Long COVID in Australia: Evidence and Key Findings

By

R. Quentin Grafton*
The Australian National University
https://crawford.anu.edu.au/people/academic/quentin-grafton

Long Chu
The Australian National University
https://researchprofiles.anu.edu.au/en/persons/long-chu

Tom Kompas
University of Melbourne
https://findanexpert.unimelb.edu.au/profile/695719-tom-kompas

Mary-Louise McLaws
University of New South Wales
https://www.unsw.edu.au/staff/marylouise-mclaws

Dan Suan
Garvan Institute of Medical Research & Westmead Hospital
https://www.garvan.org.au/about-us/people/dansua

*Contact author: quentin.grafton@anu.edu.au. Authorship is alphabetical after contact author.

This submission responds to the following sub-parts of the Standing Committee's Terms of Reference:
Terms of Reference 3. Research into the potential and known effects, causes, risk factors, prevalence, management, …;
Terms of Reference 4. The health, …and economic impacts in Australia on individuals who develop long COVID and/or have repeated COVID infections…); and
Terms of Reference 5. The impact of long COVID and/or repeated COVID infections on Australia's overall health system, particularly in relation to increased risk of various conditions including cardiovascular, neurological, and immunological conditions in the general population.

Prepared for The House of Representatives Standing Committee on Health, Aged Care and Sport Long COVID Inquiry

This version 12 November 2022

Key Findings

(1) Australia progressively removed several key public health protections in 2022. This has resulted in 2022 in a much higher number of COVID cases and, thus, long COVID cases than if reasonable and low-cost public health controls (e.g., mandatory mask wearing on public transport and isolation if infectious) had been maintained, and that are still in place in some countries, such as Singapore. A direct consequence of Australia's progressive shift in 2022 from a shared responsibilities to personal responsibilities model for COVID has been excess deaths in 2022 from COVID and post-acute COVID sequelae. These excess deaths are at a level such that Australia's cumulative COVID death rate in 2022, as of the end of October, exceeds most of its OECD peers.

(2) Exacerbated by poorly informed messaging by some decision makers and opinion leaders, the weakening of public health measures has helped to create the false view with the Australian public that the 'pandemic is over', and/or that the health consequences of COVID are minor, or even trivial, such that 'COVID is like the flu'. This public view is not supported by any scientific evidence.

(3) The most effective way for Australia to reduce the incidence of COVID and long COVID, would be to reintroduce and to ensure compliance with: mandatory mask wearing on public transport; isolation if infectious; and support for a program of mandatory air-quality monitoring and HEPA air filtering when the air quality deteriorates. Mandatory and visible indoor air-quality monitoring for COVID, with air filtration if CO_2 parts per million standards are exceeded, is already in place in Belgium as a measure to reduce COVID infections. Such public health measures, including wearing masks inside public spaces and HEPA air filtration, have a high benefit-cost ratio, that is, they would be beneficial for both public health and the overall economy.

(4) COVID generates a large tail in the form of long COVID. In addition to excess deaths associated with long COVID, about 6% of people who have had symptomatic COVID suffer from a severe form of long COVID that significantly affects their everyday life and prevents some people from participating in paid employment. A severe form of long COVID likely already affects over 300,000 Australians. This imposes huge public health, social and economic costs.

(5) COVID reinfections substantially increase the risk of long COVID. Thus, ongoing 'waves' of COVID infections in 2023, and beyond, from emerging variants will, in the absence of sensible and effective public health measures (e.g., mandatory mask wearing in most public spaces and on public transport, and isolation when people are infectious), will almost certainly result in an ever-increasing social and economic burden on Australian society. Australian governments must prepare now (in 2022) by budgeting sufficient funds and support (e.g., improvement in pay and working conditions of health professionals to ensure workers are retained) for the public health system (from GPs to hospitals) to manage this unfolding public health-social-economic crisis that will exist for years to come.

Our submission is provided in six sections. Section 1 is an overview, while sections 2 and 3, together, respond to Terms of Reference 3. Sections 4, 5 and 6, together, respond to Terms of Reference 4 and 5. Wherever we use the term 'COVID' we refer to the disease 'COVID-19' that arises from infection by the SARS-CoV-2 virus. We define long COVID as encompassing both; (1) *long COVID syndrome* that includes identifiable symptoms to sufferers and (2) *post-acute COVID sequelae (PACS)*, not necessarily identifiable to sufferers, that represents a group of medical diagnoses of morbidities some of which result in increased mortality risks.

1. Overview

It is common for viruses to have multiple short- and long-term health consequences. For example, the Varicella Zoster virus causes chickenpox early in life, and shingles only decades later. HIV infection causes an acute seroconversion illness at the time of infection, and then later AIDS. EBV infection causes glandular fever, and only years later does it cause multiple sclerosis and lymphoma in a subgroup of infected patients. Consequently, to understand the impact of SARS-CoV-2 infection on the Australian population's health, we must have a full understanding about *all* the health consequences of viral infection, both short term and long term.

We use the term 'long COVID' to encompass two post-COVID phenomena. First, *long COVID syndrome* is a heterogenous condition in which at least one symptom or a new symptom persists at least 3 months after infection by the SARS-CoV-2 virus and includes a multitude of symptoms and/or morbidities that cannot be explained by an alternative diagnosis (Sachs et al. 2022). Long COVID syndrome includes a cluster of problems that encompass but are not limited to: loss of taste and smell, shortness of breath, chest pain, musculoskeletal pain, cognitive blunting and confusion ('brain fog'), skin rashes, mental health disorders, and fatigue.

Multiple factors determine the prevalence of long COVID syndrome in a population. A more severe acute COVID infection (e.g., hospitalisation) is associated with an increased risk of having long COVID syndrome. Other factors that increase risk include; age (+), female sex (+), socio-economic deprivation (+), depression (+), and multimorbidity (+) (Hastie et al. 2022). Some of these long COVID risk factors, especially age and multimorbidity, are also associated with a higher fatality rate for those who get COVID (AIHW 2021). For example, a lower socio-economic status is associated with both a higher fatality rate (ABS 2022a) and long COVID, and includes the social determinants of health, the conditions under which people live, learn, work, and play (Pecoraro 2021). One important risk factor that is different between the risk of death from COVID in its acute phase and long COVID syndrome is that being male (rather than female) increases the COVID fatality risk, but being a female (rather than male) increases the risk of long COVID after the post-acute phase.

In addition to the long COVID syndrome, long COVID includes a group of medical diagnoses which represent serious and existing medical problems in the community that are either caused or triggered by a COVID infection. Some of these (e.g., kidney diseases) may be asymptomatic and not necessarily identifiable by long COVID sufferers. These serious morbidities, called *post-acute COVID sequelae (PACS)*, can result in premature death (Al-Aly et al. 2021; Uusküla et al. 2022) and occur in a proportion of those people who have recovered from the acute phase of COVID. These diseases include but are not limited to: cardiovascular diseases (CVD), including heart attacks and strokes (Raisi-Estabragh et al. 2022; Xie et al. 2022), kidney diseases (Bowe et al. 2021; Yende and Parikh 2021), diabetes (Xie and Al-Aly 2021), and brain disorders (Taquet et al. 2022).

While vaccinations have been, and remain, highly effective at reducing severe disease and deaths related to acute COVID infection (Figure 1), they are much less effective at reducing the risk of getting long COVID following a COVID infection (see Section 5: Vaccinations are not enough). This means that the most effective way to avoid getting long COVID is not to get COVID. Following a COVID infection, the best way not to get long COVID is not to get a second (or third, or multiple) COVID infection.

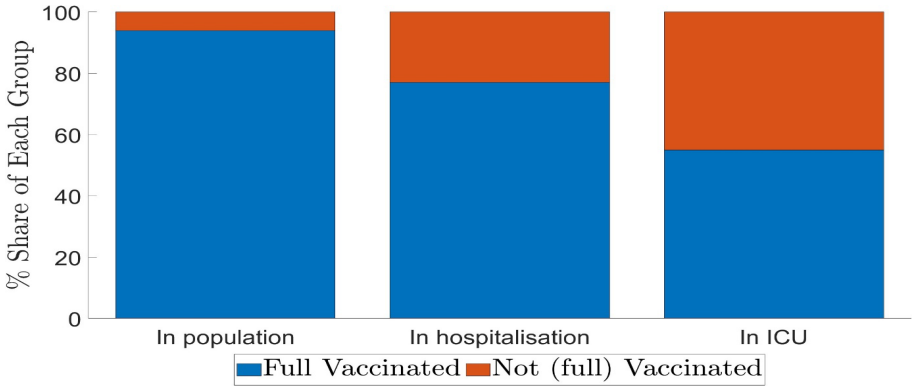


Figure 1: Vaccinated and Unvaccinated Incidence in Population, COVID Hospitalisation and COVID in Intensive Care Units for New South Wales, as of 22 May 2022
Data source: - https://aci.health.nsw.gov.au/covid-19/critical-intelligence-unit

In Australia, based on survey evidence, about 11% report having had COVID twice and 5% report having it three times or more (Biddle and Korda 2022). Avoidance of multiple COVID infections is especially important (see Figure 2) because "[r]einfection further increases risks of death, hospitalisation and sequelae in multiple organ systems in the acute and postacute phase." (Bowe et al. 2022).

Both the mortality risk (all causes) and the risk of hospitalisation at six months of long COVID increase substantially with one symptomatic infection, then continue to increase with each additional symptomatic COVID infection. Thus, Australians should expect an escalating accumulation of morbidity and mortality if COVID is continued to be allowed to spread, more or less, unchecked through the population.

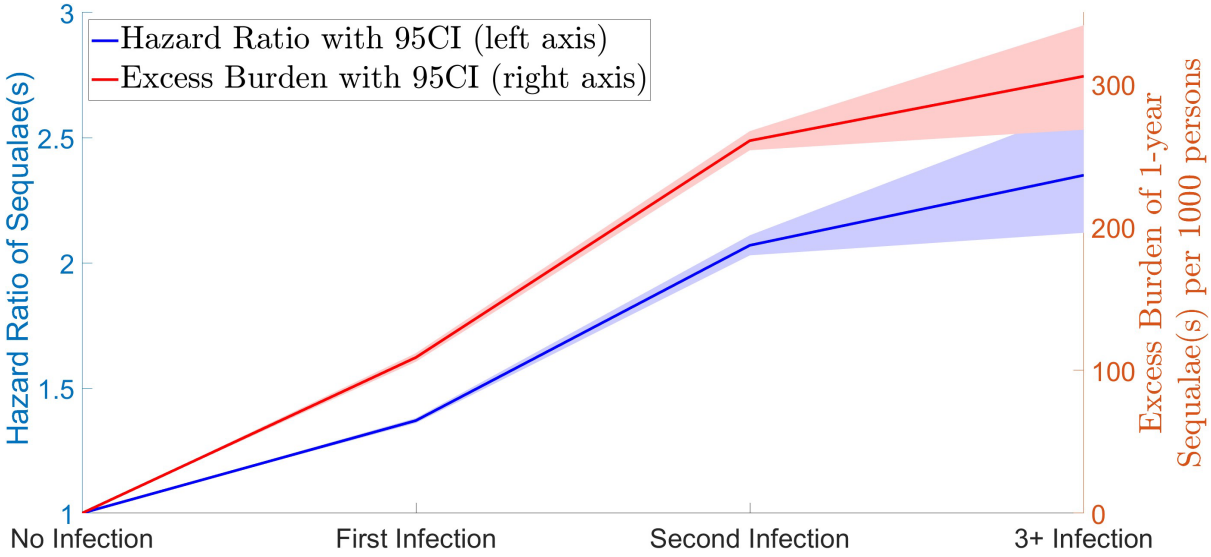


Figure 2: Hazard ratio of at least one sequalae, relative to no COVID infection controls (blue graph) and excess burden, at one-year per thousand persons (red graph) of first, second and three or more COVID infection(s)
Data source: Bowe et al. (2022)

The most effective way to avoid getting COVID *and* long COVID is to wear a well-fitted and appropriately protective mask in indoor public spaces, especially in poorly ventilated locations, and outdoors in crowded spaces. This is because the SARS-CoV-2 virus is primarily spread through airborne transmission (Greenhalgh et al. 2021) and there is overwhelming evidence that the risk of getting COVID is much reduced by wearing a well-fitted and appropriate mask, such as a nonsurgical N95 (Mayo Clinic Staff 2022), and by good ventilation, including with the use of HEPA air filters.

As noted by Howard et al. (2021) in the *Proceedings of the National Academies of Science*, "The preponderance of evidence indicates that mask wearing reduces transmissibility per contact by reducing transmission of infected respiratory particles in both laboratory and clinical contexts. Public mask wearing is most effective at reducing spread of the virus when compliance is high". Other evidence indicates that mandatory mask wearing in public spaces can reduce new community COVID infections by about 45% (Mitze et al. 2020), can reduce individual COVID infections between 70% and 77% (Brooks and Butler 2021). Evidence from Massachusetts school districts in the US shows that universal mask wearing universal was effective at reducing COVID incidence in schools and loss of in-person school days (Cowger et al. 2022).

Response to Terms of Reference 3: Research into the potential and known effects, causes, risk factors, prevalence, management, …;

2. Incidence of long COVID

Estimates of the incidence of long COVID will vary by country and study design. In the UK, the data indicate that long COVID affects between 7.8 and 17% of symptomatic COVID cases for 12 weeks or more, causing debilitating symptoms for 1.2 to 4.8% of COVID cases (Thompson et al. 2022). In a study from Scotland (Hastie et al. 2022), 6% of those with laboratory confirmed COVID infections had symptomatic long COVID to the extent "…they had not recovered at all" (Hastie et al. p. 2) at six

months or longer. In the US, as a proportion of respondents to a survey, long COVID affects about 11% of men and about 17% of women (US National Center for Health Statistics 2022).

Long COVID affects all age categories, with a preponderance of cases among the middle-aged, and not just the elderly. Thus, long COVID may affect about 8% of the US workforce and may be sufficiently severe to prevent about 2-3% of the US labour force from being in the paid workforce (Bach 2022).

Australian survey data of 3,510 respondents collected between 8-22 August 2022 indicate that 29% of responding Australians who had symptomatic COVID had some symptoms last four weeks or more, and of these, 23% (7% of those who had symptomatic COVID) reported that the symptoms had reduced their ability to carry out day-to-day activities 'a lot' compared with the time before they had COVID (Biddle and Korda 2022). Of the 29% experiencing symptoms four weeks or more after infection, the most commonly reported symptoms were 'tiredness' and 'weakness', experienced, respectively, by 82% and 58% of respondents.

We estimate that there were, as of 31 October 2022, 370,000 Australians with 'severe' long COVID. The number of 'severe' long COVID sufferers in Australia can be inferred based on the confirmed cumulative COVID cases as per 28 October 2022, namely, 10.355 million (covid19data.com.au, 2022). Based on seroprevalence studies it is highly likely that this is a substantial underestimate of the cumulative COVID cases in Australia, which could as be much as two thirds of the Australian population in September 2022, or some 17 million people (Australian COVID-19 Serosurveillance Network 2022, p. 2). Using the confirmed cases (10.355 million) as the cumulative number of COVID cases, we assumed: (1) 60% of cases are symptomatic (Ma et al. 2021); (2) 6% of symptomatic cases suffer 'severe' long COVID that lasts three months or more and substantially reduces their ability to carry out day-to-day activities.

The impact of COVID infection sweeping through the population may be illustrated in Figure 3, which demonstrates the outcomes for COVID-infected patients in Australia. Two striking observations can be made. First, the vast majority of adult infections in Australia have occurred in vaccinated individuals, confirming without a doubt that vaccination alone does not prevent long COVID. Second, unlike other countries which permitted COVID to spread early in the pandemic, ~85% of infected Australians have only been infected once by COVID.

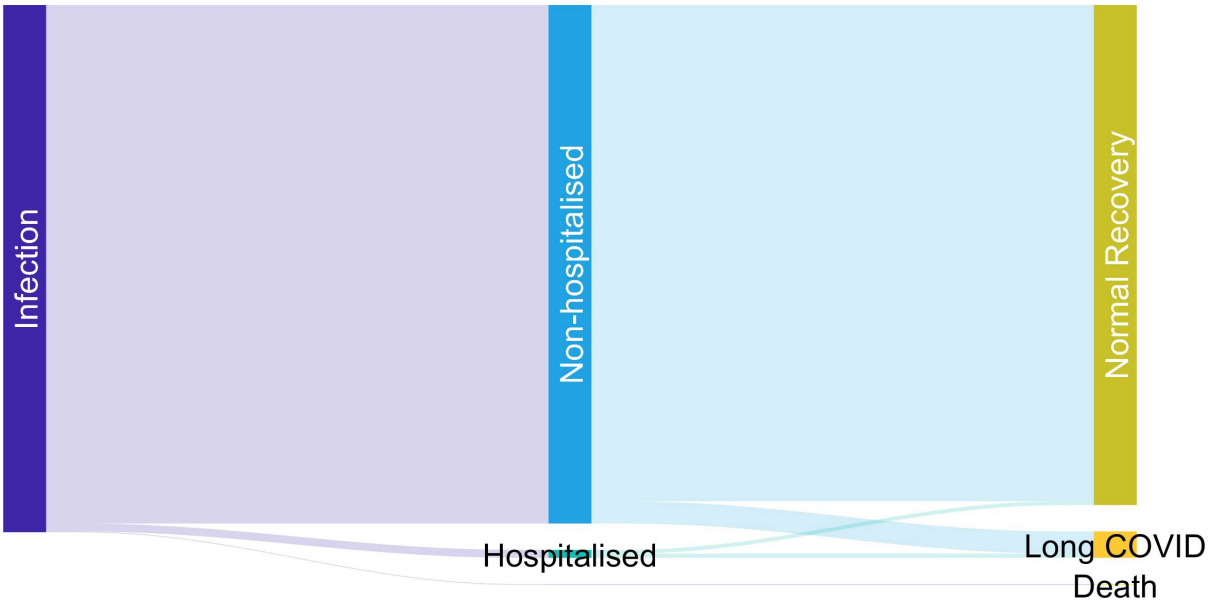


Figure 3: Relationships between Infection, Hospitalisation, Death and Long COVID
Data Sources: Case Fatality Rate in Australia in 2022 ~0.15% (based on 2022 data for Australia at covid19data.com.au and confirmed cases); ~1.5% in 2022 based on confirmed cases (covid19data.com.au); Long COVID rate in Australia ~5% COVID patients have not recovered after 90 days (Liu et al. 2021); Long COVID rate of COVID hospitalised cases ~52% (Pérez-González et al. 2022).

Australian survey data indicate that 75% of long COVID sufferers are under 55 years of age (Biddle and Korda 2022 p. 25). Thus, even if we assume that only half of severe long COVID sufferers are in the workforce, this equates to about 185,000 Australians who have a substantially reduced ability to function, including in paid employment. This is equivalent to about 1.4% of the 13.59 million paid Australian workforce (ABS 2022b). Assuming: (1) only half those with severe long COVID were working prior to COVID and are now no longer able to be in paid employment (25% of those with severe long COVID, or 92,500 Australians); and (2) if they were to eventually pass the eligibility criteria for assistance, they would be a major addition to the total number of participants under the National Disability Insurance Scheme (approximately 530,000 as of 1 August 2022) and those receiving a disability support pension (approximately 660,000).

Critical to determining an effective Australian approach to long COVID is to highlight the likely future magnitude of the long COVID problem, based on the scientific evidence understanding of *all* the health impacts of COVID infection (Section 3). That is:

a) At current public health settings, it is **highly likely that many Australians will be exposed to COVID multiple times** (Section 4),
b) An **individual can be re-infected with COVID despite vaccination (with boosters) and previous infection** (Section 5), due to evolution of the virus and waning immunity (Canetti et al. 2022) over time,
c) **Vaccinations reduce the risk of long COVID much less than they reduce the risk of hospitalisation or death from the acute phase of COVID** (Section 5), and
d) **Previous infection(s) increase the risk of long COVID** in those who are symptomatic in the acute phase of the disease (Bowe et al. 2022).

3. COVID is 'nothing like the flu' and causes excess morbidity and mortality via multiple mechanisms

A common public view is that because vaccinations are highly effective at reducing the risk of death and hospitalisation from acute COVID infection, COVID should be treated 'like the flu'. That is, according to this view, COVID has become unexceptional following vaccinations, and does not require any special public health measures. Evidence claimed to justify this view is that the risk to the health of the population from COVID is, following widespread vaccinations, similar to that of the influenza virus.

COVID, however, is nothing like the flu (Toole and Crabb 2022). Those who are infected by COVID, compared to the flu, are:

- contagious even if not symptomatic, and are contagious for longer
- more likely to experience loss of taste or smell
- more likely to suffer severe symptoms, with longer hospital stays and a much higher risk of death
- more likely to suffer post-acute symptoms that include blood clots (Mayo Clinic Staff 2022b), heart attacks, myocarditis, cardiac arrhythmias, strokes, diabetes, kidney disease and multi-system infections (Robson 2022) and disorders (Roessler et al. 2022).
- more likely to suffer from faster waning immunity (Canetti et al. 2022) following vaccination or infection (Robson 2022), rendering them susceptible to re-infection at an earlier date

3.1. The long-term consequences of COVID infection are nothing like the flu

The stark differences between infection with influenza and SARS-CoV-2 manifest as an excess burden of adverse outcomes in the form of post-acute COVID sequelae, illustrated in Figures 4 and 5. In sum, influenza infection does *not* trigger population-level arterial and venous clotting events, along with other serious medical diagnoses that will cause cumulative, chronic health burden on the community.

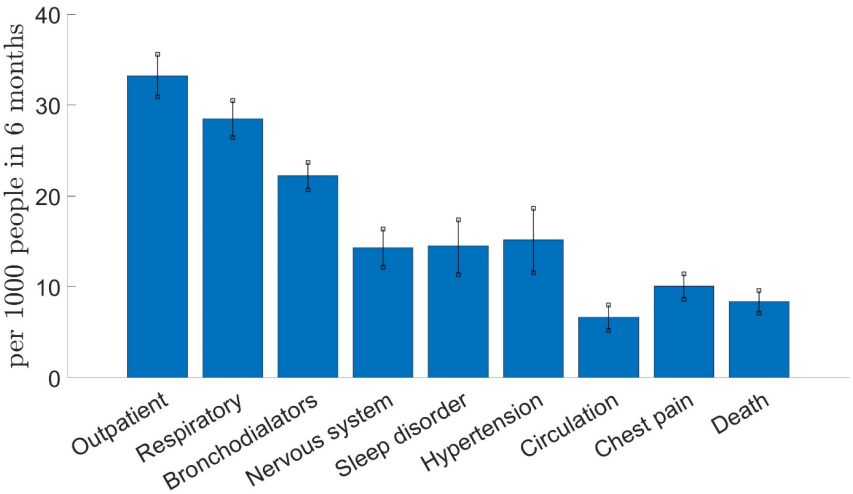


Figure 4: Excess burden of disease (per thousand persons) of post-acute COVID sequelae. Note: these estimates are for a single COVID infection
Data source: Al-Aly et al. (2021)

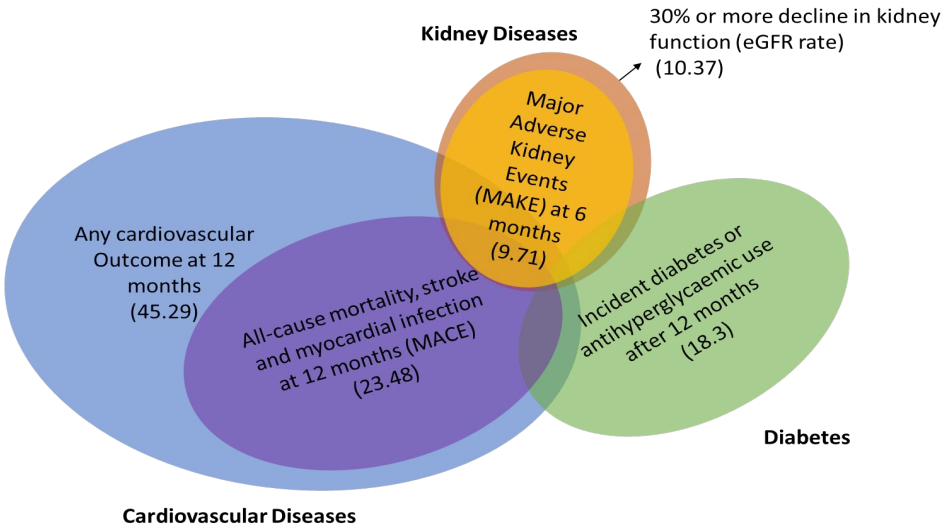


Figure 5: Excess burden of disease (per thousand persons) for cardiovascular diseases, kidney diseases and diabetes
Data sources: Bowe et al. (2021); Xie and Al-Aly (2022); Xie et al. (2022)

3.2 Despite vaccination and antiviral drugs, COVID remains a much more severe disease than influenza

COVID and influenza can be compared using death rates. There were 308 influenza associated deaths in Australia over the period 1 January-9 October 2022 (Department of Health and Aged Care 2022). By comparison, over this same period, there were 13,130 registered COVID deaths in Australia (covid19data.com.au 2022); 43 times greater than for influenza. This is despite a high proportion of the population being double, triple or quad-vaccinated, in addition to the use of monoclonal antibodies and the roll out of effective antiviral therapies in 2022.

People who get COVID, and recover from the acute infection, suffer a higher risk of increased mortality in the weeks and months after infection (Al-Aly et al. 2021). While the incidence of long COVID is higher with adults, a large study of German children and adolescents (11,950 children/adolescents and 145,184 adults) found that they also had statistically significantly higher incidence rates of 10 diagnosed symptom complexes relative to a control cohort (Roessler et al. 2022). That is, having COVID increases the incidence rate of a range of symptoms in both children and adults in the post-acute phase.

Other studies have found that mortality risk, measured as an excess number of deaths (per thousand persons), is much greater if a person is hospitalised with COVID than if the person is not hospitalised with COVID, as shown in Figure 6.

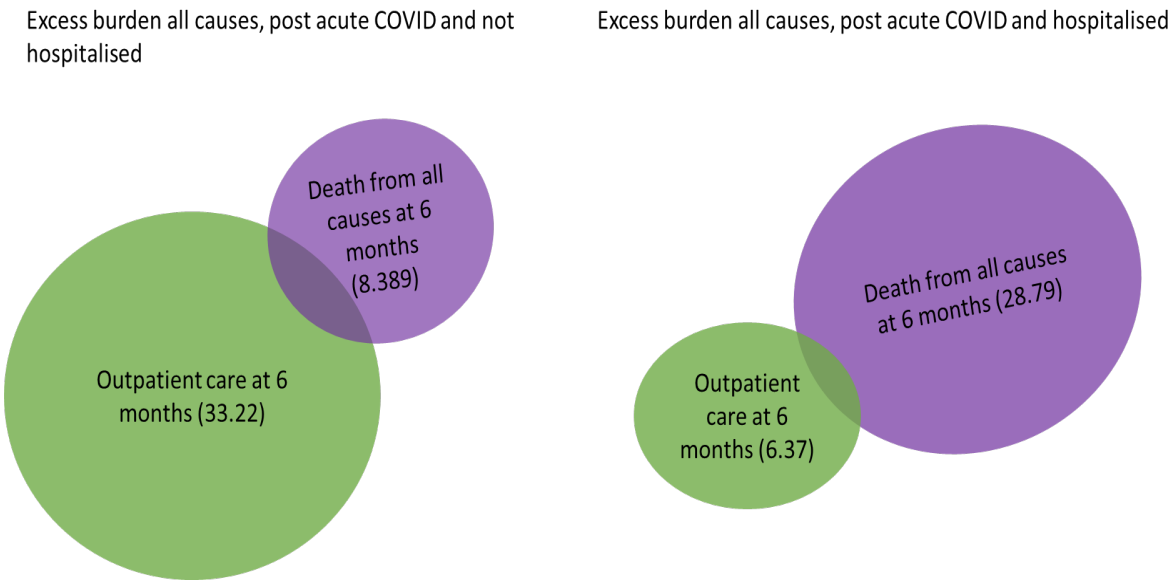


Figure 6: Excess burden (per thousand) of mortality at 6 months with symptomatic COVID infection, in hospitalised patients (right panel) and not-hospitalised patients (left panel).
Data source: Al-Aly et al. (2021)

The increased number of deaths in large cohort studies, such as with US veterans (Al-Aly et al. 2021), is of sufficient magnitude as to be identifiable by higher death rates in some countries in 2022. That is, there is an increased mortality effect identified in subpopulation studies, such as with US veterans (Al-Aly et al. 2021), and in population studies, such as in Estonia (Uusküla et al. 2022).

In the UK, excess deaths for the year January to September 2022 are presented in Figure 7, relative to two different baselines. When compared to the 2015-2019 baseline, excess deaths in England are about 25,000 for the year January-September 2022 for a total number of deaths (all causes) of 400,000 over the same period, or about a 6% excess death rate.

Excess deaths need to be interpreted with caution because they depend on the chosen baseline and should consider changes in population size and the age profile of the population since the baseline. In addition, for countries that suffered a high rate of COVID fatalities early in the pandemic, such as England, with 72,000 COVID fatalities in 2020 (UK Health Security Agency 2021), adjustments should also be made for 'mortality displacement'. That is, a proportion of those who died from COVID in 2020 COVID would likely have died in 2021 or 2022 and, thus, these premature deaths might be expected to reduce the death rate in the years immediately following.

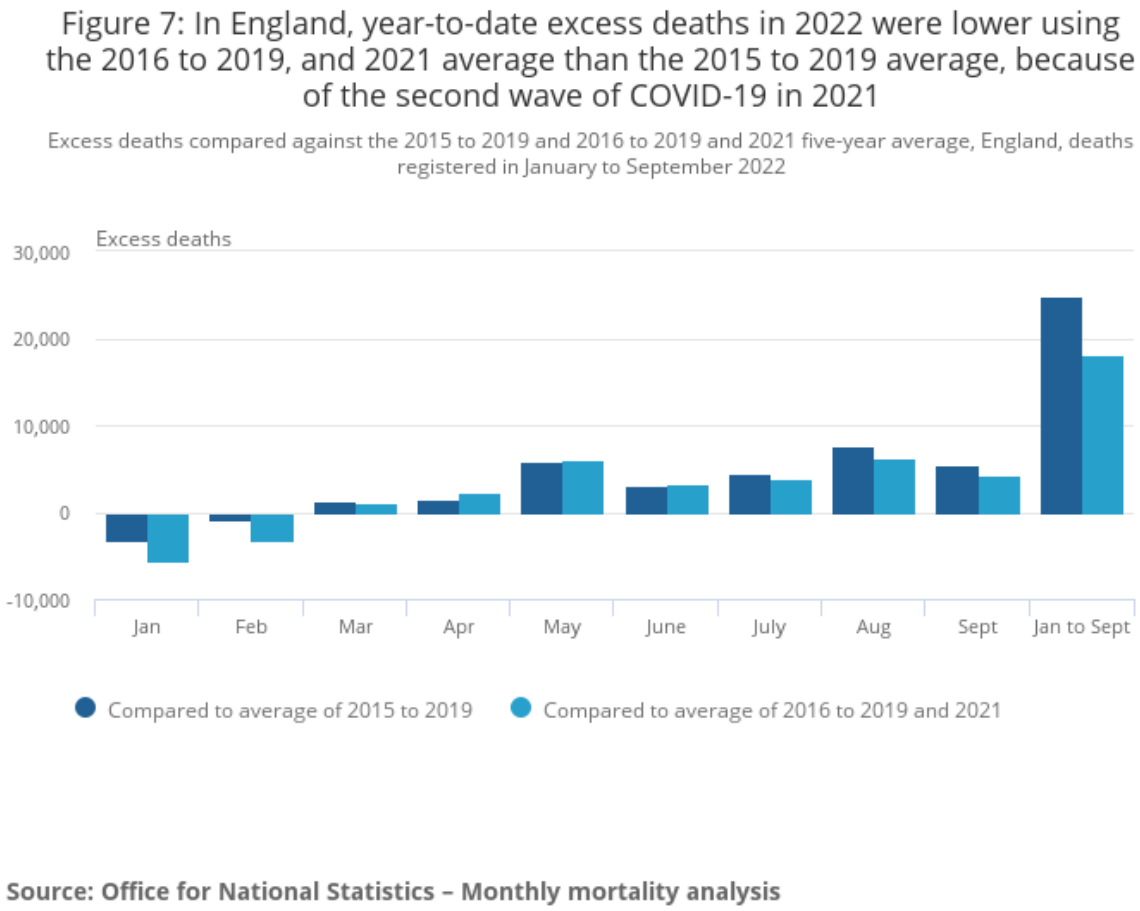


Figure 7: Excess deaths (all causes) in England, by month in 2022.
Source: Figure 7, UK Office of National Statistics (2022)

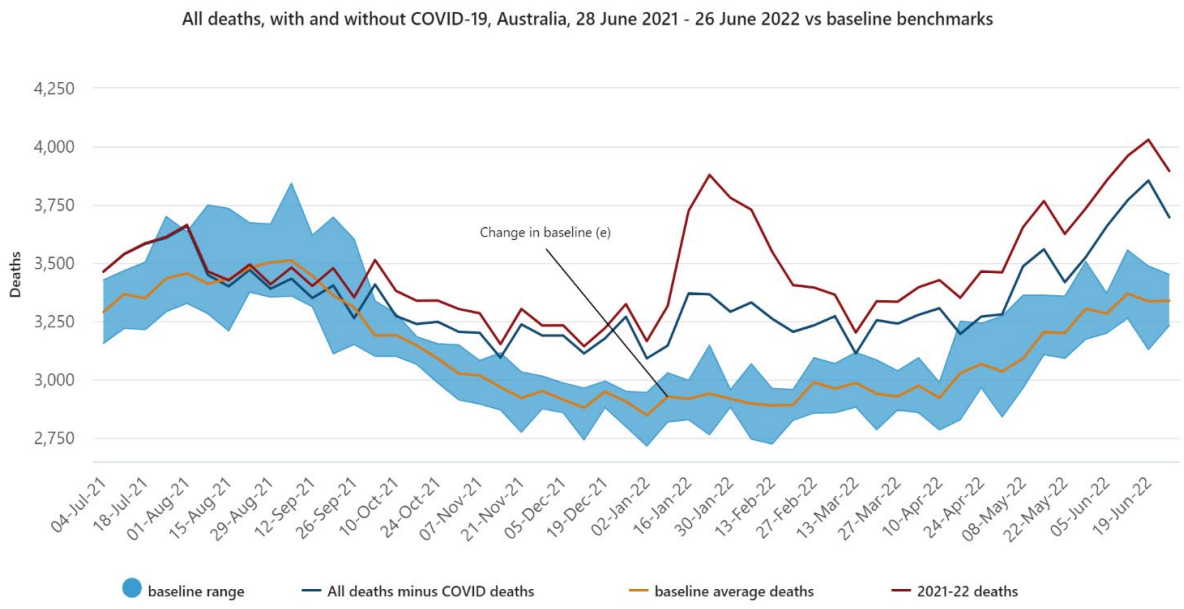
Another way to investigate the possible impacts of post-acute COVID sequelae in terms of excess deaths is to distinguish between causes of death. The UK Continuous Mortality Investigation found that increased deaths from cardiovascular diseases (CVD) were responsible for an increase in non-COVID deaths in the third quarter of 2022, while deaths from cancer in England and Wales were not different to pre-pandemic levels. This trend of higher-than-expected deaths from CVD began from about the middle of 2021 and could be a signal of post-acute COVID sequelae, given there is robust statistical evidence from a cohort of some 154,000 US veterans with COVID (Xie et al. 2022) that beyond the first 30 days after infection there is an increased risk of CVD in multiple categories (e.g., cerebrovascular disorders, ischaemic and non-ischaemic heart disease, heart failure, etc.).

A possible contributing factor to the finding of excess deaths post-acute COVID is that a proportion of those people who would have died *without* vaccination are surviving but are later dying from morbidities triggered or caused by COVID. Evidence in favour of this hypothesis is available from Singapore. In 2022, additional Singapore fatalities *not* registered as COVID deaths appear to be associated with individuals who were recently infected with COVID. No additional fatalities are identifiable with individuals who did not recently have COVID (Ministry of Health Singapore 2022). Population data from Estonia are also consistent with this hypothesis. That is, of those who have had COVID, their risk of dying over the following year is more than three times greater than those who did not get COVID; with most of the post-acute COVID deaths occurring among Estonians 60 years or older (Uusküla et al. 2022).

In Australia, the death rate from all causes over the period January-June 2022 was 12.5% higher than in the same period in 2021, and 17.1% (13,500 people) above the historical average for the chosen baseline (see Figure 8). About half the increase in deaths is explained by COVID deaths in the acute phase of the disease. The September 2022 version of the Australian Bureau of Statistics' (ABS) Provisional Mortality Statistics observed that, relative to a baseline average (2017-19 and 2021), there was an increase in registered deaths from the following causes: 19.8% from Alzheimer's Disease (age standardised death rate of 4.2 versus 4.0 per 100,0000 persons) and 21.3% from Diabetes (age standardised death rate of 1.6 versus 1.4 per 100,000 persons). There was no increase in the age standardised death rate for cancer.

Actuaries Australia (2022a, 2022b) has analysed the ABS data for Australia that are available until the end of July 2022. They conclude that total deaths until end of July 2022 were 14% higher (13,700 deaths) than the baseline, of which about half of these deaths (7,100 people) were from COVID and 6,600 deaths attributed to other causes. By comparison, excess deaths were, relative to a 2015-19 baseline, 4,000 *fewer* in 2020 and 3,000 more in 2021.

In Australia, for 2022, until the end of July; non-COVID registered deaths from heart disease, cerebrovascular disease, diabetes, and dementia were between 8% and 16% higher, deaths from unspecified causes were 12% higher, and non-COVID-19 coroner-referred deaths were 7% higher than the 2015-19 baseline (Actuaries Institute 2022b). In the view of Actuaries Australia, based on the mortality evidence to the end of July 2022, there is a 'high impact' that these excess non-COVID registered deaths in Australia are a result of post-acute COVID sequelae.



a. Data is by occurrence.
b. Data is provisional and subject to change.
c. Weeks are defined as seven-day periods which start on a Monday as per the ISO week date system. Refer to 'Weekly comparisons' on the methodology page of this publication for more information regarding the data in this graph.
d. The baseline includes deaths from 2015-19 (for 2021) and from 2017-19 and 2021 (for 2022).

Source: Australian Bureau of Statistics, Provisional Mortality Statistics Jan - Jun 2022

Figure 8: Recorded total deaths (all causes and COVID) in Australia 4 July 2021 to 26 June 2022
Source: ABS (2022) https://www.abs.gov.au/statistics/health/causes-death/provisional-mortality-statistics/latest-release

Response to Terms of Reference 4: "The health, …and economic impacts in Australia on individuals who develop long COVID and/or have repeated COVID infections…)" and

Response to Terms of Reference 5: "The impact of long COVID and/or repeated COVID infections on Australia's overall health system, particularly in relation to increased risk of various conditions including cardiovascular, neurological, and immunological conditions in the general population."

4. COVID is not over

Globally, for the week ending 29 October 2022, there were 455,000 confirmed cases and some 2,100 daily deaths, on average, over the past 7 days. Both the confirmed cases and deaths are substantial underestimates; estimates of global excess deaths (daily) from COVID were 13,500 on 24 October 2022, while the confirmed number was 1,600 (an 8.4-fold difference). Cumulative deaths from COVID globally are likely to be about three times greater than confirmed deaths; that is, an estimated 21.6 million global COVID deaths versus the official global death toll of 6.6 million (The Economist, 2022).

The SARS-CoV-2 virus has evolved since its genome was identified in January 2020 (CDC 2022). This evolution is a direct result of the very large number of confirmed cumulative COVID cases globally. Each of the 630 million cases since 22 January 2020 (Our World in Data, 2022) has represented an opportunity for viral mutation and the generation of new variants, lineages, and sub-lineages, as shown in Figure 9.

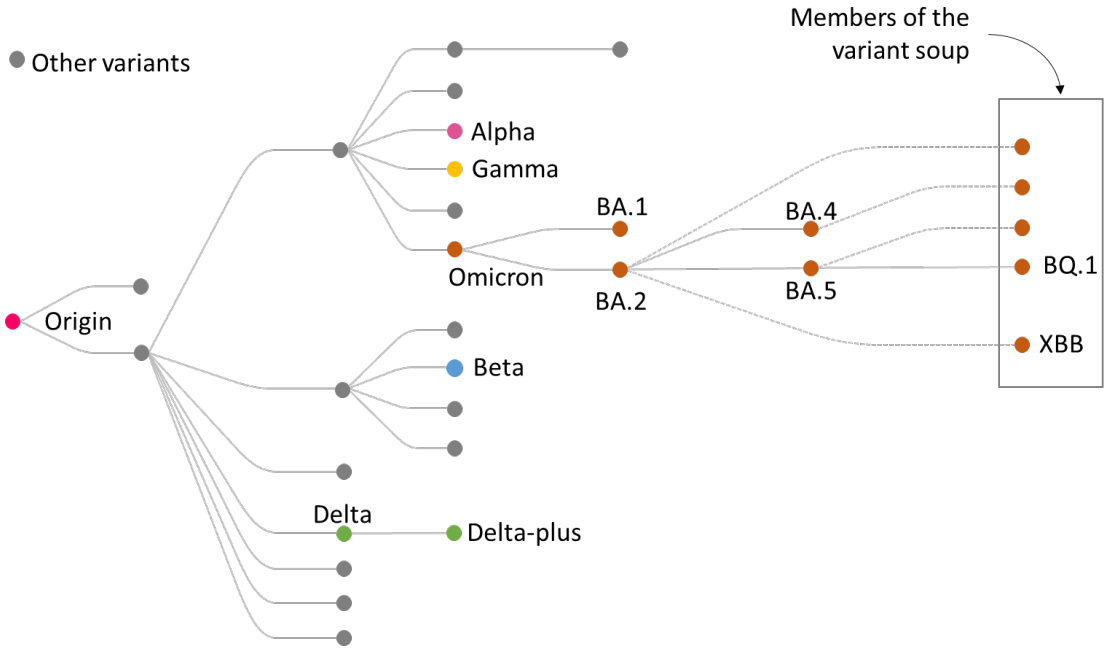


Figure 9: SARS-CoV-2 Virus lineages and sub-lineages
Adapted from Calloway (2022)

There is no definitive evidence that the current and emerging variants in Australia, or globally, will be more (or less) virulent than Omicron (B.1.1.529). Nevertheless, variants are contributing to another wave in some countries and the Omicron variant XBB is also increasing the number of cases in Australia, as of 8 November 2022 (Kelly 2022). In general, there is no *a priori* reason why emerging SARS-CoV-2 variants should become more (or less) virulent over time (Markov et al. 2022). This is because the principal evolutionary pressure on the virus is to increase its ability to spread to other

hosts and to overcome existing immunity from vaccines and/or infection in potential hosts, not to become more (or less) virulent. With SARS-CoV-2 infection, the acute phase of illness occurs *after* infected people become contagious; that is, the virulence of the virus (i.e., disease severity) plays a relatively minor role in determining a variant's fitness.

A reduction in disease severity among COVID cases will rely upon the ongoing effectiveness of vaccines, a contribution from immunity via previous infection, antiviral drugs and that mutation and selection of new variants or subvariants (Cai et al. 2022) makes the virus less virulent. Until science can deliver a vaccine that is highly effective against transmission, which current vaccines do not, then 'living with COVID' means preparing for a future where new immune-escaping variants or subvariants periodically but consistently arrive in Australia. This will cause re-infection(s) and result in mortalities and morbidities from both acute COVID infection and long COVID.

5. Vaccinations are not enough

Key to making good decisions about how to respond to the COVID pandemic is to have an evidence-based understanding of the effects of vaccination on COVID and long COVID. Data show that being fully vaccinated with three (or more) doses in the recent past provides ~90% protection against severe COVID infection, hospitalisation, and death. Data also show from large studies that vaccine protection against long COVID syndrome is substantially lower and much more variable, between 15-66% (Bowe et al. 2022; Kuodi et al. 2022).

Data are emerging from large studies into the various disorders that encompass post-acute COVID sequelae. Strikingly, Al-Aly and colleagues reported that a wide array of post-COVID sequelae (including serious cardiac events) did not appear to be much reduced in patients who had been vaccinated compared to unvaccinated (Al-Aly et al. 2021). The same research group performed a specific study designed to respond to the question of how vaccination impacts the incidence of long COVID, and they estimated vaccination before infection confers only a 15% protection against post-acute COVID sequelae.

Despite the burgeoning evidence that vaccination protects poorly against long COVID, Australia's public health interventions were progressively abandoned in 2022. These measures included: mandated mask wearing in indoor public settings, as well as on public transport, and the ending of mandatory isolation for those with COVID on 14 October 2022. This relaxation of public health measures has occurred despite more than 13,000 cumulative Australian COVID fatalities in 2022 and overwhelming evidence that airborne transmission is the principal cause of infection by the SARS-CoV-2 virus (Lewis 2022). Weakening of one of the most important public health measures, the ending of mandatory isolation, occurred without consulting Australia's health advisory committee, the Australian Health Protection Principal Committee (Borys 2022).

In the opinion of the President of the Australian Medical Association: "Easing restrictions or abandoning other protections signals to the community that things are over, and that's not correct" (Robson 2022). Further, a shift in messaging by governments and/or opinion leaders that the public and economy need to 'get over it' and 'move on' or that 'COVID is like the flu', gives a strong and false signal to the public that the pandemic is over. Yet, "[t]he most important factor in preventing the spread of the COVID-19 is to empower the people with the right information." (Reddy and Gupta 2020, pp. 3793-3794).

Much has been learned since early 2020 about COVID, and over the centuries about how to respond to epidemics. One of the key learnings is that multiple approaches are needed to reduce contagion.

That is, in many cases, including with COVID, no single measure by itself is sufficient. This can be visualised by the so-called 'Swiss Cheese Effect' (see Figure 10) developed by Ian MacKay based on an earlier non-virus-related example developed by James Reason. The Swiss Cheese Effect comprises both the 'personal responsibilities' of individuals and households to protect themselves and others from infection and the 'shared responsibilities', typically led and implemented by governments to reduce the spread of COVID.

With the exception of COVID vaccines, the shared responsibilities model in Australia has either been removed or greatly weakened in 2022. Measures that have been removed or weakened include: testing and tracing; quarantine and isolation; border controls; government messaging; financial support for those suffering from COVID; and mandatory mask wearing. That is, over 2022, Australian governments have shifted to a personal responsibilities model for COVID; a disease that is primarily spread by airborne transmission, that is causing a global pandemic, and which will be the third-leading registered cause of deaths (*not* including post-acute COVID sequelae) in Australia in 2022 (Actuaries Australia 2022b).

The transition in Australia to the personal responsibilities model is contrary to the views in 2022 of a multinational group of 386 academic, health, non-governmental organisations, and government COVID experts from 112 countries and territories. Of this group, 81% agreed that "[r]elying on individual, voluntary compliance with transmission prevention measures is insufficient to end COVID-19 as a public health threat", and 87% agreed that "[w]ide use of high-filtration and well-fitting facemasks (for example, N95, KF94, KN95, FFP2/3) is important to reduce transmission, particularly in high-risk settings." (Lazarus et al. 2022, Table 3).

We highlight that not all countries have adopted the personal responsibilities model when responding to COVID. For example, Singapore still maintains mandatory mask wearing on public transport, and Belgium enforces, with fines, mandatory indoor carbon dioxide monitors in locations visible to the public and requires air filtration should CO_2 levels exceed 900-1,200 parts per million (ppm). CO_2 levels exceeding 1,200 ppm CO_2 are a safety breach that must be resolved (O'Leary 2022).

A justification for a personal responsibilities model for COVID is that it has already, or it will become, an endemic disease such that it is persistent but at a stable level in a population. There is no credible evidence to support this claim as truly endemic diseases (e.g., malaria) do not occur in 'waves' of infection which are characteristic of COVID spread (MacIntyre 2022). Further, a transition from an epidemic disease to an endemic disease requires a substantial decline in infection due to widespread immunity by vaccination and/or infection that prevents transmission of the virus (Antia and Halloran 2022). This has not happened yet (and may never happen) for COVID. Consequently, in the absence of the widespread use of vaccines that are highly effective at preventing transmission of the SARS-CoV-2 virus, which are not yet available, there will continue to be waves (epidemics) of COVID with variants, over time, becoming more effective at evading immunity and more contagious.

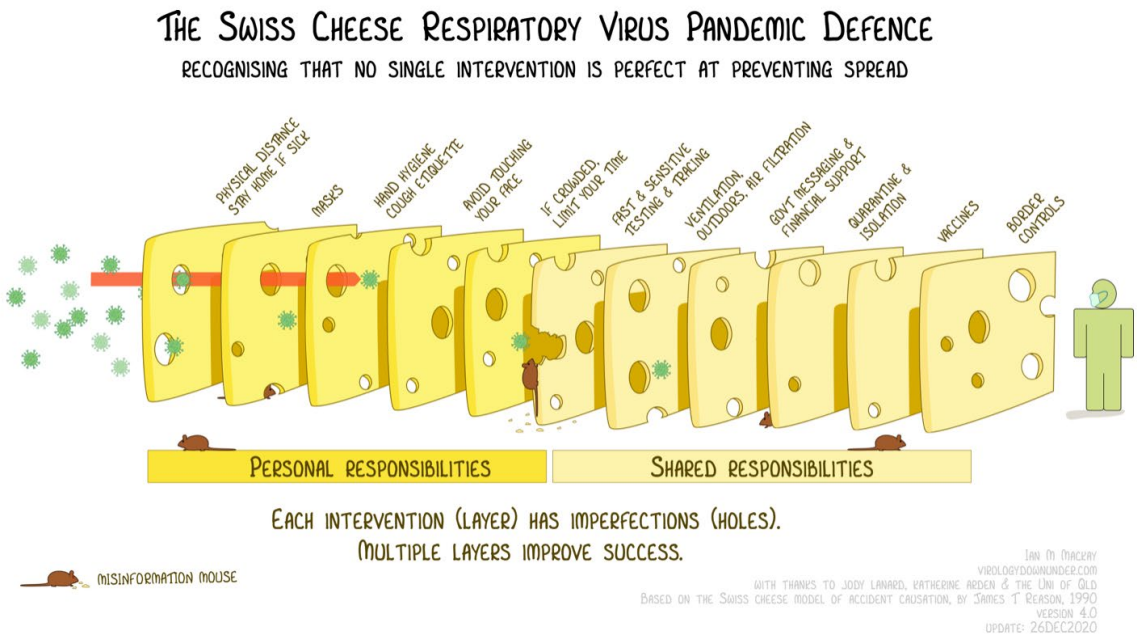


Figure 10: Shared Responsibilities and Personal Responsibilities at Preventing COVID Infections
Source: MacKay (2021)

6. Consequences of a Shift from Shared Responsibilities to Personal Responsibilities

On 12 July 2022, Chu et al. (2022) estimated the Australian economy benefits (avoided losses in labour hours worked) and direct costs of public health interventions (compliance with mandated mask wearing and CO_2 monitoring for indoor public spaces, free HEPA air filters for each Australian business) to reduce COVID case rates during the third Omicron wave. They found the benefit-cost ratio of COVID public health interventions ranges from 2.3 to 9.7; but they only accounted for the value of the lost labour hours. That is, they found there is a very large economy pay-off for reinstating some public health measures (e.g., mandatory mask wearing) to reduce COVID infection rates (between 30-50%) to mitigate losses from reduced labour work hours. The benefits of public health interventions to reduce COVID infections would be even larger if the health and social costs of long COVID were included.

To illustrate the consequences of relying on personal rather than shared responsibilities, as illustrated by the Swiss Cheese Effect (see Figure 10), it is insightful to compare Australia with Singapore. In 2020 and 2021 both countries did well, relative to other nations, in terms of having both low COVID case rates and death rates. This dramatically changed in 2022. In Singapore, over the period 1 January to 31 October 2022 the cumulative COVID death rate per 1,000 of the total population was 0.1451; virtually unchanged from its value for the period ending 31 December 2021 of 0.1417. By comparison, for Australia, over the period 1 January to 31 October 2022, the cumulative COVID death rate per 1,000 of the total population was 0.5212; a more than five-fold increase from its value for the period ending 31 December 2021 of 0.0928.

The principal explanation for the much higher COVID death rate in Australia in 2022 relative to Singapore in 2022 is the 24-fold increase (from 431,000 to 10.378 million) of confirmed cumulative Australian COVID cases from 1 January to 31 October 2022. That is, if Australia's rate of increase in COVID cases had been the same as Singapore's from 1 January to 31 October 2022, there would

have been about 4,300 fewer Australian COVID fatalities, and about 250,000 fewer severe cases of long COVID.

We contend that a key explanation as to why Singapore has had a much lower COVID case rate than Australia in 2022 is that Singapore has maintained more of the shared responsibilities model in relation to public health, which Australia progressively abandoned in 2022. For example, as of 10 October 2022, Singapore requires and enforces mask wearing on public transport and requires that all workers who test positive for COVID not return to work until they have obtained a negative result (Teng 2022).

References

Actuaries Institute (2022a). How COVID-19 has affected Mortality and Morbidity in 2020 & 2021. Institute of Actuaries of Australia. https://www.actuaries.asn.au/Library/Opinion/2022/ResearchNoteno4.pdf

Actuaries Institute (2022b). COVID-19: high excess mortality continues into July 2022. https://www.actuaries.digital/2022/11/04/covid-19-mortality-working-group-another-month-of-high-excess-mortality-in-july-2022/

Al-Aly, Z., Xie, Y., Bowe, B. (2021). High-dimensional characterization of post-acute sequelae of COVID-19. *Nature* 594: 259-264. https://www.nature.com/articles/s41586-021-03553-9

Antia, R., Halloran, E.M. (2022). Transition to endemicity: Understanding COVID-19. *Immunity* 54: 2172-2176. Transition to endemicity: Understanding COVID-19 (cell.com)

Australian Bureau of Statistics (2022a). COVID-19 Mortality in Australia: Deaths registered until 31 July 2022. COVID-19 Mortality in Australia: Deaths registered until 31 July 2022 | Australian Bureau of Statistics (abs.gov.au)

Australian Bureau of Statistics (2022b). Labour Force, Australia. Labour Force, Australia, September 2022 | Australian Bureau of Statistics (abs.gov.au)

Australian Bureau of Statistics (2022c). Provisional Mortality Statistics January-June 2022. Provisional Mortality Statistics, June 2022 (population.gov.au)

Australian COVID-19 Serosurveillance Network (2022). Seroprevalence of SARS-CoV-2-specific antibodies among Australian blood donors: Round 3 update (3 November 2022) https://kirby.unsw.edu.au/project/serosurveillance-sars-cov-2-infection-inform-public-health-responses

Australian Institute of Health and Welfare (2021). *The first year of COVID-19 in Australia: direct and indirect health effects*. ISBN 978-1-76054-866-7 (PDF). https://www.aihw.gov.au/getmedia/a69ee08a-857f-412b-b617-a29acb66a475/aihw-phe-287.pdf.aspx?inline=true

Australian Institute of Health and Welfare (2022). Chapter one 'The impact of a new disease: COVID-19 from 2020, 2021 and into 2022' in *Australia's health 2022: data insights*, 2022; catalogue number AUS 240, Australia's health series number 18, AIHW, Australian Government. https://www.aihw.gov.au/reports/australias-health/australias-health-2022-data-insights/data

Bach, K. (2022). Report New data show long COVID is keeping as many as 4 million people out of work. Brookings (24 August). https://www.brookings.edu/research/new-data-shows-long-covid-is-keeping-as-many-as-4-million-people-out-of-work/

Biddle, N., Korda, R. (2022). The experience of COVID-19 in Australia, including long-COVID – Evidence from the COVID-19 Impact Monitoring Survey Series, August 2022. https://csrm.cass.anu.edu.au/sites/default/files/docs/2022/10/The_experience_of_COVID-19_in_Australia_-_For_web.pdf

Borys, S. (2022). Here's the health advice that led to COVID isolation rules being dropped. https://www.abc.net.au/news/2022-10-01/covid-isolation-rules-chief-medical-officer-letter/101492144

Bowe, B., Vie, Y., Xu, E., Al-Aly, Z. (2021). Kidney Outcomes in Long COVID. *JASN Clinical Epidemiology* 32: 2851-2862. https://jasn.asnjournals.org/content/32/11/2851.long

Bowe, B, Xie, Y., Al-Aly, Z. (2022). Acute and postacute sequelae associated with SARS-CoV-2 reinfection. *Nature Medicine* https://www.nature.com/articles/s41591-022-02051-3

Brooks, J.T., Butler J.C. (2021). Effectiveness of Mask Wearing to Control Community Spread of SARS-CoV-2. *JAMA.* 2021;325(10):998-999. doi:10.1001/jama.2021.1505 https://jamanetwork.com/journals/jama/fullarticle/2776536

Calloway, E. (2022). COVID 'variant soup' is making winter surges hard to predict. COVID 'variant soup' is making winter surges hard to predict (nature.com)

Cao, Y., Jian, F. Wang, J. et al. (2022). Imprinted SARS-CoV-2 humoral immunity induces convergent Omicron RBD evolution. bioRxiv preprint doi: https://doi.org/10.1101/2022.09.15.507787

Canetti, M., Barda, N., Gilboa, M. (2022). Six-Month Follow-up after a Fourth BNT162b2 Vaccine Dose. *The New England Journal of Medicine* DOI: 10.1056/NEJMc2211283 https://www.nejm.org/doi/pdf/10.1056/NEJMc2211283?articleTools=true

Centers for Disease Control and Prevention (2022). SARS-CoV-2 Variant Classifications and Definitions. SARS-CoV-2 Variant Classifications and Definitions (cdc.gov)

Chu, L., Grafton, R.Q., Kompas, T. (2022). COVID costs and public health measures. https://osf.io/aswxv/ (12 July 2022).

Covid19data.com.au. (2022). https://www.covid19data.com.au/states-and-territories

Cowger, T.L., Murray, E.J., Clarke, J. et al. (2022). Lifting Universal Masking in Schools — Covid-19 Incidence among Students and Staff. *The New England Journal of Medicine* DOI: 10.1056/NEJMoa2211029 https://www.nejm.org/doi/pdf/10.1056/NEJMoa2211029?articleTools=true

Department of Health and Aged Care (2022). Australian Influenza Surveillance Report No. 14, 2022. Australian Influenza Surveillance Report No. 13 – 15 August to 28 August 2022 (health.gov.au)

Greenhalgh T., Jimenez J.L., Prather K.A. et al. (2021). Ten scientific reasons in support of airborne transmission of SARS-CoV-2. *Lancet* 2021; 397, 10285, P1603-1605. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)00869-2/fulltext

Hastie, C.E., Lowe, D.J., McAuley, A. et al. (2022). Outcomes among confirmed cases and a matched comparison group in the Long Covid in Scotland study. *Nature Communications* 13; 5663. https://www.nature.com/articles/s41467-022-33415-5

Howard, J., Huang, A., Li, Z. et al. (2021). An evidence review of face masks against COVID-19. *Proceedings of the National Academy of Sciences (PNAS)* 2021 Vol. 118 No. 4 e2014564118 https://www.pnas.org/doi/10.1073/pnas.2014564118

Kelly, P. (2022). New COVID-19 variant leads to increase in cases. Department of Health and Aged Car (8 November 2022). https://www.health.gov.au/news/new-covid-19-variant-leads-to-increase-in-cases

Kuodi, P., Gorelik, Y., Zayyad, H. et al. (2022). Association between BNT162b2 vaccination and reported incidence of post-COVID-19 symptoms: cross-sectional study 2020-21, Israel. *npj Vaccines* 7, Article number: 101 (2022) https://www.nature.com/articles/s41541-022-00526-5#Sec14

Lazarus, V.J., Romero, D., Kopka, C.J. et al. (2022). A multinational Delphi consensus to end the COVID-19 public health threat. *Nature* https://doi.org/10.1038/s41586-022-05398-2.

Lewis, D. (2022). Why the WHO took two years to say COVID is airborne. https://www.nature.com/articles/d41586-022-00925-7

Liu, B., Jayasundara, D., Pye, V., Dobbins, T., Dore, G.J., Matthews, G., Kaldor, J., Spokes, P., (2021). Whole of population-based cohort study of recovery time from COVID-19 in New South Wales Australia. *The Lancet Regional Health - Western Pacific*. 12, 100193. https://doi.org/10.1016/j.lanwpc.2021.100193

Ma, Q., Liu, Q., Kang, L. et al. (2021). Global Percentage of Asymptomatic SARS-CoV-2 Infections Among the Tested Population and Individuals with Confirmed COVID-19 Diagnosis A Systematic Review and Meta-analysis. *JAMA Network Open.* 2021;4(12):e2137257. https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2787098?resultClick=3

MacIntyre, R. (2022). Why Covid-19 will never become endemic. https://www.thesaturdaypaper.com.au/opinion/topic/2022/01/15/why-covid-19-will-never-become-endemic/164216520013155

Mackay, I. (2021). COVID-19: The Swiss cheese infographic that went viral https://www.businessnewsaustralia.com/articles/the-swiss-cheese-infographic-that-went-viral.html

Markov, P.V., Katzourakis, A., Stilianakis, N.I. (2022). Antigenic evolution will lead to new SARS-CoV-2 variants with unpredictable severity. *Nature Reviews Microbiology* 20: 251–252. https://www.nature.com/articles/s41579-022-00722-z

Mayo Clinic Staff (2022a). How well do face masks protect against COVID-19? How well do face masks protect against COVID-19? - Mayo Clinic

Mayo Clinic Staff (2022b). COVID-19 vs. flu: Similarities and differences. COVID-19 vs. flu: Similarities and differences - Mayo Clinic https://www.mayoclinic.org/diseases-conditions/coronavirus/in-depth/coronavirus-vs-flu/art-20490339

Ministry of Health Singapore. (2022). Report on excess mortality during the COVID-19 pandemic up to June 2022. https://www.moh.gov.sg/resources-statistics/reports/report-on-excess-mortality-during-the-covid-19-pandemic-up-to-june-2022

Mitze T., Kosfeld R., Rode J. et al. (2020). Face masks considerably reduce COVID-19 cases in Germany. *PNAS* 2020; 117 (51) 32293-32301 https://doi.org/10.1073/pnas.2015954117

New South Wales Health Critical Intelligence Unit (2022). COVID-19. https://aci.health.nsw.gov.au/covid-19/critical-intelligence-unit

O'Leary, N. (2022). Belgium imposes ventilation rules for businesses to combat new Covid surge. Irish Times, 5 July 2022. https://www.irishtimes.com/news/world/europe/belgium-imposes-ventilation-rules-for-businesses-to-combat-new-covid-surge-1.4612101

Our World in Data (2022). Cumulative Confirmed COVID-19 Cases by World Region. https://ourworldindata.org/grapher/cumulative-covid-cases-region

Pecoraro, K. (2021). How social determinants of health affect COVID-19-related morbidity and mortality. *Nursing*: May 2021 - Volume 51 - Issue 5 - p 24-32.

Pérez-González, A., Araújo-Ameijeiras, A., Fernández-Villar, A. et al. (2022). Long COVID in hospitalized and non-hospitalized patients in a large cohort in Northwest Spain, a prospective cohort study. *Scientific Reports* 12, 3369. 10.1038/s41598-022-07414-x. https://www.nature.com/articles/s41598-022-07414-x

Perlis, R.H., Santillana, M., Ognyanova, K. et al. (2022). Prevalence and Correlates of Long COVID Symptoms Among US Adults. *JAMA Network Open.* 2022;5(10):e2238804. doi:10.1001/jamanetworkopen.2022.38804 https://www.nature.com/articles/s41598-022-07414-x

Raisi-Estabragh, Z., Cooper, J., Salih, A. et al. (2022). Cardiovascular disease and mortality sequelae of COVID-19 in the UK Biobank. *BMJ Heart* 2022; 0:1–8. doi:10.1136/heartjnl-2022-321492. https://heart.bmj.com/content/early/2022/09/21/heartjnl-2022-321492.long

Reddy, B.V., Gupta, A. (2020). Importance of effective communication during COVID-19 infodemic. *J Family Med Prim Care* 2020 Aug; 9(8): 3793–3796. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7586512/

Roessler, M, Tesch, F., Batram, M. (2022). Post-COVID-19-associated morbidity in children, adolescents, and adults: A matched cohort study including more than 157,000 individuals with COVID-19 in Germany. *PLOS Medicine* 19(11): e1004122. https://doi.org/10.1371/journal.pmed.1004122

Robson, S. (2022) as President of the Australian Medical Association and cited in Makkar 'Experts reason why COVID shouldn't be treated like the flu' SBS Experts reason why COVID shouldn't be treated like the flu | SBS English.

Sachs, J.D., Karim, S.S.A., Aknin, L. et al. (2022). The lancet Commission on lessons for the future from the COVID-19 pandemic. *Lancet* 40: 1224-1280. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(22)01585-9/fulltext

Tacquet, M., Sillett, R., Zhu, L. et al. (2022) Neurological and psychiatric risk trajectories after SARS-CoV-2 infection: an analysis of 2-year retrospective cohort studies including 1 284 437 patients. *Lancet Psychiatry* 2022; 9: 815–27. https://www.thelancet.com/journals/lanpsy/article/PIIS2215-0366(22)00260-7/fulltext

Teng, N.T.W. (2022). COVID-19 Rules and Restrictions in Singapore (Oct 2022). COVID-19 Rules and Restrictions in Singapore (Oct 2022) – SingaporeLegalAdvice.com

The Economist (2022). The pandemic's true death toll (25 October 2022). https://www.economist.com/graphic-detail/coronavirus-excess-deaths-estimates

Thompson E.J., Williams D.M., Walker A.J., et al. (2022) Long COVID burden and risk factors in 10 UK longitudinal studies and electronic health records. *Nature Communications* 2022; 13:3528 https://www.nature.com/articles/s41467-022-30836-0

Toole, M., Crabb, B. (2022). Imagining COVID is 'like the flu' is cutting thousands of lives short. It's time to wake up. Imagining COVID is 'like the flu' is cutting thousands of lives short. It's time to wake up (theconversation.com)

UK Health Security Agency. (2021). Research and analysis COVID-19 confirmed deaths in England (to 31 December 2020): Report. COVID-19 confirmed deaths in England (to 31 December 2020): report - GOV.UK (www.gov.uk)

UK Office of National Statistics (2022). Monthly mortality analysis, England and Wales: September 2022. https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/monthlymortalityanalysisenglandandwales/september2022#calculating-excess-deaths

US National Center for Health Statistics (2022). Household Pulse Surveys. Long COVID - Household Pulse Survey - COVID-19 (cdc.gov)

Uusküla, A., Jürgenson, T, Pisarev, H. et al. (2022). Long-term mortality following SARS-CoV-2 infection: A national cohort study from Estonia. *The Lancet Regional Health – Europe* 2022;18: 100394. https://www.thelancet.com/journals/lanepe/article/PIIS2666-7762(22)00087-4/fulltext

Xie, Y., Al-Aly, Z. (2022) Risks and burdens of incident diabetes in long COVID: a cohort study. *Lancet Diabetes Endocrinol* 2022; 10: 311–21 https://www.sciencedirect.com/science/article/pii/S2213858722000444

Xie, Y., Xu, E., Bowe, B., Al-Aly, Z. (2022) Long-term cardiovascular outcomes of COVID-19. *Nature Medicine* 28: 583-590. https://www.nature.com/articles/s41591-022-01689-3

Yende, S, Parikh, C.R. (2021). Long COVID and kidney disease. *Nature Reviews Nephrology* 17, pages 792–793 (2021) https://www.nature.com/articles/s41581-021-00487-3