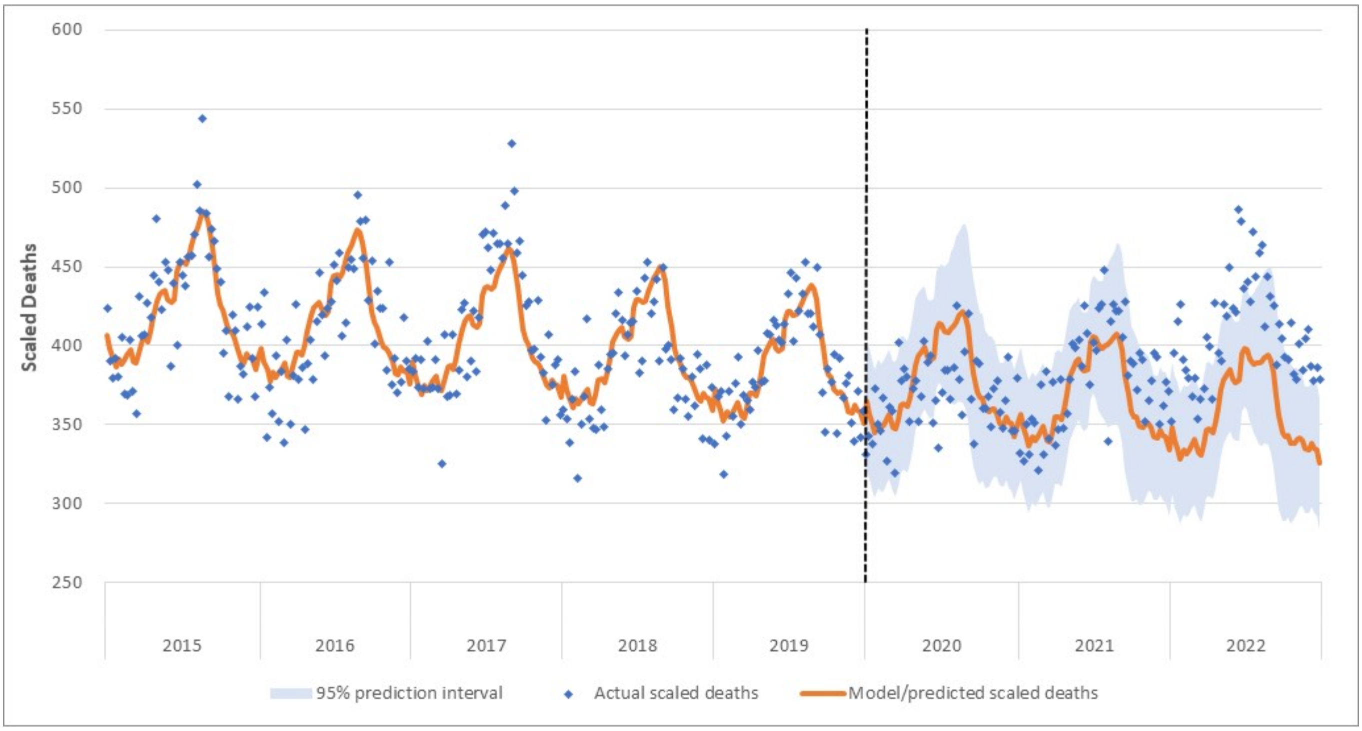


Figure 75 – Deaths of females aged 85+

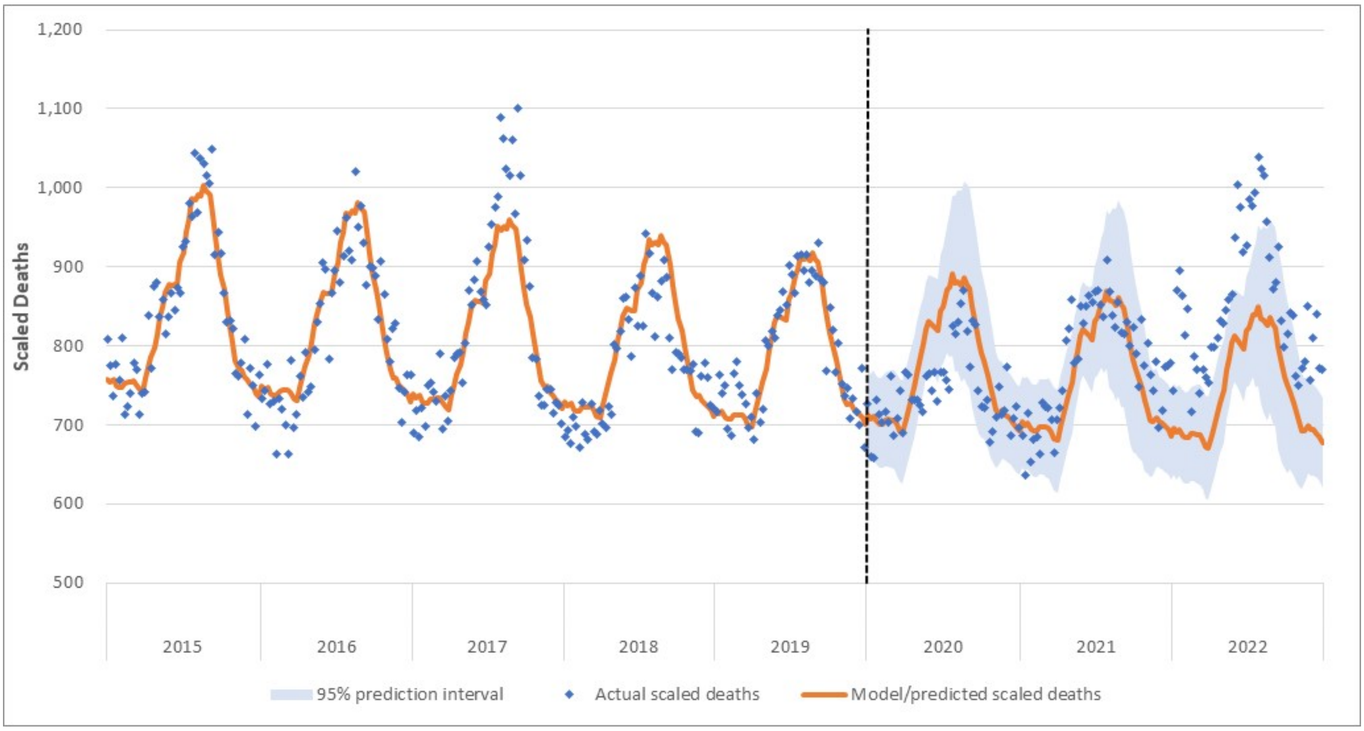
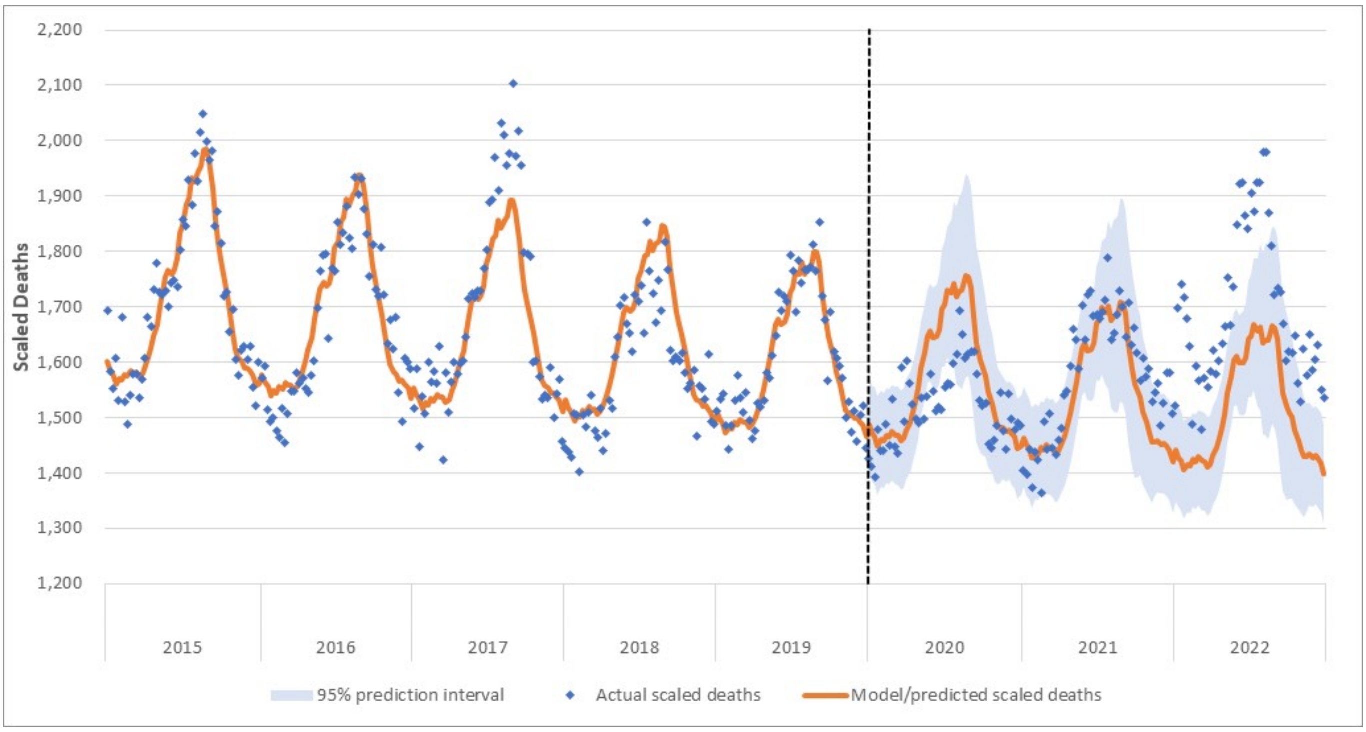


Figure 76 – Deaths of all females



Appendix E Excess deaths by State/Territory

This appendix includes graphs for each state and territory, showing:

- The actual scaled deaths (scaled to reflect the 2022 population size and age mix)
- The modelled scaled deaths (for the 2015-2019 years) and predicted scaled deaths (2020-2022 years)
- The 95th percentile prediction interval for the 2020 to 2022 years.

Figure 77 – Deaths NSW

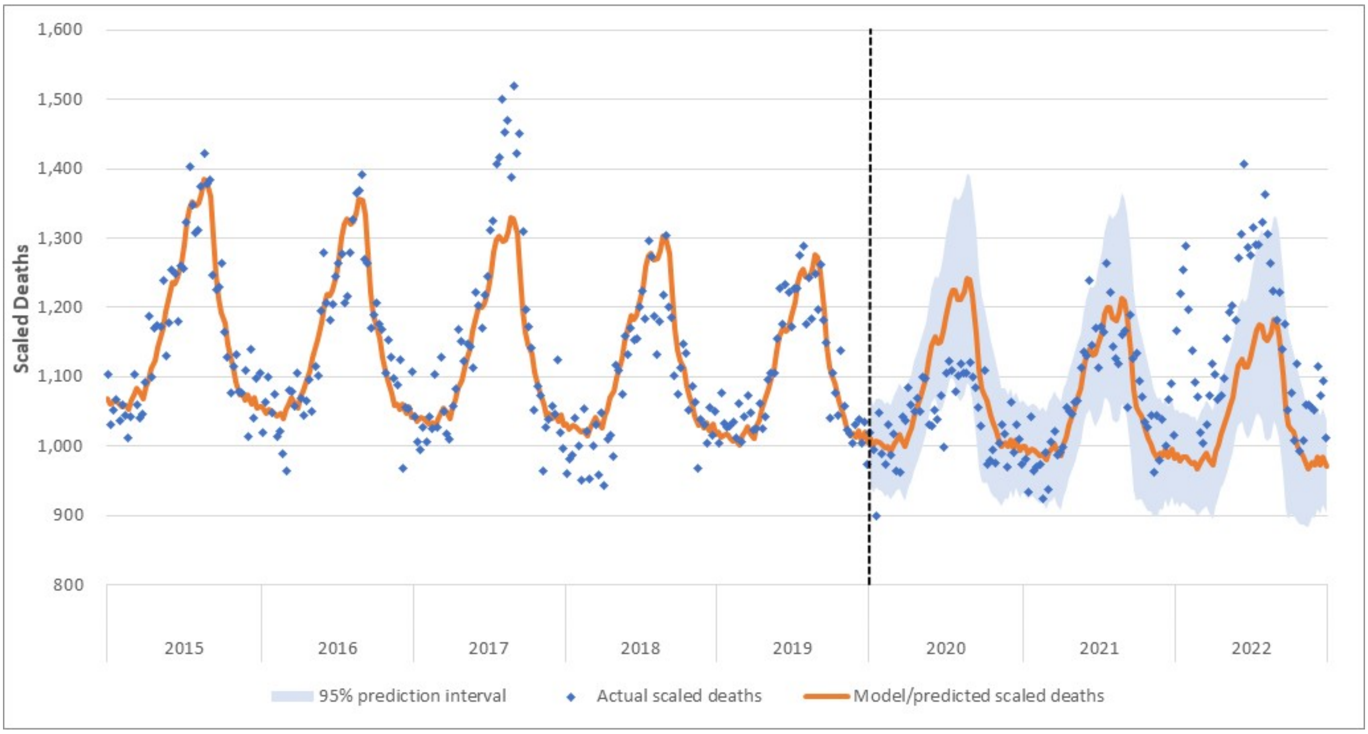


Figure 78 – Deaths Victoria

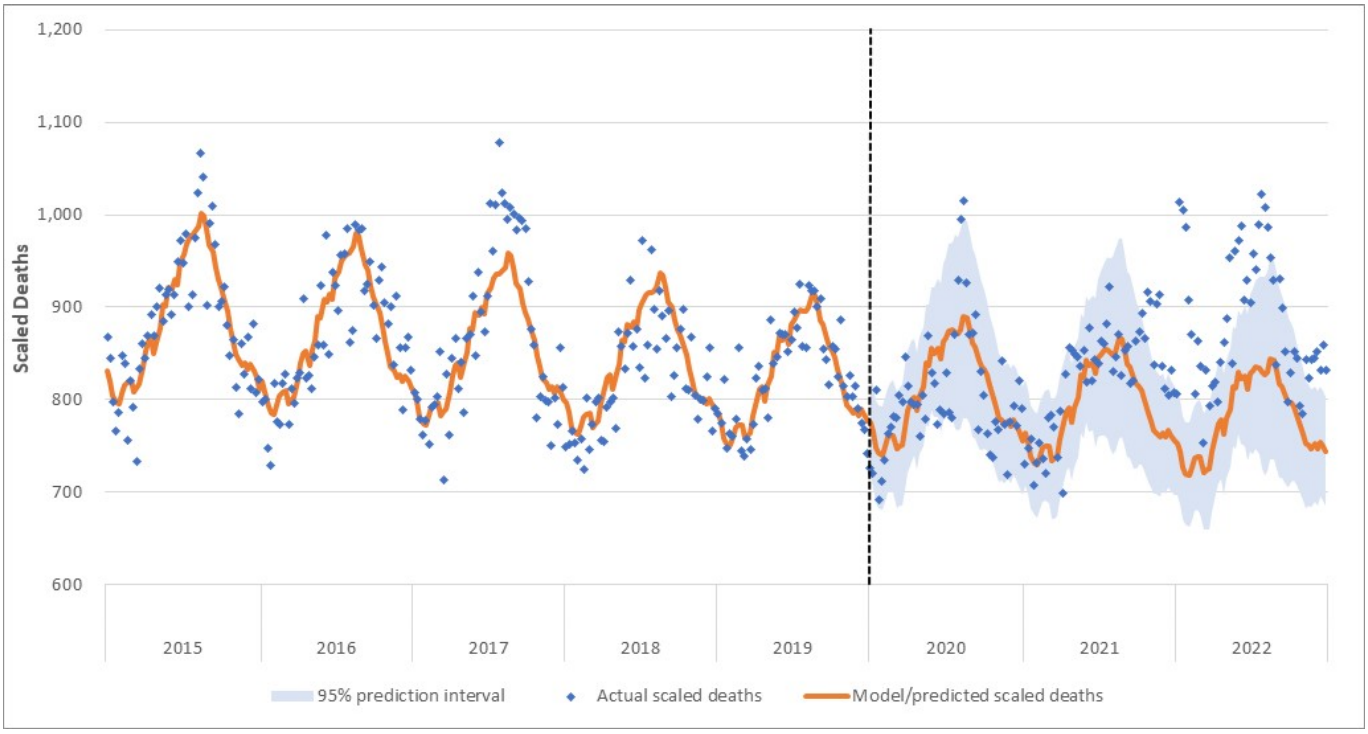


Figure 79 – Deaths Queensland

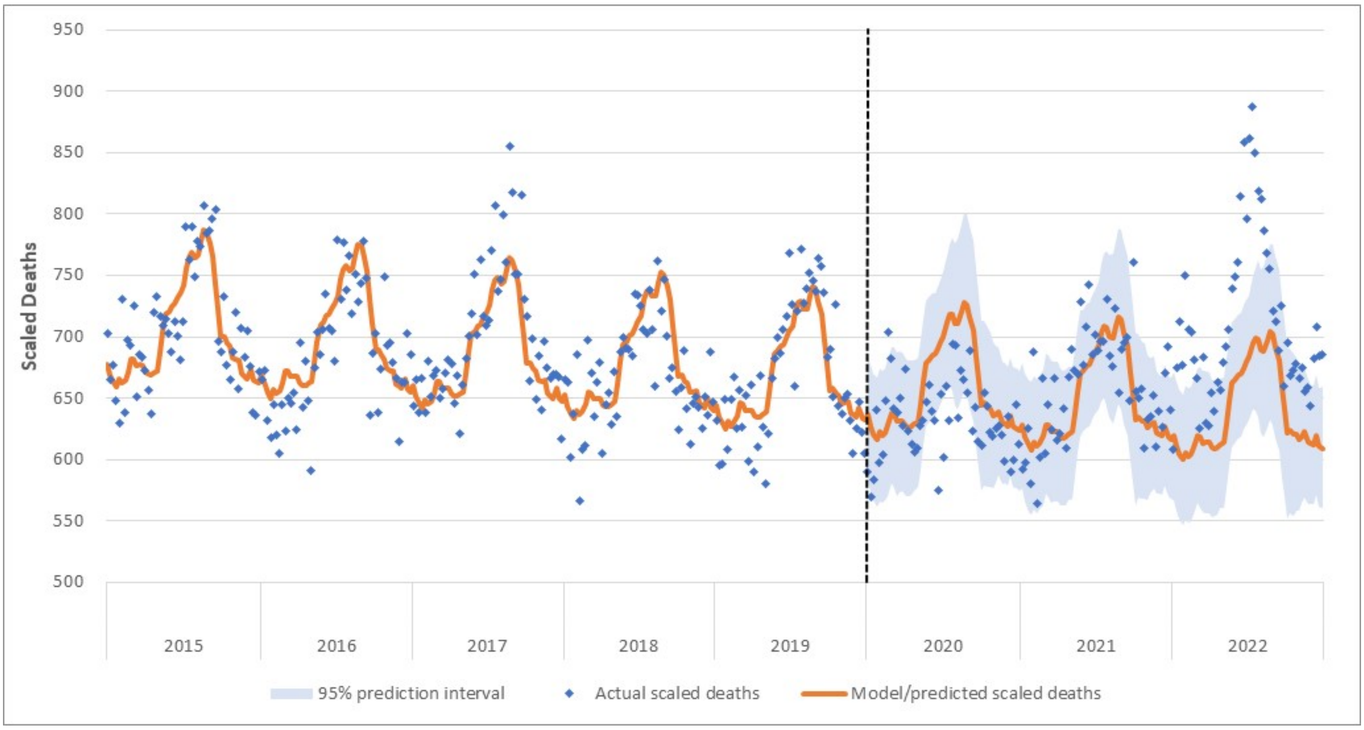


Figure 80 – Deaths South Australia

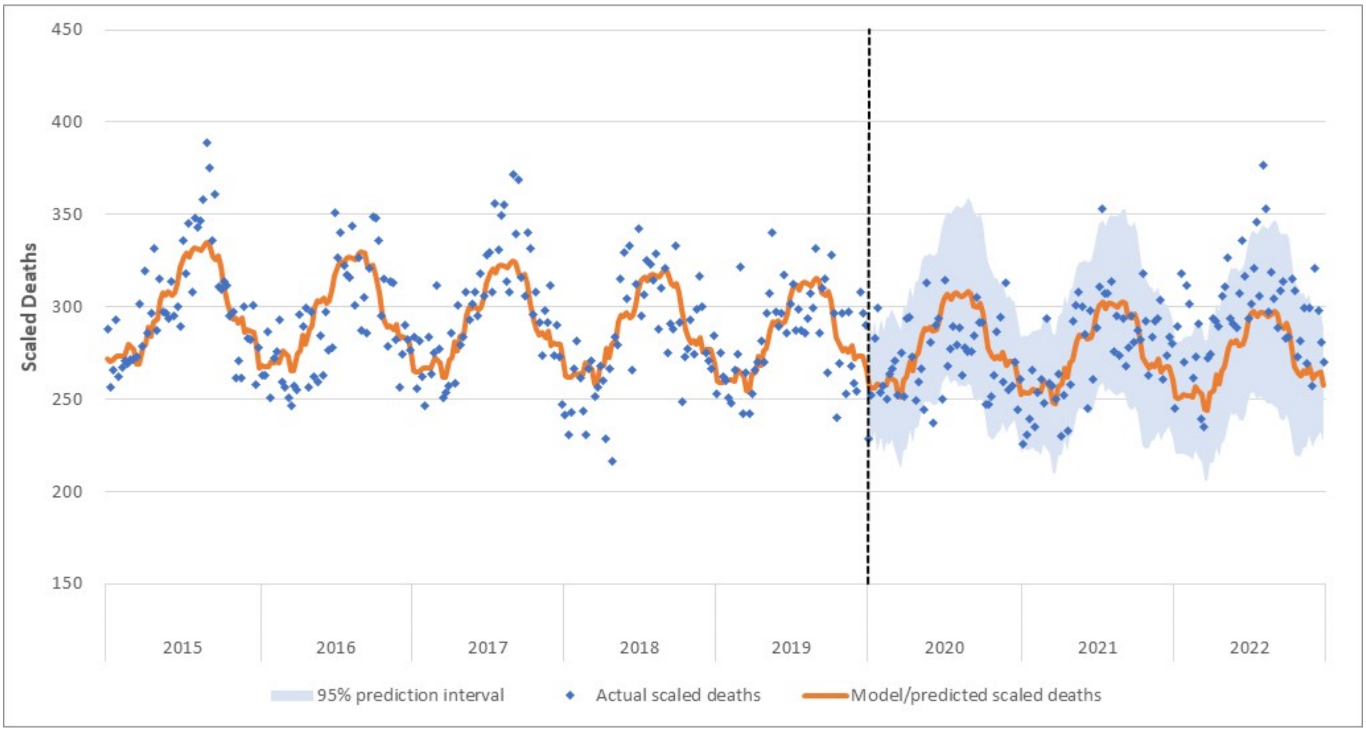


Figure 81 – Deaths Western Australia

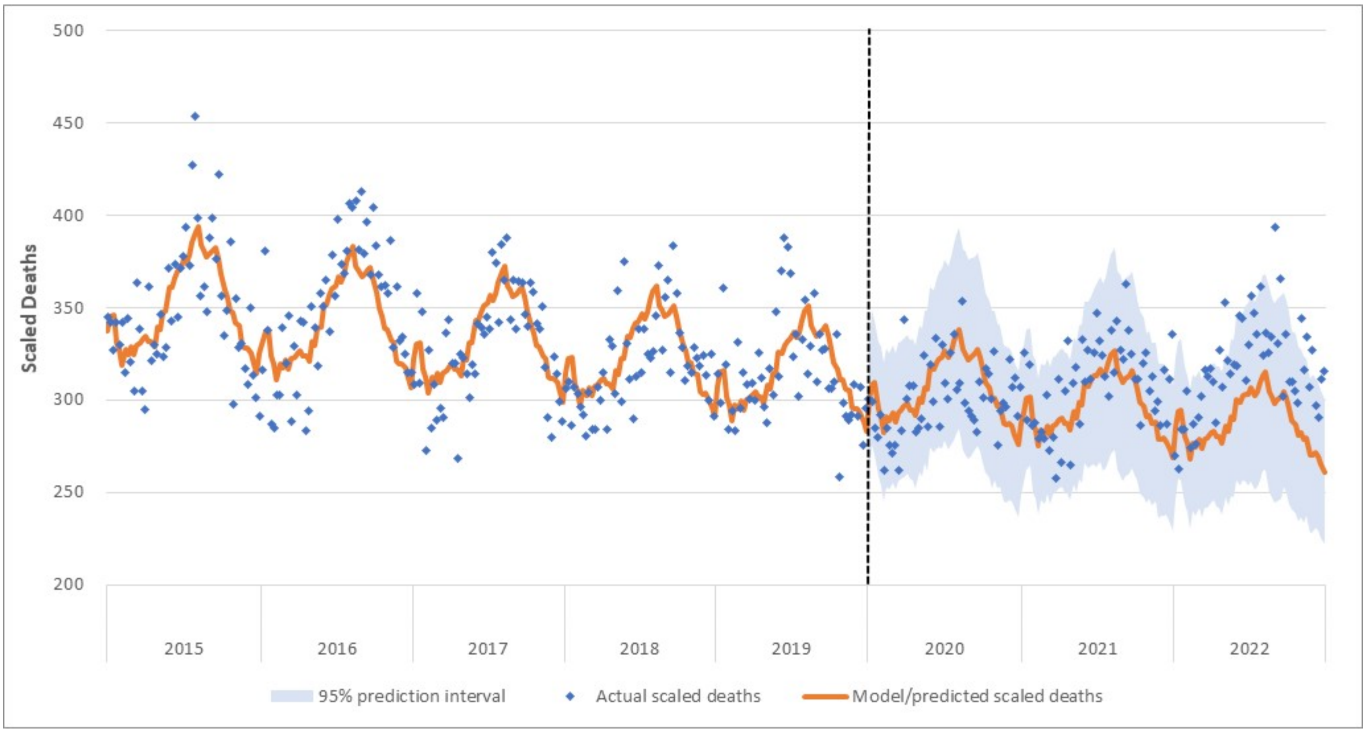


Figure 82 – Deaths Tasmania

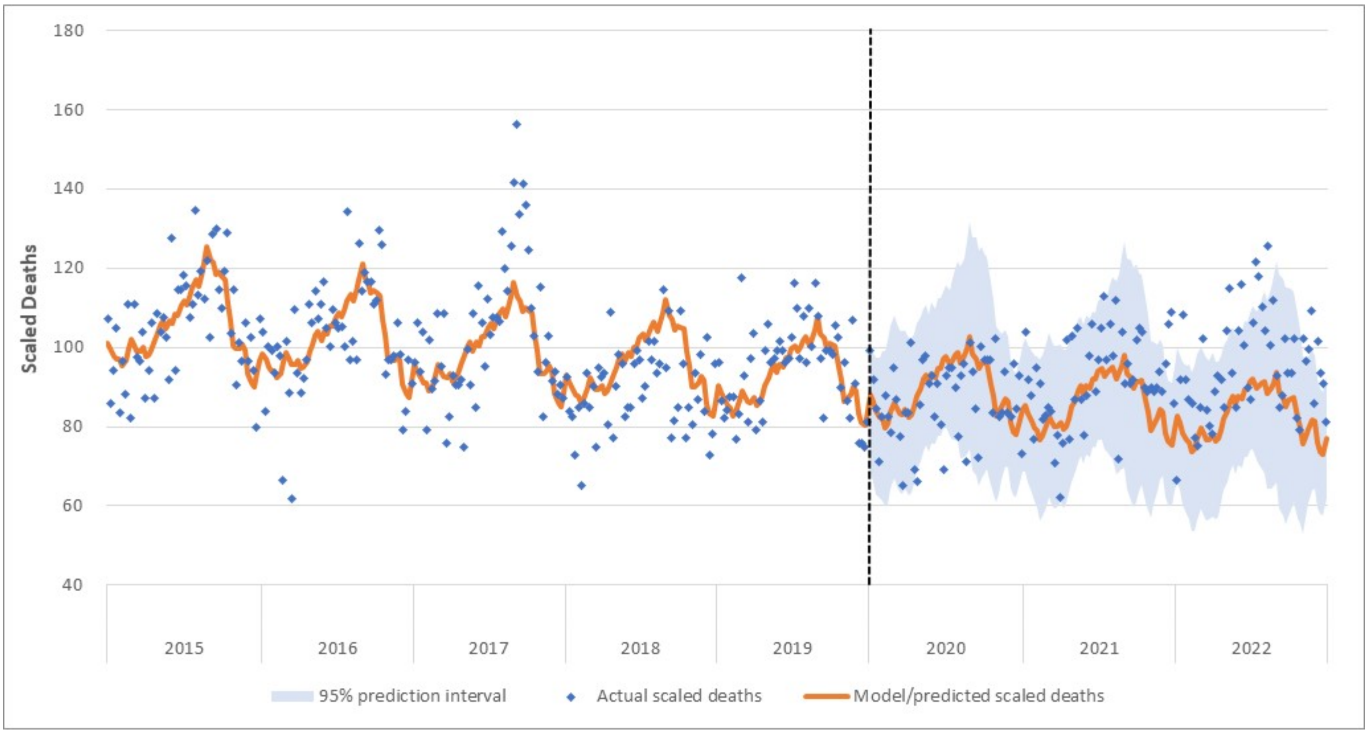


Figure 83 – Deaths Northern Territory

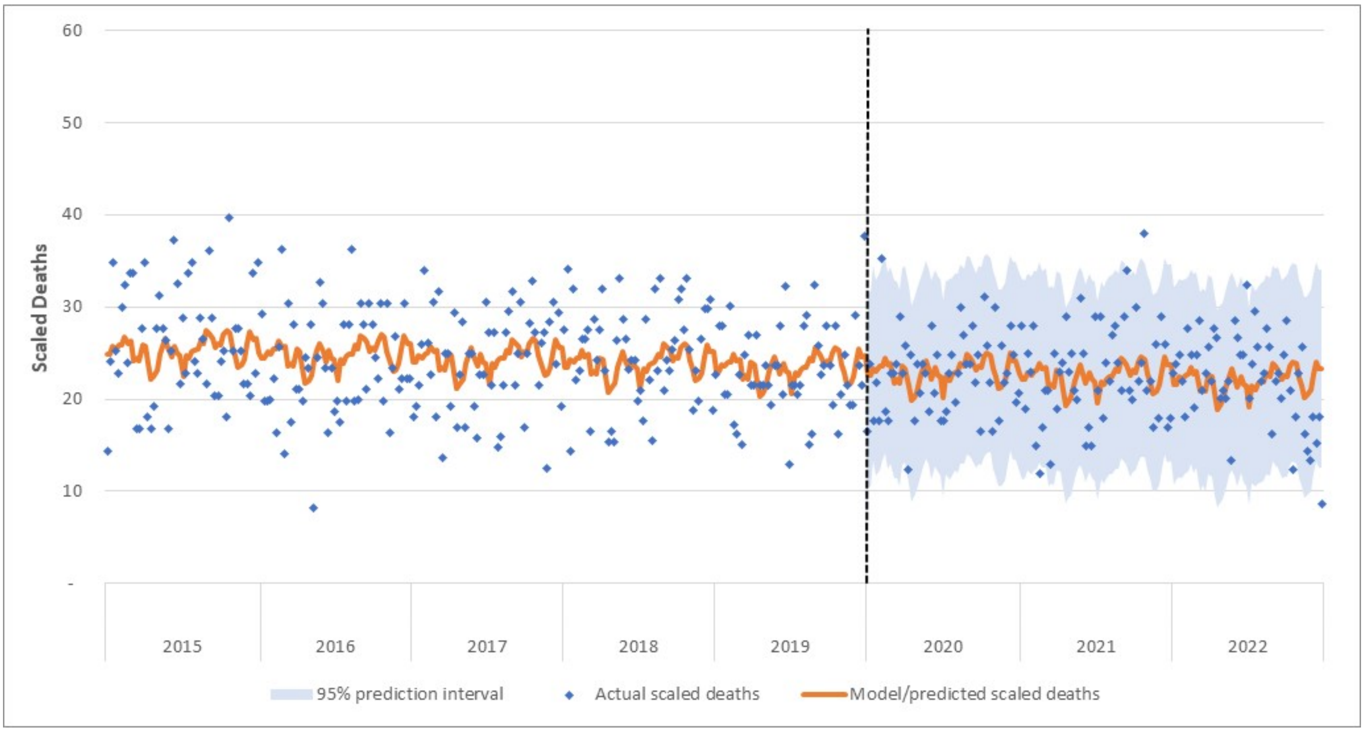
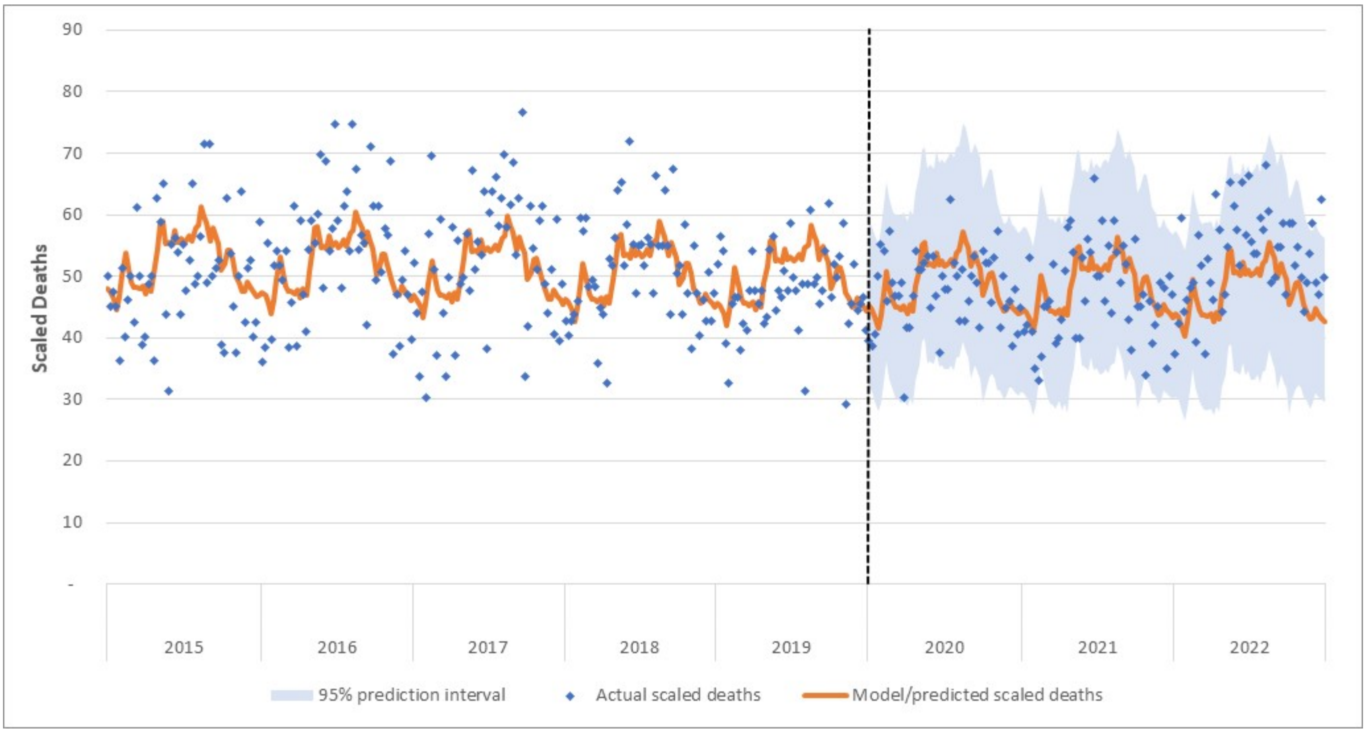


Figure 84 – Deaths ACT



Appendix F Excess mortality by region in 2020-22

Figure 85 – Excess mortality by region in 2020-22, showing differences in regional trends

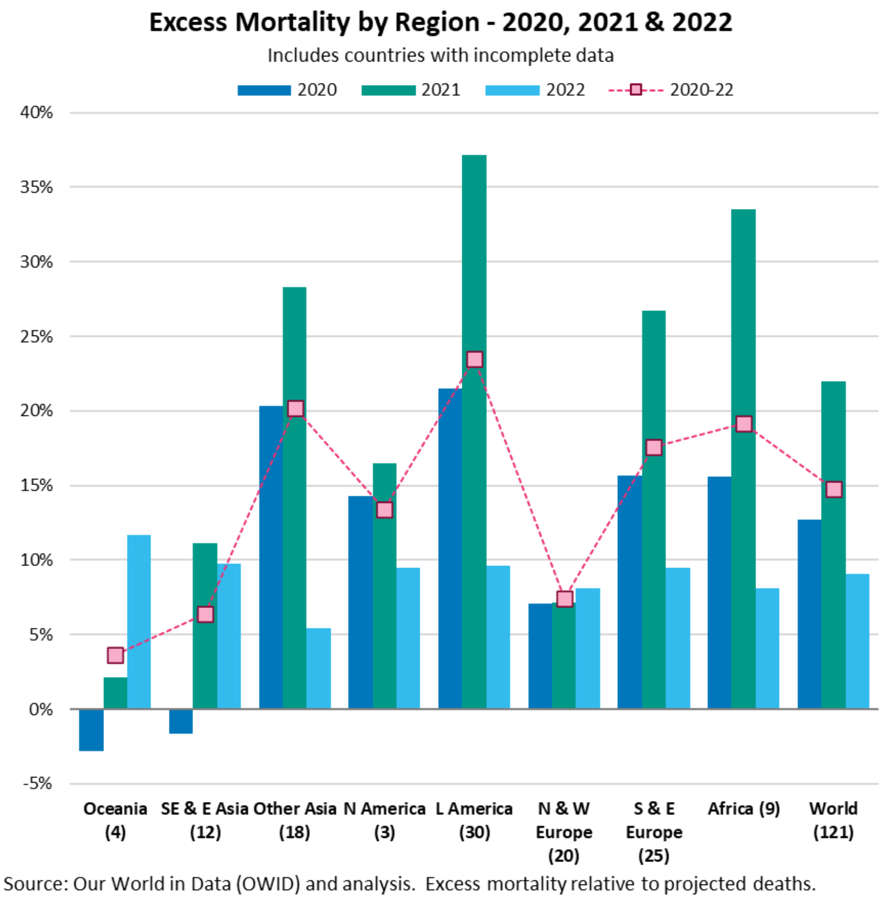


Figure 85 is a repeat of Figure 35, showing the different shapes of annual excess mortality in different regions. In this Appendix, we will look at these regions in more detail. In so doing, we will look at both annual excess mortality and a weekly[49] comparison of COVID-19 and excess mortality for each of our selected countries. Because this comparison no longer requires data for the whole of 2022, we are also able to include several other countries.

In the weekly comparison, we have adopted a style modelled on similar charts produced by The Economist. Each chart, apart from a few Latin American countries[50], uses the same scale for ease of comparison across countries[51]. For all the weekly comparison charts, COVID-19 deaths (as a percentage of expected deaths[52]) are shown in blue, while total excess deaths are shown by a red line.

[49] In several countries, the data is only available monthly; these countries are indicated with (M)
[50] Excess mortality has been so high in Bolivia, Cuba, Ecuador and Peru that we have had to use double the standard scale
[51] For some countries, a peak of excess mortality exceeds the top end of the scale (-25% to +125%), but we consider that this does not detract from the reader's understanding
[52] Where necessary, expected deaths have been estimated, but any consequent error in the COVID-19 mortality rate will be extremely small

Oceania

Figure 86 – Annual excess mortality in Oceania in 2020-22, showing the dominance of Australia

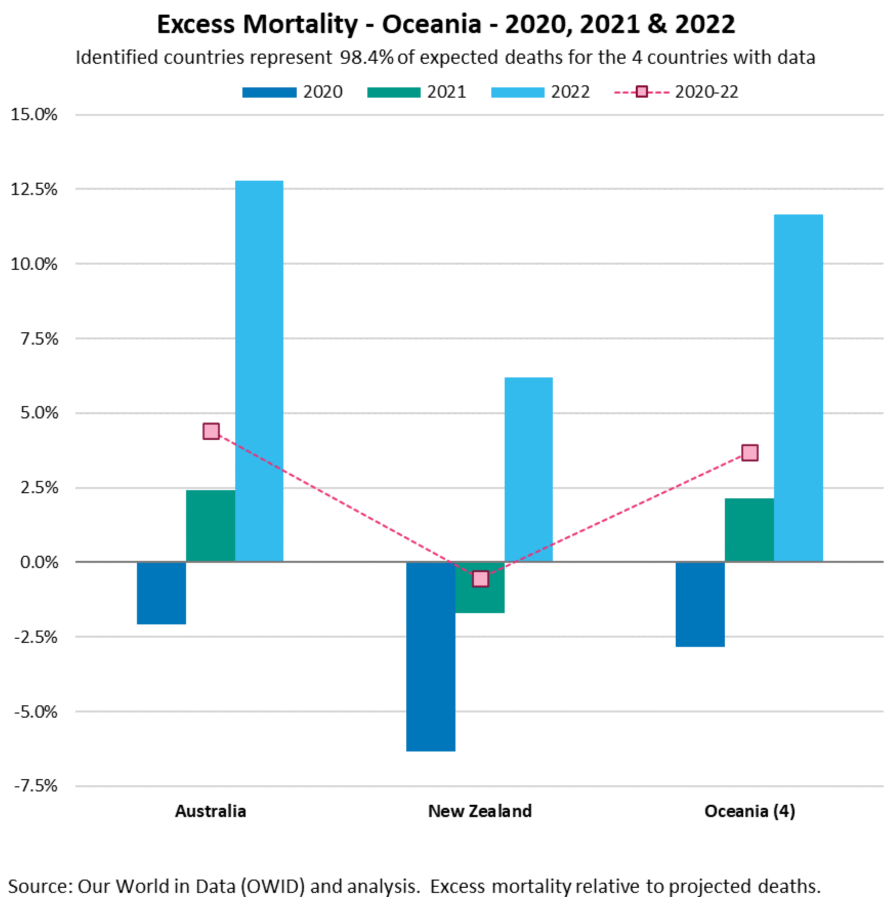
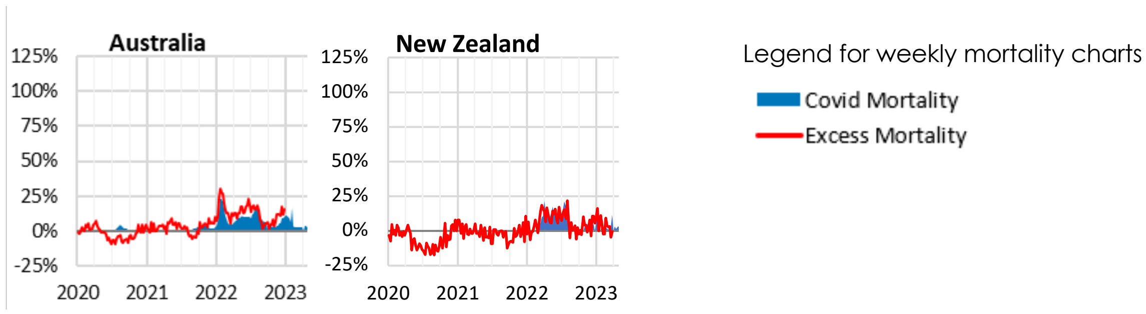


Figure 87 – Comparison of weekly COVID-19 mortality and total excess mortality in Oceania in 2020-22, showing similar trends in Australia and New Zealand



As Figure 86 shows, excess mortality in Oceania is dominated by Australia. New Zealand has experienced consistently lower excess mortality than Australia every year. In fact, New Zealand is the largest of only three countries in the OWID database with negative aggregate excess mortality over the three years[53].

Figure 87 shows the similarity in mortality patterns between Australia and New Zealand, apart from the Omicron peak in early 2022 in Australia, when New Zealand's borders were still closed.

[53] The other two are Luxembourg (W Europe) and Greenland (N America), the only country with negative excess mortality every year

South-East & East Asia

Figure 88 – Annual excess mortality in SE & E Asia in 2020-22, showing significant differences between countries

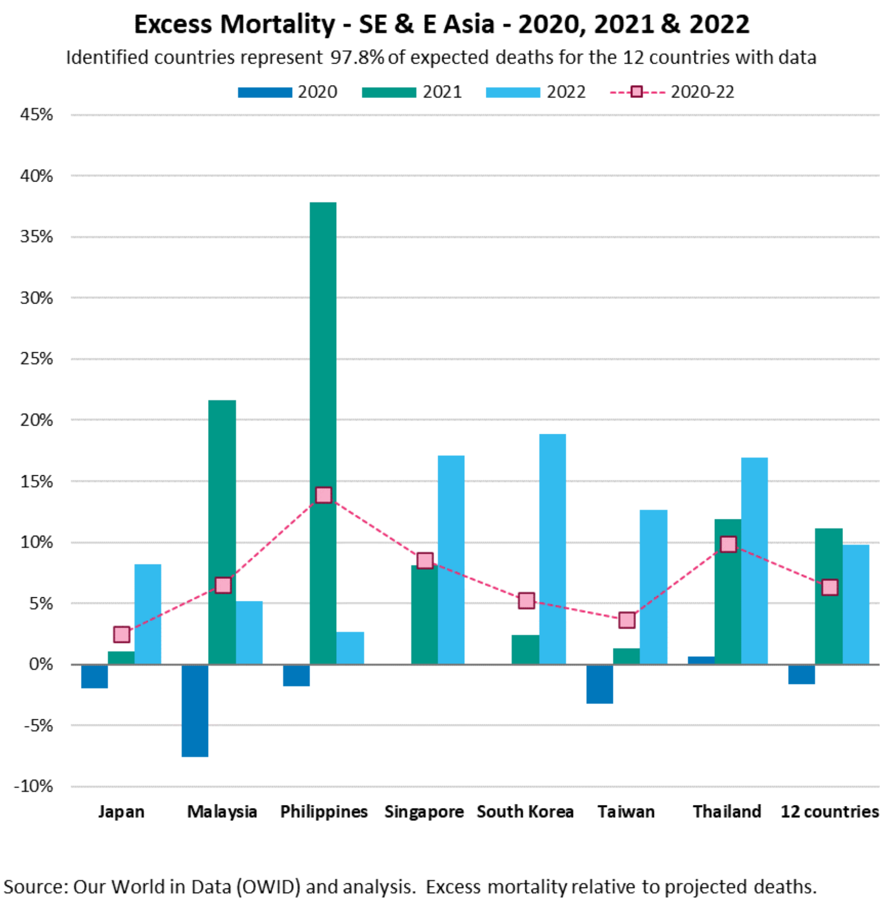
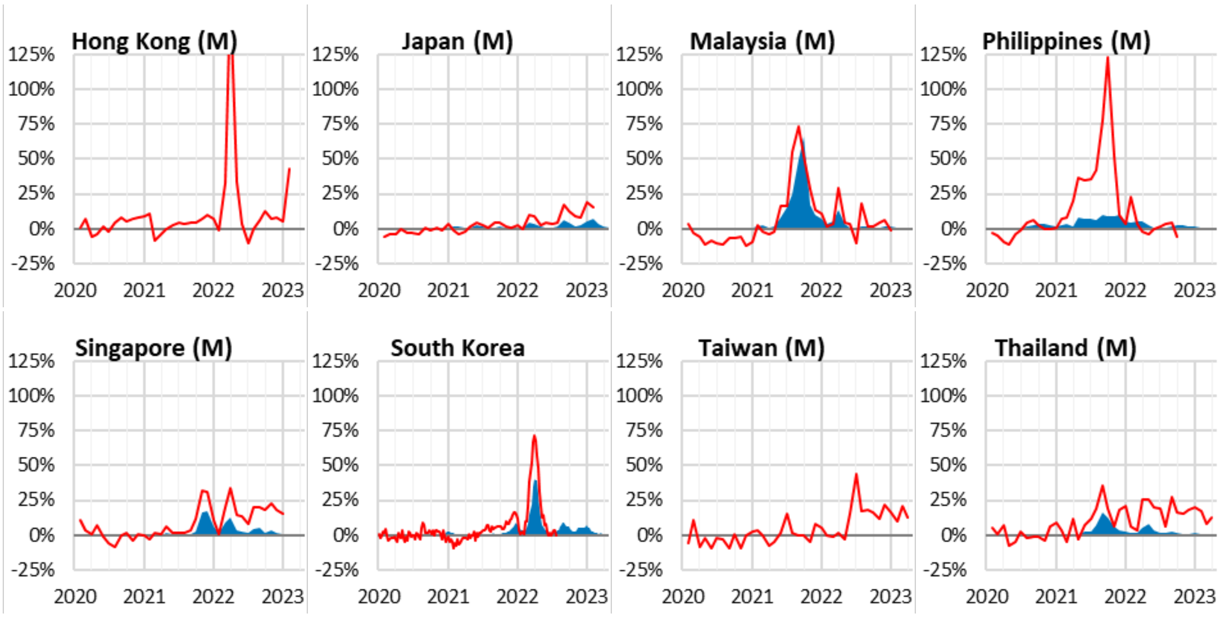


Figure 89 – Comparison of weekly COVID-19 mortality and total excess mortality in SE & E Asia in 2020-22, showing high spikes in Malaysia and the Philippines in 2021 and in Hong Kong and South Korea in 2022

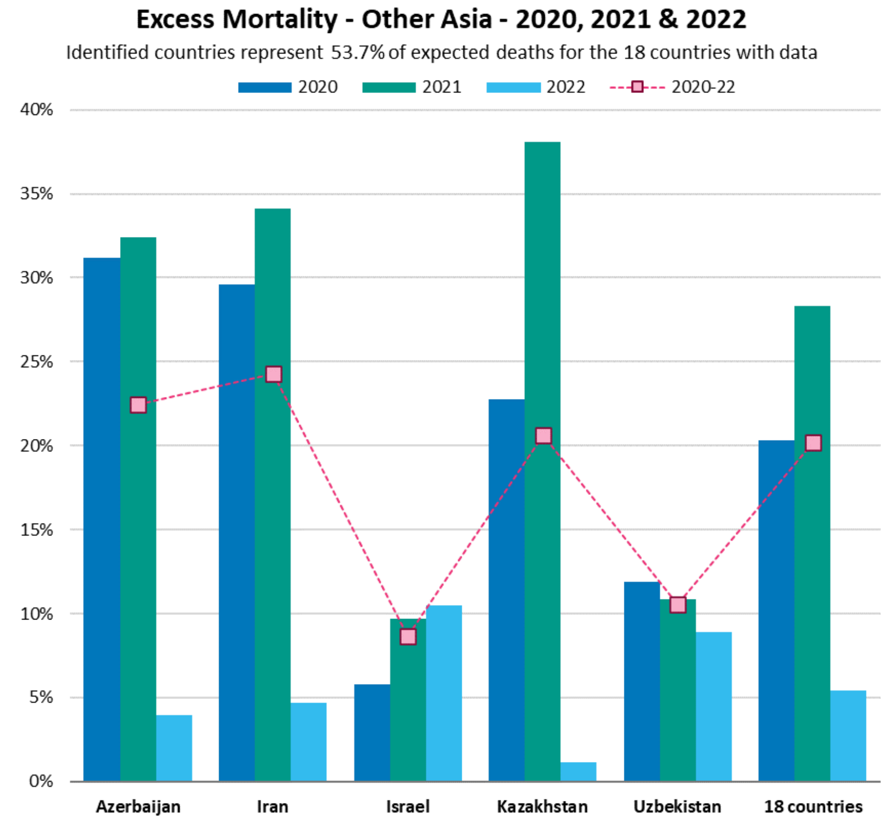


We see (Figure 88) significant differences between countries in SE & E Asia. Some (including Japan, South Korea and Taiwan) show a similar pattern to Australia. However, Malaysia and the Philippines saw very high excess mortality in 2021 and a decline in 2022.

These observations are borne out by Figure 89, where it is also clear that COVID-19 deaths have surely been under-reported in some countries and/or time periods.

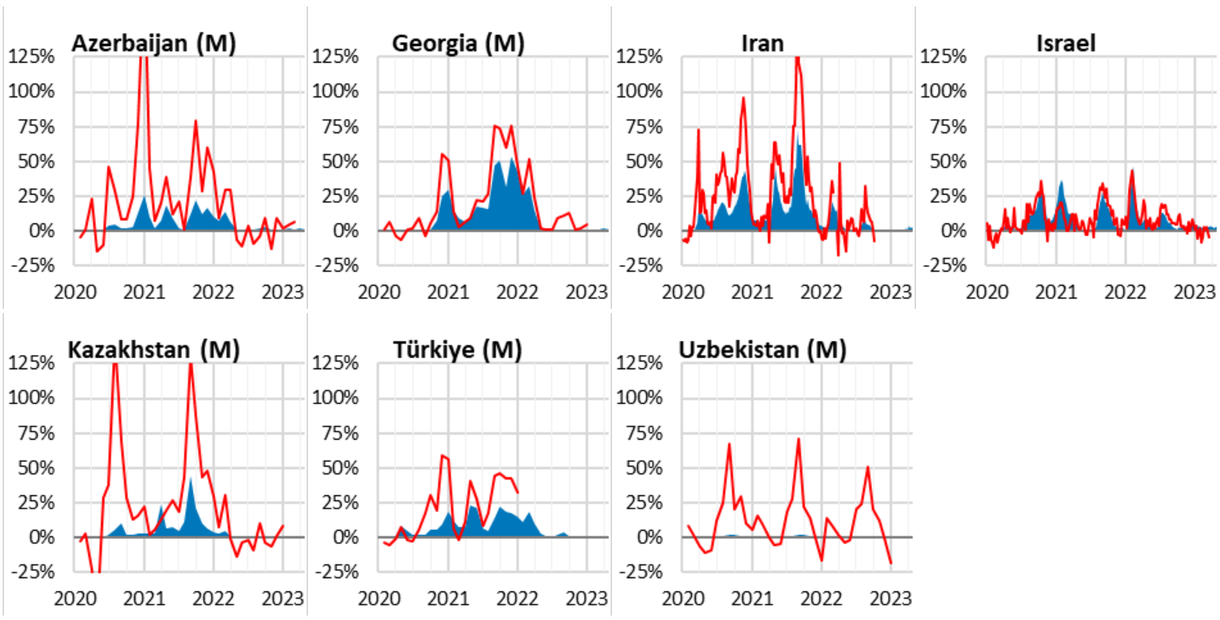
Other Asia

Figure 90 – Annual excess mortality in Other Asia in 2020-22, showing a generally consistent pattern



Source: Our World in Data (OWID) and analysis. Excess mortality relative to projected deaths.

Figure 91 – Comparison of weekly COVID-19 mortality and total excess mortality in Other Asia in 2020-22, showing high spikes in several countries at various times



In Figure 90, we can see a general pattern of high 2020 excess mortality, increasing in 2021 and dropping to much lower levels in 2022. Israel, however, has behaved more like a North or West European country, and Uzbekistan is also different.

Figure 91 shows that Uzbekistan has had a mortality spike in August of each of the three years. It is not clear why this should be the case. There are spikes in other countries at various times.

North America

Figure 92 – Annual excess mortality in North America in 2020-22, showing the dominance of the USA

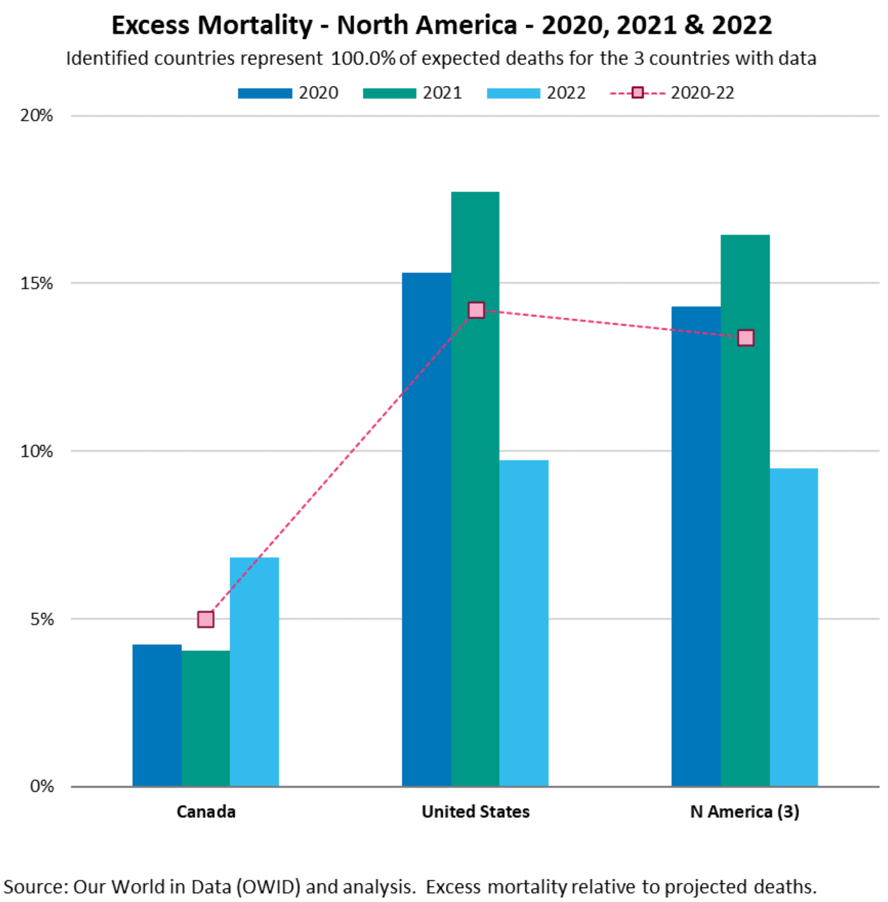


Figure 93 – Comparison of weekly COVID-19 mortality and total excess mortality in North America in 2020-22, showing that mortality in Canada has been consistently much better than in the USA

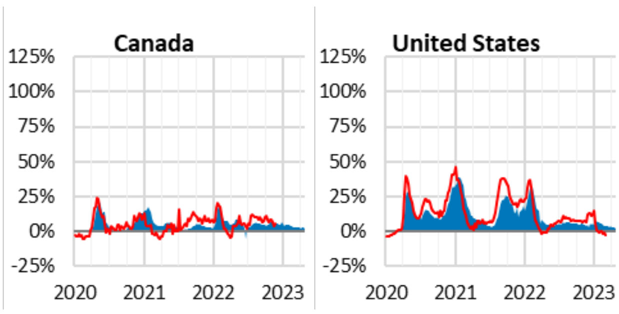
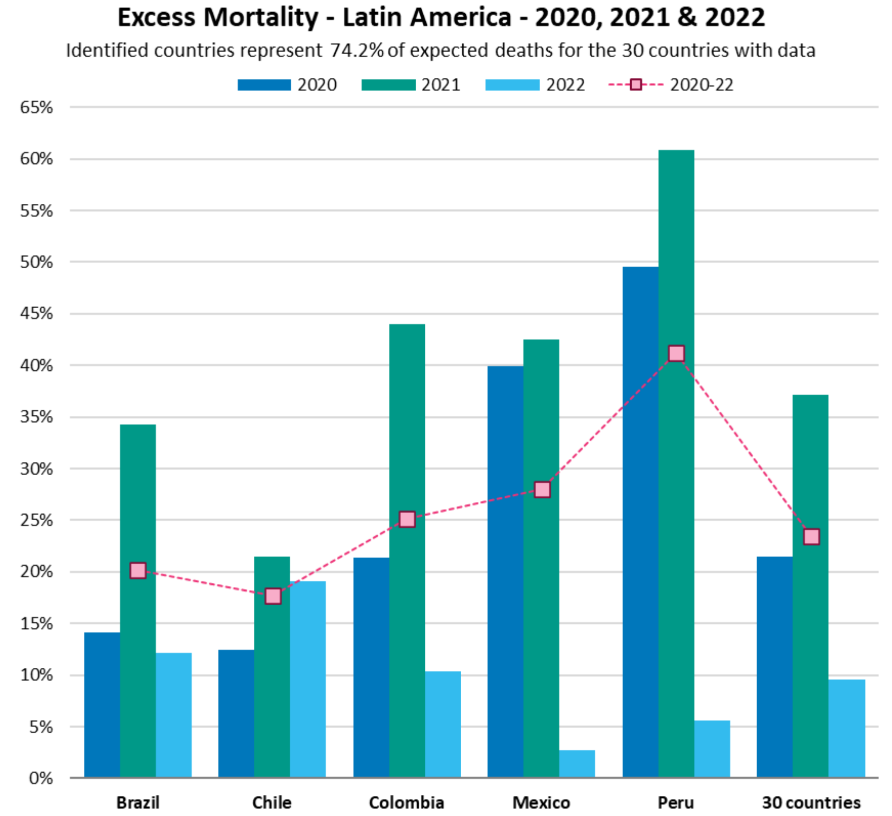


Figure 92 shows that excess mortality in the USA was above 15% in 2020 and even higher in 2021, dropping just below 10% in 2022. Canadian excess mortality has consistently been lower on an annual basis and (as can be seen in Figure 93) on a weekly basis.

Note that the UN geoscheme includes Mexico in Latin America and the Caribbean.

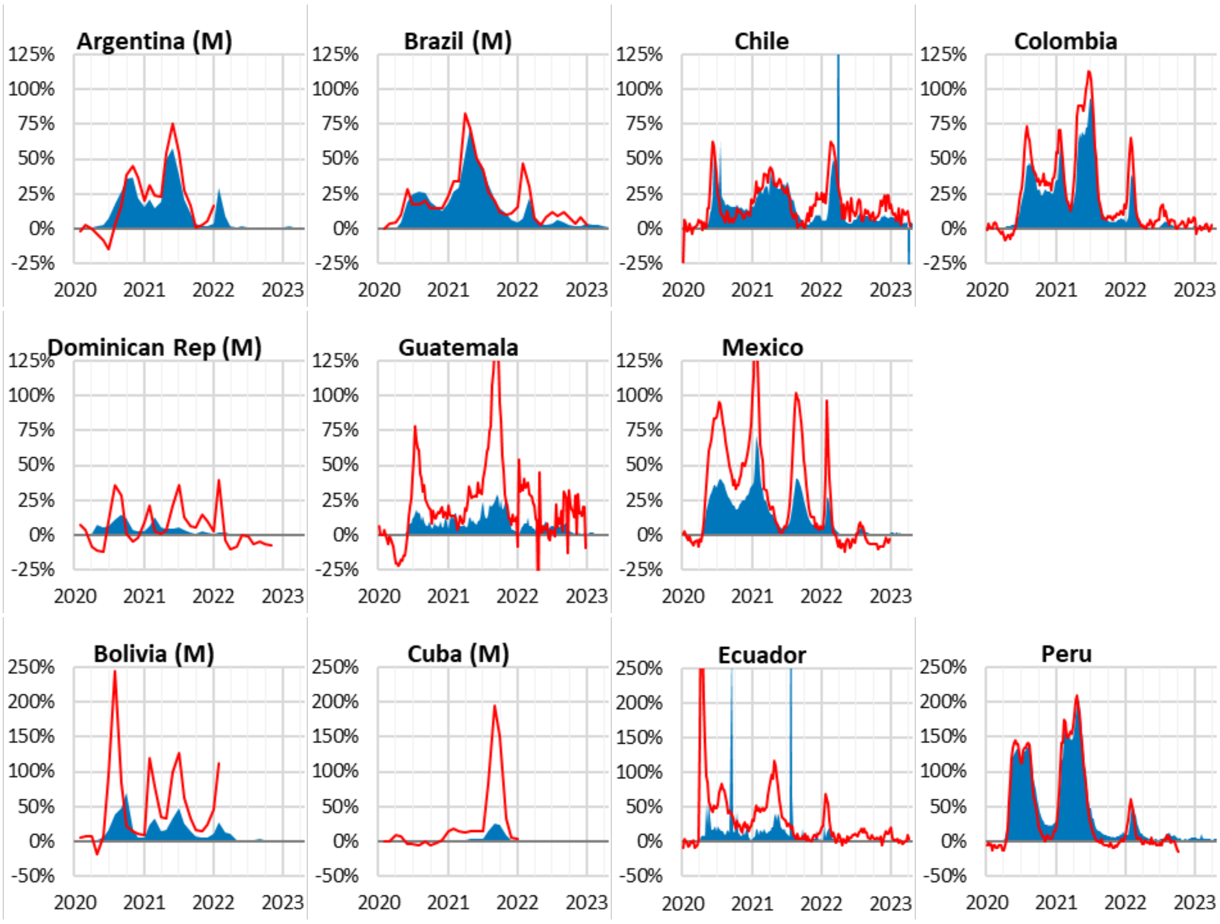
Latin America and the Caribbean

Figure 94 – Annual excess mortality in Latin America and the Caribbean in 2020-22, showing a range of outcomes



Source: Our World in Data (OWID) and analysis. Excess mortality relative to projected deaths.

Figure 95 – Comparison of weekly COVID-19 mortality and total excess mortality in Latin America and the Caribbean in 2020-22, with four countries shown on a double scale due to extremely high excess mortality spikes



An interesting dichotomy can be seen in Figure 94, where countries with very high excess mortality in 2020 and 2021 had low excess mortality in 2022, while lower mortality in those years is generally associated with higher 2022 excess mortality.

Figure 95 sheds further light on this. Where there is data, every country shows an Omicron spike in early 2022, but the relative level of that spike depends on how bad mortality has been in 2020 and 2021. Moreover, there has generally been little (or negative) excess mortality after early 2022, particularly in countries where mortality was very high in 2020 and 2021.

Countries in this region tend to be poor, with little financial or health services capacity to support their population through a pandemic. Some of these charts perhaps demonstrate the achievement of a form of "herd immunity", albeit it at the cost of a huge loss of life.

In this context, it is interesting to note that total reported vaccinations per capita are running slightly higher in Peru (about 2.6) than in Australia (2.5), while Chile is the stand-out, at 3.2 vaccinations per person. By comparison, both Mexico and Colombia were at about 1.75 vaccinations per person at last report and Brazil was at 2.25.

Northern and Western Europe

Figure 96 – Annual excess mortality in Northern and Western Europe in 2020-22, showing a range of outcomes

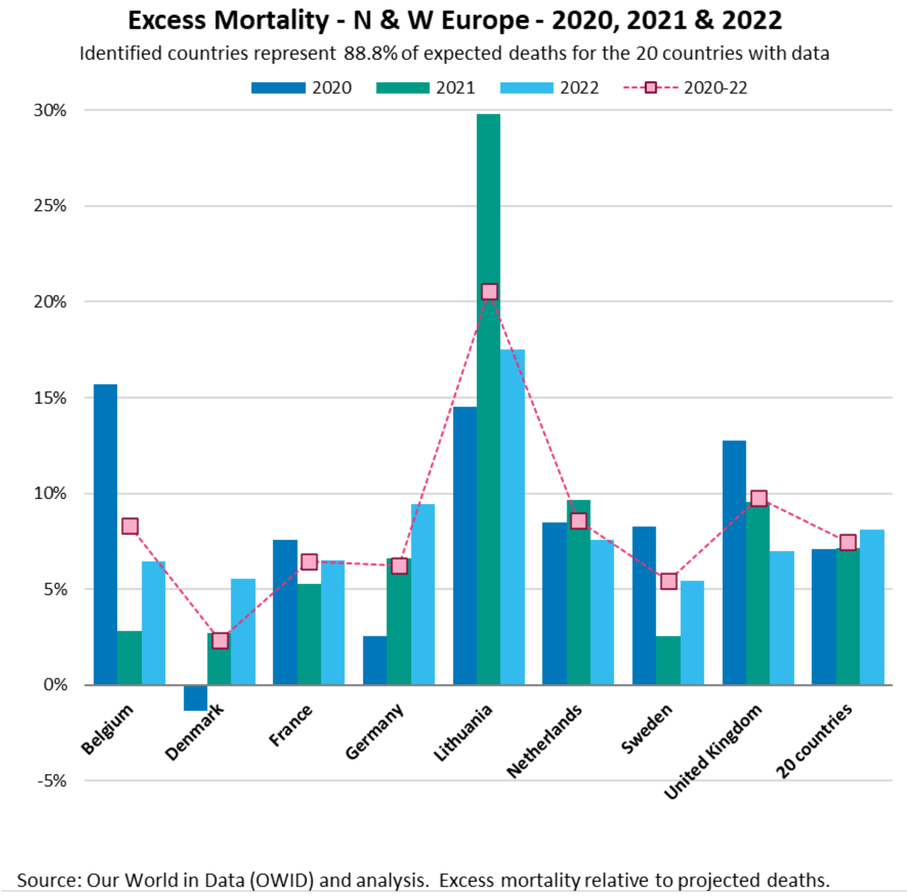
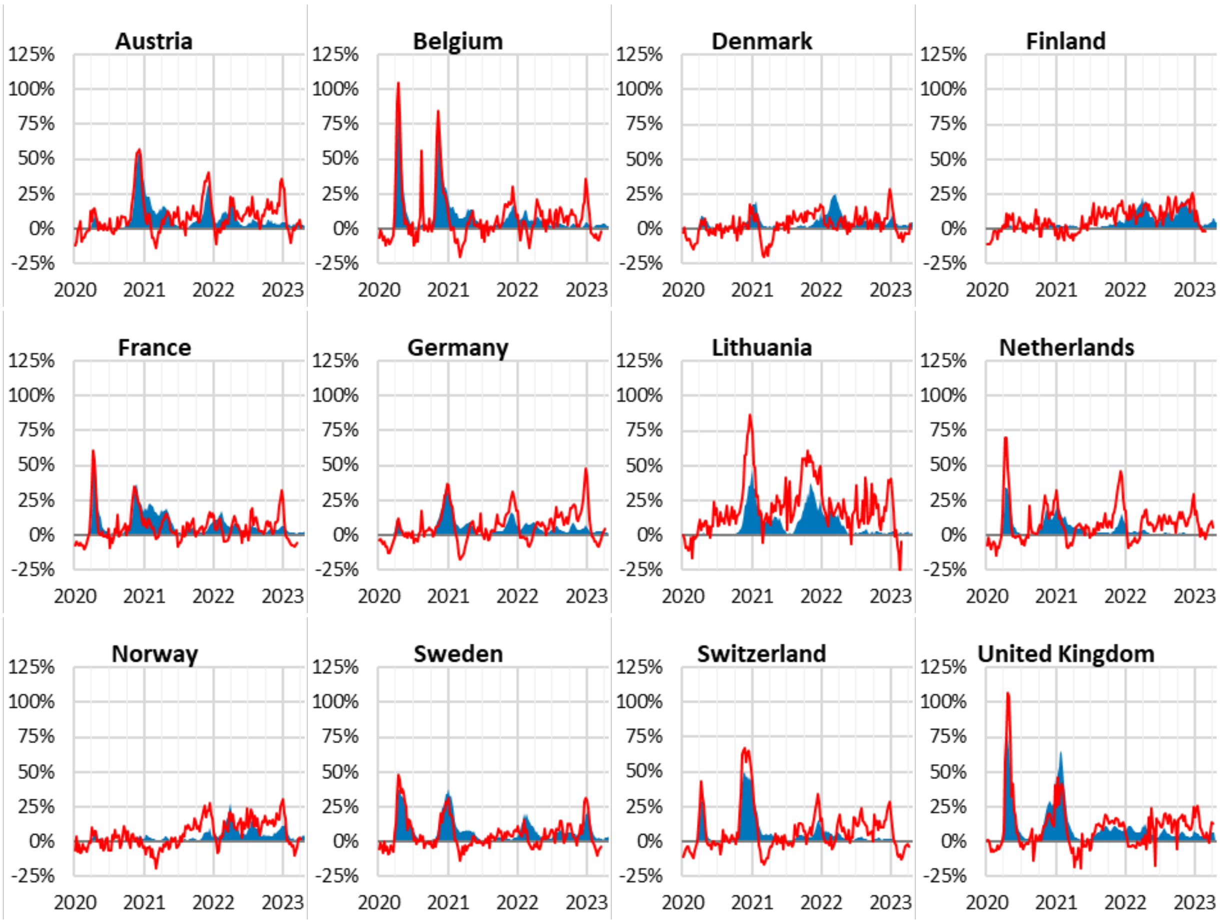


Figure 97 – Comparison of weekly COVID-19 mortality and total excess mortality in Northern and Western Europe in 2020-22, showing countries that have experienced or avoided high excess mortality spikes



In Figure 85, we saw that excess mortality in Northern and Western Europe had been quite flat in 2020 and 2021, increasing in 2022. Figure 96 shows that this has **not** been the case for individual countries in the region. Indeed, there is no consistent pattern at all. Neighbouring countries have had quite different experience – see, for example, Belgium and the Netherlands, France and Germany, and Denmark and Sweden (but note that the significant difference between these last two is in 2020, when they adopted different strategies). On the other hand, Lithuania has had mortality experience that more closely mirrors its East European neighbours (Poland, Belarus and Russia) than its Northern European neighbour, Latvia (not shown).

Figure 97 shows that some neighbours are similar after all (for example, Austria and Switzerland, and Norway and Finland – and Denmark and Sweden after 2020). It also shows that much of the difference between neighbours relates to how well they avoided mortality spikes, particularly in 2020.

We note that a national view does not necessarily translate to all groups within that country. For example, a paper[54] at the recent International Congress of Actuaries found that life expectancy to age 90 for 65-year-old Lithuanians had fallen from 15.2 years (men) and 19.4 years (women) in 2015-19 to 14.1 years and 18.5 years respectively in 2021, a smaller reduction than is implied by the almost 30% excess mortality shown in Figure 96. Moreover, capped life expectancy had almost returned to pre-pandemic levels (14.9 and 19.3 years, respectively) in 2022, despite OWID data suggesting over 15% excess mortality.

[54] A. Skucaite, *Income Related Mortality in Lithuania*, presented to ICA 2023 in Sydney, May 2023

Southern and Eastern Europe

Figure 98 – Annual excess mortality in Southern and Eastern Europe, generally showing higher excess mortality in 2021 than in either 2020 or 2022

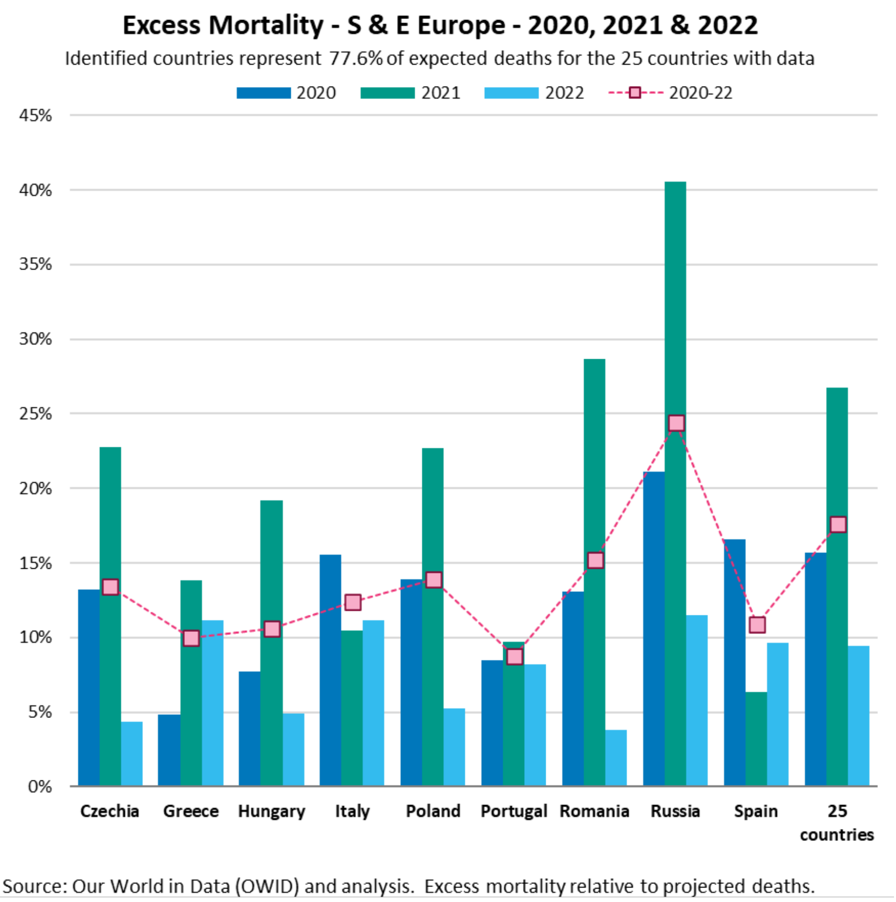
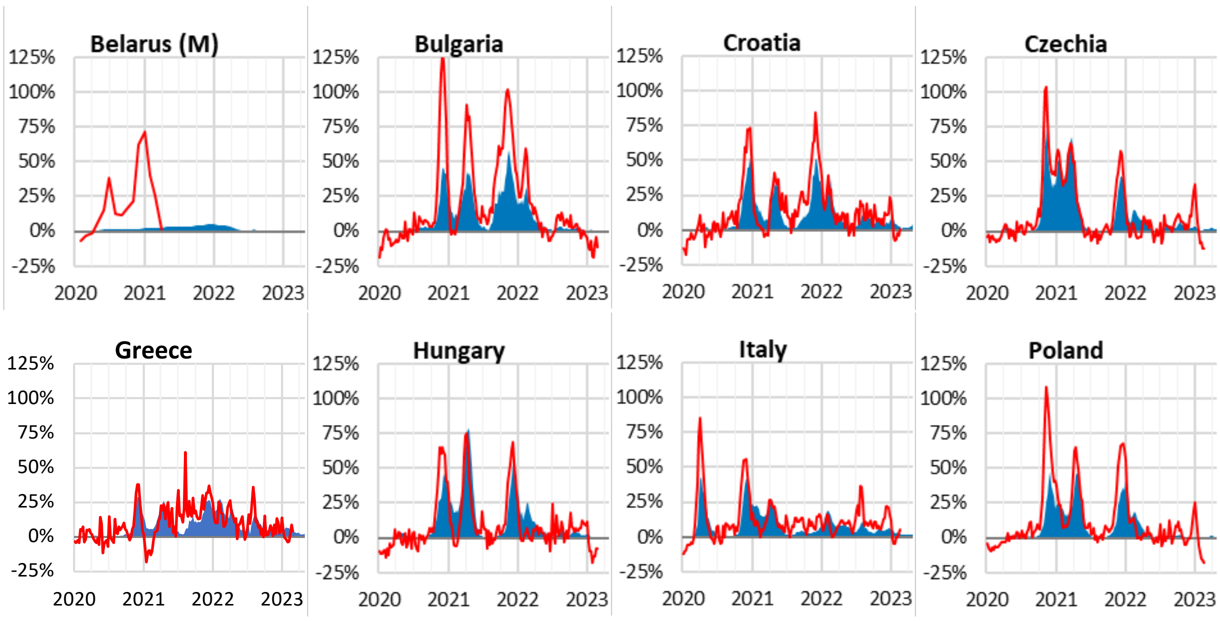


Figure 99 – Comparison of weekly COVID-19 mortality and total excess mortality in Southern and Eastern Europe in 2020-22, showing multiple high excess mortality spikes in most countries



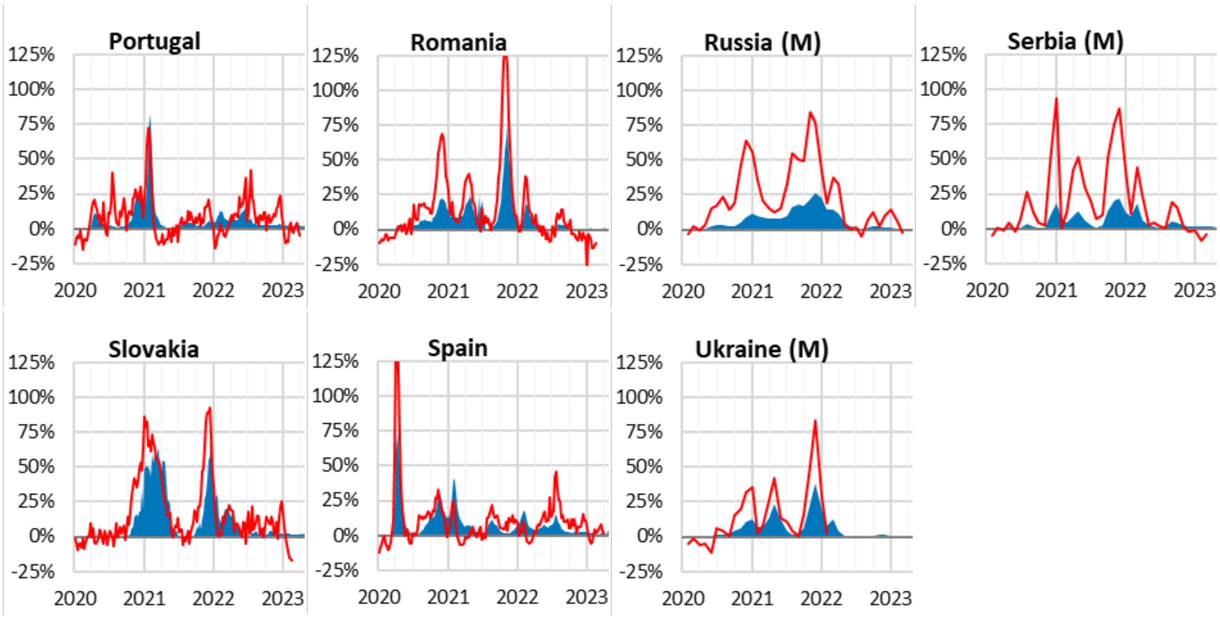


Figure 98 shows that former Soviet states (Czechia, Hungary, Poland, Romania and Russia) had relatively high excess mortality in 2020 – generally above 10% – and even higher mortality in 2021, with much lower mortality in 2022. This is quite similar to what we saw for Lithuania (another ex-Soviet state) in Figure 96. Meanwhile, Italy and Spain had experience like their mutual neighbour, France (again, see Figure 96), with excess mortality falling in 2021 before climbing again in 2022.

As with N & W Europe, Figure 99 shows the impact of mortality spikes, with the ex-Soviet countries demonstrating clear winter spikes in 2020-21 and 2021-22.

Per capita vaccination rates are low in the ex-Soviet countries, ranging from below 1 in Romania to about 1.8 in Czechia.

Note that Russian excess mortality in 2022 would include war deaths in Ukraine. Estimates of that number vary significantly. However, as the baseline for excess mortality in Russia is about 1.8 million deaths, it is not unreasonable to suppose that the war contributed about 2% excess mortality in 2022.

Africa

Figure 100 – Annual excess mortality in Africa, showing very high excess mortality in 2021

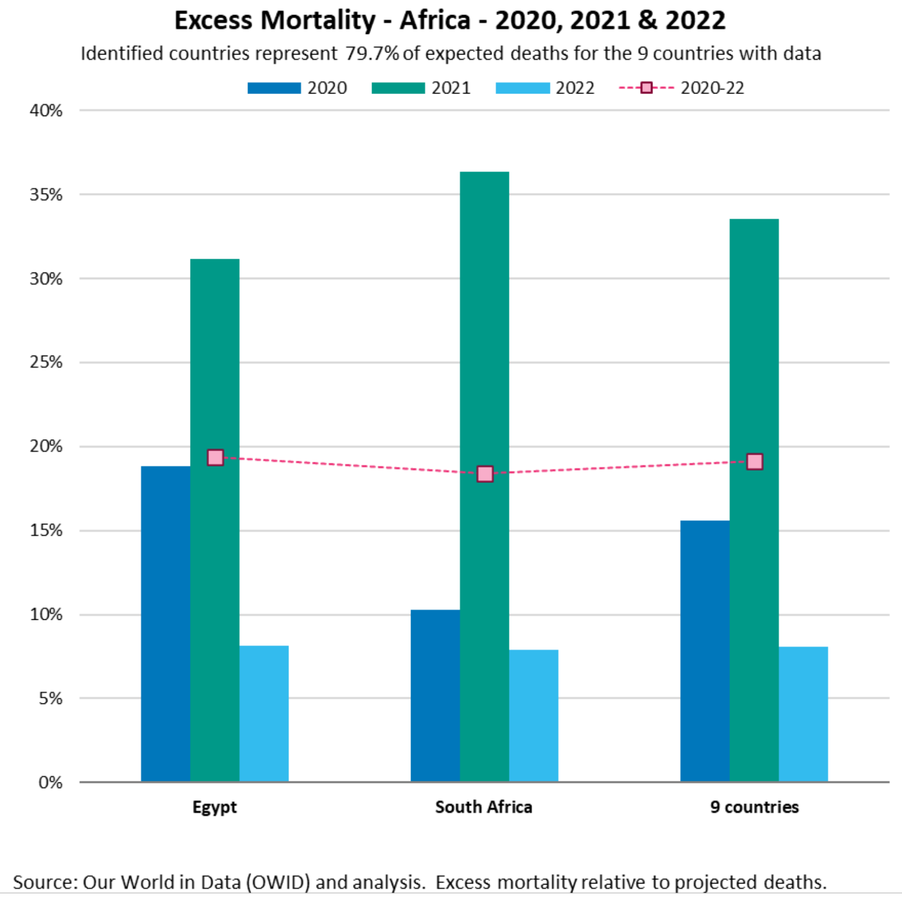
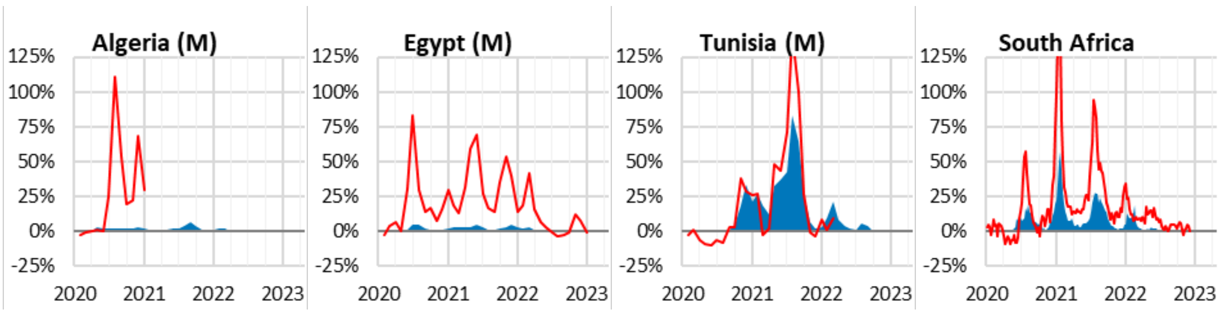


Figure 101 – Comparison of weekly COVID-19 mortality and total excess mortality in Africa in 2020-22, showing high excess mortality spikes



As previously mentioned, we have little useful data on African countries. Figure 100 shows that Egypt and South Africa had similar patterns of annual excess mortality, and Figure 101 suggests that this is typical of other African countries as well.

OWID data suggests that very few African nations have per capita vaccination rates above 1. Of the four shown in Figure 101, Tunisia (1.1) has the highest rate and Algeria (0.3) the lowest. Egypt is at 0.9 and South Africa at 0.6.

As with Latin America, it seems that a degree of "herd immunity" has been achieved – again, at a very high cost of lives.

Appendix G COVID-19 and Other Excess Deaths in 40 Countries

Table 11 – COVID-19 and other excess deaths in 40 countries – 2020-22 combined

Region	Country	Code	COVID-19 Deaths	Total Deaths	Expected Deaths	COVID-19 %	Other Excess %	Total Excess %
Average	Average (40)	AVE	123,486	1,516,475	1,326,983	9.3%	5.0%	14.3%
Oceania	Australia	AUS	17,816	522,608	500,460	3.6%	0.9%	4.4%
Oceania	New Zealand	NZL	2,331	105,789	106,358	2.2%	-2.7%	-0.5%
SE & E Asia	Japan	JPN	57,266	4,418,866	4,312,315	1.3%	1.1%	2.5%
SE & E Asia	Malaysia	MYS	36,853	590,145	554,060	6.7%	-0.1%	6.5%
SE & E Asia	Philippines	PHL	65,309	1,991,016	1,747,643	3.7%	10.2%	13.9%
SE & E Asia	Singapore	SGP	1,740	73,175	67,427	2.6%	5.9%	8.5%
SE & E Asia	South Korea	KOR	32,219	837,211	795,081	4.1%	1.2%	5.3%
SE & E Asia	Taiwan	TWN	No Data	564,118	544,256	No Data	3.6%	3.6%
SE & E Asia	Thailand	THA	33,729	1,661,053	1,511,723	2.2%	7.6%	9.9%
Other Asia	Azerbaijan	AZE	10,008	213,335	174,207	5.7%	16.7%	22.5%
Other Asia	Iran	IRN	144,682	1,347,683	1,084,293	13.3%	10.9%	24.3%
Other Asia	Israel	ISR	12,064	150,521	138,516	8.7%	0.0%	8.7%
Other Asia	Kazakhstan	KAZ	19,058	480,679	398,432	4.8%	15.9%	20.6%
Other Asia	Uzbekistan	UZB	1,637	522,252	472,442	0.3%	10.2%	10.5%
N America	Canada	CAN	49,099	909,470	866,159	5.7%	-0.7%	5.0%
N America	United States	USA	1,084,893	10,083,840	8,827,293	12.3%	1.9%	14.2%
L America	Brazil	BRA	693,734	4,982,063	4,145,728	16.7%	3.4%	20.2%
L America	Chile	CHL	63,149	398,177	338,295	18.7%	-1.0%	17.7%
L America	Colombia	COL	142,179	944,791	755,014	18.8%	6.3%	25.1%
L America	Mexico	MEX	331,499	2,968,548	2,319,464	14.3%	13.7%	28.0%
L America	Peru	PER	218,178	638,044	451,950	48.3%	-7.1%	41.2%
N & W Europe	Belgium	BEL	33,357	354,268	327,032	10.2%	-1.9%	8.3%
N & W Europe	Denmark	DNK	7,782	170,528	166,652	4.7%	-2.3%	2.3%
N & W Europe	France	FRA	158,356	1,947,909	1,829,766	8.7%	-2.2%	6.5%
N & W Europe	Germany	DEU	166,348	3,056,901	2,877,320	5.8%	0.5%	6.2%
N & W Europe	Lithuania	LTU	9,481	132,822	110,155	8.6%	12.0%	20.6%
N & W Europe	Netherlands	NLD	22,990	506,087	466,108	4.9%	3.6%	8.6%
N & W Europe	Sweden	SWE	22,306	283,208	268,614	8.3%	-2.9%	5.4%
N & W Europe	United Kingdom	GBR	216,199	2,007,778	1,829,265	11.8%	-2.1%	9.8%
S & E Europe	Czechia	CZE	42,151	387,008	341,234	12.4%	1.1%	13.4%
S & E Europe	Greece	GRC	34,925	414,242	376,746	9.3%	0.7%	10.0%
S & E Europe	Hungary	HUN	48,495	430,837	389,561	12.4%	-1.9%	10.6%
S & E Europe	Italy	ITA	184,792	2,157,996	1,920,284	9.6%	2.8%	12.4%
S & E Europe	Poland	POL	118,533	1,439,481	1,263,557	9.4%	4.5%	13.9%
S & E Europe	Portugal	PRT	25,808	371,740	341,768	7.6%	1.2%	8.8%
S & E Europe	Romania	ROU	67,374	897,326	779,019	8.6%	6.5%	15.2%
S & E Europe	Russia	RUS	393,712	6,485,958	5,212,660	7.6%	16.9%	24.4%
S & E Europe	Spain	ESP	118,517	1,399,689	1,262,573	9.4%	1.5%	10.9%
Africa	Egypt	EGY	24,802	2,006,614	1,680,961	1.5%	17.9%	19.4%
Africa	South Africa	ZAF	102,568	1,805,222	1,524,916	6.7%	11.7%	18.4%

Table 11 contains the excess mortality data used in Figure 36, with COVID-19 mortality shown for comparison. It should be read in conjunction with descriptions of the data, methodology and caveats in the paper.

Table 12 – COVID-19 and other excess mortality in 40 countries – 2022 v 2020-21

Region	Country	Code	COVID-19 2020-21 %	COVID-19 2022 %	Other 2020-21 %	Other 2022 %	Total 2020-21 %	Total 2022 %
Average	Average (40)	AVE	10.8%	5.5%	6.0%	3.5%	16.9%	9.0%
Oceania	Australia	AUS	0.7%	9.1%	-0.5%	3.7%	0.2%	12.8%
Oceania	New Zealand	NZL	0.1%	6.3%	-4.1%	-0.1%	-4.0%	6.2%
SE & E Asia	Japan	JPN	0.6%	2.7%	-1.1%	5.5%	-0.5%	8.2%
SE & E Asia	Malaysia	MYS	8.6%	2.8%	-1.4%	2.3%	7.2%	5.2%
SE & E Asia	Philippines	PHL	4.1%	2.8%	14.2%	-0.2%	18.2%	2.7%
SE & E Asia	Singapore	SGP	1.9%	3.9%	2.2%	13.2%	4.1%	17.1%
SE & E Asia	South Korea	KOR	0.9%	14.6%	0.3%	4.3%	1.3%	18.9%
SE & E Asia	Taiwan	TWN	No Data		-0.9%	12.7%	-0.9%	12.7%
SE & E Asia	Thailand	THA	2.2%	2.3%	4.1%	14.6%	6.3%	16.9%
Other Asia	Azerbaijan	AZE	7.2%	2.8%	24.6%	1.1%	31.8%	4.0%
Other Asia	Iran	IRN	16.8%	4.4%	15.1%	0.3%	31.9%	4.7%
Other Asia	Israel	ISR	9.0%	8.2%	-1.2%	2.3%	7.8%	10.5%
Other Asia	Kazakhstan	KAZ	6.9%	0.6%	23.5%	0.5%	30.4%	1.2%
Other Asia	Uzbekistan	UZB	0.5%	0.1%	10.9%	8.8%	11.4%	8.9%
N America	Canada	CAN	5.1%	7.0%	-0.9%	-0.1%	4.1%	6.8%
N America	United States	USA	14.0%	8.9%	2.5%	0.8%	16.5%	9.7%
L America	Brazil	BRA	22.5%	5.4%	1.7%	6.8%	24.3%	12.1%
L America	Chile	CHL	17.5%	21.0%	-0.5%	-1.9%	17.0%	19.1%
L America	Colombia	COL	26.1%	4.8%	6.7%	5.6%	32.8%	10.4%
L America	Mexico	MEX	20.0%	3.5%	21.2%	-0.7%	41.2%	2.7%
L America	Peru	PER	62.5%	12.2%	-7.3%	-6.6%	55.2%	5.6%
N & W Europe	Belgium	BEL	13.0%	4.6%	-3.8%	1.9%	9.3%	6.5%
N & W Europe	Denmark	DNK	2.9%	8.1%	-2.3%	-2.5%	0.7%	5.5%
N & W Europe	France	FRA	10.0%	6.1%	-3.5%	0.5%	6.4%	6.5%
N & W Europe	Germany	DEU	6.2%	4.9%	-1.6%	4.5%	4.6%	9.5%
N & W Europe	Lithuania	LTU	10.0%	5.8%	12.1%	11.7%	22.1%	17.5%
N & W Europe	Netherlands	NLD	6.8%	1.3%	2.3%	6.3%	9.1%	7.6%
N & W Europe	Sweden	SWE	8.6%	7.8%	-3.2%	-2.3%	5.4%	5.5%
N & W Europe	United Kingdom	GBR	14.6%	6.4%	-3.4%	0.6%	11.2%	7.0%
S & E Europe	Czechia	CZE	16.1%	5.1%	2.0%	-0.7%	18.0%	4.4%
S & E Europe	Greece	GRC	8.3%	11.3%	1.1%	-0.1%	9.4%	11.1%
S & E Europe	Hungary	HUN	15.1%	7.2%	-1.6%	-2.3%	13.4%	4.9%
S & E Europe	Italy	ITA	10.7%	7.4%	2.3%	3.7%	13.0%	11.1%
S & E Europe	Poland	POL	11.6%	5.1%	6.8%	0.2%	18.3%	5.2%
S & E Europe	Portugal	PRT	8.4%	6.0%	0.7%	2.2%	9.1%	8.2%
S & E Europe	Romania	ROU	11.3%	3.3%	9.6%	0.5%	20.8%	3.8%
S & E Europe	Russia	RUS	8.8%	5.0%	21.9%	6.5%	30.7%	11.5%
S & E Europe	Spain	ESP	10.9%	6.4%	0.6%	3.3%	11.5%	9.7%
Africa	Egypt	EGY	1.9%	0.6%	23.1%	7.6%	25.0%	8.1%
Africa	South Africa	ZAF	8.8%	2.4%	14.5%	5.5%	23.3%	7.9%

Table 12 contains the excess mortality data used in Figure 37, with COVID-19 mortality again shown for comparison.

Table 13 – COVID-19 and other excess mortality compared with GDP per capita (2017, USD)

Region	Country	Code	GDP per Capita (USD)	COVID-19	Other Excess	Total Excess	COVID-19 Proportion
Average	Average (40)	AVE	25,206	9.1%	5.2%	14.3%	63.5%
Oceania	Australia	AUS	53,831	3.6%	0.9%	4.4%	80.4%
Oceania	New Zealand	NZL	43,415	2.2%	-2.7%	-0.5%	-409.4%
SE & E Asia	Japan	JPN	38,214	1.3%	1.1%	2.5%	53.7%
SE & E Asia	Malaysia	MYS	10,118	6.7%	-0.1%	6.5%	102.1%
SE & E Asia	Philippines	PHL	2,982	3.7%	10.2%	13.9%	26.8%
SE & E Asia	Singapore	SGP	56,746	2.6%	5.9%	8.5%	30.3%
SE & E Asia	South Korea	KOR	29,958	4.1%	1.2%	5.3%	76.5%
SE & E Asia	Taiwan	TWN	25,062	No Data	3.6%	3.6%	No Data
SE & E Asia	Thailand	THA	6,579	2.2%	7.6%	9.9%	22.6%
Other Asia	Azerbaijan	AZE	4,139	5.7%	16.7%	22.5%	25.6%
Other Asia	Iran	IRN	5,628	13.3%	10.9%	24.3%	54.9%
Other Asia	Israel	ISR	42,852	8.7%	0.0%	8.7%	100.5%
Other Asia	Kazakhstan	KAZ	9,009	4.8%	15.9%	20.6%	23.2%
Other Asia	Uzbekistan	UZB	1,554	0.3%	10.2%	10.5%	3.3%
N America	Canada	CAN	44,841	5.7%	-0.7%	5.0%	113.4%
N America	United States	USA	59,939	12.3%	1.9%	14.2%	86.3%
L America	Brazil	BRA	9,881	16.7%	3.4%	20.2%	82.9%
L America	Chile	CHL	15,001	18.7%	-1.0%	17.7%	105.5%
L America	Colombia	COL	6,429	18.8%	6.3%	25.1%	74.9%
L America	Mexico	MEX	9,224	14.3%	13.7%	28.0%	51.1%
L America	Peru	PER	6,723	48.3%	-7.1%	41.2%	117.2%
N & W Europe	Belgium	BEL	43,325	10.2%	-1.9%	8.3%	122.5%
N & W Europe	Denmark	DNK	57,545	4.7%	-2.3%	2.3%	200.8%
N & W Europe	France	FRA	39,827	8.7%	-2.2%	6.5%	134.0%
N & W Europe	Germany	DEU	44,680	5.8%	0.5%	6.2%	92.6%
N & W Europe	Lithuania	LTU	16,709	8.6%	12.0%	20.6%	41.8%
N & W Europe	Netherlands	NLD	48,796	4.9%	3.6%	8.6%	57.5%
N & W Europe	Sweden	SWE	54,075	8.3%	-2.9%	5.4%	152.8%
N & W Europe	United Kingdom	GBR	39,532	11.8%	-2.1%	9.8%	121.1%
S & E Europe	Czechia	CZE	20,291	12.4%	1.1%	13.4%	92.1%
S & E Europe	Greece	GRC	19,214	9.3%	0.7%	10.0%	93.1%
S & E Europe	Hungary	HUN	14,364	12.4%	-1.9%	10.6%	117.5%
S & E Europe	Italy	ITA	32,038	9.6%	2.8%	12.4%	77.7%
S & E Europe	Poland	POL	13,871	9.4%	4.5%	13.9%	67.4%
S & E Europe	Portugal	PRT	21,316	7.6%	1.2%	8.8%	86.1%
S & E Europe	Romania	ROU	10,781	8.6%	6.5%	15.2%	56.9%
S & E Europe	Russia	RUS	10,846	7.6%	16.9%	24.4%	30.9%
S & E Europe	Spain	ESP	28,175	9.4%	1.5%	10.9%	86.4%
Africa	Egypt	EGY	2,441	1.5%	17.9%	19.4%	7.6%
Africa	South Africa	ZAF	6,120	6.7%	11.7%	18.4%	36.6%

Table 13 contains the excess mortality and GDP data used in Figure 40, with COVID-19 mortality shown for comparison.

The countries in these tables and the associated figures were selected on the following basis:

First, we identified the 90 countries in the OWID database for which relevant data was available for all of 2020 and 2021 and more than half of 2022[55].

Of these, we selected the 33 with the highest expected deaths, on the basis that these would give the greatest global coverage and relevance and the least spurious variation. These countries included Australia (23rd on this list).

Then, we identified a further seven countries with special relevance. These were (in declining order of expected deaths):

- Sweden (36), because it adopted a COVID-19 strategy that differed greatly from the other Nordic nations;
- Azerbaijan (41), because of its very high mortality in late 2020;
- Denmark (42), because it represents the Nordic nations other than Sweden;
- Israel (47), because it was a leader in vaccine take-up;
- Lithuania (51), because it is representative of the Baltic states;
- New Zealand (54), for direct comparison to Australia; and
- Singapore (63), because it always seemed to be a point of comparison for Australia, at least early in the pandemic.

The resultant list of 40 countries differs from the 37 in our previous analysis as follows:

- Ukraine, which would have been #11, has been omitted due to insufficient 2022 data;
- Latvia (60) has been replaced by Lithuania (51), on the basis that Lithuania is higher on the list; and
- The Philippines (8), Egypt (11), Canada (18) and Malaysia (21) have been added.

[55] If we had required complete data for 2022, we would have excluded The Philippines, South Africa, Iran, South Korea, Canada and Peru

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