



The course of COVID-19 in Australia

Submission to the Senate Inquiry into the
Australian Government's response to the COVID-19 pandemic

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Overview

The SARS-CoV-2 virus (coronavirus) galvanised a public health response not seen in Australia for more than a century. To prevent its spread, and the disease it causes, COVID-19, social and economic activity was shut down. Australia emerged with low numbers of deaths, and a health system which coped with the outbreak.

Australia's response passed through four stages – containment, reassurance amid uncertainty, cautious incrementalism, and then escalated national action – as the gathering storm of the pandemic became more apparent.

There were four key successes in the response: cooperative governance informed by experts (most notably seen in the establishment of the National Cabinet), closure of international borders and mandatory quarantine, rapid adoption and acceptance of spatial distancing measures, and expansion of telehealth.

The health system mostly adapted well to the pandemic challenge. Governments expanded intensive care unit capacity quickly, redeploying staff and equipment to this new higher priority. Doctors and clinics pivoted quickly to telehealth.

But unfortunately there were also four key failures: the handling of the Ruby Princess cruise ship was scandalous, borders weren't closed quickly enough, some aspects of the health system response were too slow, and there were mixed messages about what was expected of the population.

Australia is now at the beginning of a fifth stage, a transition to 'the new normal'. Unless or until there is a vaccine, this stage has no endpoint. We all will live with the risk of more outbreaks and

shutdowns, and the need for vigilance and swift responses to outbreaks.

Choices are being made about how and when the lockdown will be eased, with each state and territory taking a different path. While the virus continues to circulate, there will be a risk of a second wave.

In this report we describe a model developed at Grattan Institute which simulates the risks of different relaxation strategies, and we draw some lessons for the health system. We show that some strategies, such as reopening schools, involve some risk of outbreaks, but these outbreaks most likely can be controlled. We highlight those strategies which are riskier, particularly reopening large workplaces. As those workplaces reopen, employers should be required to implement protocols to ensure transmission of the virus is minimised. This may require fewer people being at work at any one time, with staggered start and finish times and even staggered working days. Lessons from the health system response should be incorporated into a new normal: expand telehealth to give more people quicker access to care; reform primary care to provide better care for people with chronic conditions; improve health system readiness by better planning and coordination; strengthen supply chains to ensure adequate supplies of personal protective equipment and ventilators in the event of a second wave or new pandemic.

Planning for this transition is as important as the planning of the response during the pandemic. Without good planning for the transition, we risk a second wave and we risk not benefiting from the health system changes that occurred during the pandemic. That would be another tragedy on top of the trauma caused by the pandemic itself.

Recommendations to transition out of lockdown

1. Maintain social distancing efforts while there are active COVID-19 cases in Australia

- Maintain high levels of testing, contact tracing and isolation.
- Workplaces should be re-opened slowly, with as many people continuing to work from home as possible. Minimise the number of people interacting in workplaces where possible.
- There needs to be continued messaging about density, touching, and protective behaviour such as masks. Social distancing in workplaces is crucial. Government guidelines for businesses should be clear, and their implementation should be enforced.
- Workers who show symptoms linked to COVID-19 must not be allowed in the workplace, and must be supported to continue their work from home where possible, or through Government support.
- Schools should continue to be re-opened with social distancing policies in place to reduce risk of outbreaks before detection. Schools should be closed, and rigorous contact tracing implemented when a case is detected.
- People in the community must continue to take social distancing precautions, including wearing masks. As fewer COVID-19 cases are reported and risk perceptions are lowered, people must be reminded about their social distancing responsibilities, with clear and frequent provision of hand sanitiser remaining the norm.
- Policies that govern patron spacing limits in shops should be maintained if local transmission of COVID-19 continues in particular cities.

2. Ramp up local lockdowns when outbreaks occur to prevent a second wave

- State governments must actively monitor cases in local areas.
- States must be prepared to act decisively to control major outbreaks.
- Local lockdowns should be considered, but the mechanics – the threshold of cases for a lockdown, who can enter and exit the affected area, what happens to workplaces and schools and workplaces – must be communicated with the public. This will ensure the public and local authorities know what to expect and how to react, and will remind the public of the risks of COVID-19 spread.

3. When there are no active COVID-19 cases in Australia

- When there are no active cases in the community more of life can return to normal. Capacity constraints on workplaces, shops and hospitality can be removed. People can start to move freely within and between states.
- Testing must remain a routine part of life even after Australia declares itself COVID-19-free. If local cases are identified, contact tracers must be at the ready, and widespread testing should restart in affected areas.
- Current mandatory quarantining of international arrivals must remain in place.
- The Commonwealth should maintain and enforce safety guidelines for new arrivals as updated information about the virus and new technology to assess infectivity of individuals is developed.
- Quarantine exemptions could be made with other countries, like New Zealand, that also have no active COVID-19 cases and that have effective international arrival practices in place.

Recommendations for the health system

Commonwealth Government

1. Expand telehealth to expand people's access to care

- The Commonwealth should introduce new telehealth items, replacing the pandemic ones, limited to patients with an established relationship to a practice, and in the case of people aged 70+, to the practice in which the patient is enrolled.
- Build evidence about whether there should be a limit on telephone consultations as a proportion of total practice telehealth consultations.
- Bulk-bill telehealth items, and subject them to strict electronic verification requirements.
- The 'digital divide' means that a patient's digital and health literacy will need to be assessed in customising care to ensure the most vulnerable are not left behind.

2. Provide better care for people with chronic conditions by reforming primary care

- Consider new funding models for general practice, to pay for more telehealth items and to encourage practice co-location and consolidation.
- Review the barriers in the Medicare Benefit Schedule to practices reforming their workforce.

State governments

3. Make the system more efficient by connecting public and private

- States should negotiate contracts with private hospitals for elective procedures to be performed in these hospitals to help clear the elective surgery backlog.
- States should also consider this strategy to meet future demand for elective procedures.
- States should develop agreed assessment processes for high-volume procedures, such as knee and hip replacements and cataract operations, and reassess all patients on hospital waiting lists.
- Multidisciplinary teams should prepare care paths to ensure non-medical treatments are appropriately considered.
- The full range of elective procedures should not be re-established in every hospital.
- Private health insurers should be empowered to participate in funding diversion options so patients are able to have their rehabilitation at home rather than in a hospital bed.

Both Commonwealth and state governments

4. Improve convenience and access by expanding out-of-hospital care

- States should expand hospital in the home, rehabilitation in the home, and outreach into residential aged care facilities.
- The Commonwealth should develop new Medicare Benefit Schedule items to facilitate telemonitoring and primary care outreach, limited to enrolled patients.
- The Commonwealth and the states should review public hospital funding to ensure it does not inhibit expansion of in-

home services, services in residential aged care facilities, and telemonitoring.

- States with plans to expand public hospital bricks and mortar should review those to assess to what extent out-of-hospital and telehealth expansion might obviate the need for some of these builds.

5. Improve health system readiness by better planning

- Australia's national and state governments should review their governance approaches to the COVID-19 pandemic, and incorporate lessons learned into Australia's pandemic preparedness arrangements.
- Australia needs better public health planning, with clear roles and responsibilities for the Commonwealth and state governments. In particular, states need to review their ICU strategies to prepare for surges in demand. These strategies should include plans for rapid access to PPE supplies through improved supply chains. A workforce strategy should enable quicker training of health workers, and deployment of workers from less-affected regions.
- Australia's preparedness regime should include a national surveillance strategy for the collection, analysis, and reporting of data at a national level. Real-time and accurate reporting of data would assist with government decision-making, improve testing regimes, and provide clearer information to the Australian community.
- The secondary health effects of a pandemic, including significant mental health and alcohol and drug use effects, should be incorporated into pre-pandemic planning, to help mitigate these effects during and after the crisis. The final stage of a pandemic plan should not be 'stand down' but

should incorporate management of these conditions which arise during and after the immediate crisis.

6. Increase the resilience of the health system by reforming the supply chain

- State supply agencies should review the vulnerability of their supply chains and build 'intrinsic' resilience by making the demand side of the chain more sustainable.
- States should consider:
 - giving a greater price premium to local supply and manufacture;
 - rewriting supply contracts to increase obligations on suppliers to ensure continuity of supply;
 - increasing product standardisation across the health system to allow easier substitution of products and to reduce the cost of inventory;
 - increasing flexibility by spreading the supply chain across more than one supplier.
- The Commonwealth should ensure that the national stockpile is reviewed regularly to ensure it contains the right mix of products.

7. Integrate regional planning and system management

- Primary care agreements should be struck between the Commonwealth and each state.
- Specific tripartite agreements should be struck with every Primary Health Network around Australia.

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1 The nature of pandemics

In 1948, Albert Camus aptly remarked: ‘Everybody knows that pestilences have a way of recurring in the world; yet somehow we find it hard to believe in ones that crash down on our heads from a blue sky.’¹

New infectious diseases frequently emerge throughout human history. In some cases, they can sweep across the world causing widespread illness, death, and destruction.² When a disease breaks out and rapidly spreads through a community, it can become an ‘epidemic’, and if it spreads worldwide and affects a large number of people simultaneously it becomes a ‘pandemic’.³

After emerging in China in late 2019, the novel coronavirus rapidly became a pandemic as it spread to nearly every corner of the globe by early 2020, making millions sick and causing hundreds of thousands of deaths.⁴ After first spreading to some Asian countries, Europe fast became the epicentre for the disease, followed by the United States, which by June had the highest number of cases in the world.

In the face of the pandemic, governments needed to manage three categories of risks: risk to health, risk to health systems, and risk to economic livelihoods. But many countries were not fully

prepared to act fast enough and contain the rapidly spreading COVID-19.

Governments sought to introduce measures – to varying degrees and with varying effectiveness – to slow the spread of the virus. Many countries, including Australia, went into some degree of lockdown. Shops, restaurants, and cafes closed, and people were asked or directed to stay at home. The skies cleared of planes, city roads went quiet, and pollution lifted. These measures helped contain the virus and slow the spread. After reaching a peak in new cases, many countries, including Australia, have managed to keep the number of new cases down for now, and after enhancing response capabilities, measures could be slowly unwound. Other countries, such as Brazil and India, are struggling to contain the virus.

Now the world needs to adapt to a ‘new normal’, where the economic fallout continues, and the virus continues to pose a threat.

This report focuses on the epidemiological and healthcare aspects of the COVID-19 crisis.⁵ This chapter summarises the key aspects of the COVID-19 pandemic by providing context on the emergence of infectious diseases, global preparedness for pandemics, and the risks that pandemics pose to communities.

¹ Albert Camus, ‘The Plague’, 1948.

² Saunders-Hastings and Krewski (2016).

³ This is the classical definition of an influenza pandemic. Note that influenza pandemics can vary in terms of transmissibility and disease severity: Kelly (2011).

⁴ There is some evidence that it may have emerged earlier: Deslandes et al. (2020).

⁵ Note that this report accounts for events up till and including 1 June 2020.

1.1. The origins of pandemics

Pandemics can begin with the emergence of a new disease pathogen or variant. This can occur via genetic change or when transmission pathways of a pathogen change – or sometimes both at the same time.⁶ Disease pathogens can be viruses, parasites, fungi, or bacteria. Pathogens can be transmitted by water, air, food, or by contact with insects, animals, or humans.⁷

The emergence of new infectious diseases is driven by environmental, social, and economic change.⁸ In the past, new infectious diseases were often associated with urbanisation, population movement, and colonisation.⁹ More recently, rapidly increasing global trade, travel, environmental degradation, and climate change have altered disease pathways, potentially increasing the risk of pandemics and global transmission of diseases.¹⁰

Although most new viruses do not easily infect humans, when they do, they can pose a significant risk.¹¹ The danger to human

populations then depends on the severity of the infection and how easily it can transmit between humans. For example, Middle East Respiratory Syndrome (MERS) kills about 30 per cent of people who catch it (often from camels), but human-to-human transmission is limited.¹² This was not the case for SARS-CoV-2,¹³ which causes the COVID-19 disease.¹⁴ It can easily transmit between humans, making it a significant threat to public health.

The emergence of COVID-19 disease was first documented in Wuhan, Hubei Province, China, but the exact origin of the virus is not yet known. It was originally suggested the virus may have jumped from bats or another intermediary animal to humans at a wet market in Wuhan, but this is only one of a number of hypotheses.¹⁵ More research is needed to test these theories.¹⁶

1.2 The history of pandemics

Outbreaks of new infectious diseases vary in their scale and severity, and even in the modern world continue to pose a threat. The most famous pandemic, known as the Black Death, occurred

⁶ For influenza, genetic change can occur via two mechanisms; reassortment or mutation. Reassortment is the mixing of a human influenza virus with genes from a bird or animal virus. For example, the Asian Flu came from the genetic reassortment of a bird virus. Genetic mutation is the change in the genes of an animal influenza virus. See Department of Health (2010).

⁷ National Institutes of Health (2007).

⁸ Lindahl and Grace (2015).

⁹ Lindahl and Grace (2015).

¹⁰ Epstein (2001); Hughes et al. (2010); Saunders-Hastings and Krewski (2016); Lindahl and Grace (2015).

¹¹ Department of Health (2010); Hughes et al. (2010).

¹² World Health Organization (2019); Rafiq et al. (2020).

¹³ The International Committee of Taxonomy of Viruses (ICTV) named the virus as SARS-CoV-2, because of the previously identified variant severe acute respiratory syndrome coronavirus (SARS-CoV): Rafiq et al. (2020).

¹⁴ SARS-CoV-2 is a coronavirus. There are many of these viruses, including SARS-CoV and MERS-CoV: Gorbalenya et al. (2020).

¹⁵ Andersen et al. (2020); F. Wu et al. (2008); Zhou et al. (2012). This theory proposes that bats may have served as a reservoir host, and that Malayan pangolins sold at the wet market may have acted as an intermediary host before the virus was passed on to humans.

¹⁶ Most theories suggest that the virus originated in bats. Bats are a significant natural reservoir for coronaviruses. Bats have extremely active and competent immune systems for managing these virulent viruses. Coronaviruses that evolve in bats are therefore more likely to be dangerous for species with less powerful immune systems.

in the 14th Century, killing between 30 to 50 per cent of the European population within four years.¹⁷

Over the past 100 years, the world has experienced four influenza pandemics (see Figure 1.1).¹⁸ The 1918 Flu ('Spanish Flu') caused about 50 million deaths, the 1957 Flu ('Asian Flu') caused between one and four million deaths, the 1968 Flu ('Hong Kong Flu') also caused between one and four million deaths, and the 2009 H1N1 (Swine Flu) influenza caused between 200,000 to 300,000 deaths worldwide.¹⁹

Several recent respiratory disease epidemics, including COVID-19, have been caused by coronaviruses. Coronaviruses are a type of virus that can cause illnesses ranging from the common cold to severe acute respiratory syndrome.²⁰ In 2003, Severe Acute Respiratory Syndrome (SARS) epidemic infected 8,098 people, mainly in China and South-East Asia, and caused about 774 deaths.²¹ In 2012, the MERS epidemic emerged in Saudi Arabia and spread to 27 countries.²² MERS has infected 2,519 people and has caused 866 deaths to date.²³

Each epidemic or pandemic runs its own course. Pandemics can also have second and third waves of infection, like the 1918 Flu.²⁴ The diseases are then often here to stay, continuing to circulate in the community. But they may not continue to pose a significant threat if a vaccine or treatment is developed.²⁵

¹⁷ DeWitte (2014).

¹⁸ Influenza is a contagious disease of the respiratory tract caused by influenza viruses: Department of Health (2011). Other major non-influenza type pandemics that started in the 20th Century include HIV/AIDS, cholera, and polio.

¹⁹ Rafiq et al. (2020). Note that there is uncertainty about the total deaths related to Swine Flu. Rafiq et al. (2020) quote the lab-confirmed death toll for H1N1 at 18,631. But modelling in 2012 estimates that the death toll for respiratory deaths is more likely be 201,200 respiratory deaths (range 105,700 - 395,600): Dawood et al. (2012). And 2013 modelling done as part of a WHO group estimated that

the main pandemic wave in 2009 there were between 123,000 to 203,000 deaths: Simonsen et al. (2013).

²⁰ World Health Organization (2020).

²¹ World Health Organization (2012); Centers for Disease Control and Prevention (2017).

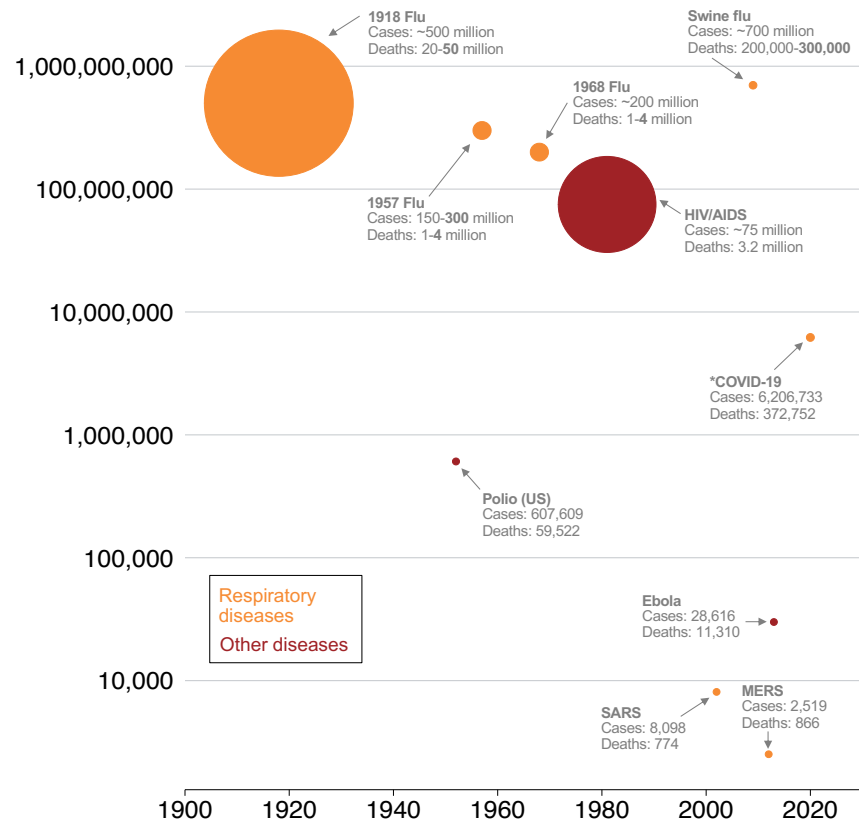
²² World Health Organization (2019).

²³ World Health Organization: Regional Office for the Eastern Mediterranean (2020).

²⁴ Saunders-Hastings and Krewski (2016).

²⁵ Madhav et al. (2017).

Figure 1.1: Over the last 100 years, major infectious disease outbreaks have varied in scale and severity.
Total number of infections (log scale) with death toll shown by bubble size.



Notes: The bubble size is indicative only and not exactly proportional due to a minimum bubble size. Case numbers are estimations only. The bubbles are located at the start date of the pandemic, noting that some pandemics, such as HIV/AIDS, peaked about 20 years later. Polio is an exception, as it came in waves across the first half of the 20th Century. The 1957 Flu case number is calculated using a 0.67% CFR and assuming 1-2 million deaths to arrive at 150-300 million total infection (Nichol and Kindrachuk (2019)). The 1968 Flu case number is calculated from an 0.5% death rate assuming 1 million deaths, which amounts to about 200 million cases (Sino Biological (2020)). The Swine Flu case number is calculated by assuming an 11% (lower bound) total population infection rate from Kelly et al. (2011) to bring the number to 700 million (upper bound was 21 percent). COVID-19 numbers as at 1 June 2020.

Sources: Data on 1918 Flu: Rafiq et al. (2020) and Centers for Disease Control and Prevention (2019). Data on Polio: Ochman and Roser (2017). Data on 1957 Flu: Rafiq et al. (2020) and Nichol and Kindrachuk (2019). Data on 1968 Flu: Rafiq et al. (2020) and Sino Biological (2020). Data on HIV/AIDS: World Health Organisation (2018). Data on SARS: Centers for Disease Control and Prevention (2017). Data on Swine Flu: Dawood et al. (2012), Simonsen et al. (2013) and Kelly et al. (2011). Data on MERS: World Health Organisation: Regional Office for the Eastern Mediterranean (2020). Data on Ebola: World Health Organisation (2016). Data on COVID-19: Johns Hopkins Coronavirus Resource Center (2020).

1.3 Global pandemic preparedness

Since the 1960s there has been much less focus on the possibility of major infectious disease outbreaks.²⁶ But a renewed global focus on infectious diseases began after the 2003 SARS epidemic, which brought increased attention to the need for better preparedness against new infectious diseases.²⁷ This helped with a more coordinated global response to Swine Flu in 2009,²⁸ but the 2014 West Africa Ebola epidemic exposed further gaps in preparedness.²⁹

A UN Global Health Crises Task Force noted in 2017 that ‘the high risk of major health crises is widely underestimated, and that the world’s preparedness and capacity to respond is woefully insufficient.’³⁰ The Task Force made 27 recommendations to improve global preparedness and concluded that ‘future pandemic threats will emerge and have potentially devastating consequences. We can either take immediate action to ensure that future threats are contained, and humanity is protected, or we

will remain vulnerable to losing millions of lives and suffering devastating social, political and economic consequences.’³¹

Experts have called for a boost in health sector capacities, investment in research and development, improved national preparedness systems, financial risk planning, and global coordination.³²

A September 2019 report by the Global Preparedness Monitoring Board for global health risks,³³ set up by the UN Task Force, lamented that the global pandemic response typically cycled through panic in the face of a threat, followed by neglect once a crisis was forgotten.³⁴ It noted that if the ‘past was prologue, then there is a very real threat of a rapidly moving, highly lethal pandemic of a respiratory pathogen killing 50-to-80 million people and wiping out nearly 5 per cent of the world’s economy’.³⁵ Within months, COVID-19 emerged.

While COVID-19 has been successfully contained in several countries, many countries did not respond fast enough or

²⁶ There have been some exceptions. The HIV-AIDS pandemic in the 1980s resulted in a very significant effort to prevent transmission that has only lessened with the development of effective anti-retroviral treatment. But public health planning in highly industrialised countries such as Australia, has focused more on chronic disease management and prevention, given the huge burden of disease of these health issues, such as cancer and cardiovascular disease: Australian Institute of Health and Welfare (2015) p. iv.

²⁷ Madhav et al. (2017). The delayed reporting of the SARS outbreak in some countries resulted in WHO updating the International Health Regulations to require countries to meet standards for reporting and managing outbreaks. But progress towards meeting these standards has been uneven across countries.

²⁸ Katz (2009)

²⁹ Madhav et al. (2017).

³⁰ Kikwete et al. (2016), p. 5.

³¹ Kikwete et al. (2016), p. 5.

³² Yamey et al. (2017); Global Preparedness Monitoring Board (2019), pp. 7-10.

³³ The board is co-convened by the World Health Organization and the World Bank and was created in 2018 in response to recommendations in 2017 by the UN Secretary-General’s Global Health Crises Task Force: Global Preparedness Monitoring Board (2018).

³⁴ Global Preparedness Monitoring Board (2019); Yamey et al. (2017).

³⁵ Global Preparedness Monitoring Board (2019), p. 6. The 2019 Global Health Security Index report also found that ‘no country is fully prepared to handle an epidemic or pandemic’: Cameron et al. (2019), p.9. The Global Health Security Index score for pandemic preparedness was 40.2 out of 100. Australia had the fourth highest overall score at 75.5.

effectively enough. This meant that COVID-19 quickly spread out of control, particularly in Europe, the US and now South America.³⁶

Australia drew on its pandemic preparedness regime, which had largely been established since SARS in 2003 and further improved since Swine Flu in 2009.³⁷ The state governments have emergency public health response plans, and the Commonwealth Government has an Australian Health Pandemic Plan for Pandemic Influenza and a National Medical Stockpile.³⁸ But COVID-19 revealed some key gaps in Australia's preparedness for a crisis of this scale (see Chapter 2 and 5).

1.4 The three major risks of a pandemic

An outbreak of a new disease can damage human health, and depending on its infectiousness and severity, can put a significant burden on health systems. These risks, combined with the consequent measures to slow the spread of a disease, have flow-on economic effects. Government must manage these three risks in combination – not as trade-offs, but as inter-related issues.³⁹ Governments can best minimise these three risks by treating them as a whole; a more effective public health response to

reduce the spread of the virus means reduced burden on hospitals, and a reduced burden on the economy in the longer term.

1.4.1 Risk to health

Infectious diseases cause illness – each with its own symptoms and severity. After about six months (and as at 1 June), COVID-19 has made more than six million people sick globally, causing nearly 400,000 deaths. Australia has suffered less than many countries; there have been about 7,200 cases, including 103 deaths.⁴⁰

The nature of COVID-19

SARS-CoV-2 is a new coronavirus. Humans have no natural immunity to it, so everyone is susceptible to COVID-19 disease.

Most people who get COVID-19 experience a mild-to-moderate respiratory illness and recover without needing special treatment.⁴¹ Some people, especially younger people, may not even experience any symptoms. Children appear less likely to get COVID-19, and less likely to spread it to others (see more in Chapter 3).⁴²

³⁶ Countries, particularly in East Asia, that had more recently experienced epidemics, such as the SARS epidemic in 2003 and H1N1 influenza in 2009, responded more successfully to COVID-19. For example, Taiwan had fewer than 500 cases and fewer than 10 deaths four months after its first case.

³⁷ Brew and Burton (2004), pp. 12-13; Department of Health and Ageing (2011)

³⁸ Department of Health (2019a).

³⁹ See more on this issue in Grattan Institute's forthcoming report: 'The Recovery Book: What Australian governments should do now'.

⁴⁰ As at 1 June 2020: Johns Hopkins Coronavirus Resource Center (2020); Department of Health (2020c).

⁴¹ About 80 per cent who get COVID-19 will have a mild illness, about 20 per cent will need hospital treatment, and about 3-to-5 per cent will require treatment in an intensive care unit: Department of Health (2020f); World Health Organisation (2020b). Note that as at 17 May, about 13 per cent of Australia's total cases have resulted in hospitalisation, with 19 per cent of those hospitalised admitted to ICU: National Incident Room Surveillance Team (2020).

⁴² See also a Grattan blog on this issue: Duckett and Mackey (2020a).

But COVID-19 is a virulent disease. About 20 per cent of people who get it become seriously ill, and about 1 per cent die.⁴³ The severity of the illness tends to increase with the person's age; older people, and those with underlying health problems, are particularly at risk (see more in Chapter 3).

Much is still not known about COVID-19, making it difficult to manage the risk – both for health professionals and governments. New research about the virus and its symptoms is rapidly evolving (see more in Chapter 3).⁴⁴

Reducing the health risk

There is currently no vaccine for COVID-19. Medical researchers around the world have developed 120 potential candidates (as at 30 May).⁴⁵ Any that are finally produced for widespread use will need to go through a rigorous trial process first.⁴⁶ Most are still in the preclinical phase. About 10 are being tested with small groups of people to check their safety and to see whether they have the desired immune response.⁴⁷

⁴³ Verity et al. (2020).

⁴⁴ For example, recent research shows that COVID-19 can affect the endothelial cells that line blood vessels and protect the cardiovascular system – suggesting it may be more than just a respiratory illness: Varga et al. (2020). This could help explain other recent evidence that the virus causes a much broader set of issues than originally understood, including causing blood clots, strokes, problems with digestion, joint pain, abdominal pain, vomiting, and diarrhoea: Docherty et al. (2020).

⁴⁵ World Health Organisation (2020h).

⁴⁶ Singh and Mehta (2016).

Despite the unprecedented international effort to develop an effective vaccine there is no certainty of success.⁴⁸ Trials will need to assess a range of outcomes including the extent of protection; how long protection lasts; whether children, adults and older people are equally protected, and major and minor adverse effects.⁴⁹ Most new vaccine candidates fail to demonstrate enough immune protection during early trials. Others fail because they are unsafe.⁵⁰ When a vaccine is found to be effective and safe production and distribution have to be scaled up for widespread use in the population. It is therefore unlikely that a vaccine will be generally available for at least 12 months.⁵¹ Even this timeline would require vaccine development to move at unprecedented speed, because this process usually takes about 10 years.⁵²

There is also currently no effective treatment for COVID-19, with clinicians aiming to manage symptoms of the disease. New research is being conducted to try and find treatments for the disease.⁵³ As of 18 May 2020, about 30 agents – both natural and artificial – have shown some potential effectiveness against COVID-19. Numerous potential antiviral drugs, including Hydroxychloroquine, Lopinavir/Ritonavir and Remdesivir, are

⁴⁷ One, the University of Oxford/AstraZeneca candidate, is the third phase of testing for any adverse effects and its effectiveness participants in preventing COVID-19 with 10,260 participants in the trial: N. P. Taylor (2020). It will take between two and six months to see whether the vaccine is effective and safe.

⁴⁸ Kahn (2020). Vaccines have not been developed for other types of coronaviruses.

⁴⁹ N. Lee and McGeer (2020).

⁵⁰ Fogel (2018).

⁵¹ Swerissen (2020); Thanh Le et al. (2020).

⁵² Thanh Le et al. (2020).

⁵³ Rafiq et al. (2020).

going through trials.⁵⁴ At best these treatments are only likely to partially reduce severity and death from COVID-19. The anti-tuberculosis BCG vaccine may have potential to reduce COVID-19 infections. The BCG produces a stronger innate immune response to a range of infectious diseases and may have a protective effect for COVID-19, but trials are only just beginning.⁵⁵

Without a vaccine or effective treatments, and without any measures to reduce transmission between people, a disease can rip through a community (see the ‘uncontrolled scenario’ in Figure 1.2). It would continue transmitting – first rapidly and then more slowly – until it infects a certain number of people in the population to build ‘herd immunity’ (estimated to be between 60 to 70 per cent of the population for COVID-19).⁵⁶ This means the infection rate would then slow because there are insufficient susceptible people for increased transmission. Over time, herd immunity would ultimately diminish the incidence of the disease.

But governments can avoid this scenario by using public health interventions to slow the spread of a virus. Interventions seek to reduce the rate of transmission – to ‘flatten the curve’ (see the ‘controlled scenario’ in Figure 1.2). And after reaching a lower

peak than the ‘uncontrolled’ scenario, it should begin to decline again if the rate of transmission (R_0) is kept low (see Figure 1.2).

There are a range of public health interventions to reduce spread of a disease. This includes case identification and contact tracing, such as testing and isolating confirmed cases (see more in Chapter 4). They also include social distancing measures, such as banning gatherings of people, requiring people to stay at home, closing schools and so on.⁵⁷ It is not only the types of interventions, but also the timing that determines their effectiveness.⁵⁸

But unless these interventions are able to effectively eliminate the virus in a country, the virus is still likely to make many people sick from the disease – but at a slower rate over a longer period – if some interventions remain in place. The benefit of ‘flattening the curve’ (the ‘controlled scenario’) is that the health system is not overwhelmed, meaning that people can get better treatment, and there will probably be fewer deaths or severe illness. It also means that the health system is still able to adequately treat people who have other health problems.⁵⁹

⁵⁴ Rafiq et al. (2020).

⁵⁵ Slessor (2020).

⁵⁶ The threshold for ‘herd immunity’ is calculated as: $\text{herd immunity} = 1 - 1/R_0$: Randolph and Barreiro (2020). The 60 to 70 per cent figure is based on an R_0 of 2.5 to 3 for COVID-19 and assumes homogenous spread of the disease: Gabriela et al. (2020). But note that some papers have indicated that developing herd immunity naturally (rather than via a vaccine) means that the threshold may be lower, as it involves heterogenous spread: Britton et al. (2020) and Gabriela et al. (2020). For example, Britton et al. (2020) calculated it to be about 43 per cent. In addition, herd immunity only works if infection results in immunity and

the immunity lasts. Although early evidence shows that immunity is conferred for COVID-19, it is unclear how long immunity to COVID-19 lasts after infection. Some early research shows it lasts at least one month, and looking at the previous SARS disease, could persist for several months to two years: Randolph and Barreiro (2020).

⁵⁷ We use the common term ‘social distancing’ in this Report, although recognising that the actual aim is spatial or physical distancing.

⁵⁸ Hollingsworth et al. (2011)

⁵⁹ See more at Section 1.4.2 on risk to health systems.

Another option is to ‘eliminate’ the virus all together (See ‘eliminated scenario’ in Figure 1.2).⁶⁰ Although elimination may not be an option for countries with high case numbers and/or land borders with other nations, Australia, like New Zealand and Taiwan, may have a chance. This may be achieved if infection rates are so low that each remaining case and their close contacts can be isolated and controlled.⁶¹

Secondary health effects

A health system focused on responding to a pandemic can struggle to adequately care for people with other health problems. For example, the re-allocation of resources towards COVID-19 in Australia resulted in the suspension of non-urgent elective surgeries. And significantly fewer people than usual sought medical treatment or screening for cancer, because they were concerned that they may put themselves at risk at a health clinic or hospital, unnecessarily burden the health system,⁶² or services were suspended.⁶³

Widespread job losses, financial difficulties, and changes to everyday life created by lockdowns, forced closure of businesses such as restaurants and gyms, national and international travel restrictions and social distancing, all have flow-on effects. They can trigger or exacerbate mental health problems.⁶⁴ Mental health

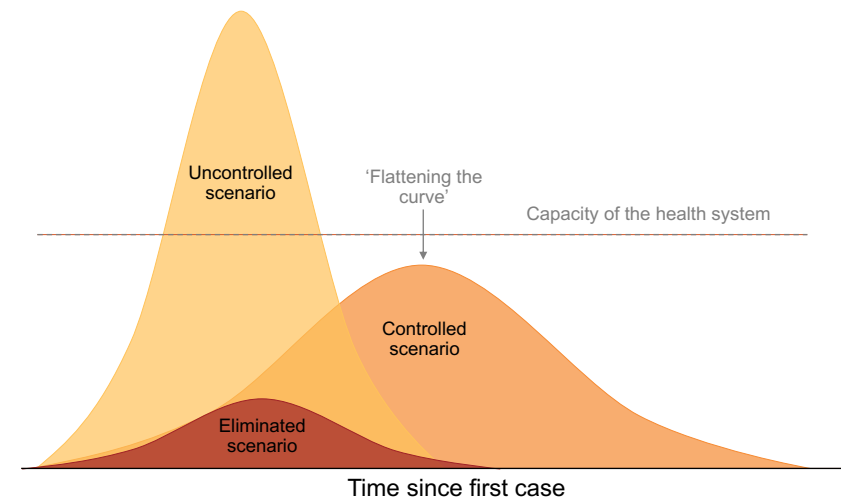
⁶⁰ Note that we define ‘elimination’ as keeping cases very low so as to be effectively eliminated. This can occur in defined geographical areas. This is different to ‘eradicate’, which means a permanent reduction to zero of the worldwide incidence of the disease: Dowdle (1998)

⁶¹ Daley and Duckett (2020); Duckett (2020a).

⁶² Cunningham (2020b). These trends were also seen elsewhere. For example, in Italy, a study found that substantially fewer children were seeking medical

hotlines in Australia have reported a 25-to-50 per cent increase in the number of calls received, compared to the same time last year.⁶⁵

Figure 1.2: The ‘pandemic curve’ scenarios
Number of new cases



Source: Adapted from *The Economist* (2020).

treatment – up to 88 per cent fewer children went to emergency departments compared to the same time in the previous year: Lazzerini et al. (2020).

⁶³ For example, routine screenings for breast cancer were suspended in NSW: Raper (2020).

⁶⁴ Xiang et al. (2020); Torales et al. (2020).

⁶⁵ Morrison (2020k).

Lockdowns and job losses can also increase the risk of domestic violence. The number of online searches on Google for domestic violence help leapt during the pandemic.⁶⁶

1.4.2 Risk to health systems

At their extreme, pandemics can threaten the viability of health systems. Under the ‘uncontrolled scenario’, a health system could be at risk of collapse. As many people get sick very quickly, pressure builds on hospitals.

The main purpose of flattening the curve is to avoid overwhelming a health system’s capacity (see Figure 1.2).

There are limits to a health system’s capacity: the number of beds and intensive care units (ICUs), the size of the workforce, and supplies of personal protective equipment (PPE), ventilators, and medications. While purchasing more resources is fairly easy (provided there are reliable supply chains), rapidly increasing the workforce – particularly highly trained health professionals for ICUs – is harder. For example, a 200 per cent increase in ICU capacity in Australia requires more than 4,000 additional senior doctors and more than 42,000 additional registered ICU nurses.⁶⁷ As a pandemic escalates, the number of health workers may also diminish, because working in a high-risk setting makes them more

likely to become infected with the disease (particularly if PPE is in short supply),⁶⁸ and experience mental health problems.⁶⁹

Once COVID-19 spread beyond China, Italy was one of the first countries to have a high number of confirmed cases. The virus spread quickly in the community, growing at such a rate that the number of people needing hospital treatment began to overwhelm the health system’s capacity. In the most affected regions of Italy, the health system was close to collapse.⁷⁰ Hospitals were faced with difficult decisions about how to prioritise care.

At the peak of the crisis in Australia, in late March 2020, when the vast majority of cases were coming from overseas, Australia’s cases were doubling every 3-to-4 days. Without any effective interventions, and assuming the disease would follow the same pattern as other countries, there was a risk Australia’s ICU capacity would be overwhelmed by mid-April (see Figure 1.4).⁷¹

⁶⁶ Morrison (2020f).

⁶⁷ Litton et al. (2020).

⁶⁸ For example, during the early stages of the crisis in Italy (between 20 February and early March 2020) about 20 per cent of responding health-care workers were infected with COVID-19: The Lancet (2020). Some of those infected also died, permanently reducing workforce numbers.

⁶⁹ Lai et al. (2020). Mental health problems were also seen in Beijing healthcare workers after the SARS epidemic: P. Wu et al. (2009).

⁷⁰ Armocida et al. (2020).

⁷¹ Before COVID-19, Australia had 2,400 ICU beds: Senate Select Committee on COVID-19 (2020a).

Box 1: The language of pandemics – ‘R0’

R0, pronounced ‘R naught’, is an epidemiological term to describe the rate of transmission of a disease in a totally susceptible population. Technically, it is known as the basic reproduction number, where R is for reproduction, and 0 is for patient zero.⁷²

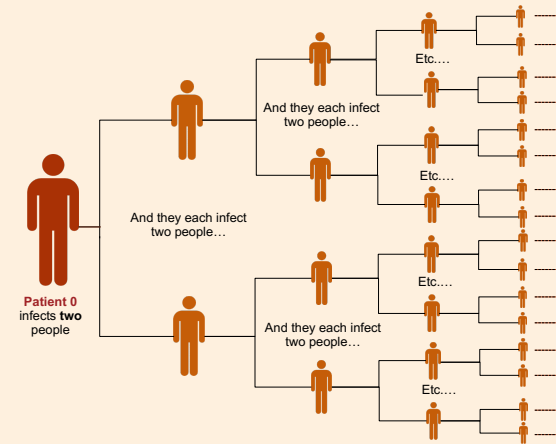
The R0 is the average number of infections to stem from a single case (assuming the whole population is susceptible and there are no interventions in place). For example, if an R0 is 2, then one person with the disease is expected to infect two others, and so on (see Figure 1.3). The Department of Health most recently estimated the R0 for COVID-19 at about 2.5.⁷³

R0 is useful in determining the intensity of an infectious disease outbreak.⁷⁴ A high R0 number means that the disease is likely to rapidly spread through a community. For example, the R0 for measles ranges from 12 to 18 – showing that measles is a highly infectious disease.

But R0 is often misrepresented or misinterpreted, because it is determined by a complex set of factors including the properties of the disease pathogen itself, and also biological, socio-behavioural, and environmental factors.

The ‘effective’ reproduction (Reff) is a statistic used to describe the transmissibility at a given time. The Reff is useful in determining whether public health interventions are having an effect. Effective COVID-19 interventions, such as lockdowns, can reduce the Reff over time. If the Reff is greater than 1, then the rate of new cases is growing. If the Reff is less than 1, then the rate of new cases is decreasing.

Figure 1.3: How a virus with a reproduction number (R0) of 2 spreads



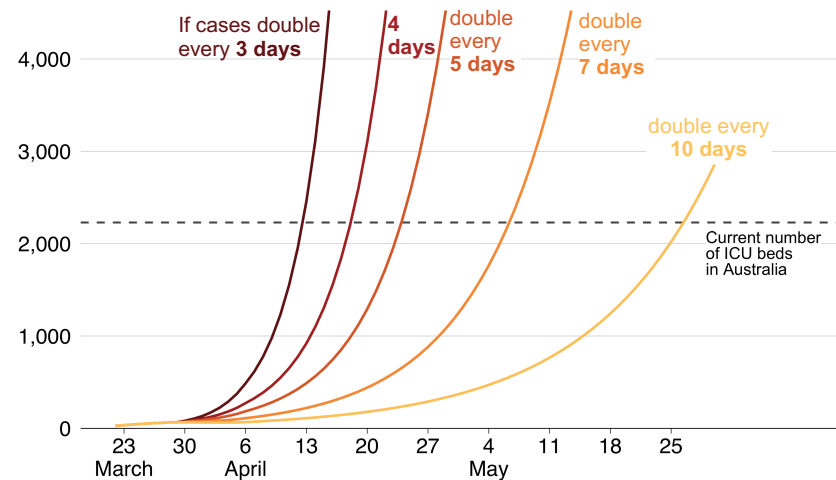
Source: Adapted from Eisenberg (2020).

⁷² Eisenberg (2020). See also Delamater et al. (2019).

⁷³ Department of Health (2020e)

⁷⁴ Eisenberg (2020)

Figure 1.4: In March 2020, there was a risk Australia's ICU capacity would reach capacity if there were no effective interventions and rapid growth in COVID-19 cases continued
ICU bed demand from COVID-19 (with average length of stay of 8 days)



Source: Australian state data collated by The Guardian Australia.

But by the end of March, the Australian Government's border closures, contact tracing and isolation and lockdown measures began to have an impact and slow the rate of new cases (see Chapter 2). These significant public health interventions meant that Australia very quickly turned a corner; the growth rate fell to merely 5 per cent per day by the start of April.⁷⁵ Australia's case

numbers have remained low ever since, and at this rate, Australia's healthcare system is not under threat.

1.4.3 Risk to the economy

The risk of global health crises goes far beyond health and health system costs; the short and long-term economic costs are also significant. The economic costs affect many more people than the underlying disease.⁷⁶

The economic costs of global pandemics stem from multiple and interrelated causes. The flow-on costs of public health interventions – such as shutting down businesses and requiring people to stay at home – are significant. Many people's livelihoods are cut-off, as businesses struggle to survive. This requires governments to increase their debt, as they try to buffer some of these effects. For example, Australia's federal government has committed nearly \$200 billion against the coronavirus crisis so far (see more in Chapter 2).

In 2016, economists warned that pandemics could cause an average annual economic loss of 0.7 per cent of global GDP or \$570 billion each year in the coming decades.⁷⁷

A World Economic Forum blog in April said that the COVID-19 crisis is the worst economic downturn since the Great Depression,

⁷⁵ Duckett and Mackey (2020c), see the second chart.

⁷⁶ Kikwete et al. (2016), p. 29.

⁷⁷ Fan et al. (2016) who noted that this is similar to the estimated cost of climate change. A Lowe Institute study in 2006 also had similar findings on the cost of

pandemics, but noted that the scale of the pandemic determines the extent of economic loss: McKibben and Sidorenko (2006).

with projected global growth in 2020 expected to fall by 3 per cent.⁷⁸

In March, the Organisation for Economic Co-operation and Development (OECD) estimated there would be a 22 per cent hit to Australia's economy directly as a result of the shutdowns. The hit will probably be even worse once the effects on other sectors are considered.⁷⁹ The Reserve Bank of Australia (RBA) forecast a 20 per cent drop in total hours worked over the first half of 2020.⁸⁰ Unemployment is also expected to rise to 10 per cent in the June quarter.⁸¹ Some people are economically worse off than others. About 36 per cent of the people who have lost their jobs are aged 15 to 24, and women are also disproportionately affected.⁸² In June 2020 the Federal Treasurer announced that Australia was in recession.⁸³

Governments can minimise the damage caused by a pandemic, through economic support packages and other social and fiscal policies that help carry the community through and out of the crisis. Grattan Institute will shortly be releasing a report titled 'The Recovery Book: What Australian governments should do now', which includes recommendations on the economic response coming out of the crisis.

1.5 Moving forward in uncertainty

Australia has been remarkably successful in managing the virus to date (see Chapter 2). But as Australia moves out of the emergency phase and towards a 'new normal', there are still many uncertainties. It is uncertain whether there will be a second wave or resurgence of infections. It is uncertain whether Australia can eliminate the virus. It is uncertain how large the economic effects will be. It is uncertain when border restrictions can be lifted. It is uncertain if there will ever be a vaccine.

Governments can help, by investing in research and learning the lessons from this pandemic. This includes developing policies that best manage further outbreaks (see Chapters 3 and 4) and developing policies that strengthen Australia's healthcare systems (see Chapter 5).

⁷⁸ Gopinath (2020).

⁷⁹ Coates (2020).

⁸⁰ Lowe (2020).

⁸¹ Lowe (2020).

⁸² Morrison and Frydenberg (2020). Grattan Institute has published a working paper on the estimated employment shock of COVID-19 in Australia: Coates et al. (2020), p. 22.

⁸³ Frydenberg (2020a)

2 The course of Australia's COVID-19 response

Australia's response to the COVID-19 pandemic has been remarkably successful. After an exponential increase that peaked at more than 400 cases a day in late March 2020, many coming from overseas, daily cases declined to almost zero a month later. At the same time, rapid growth in infections in almost every other comparable country threatened to overwhelm their health systems.

This chapter charts what happened, what was successful, and where Australia could have done better. These lessons should inform the next stage of Australia's response (see Chapters 3 and 4), and how Australia can strengthen its healthcare system (Chapter 5).

2.1 What happened

In late December 2019, China notified the World Health Organisation (WHO) of a mysterious pneumonia cluster.⁸⁴ The disease that was to be named COVID-19 made its way into history. Cases in Hubei province grew exponentially: seemingly slow at first, then very rapidly from late January 2020.

The Chinese Government responded on 23 January 2020 with a massive program of testing, contact tracing, and quarantining of

people likely to be infected. The population of Hubei was required to follow stringent social isolation. Travel, industry, education, recreation, and social gatherings were severely restricted to prevent the spread of infection.⁸⁵

The virus spread internationally in mid-January 2020, first to Thailand and then to South Korea, Japan and Singapore and beyond.⁸⁶

On 30 January 2020, WHO declared the coronavirus a global Public Health Emergency, when China's death toll reached 170 and 7,711 cases were reported in the country, and the virus had spread to at least 18 other countries.⁸⁷ Daily cases in China peaked at nearly 4,000 in February and then declined to less than a 100 a day by early March.

2.1.1 Australia's five-phase response

Australia's response to the pandemic passed through four phases: containment, reassurance amid uncertainty, cautious incrementalism, and escalated national action. Australia has now entered a fifth phase: gradual transition to a new normal.

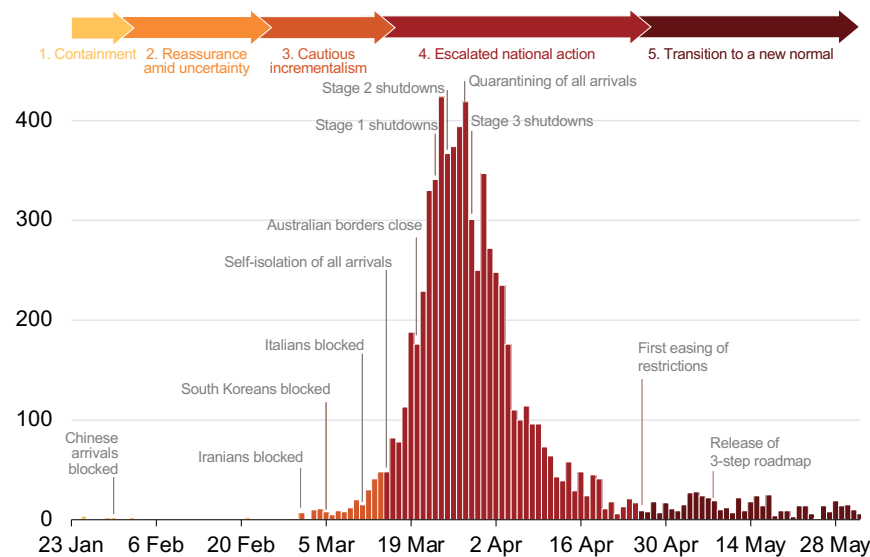
⁸⁴ World Health Organisation (2020f).

⁸⁵ Wang et al. (2020).

⁸⁶ World Health Organisation (2020g).

⁸⁷ World Health Organization (2020b).

Figure 2.1. The five phases of Australia's response
Daily new COVID-19 cases in Australia by response phase



Notes: Only major lockdown events shown in grey. Data current as at 1 June 2020.
Source: Grattan analysis of Guardian Australia data.

Phase 1: Containment

Australia recorded its first case on 25 January 2020, less than a month after the early cases were reported in China.⁸⁸ During the early period of infection in Australia, the Commonwealth Government took main responsibility for managing COVID-19, acting on the advice of the Commonwealth Chief Medical Officer

⁸⁸ Hunt (2020a).

and the state and territory chief public health officers meeting as the Australian Health Protection Principal Committee.

The initial Commonwealth response was primarily focused on containing the external threat presented by the virus. During late January and early February 2020, Australia's first coronavirus cases were linked to travellers returning from Wuhan, China. The Commonwealth focused its efforts on screening arrivals from Wuhan and evacuating vulnerable Australians out of Hubei to designated, well-controlled quarantine facilities in Australia (such as Christmas Island).

As the virus rapidly spread in China to more than 10,000 confirmed cases by 1 February 2020, Australia moved quickly – earlier than other countries – to ban foreign nationals entering the country from China. It also required Australians travelling home from China to self-isolate for 14 days.

Phase 2: Reassurance amid uncertainty

After introducing travel restrictions from China, the Commonwealth Government did not take any significant steps until late February 2020. Instead, February was marked by uncertainty about the scale of the crisis, while the Commonwealth downplayed the risks to Australians.

With the exception of the outbreak of cases affecting Australians on the Diamond Princess cruise ship stranded in Japan, very few Australians contracted COVID-19 during February 2020. At the

same time, it appeared the major outbreak in Hubei had subsided and the number of cases in other countries remained low.

There was uncertainty about the susceptibility, incubation, duration, transmission, morbidity, and mortality of COVID-19. Data and research were changing rapidly, on almost a daily basis. In the absence of clear data and analysis, there was concern about the potential social and economic cost of widespread action to prevent the possible spread of infection.

On 18 February, the Commonwealth Government released the *Australian Health Sector Emergency Response Plan for Novel Coronavirus COVID-19*, which characterised COVID-19 as a significant risk to Australia, emphasised a 'proportionate response' to the risk, and did not contemplate closure of international borders.⁸⁹

Australia's response was reinforced by advice from WHO. Although WHO declared a Public Health Emergency at the end of January 2020, it did not consider travel or trade restrictions necessary.⁹⁰ WHO emphasised containment based on detection, isolation, contact tracing, and information. It did not recommend mandatory quarantine of international travellers. Nor did it advise member countries to prepare broader spatial distancing measures and increase the capacity of their health systems, despite the experience in Hubei.

Australia's Prime Minister, Health Minister, and Chief Medical Officer rejected calls for extended travel bans and tighter quarantine for overseas travellers. Meanwhile, state and territory governments mainly continued business as usual, with the NT and Queensland launching international tourism campaigns after the summer bushfire crisis.⁹¹

Yet COVID-19 cases were rapidly spreading in countries beyond China. South Korea had more than 1000 cases by 26 February 2020, Italy exceeded this number three days later, and Iran reported a doubling of its cases overnight to reach 1000 cases on 2 March 2020. By this time, the virus had spread to at least 75 countries worldwide.⁹²

Amid the uncertainty, the Prime Minister sought to reassure Australians in early March 2020 that they could 'go about their daily business', and that he was 'looking forward to going to places of mass gathering such as the football'.⁹³

But this message missed the mark. Community concern about the virus was reaching a tipping point, with Australians panic-buying toilet paper and other goods. By 2 March 2020, Australia recorded its first case of community transmission, and Australia's policy response was propelled into the next phase of policy action.

⁸⁹ Department of Health (2020b), pp 2, 40, 42.

⁹⁰ World Health Organization (2020c).

⁹¹ Lawler (2020); Palaszczuk and Jones (2020).

⁹² Morrison (2020a)

⁹³ Morrison (2020a).

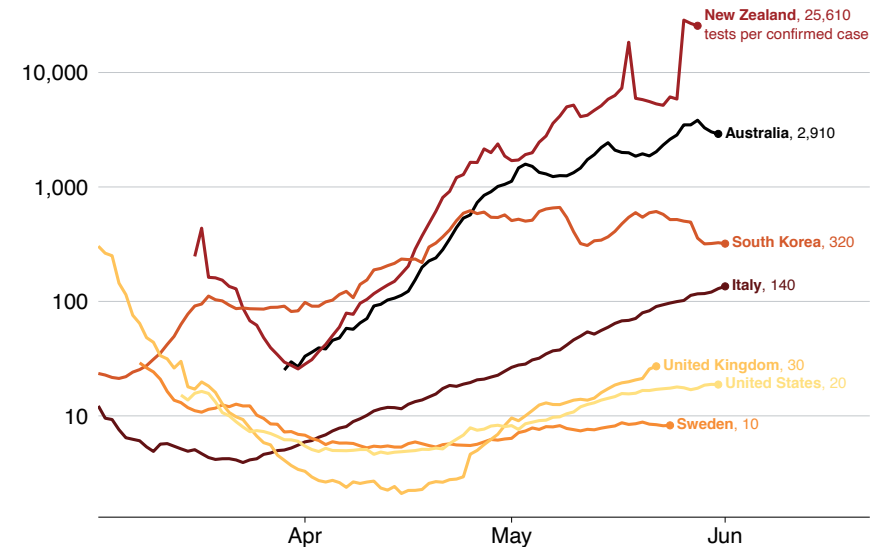
Phase 3: Cautious incrementalism

Throughout early March 2020, the Commonwealth Government's response shifted. It became clearer that COVID-19's long incubation period and mildly symptomatic and pre-symptomatic infections made it difficult to prevent transmission. Action grew incrementally, with additional measures to 'slow the spread'. The Government took cautious steps during this phase, careful to have a 'proportionate' response to specific high-risk countries.

Bans on foreign nationals entering Australia were extended to Iran, South Korea, and Italy in the first two weeks of March 2020, as COVID-19 spread in these countries. Australian travellers from these countries were required to self-isolate for 14 days on arrival. When these bans were introduced, Iran had 978 cases (2 March), South Korea had 6,284 (5 March), and Italy had 12,462 (11 March).

By 15 March, when Australia had 300 confirmed cases, mostly from overseas arrivals, self-isolation was made mandatory for all international arrivals, although enforcement measures were weak. Health officials ramped up contact tracing systems to reduce the risk of community transmission. As more testing kits became available, testing regimes, led by the states, were widened. Australia had one of the highest testing rates per person in the world. By mid-March 2020, more than 100,000 tests had been conducted.

Figure 2.2: Testing rates around the world



Notes: The number of tests shown in this chart can mean different things in different countries. Some countries report the number of people tested; some report the number of tests; for others it is unclear. See Our World in Data (2020).
Source: Data from Our World in Data (2020).

In early March, the Commonwealth began preparing for the inevitable pressures on Australia's health system and impacts on its economy. But the Government's measures still appeared to underestimate the scale of the response required to combat the virus.

The Commonwealth made an uncapped health funding agreement with the states and territories on 6 March 2020, agreeing to meet half the increased health costs of patients with COVID-19, with an initial Commonwealth commitment of \$500

million. This was quickly followed by a \$2.4 billion health package on 11 March 2020, which provided funding to purchase more PPE and for other measures such as telehealth.⁹⁴

A day later, the Commonwealth announced its first (relatively small) \$17.6 billion economic package of measures, framed as an 'economic stimulus' (i.e. still not seeing the size of the problem and the need to support rather than stimulate). It did not include support for people who had lost employment because of business closures.

By early March 2020, the states and territories also shifted their focus to COVID-19 and began to slowly announce a ramped-up public health response. In advance of the Commonwealth, Victoria released its pandemic plan. Some states began to set up specific COVID-19 testing clinics and South Australia established the first drive-through testing centre.

But by mid-March, it became clear that much more was needed to restrain the emerging exponential growth of the virus.

Phase 4: Escalated national action

The second half of March 2020 was a turbulent period of significant change. Within two weeks, Australia moved to a full shutdown. Widespread social distancing measures were announced alongside broader travel bans, testing, contact tracing, and quarantine.

During this phase, debate centred on how far Australia should go, whether it should 'slow the spread', or go harder and 'stop the spread'. The primary motivation was to protect Australia's health system and prevent hospital ICUs being overwhelmed by COVID-19 patients.

This phase started with pressure mounting on governments to take stronger action to reduce the risk of community transmission. Debate heightened about whether the Melbourne Grand Prix should go ahead on 13-15 March 2020.

Because critical responsibilities – such as imposition of social distancing requirements – are vested in state governments, the Commonwealth had no power over such changes, either to introduce lock-downs or allow people and the economy to continue as normal. But there was no consistency among states in their approaches. It became clear that a national approach to coordination was needed, and on 13 March 2020 a new National Cabinet made up of the Prime Minister, Premiers, and Chief Ministers was set up. It began to meet at least weekly to coordinate Australia's response to COVID-19.

The national Cabinet dealt the Prime Minister into discussion of state decisions, and gave the states political cover for difficult choices. Because it was set up in haste, there were no real rules for its operation. It has no decision-making power – that still rests with each of the participants – and there is no collective accountability to the public through any of the parliaments. Often the outcome of a National Cabinet meeting was a 'decision' in name only. Often, behind the fig-leaf of unity, each state and

⁹⁴ Morrison (2020b).

territory went its own way (e.g. on the timing of easing of restrictions, and of schools reopening).

Nevertheless, the public appreciated the veneer of cooperative action. The National Cabinet helped build a unified federated voice at a time when clear and consistent messaging was key (although this didn't always work). It (partially) corralled the cats, a task made easier because their interests were aligned.

The first national social distancing announcement followed immediately on 13 March. Social gatherings were limited to fewer than 500 people. But the Commonwealth still hesitated on the precipice of change, when the Prime Minister sought to reassure Australians that the limit would only take effect after the weekend, during which he was still intending to go to the footy. Governments continued to move incrementally, limiting social gatherings to 100 people.

Australia's case numbers began to increase exponentially, doubling every 3 to 4 days (mostly due to overseas travellers). Australians, seeing the daily news broadcasts of Italy's overwhelmed health system, feared that could be Australia's fate unless stronger action was taken. Many Australians, including influential commentators, thought the Government was doing too little.⁹⁵ Pressure mounted to introduce much tougher restrictions earlier to minimise the long-term damage.⁹⁶ Further social distancing measures were announced, limiting indoor social gatherings to 10 people, and then, by the end of the month, to two

people. State and territory government directives shut down all non-essential businesses and activities, and Australians were urged to 'stay at home'. The Australian people increasingly accepted these measures.

It was also clear that a number of Australians returning from international travel had contracted COVID-19, particularly after travel in the United States and on cruise ships, the latter mostly from the Ruby Princess, whose passengers were allowed to disembark in Sydney on 19 March despite having active cases on board. About two thirds of Australia's cases have come from overseas. It had quickly become clear that some returning travellers were not adhering to the self-isolation requirement, and so eventually, on 28 March, the Commonwealth Government further tightened border controls, requiring mandatory quarantine in designated facilities for all remaining arrivals.⁹⁷

In their efforts to control the spread of the virus, states and territories closed their interstate borders. Border restrictions started with Tasmania on 20 March, followed by the NT, WA, SA, and Queensland within a few days.

Aboriginal and Torres Strait Islander people also led responses to COVID-19. Land councils moved early to effectively close access to communities.⁹⁸ Other preparedness steps included building testing capacities in communities, preparing local action plans,

⁹⁵ Doelitzsch (2020).

⁹⁶ Daley (2020).

⁹⁷ Houston (2020); Cunningham (2020a)

⁹⁸ Involving First Nations people in pandemic preparedness and response was a key recommendation coming out of the review of Australia's response to H1N1, where a disproportionate number of First nations people were infected by the disease: Department of Health and Ageing (2011); Crooks et al. (2020)

and creating additional spaces for isolation and quarantine.⁹⁹ No Indigenous people have been diagnosed with COVID-19 in remote or very remote areas.¹⁰⁰

During this period of rapid change, inconsistencies in the messages and approach between the Commonwealth and the states began to emerge. The Commonwealth continued to take a more cautious and risk-tolerant approach to the introduction of widespread infection control measures. The states and territories, particularly NSW and Victoria, were more risk-averse and enacted more comprehensive measures such as school closures to prevent spread of infection and to reduce the prospect that public hospitals, the responsibility of states, would be overwhelmed.

States and territories also rapidly increased their public hospital ICU capacity. Governments worked to prepare for the tripling of Australia's ICU capacity, from 2,400 beds to 7,000.¹⁰¹ The Commonwealth allocated PPE from the national stockpile, while governments ordered more supplies, including ventilators, from overseas. The Commonwealth also boosted its public health funding with another \$1.1 billion, including significant resources for mental health care.¹⁰²

The Commonwealth refined its crisis governance structures to manage the economic and social fall-out. It established a new National COVID-19 Coordination Commission, with leaders from the private and not-for-profit sectors, to advise the government on

how to limit the economic and social damage caused by the crisis.¹⁰³

Within 10 days, the Commonwealth rolled out two large economic support packages amounting to \$176 billion of spending.¹⁰⁴ These included the doubling of the JobSeeker payment (previously called Newstart), and a JobKeeper wage subsidy to keep people connected to their employer.

State governments began to progressively implement their own support packages for their local economies and industries, including grants, loans, and tax deferrals. As at 2 April, these announcements amounted to almost \$15 billion nationally.¹⁰⁵

By the end of March 2020, once the shock of the shutdowns had set in, the Commonwealth sought to cushion the blow by providing free childcare, and the National Cabinet announced a moratorium on rental evictions, to be implemented by the states and territories.¹⁰⁶

A range of health measures was also introduced. At the end of March, the National Cabinet temporarily suspended all non-urgent elective surgery in both the public and private hospital systems, to free up capacity to treat COVID-19 patients and to preserve PPE, which was in short supply. In record time, the Commonwealth struck a \$1.3 billion deal to underwrite private hospitals during the elective surgery shutdown, and states negotiated to contract to

⁹⁹ Crooks et al. (2020).

¹⁰⁰ National Incident Room Surveillance Team (2020), p. 2.

¹⁰¹ Senate Select Committee on COVID-19 (2020a).

¹⁰² Morrison (2020f).

¹⁰³ Morrison (2020e).

¹⁰⁴ Wood, Griffiths, et al. (2020).

¹⁰⁵ Wood, Emslie, et al. (2020).

¹⁰⁶ Morrison (2020g).

use private hospital beds, including for the transfer of public hospital patients to private hospitals.

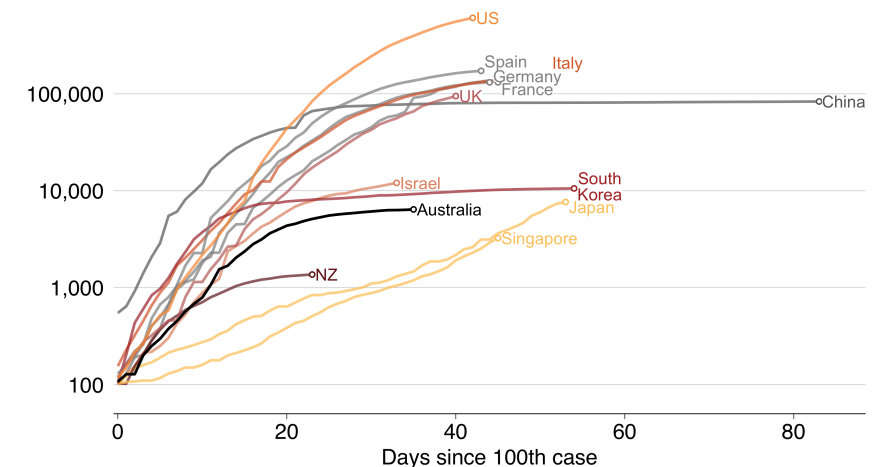
Because most of the COVID-19 deaths were among older people, new measures were imposed on aged-care facilities. The number of visitors was restricted, as were resident movements, and staff were required to get vaccinated against the flu. The Commonwealth announced \$445 million of additional funding for residential and home-care services for older people.¹⁰⁷

Some states enhanced their social distancing measures, including effectively closing their public schools by bringing the Easter holidays forward. They also focused their attention on enforcing the restrictions, with police issuing hefty on-the-spot fines to people breaking the social distancing rules.

As Australians settled into the 'new normal' of stay-at-home life, their efforts were quickly rewarded in the case count: Australia appeared to be flattening the curve. New cases were rapidly falling, with an average daily new case rate of 70 through April 2020. This was in stark contrast to some comparable countries, such as the United States (US) and the UK, which struggled to get the virus under control.

¹⁰⁷ Morrison (2020d)

Figure 2.3: By mid-April, Australia's case numbers had slowed while they continued to increase in some comparable countries
Number of confirmed cases of COVID-19 by country (log scale)



Notes: Data current as at 15 April 2020. The rate of testing is not equal across countries.
Source: John Hopkins University Centre for Systems Science and Engineering.

This coincided with expanded testing, as new testing kits came into the market. At first, testing was limited to people who were showing symptoms and had recently been overseas or had had contact with a confirmed COVID-19 case. But then testing was expanded to health workers, people in high-risk areas, and people in known clusters, and then to any person showing symptoms. The aim was to capture community transmission. Some states went further still: South Australia and Victoria launched testing 'blitzes' to uncover remaining cases in the community. Victoria's

testing blitz exceeded its aim of testing 100,000 people within two weeks; anyone with symptoms was eligible for testing. By the end of April 2020, more than half a million Australians had been tested for COVID-19, with an average positive testing rate at the time of 1.2 per cent.¹⁰⁸

Phase 5: Transition to a new normal

After over a month of 'stay-at-home' life, Australia began to move to a new normal at the end of April 2020. Case numbers were dwindling to below an average of 20 new cases a day at the start of May 2020, with some states recording successive days with no new cases. As at 1 May, 83 Australians were in hospital with COVID-19 and 28 people were in ICUs, far short of the original, pre-lockdown, gloomy predictions and nowhere near overwhelming Australia's healthcare system.¹⁰⁹

Governments finalised their preparations to manage the virus into the longer-term in a world with eased restrictions. This involved further boosting contact tracing capabilities and increasing testing to identify community cases.

To assist with contact tracing efforts, on 26 April 2020, the Commonwealth Government launched its COVIDSafe app to 'automate and improve what state and territory health officials

already do manually'.¹¹⁰ The app aims to track other phones – also running the COVIDSafe app – it comes near to for 15 minutes or longer. If a person is subsequently diagnosed with COVID-19, a health official provides a PIN that allows the user to upload their list of contacts to the cloud, to be accessed by state or territory contact tracers.¹¹¹ About 6 million people have downloaded the app as at 1 June,¹¹² short of the Government's original 40 per cent target.¹¹³ How many actually have the app working as it should – keeping it open, with Bluetooth on¹¹⁴ – is unknown, as is the number of people who have removed it (see more in Section 4.1).¹¹⁵

But state governments moved forward regardless, armed with the confidence of low case numbers. Queensland, the Northern Territory, and Western Australia were the first to announce small changes. This included the lifting of restrictions on national parks, and WA joining the NT in allowing gatherings of up to 10 people.

At the same time, the Prime Minister started to shift his rhetoric from concern about the health risks to concern about the economic fall-out from the crisis. The Government estimated the lockdown was costing Australia's economy about \$4 billion each week.¹¹⁶

¹⁰⁸ As at 30 April 2020. Positive testing rates varied between 0.6 per cent in the NT and 1.9 per cent in Tasmania as at 30 April 2020. Note that the testing rate per person also varied between the states and territories. See Department of Health (2020g).

¹⁰⁹ Department of Health (2020h)

¹¹⁰ Morrison (2020i)

¹¹¹ Duckett and Mackey (2020d).

¹¹² Morrison (2020j); O'Brien et al. (2020).

¹¹³ Although the government has since moved away from that target: J. Taylor (2020b).

¹¹⁴ The iPhone version of the app may also not work as intended: J. Taylor (2020a).

¹¹⁵ T. Taylor and Swan (2020).

¹¹⁶ Frydenberg (2020b).

Building on the momentum to ease restrictions, on 8 May 2020 the National Cabinet agreed to a three-step plan and a national framework to bring Australia out of lockdown over the next few months.¹¹⁷ Step 1 allows outdoor gatherings of up to 10 people and 5 visitors in the home, some businesses to open, and some recreational activities. Step 2 allows outdoor gatherings of up to 20 people and further businesses to open including gyms and entertainment venues like cinemas, and Step 3 allows gatherings of up to 100 people and remaining people to go back to work. International border restrictions will remain for the ‘foreseeable future’.

Within the national framework, state governments are ultimately responsible for deciding on lockdown restrictions. Some jurisdictions, such as WA and the NT, which have lower case numbers, are moving faster than other states with higher case numbers, such as Victoria and NSW.

As at 1 June, case numbers have remained under 20 new cases a day as restrictions continue to unwind. This is complemented by continued contact tracing efforts by state authorities, with continued high rates of testing. Australia has now undertaken nearly 1.5 million tests.¹¹⁸

To continue managing the ongoing secondary health impacts of the crisis, the Commonwealth Government announced a \$48 million mental health program on 15 May and launched another inquiry into domestic violence on 30 May.

But as restrictions unwind, attention is turning to the adequacy of the Commonwealth Government’s economic response to the crisis. There is mounting criticism that the Government’s income support payments are too narrowly targeted. Many people in industries hardest hit, such as workers in the arts and entertainment industry or in hospitality, and migrant workers, do not qualify for the wage subsidy scheme. Public universities were also effectively excluded from the scheme. This criticism was amplified when the Government announced on 22 May that it had made a mistake. It had revised the expected cost of the JobKeeper program down by \$60 billion from \$130 billion to \$70 billion – which arguably makes room to expand the eligibility of the scheme.¹¹⁹

To focus efforts on the economic road out, and to build on the cooperative effort of the National Cabinet, Prime Minister Scott Morrison made the National Cabinet a permanent fixture, replacing the previous interjurisdictional forum (Council of Australian Governments, ‘COAG’).¹²⁰

¹¹⁷ Morrison (2020j)

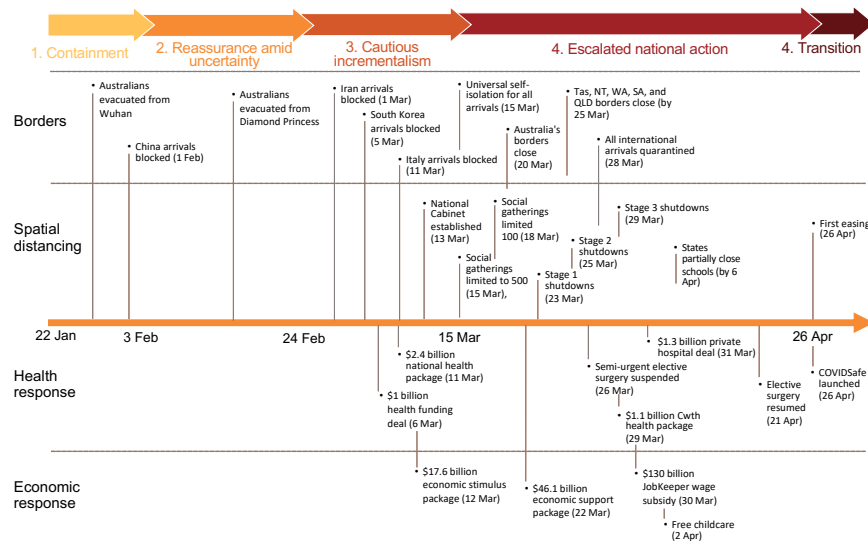
¹¹⁸ Department of Health (2020c). Note the rate of testing varies between states and territories.

¹¹⁹ Hitch (2020)

¹²⁰ Morrison (2020l)

Figure 2.4: A timeline of Australia's major COVID-19 policy measures

Categories of response measures by each policy phase



Source: Grattan Institute's coronavirus announcements tracker.

2.2 Reflections

2.2.1 Four successes

Australia's response to COVID-19 to date has been among the most successful in the world. From a peak of more than 400 new cases a day, the rate has fallen to less than 20, and some states are recording successive days with no new cases.¹²¹

Australia has avoided the worst of the pandemic (at least for now). Comparable countries, such as the UK and US, are mourning many thousands of lives lost and are still struggling to bring the pandemic under control. The reasons for Australia's success story are complex, and success may yet be temporary, but four factors have been important.

Success 1: Cooperative governance informed by experts

The formation of a National Cabinet, comprising the Prime Minister and the leaders of each state and territory government, was a key part of Australia's successful policy response to COVID-19.

The states and territories have primary responsibility for public hospitals, public health, and emergency management, including the imposition of lockdowns and social distancing restrictions. The Commonwealth has primary responsibility for income and business support programs. Coordination of these responsibilities was critical.

Although the National Cabinet was created quite late – in mid-March 2020 when cases were beginning to increase exponentially – it has proven to be an effective mechanism to resolve most differences and coordinate action as much more dramatic and far-reaching measures were put in place.

Within a week of the National Cabinet being formed, Australia began to progressively implement restrictions on social gatherings. On 22 March, in advance of a National Cabinet

¹²¹ As at 1 June 2020.

meeting that evening, Victoria, NSW, and the ACT announced they were proceeding in the next 48 hours to implement a shutdown of all non-essential activity. This helped push all other governments into widespread business shutdowns announced by the Prime Minister that night, to take effect the following day.

The inter-jurisdictional Australian Health Protection Principal Committee (AHPPC) further enhanced national cooperation. From the start of the crisis, this forum helped underpin Australia's decisions with public health expertise. The AHPPC's recommendations informed government decisions, particularly the expansion of social distancing measures. It is now commonplace to have the Prime Minister give a national press briefing alongside the Chief Medical Officer, who chairs the AHPPC.

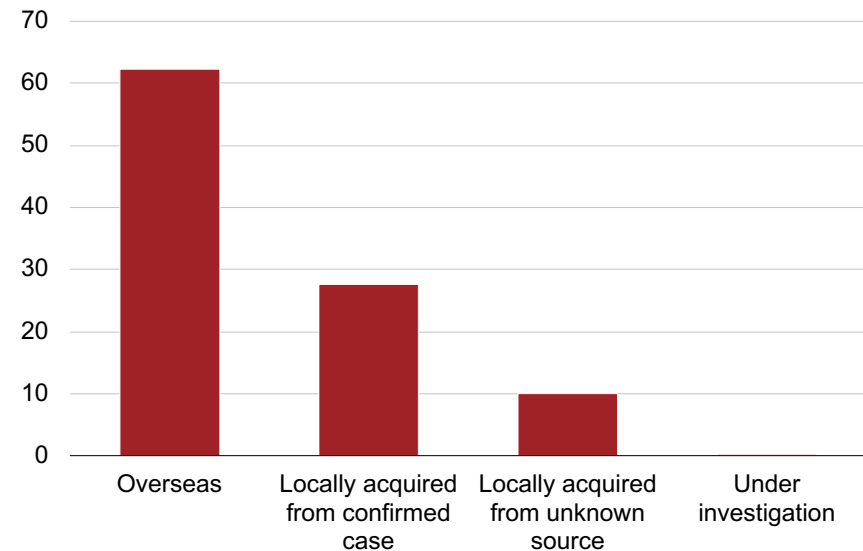
The Commonwealth Government was criticised, however, for announcing it was suspending Parliament till August.¹²² While the Commonwealth was making significant national decisions, including record spending commitments, the suspension meant the Government had minimal formal oversight. To at least partially overcome this deficiency, on 8 April 2020 the Senate set up a select committee to provide some checks and balances on the Government's response.

Success 2: Closure of international borders and mandatory quarantine

Australia's 20 March decision to close its borders to all foreigners to 'align international travel restrictions to the risks' was a turning

point in Australia's response.¹²³ The overwhelming number of new cases during the peak of the crisis came (about 80 per cent) from or were directly linked to someone who had been overseas.¹²⁴ And overseas sources of infection have accounted for nearly two-thirds of Australia's total cases to date (see Figure 2.5).

Figure 2.5: Nearly two-thirds of Australia's COVID-19 cases have come from overseas
Percent of total cases



Notes: This is based on Australia's total number of cases from 22 January to 1 June. Overseas means the person was infected in another country or at sea. Locally acquired from unknown source means that the person was infected in Australia, but the source of infection is not yet known. Under investigation, accounting for 0.2 per cent of total cases as

¹²² Horne (2020).

¹²³ Morrison (2020d).

¹²⁴ Morrison (2020c)

at 1 June, means that the source of the infection has not yet been determined but is being investigated through public health actions.

Source: Department of Health¹²⁵

This marked the start of Australia's 'escalated national action' phase. Within two weeks of Australia's borders being closed to foreigners, Australia's daily case numbers began to fall.

And once this measure was coupled a week later with mandatory quarantine at designated facilities for all Australian international arrivals, Australia had much more control over the spread of the virus.¹²⁶

Success 3: Rapid adoption and acceptance of enhanced social distancing measures

Australia's rapid adoption of social distancing measures reduced the risk of community transmission.

Once Australians could see the risk of the virus overwhelming the nation's health system, highlighted by Italy's struggling health system at the brink of collapse, people quickly complied with shutdown laws.¹²⁷ In fact, Australians had already begun reducing their activity before the restrictions were imposed.¹²⁸

Australians' compliance is demonstrated by the low number of community transmissions, despite having less-strict lockdown

laws than some other countries such as France and New Zealand.

Success 4: Expansion of telehealth

One of the Commonwealth Government's early healthcare interventions was to radically expand Australians' access to telehealth. Telehealth enables patients to consult health professionals via videoconference or telephone, rather than face-to-face. This means that healthcare workers and patients can remain home rather than put themselves at risk by having to visit a healthcare clinic or a doctor's waiting room.

The Commonwealth commenced a drip-feed of these measures in its \$2.4 billion health package on 11 March 2020, and subsequently phased-in broad-scale telehealth services for all Australians. Within six weeks, more than 250 new 'temporary' items had been added to the Medicare Benefits Schedule, which extends to seeking advice from allied health workers and specialists.¹²⁹ These changes were complemented with changes to medication services, enabling electronic delivery of prescriptions to the pharmacy, with options for patients to have medications delivered to their homes.

Australians have enthusiastically taken up telehealth services, with more than 4.3 million medical and health services delivered to three million patients in the first month.¹³⁰ A Royal Australian College of General Practitioners survey of more than 1,000 GPs

¹²⁵ Department of Health (2020a)

¹²⁶ Dickens et al. (2020).

¹²⁷ Armocida et al. (2020).

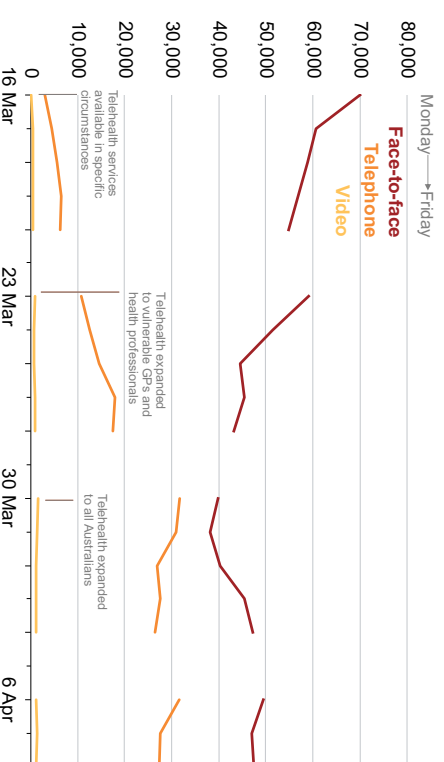
¹²⁸ Terrill (2020).

¹²⁹ Department of Health (2020d)

¹³⁰ Hunt (2020b).

found that 99 per cent of GP practices were now offering telehealth services, with 97 per cent also continuing to offer face-to-face consultations.¹³¹ See Section 5.1 on the future of telehealth.

Figure 2.6: Australians have taken to telephone General Practice (GP) consultations during the COVID-19 outbreak.
MBS items on weekdays



Notes: Data from five Primary Health Networks: Central & Eastern Sydney, South Western Sydney, Gippsland, Eastern Melbourne, and South Eastern Melbourne. Face-to-face MBS items 3, 23, 36, 44; Telephone MBS items 91795, 91809, 91810, 91811; and Telehealth Video MBS items 91790, 91800, 91802.

Source: POLAR GP 'COVID-19 and General Practice' report.

¹³¹ RACGP (2020).

¹³² NSW Government (2020).

2.2.2 Four failures

Unfortunately, Australia has also had failings. The most obvious is the handling of the Ruby Princess cruise ship, but Australia might have been in a better position today if it had acted against the virus more quickly and if our leaders had been clearer about their overall longer-term strategy for managing the virus.

Australia eventually 'went hard', but it was too slow to get started. The Commonwealth Government spent too long in the early days flailing in uncertainty about the scale of the crisis. As a result of this hesitancy, the Government was too slow to shut international borders and to prepare the healthcare system for the possibility of a huge influx of COVID-19 patients.

Failure 1: The Ruby Princess

About 2,700 Ruby Princess passengers were allowed to disembark freely in Sydney on 19 March 2020, despite some showing COVID-19 symptoms. The cruise ship has become Australia's largest single source of infection. About 700 cases (10 per cent of Australia's cases) and 22 deaths (about 20 per cent of Australia's deaths) are linked to the ship.

On 15 April 2020, NSW launched a Special Commission of Inquiry¹³² to investigate what went wrong, and a Senate Select Committee began to inquire into the case.¹³³ NSW police will also spend the next six months investigating what was known about

¹³³ Senate Select Committee on COVID-19 (2020b).

the potential coronavirus cases before the Ruby Princess was allowed to dock.

Failure 2: Too slow to fully close the borders

While the closure of international borders was a turning point, Australia spent too long in the uncertainty phase. Australia was comparatively quick to ban foreign nationals coming from China, but it was slow to introduce any further travel restrictions.

As the virus spread beyond China, and Australia continued to have thousands of international arrivals each day, it took more than six weeks after Australia's first confirmed case for the Government to introduce universal travel restrictions. This, restrictions were targeted at specific countries, such as Iran, South Korea and, belatedly, Italy – despite other countries such as the US posing similar or even greater risks.

Failure 3: Too slow to prepare the health system

Australia was too slow to ready its health system for the prospect of the virus spreading rapidly. When cases began to rise exponentially, Australia was ill-prepared for a pandemic-scale response.

This was particularly evident in Australia's testing regime. At first, some people with symptoms went to community GP clinics or

hospitals, without calling ahead, putting others at risk.¹³⁴ On 11 March 2020 the Commonwealth Government announced 100 testing clinics would be established, but this was only completed two months later, once the peak of the crisis had passed.¹³⁵

As cases began to increase in mid-March, Australia very quickly hit supply shortages for testing.¹³⁶ The testing regime remained narrow for too long before new testing kits could be acquired. This meant that many people with symptoms could not be tested, potentially increasing the chances of community transmission. Broader community testing, led by state governments, did not begin until April.

As it became clearer that access to ICU beds might be a critical factor, expansions of capacity were announced – almost tripling available ICU beds, but in some cases these announcements were not made until after the peak had passed.

Australia also struggled to get adequate supplies of PPE quickly enough to meet demand. Australia's initial national stockpile of 12 million P2/N85 masks and 9 million surgical masks was not sufficient.¹³⁷ Supplies of gowns, visors, and goggles had also not been set aside in Australia's national stockpile in the event of a crisis.¹³⁸ General practitioners complained of inadequate supplies hampering their work.¹³⁹ Eventually, on 26 March 2020, elective surgery was severely curtailed so that PPE could be diverted to frontline health workers dealing with the pandemic.

had occurred. The Commonwealth Government acquired hundreds of millions of masks by April to cover the shortfall.

¹³⁴ Woodley (2020).

¹³⁵ Hunt (2020c).

¹³⁶ Murphy (2020).

¹³⁷ Senate Select Committee on COVID-19 (2020a), p.5. At the early stages of the pandemic, Australia's PPE supply would have run out if a bigger outbreak

¹³⁸ McCauley (2020).

¹³⁹ See for example: Knaus (2020) and Ryan and Florance (2020).

As shortages loomed, Australian health departments joined global bidding competitions for fast-track supplies from overseas manufacturers. Some state governments turned to local manufacturers to boost supplies.

Failure 4: Shifting strategies and mixed messages

The lack of a clear overarching strategy to respond to the crisis has resulted in a reactive policy approach. This has led to mixed and confusing messages.

At first there was confusion about the shutdown measures: which businesses or events should close (for example, the Grand Prix). There have been inconsistencies between the Commonwealth's position and the states'. For example, most states closed or partially closed their public schools around Easter, and began re-opening them when cases went down over a month later. Despite concerns raised by some state governments, the Commonwealth asserted children were not at risk, with the Prime Minister repeatedly encouraging parents to send their children to school. Childcare centres also remained open.

The mixed messages have been particularly pronounced on Australia's strategy to manage the virus. Initially the Commonwealth Government talked about 'slowing the spread', but some states argued for a 'stop the spread' strategy. This tension increased confusion about how far Australia's lockdown restrictions should go. Debate raged between people who argued

that 'herd immunity' was Australia's only option, and people who pushed for 'elimination' of COVID-19 in Australia.¹⁴⁰

When clarity was sought from the Commonwealth, the messaging remained unclear. A 16 April 2020 statement from the Prime Minister, designed to clarify the Commonwealth's position on its longer-term strategy, confused two different strategies as one, by saying Australia was continuing to 'progress a successful suppression/elimination strategy for the virus'.¹⁴¹ As the debate continued, the case count forged its own story, showing that elimination may be possible as more and more states began to record multiple days and weeks with no new cases.

2.3 Now for the new normal

As restrictions unwind, a new normal will set in. The risk of COVID-19 cases jumping again means Australians' way of life will have to fundamentally change. Significant risks remain, particularly for states that ease restrictions too fast. Continual monitoring will be required to prevent further outbreaks or a second wave (see more in Chapter 4).

As Australia re-sets to a new normal, the successes and failures to date should guide policymakers in the recovery phase and into longer term. In particular, we need to heed the lessons from this pandemic to build a more effective, efficient, and equitable health system (Chapter 5).

¹⁴⁰ Duckett (2020b); Daley and Duckett (2020).

¹⁴¹ Morrison (2020h). Note that we interpret 'suppression' to mean controlling the incidence of new cases so the health system can cope. 'Elimination' is where cases are at effectively zero.

3 Modelling the spread of COVID-19 in Australia

3.1 The importance of modelling COVID-19 spread

Modelling plays an important role in our understanding of how disease spreads. It helps us understand the impact of past decisions, and allows us to peer into possible futures to plan ahead.¹⁴²

While the UK was pursuing a herd immunity strategy in early March 2020, the Imperial College COVID-19 Response Team released simulation-based modelling showing the proposed plan would overwhelm hospitals and cost more than 500,000 lives.¹⁴³ Their model's results made clear a disastrous likely scenario, and policymakers abandoned this folly.

In Australia, the Doherty Institute of Infection and Immunity and the Melbourne School of Population and Global Health developed models for the Commonwealth Government. As COVID-19 started to spread in China and beyond, researchers developed models of the virus' potential spread through the Asia Pacific region, to inform decisions on travel restrictions.¹⁴⁴

As the virus landed and began to take off in Australia, these researchers provided a mathematical model that demonstrated

the potential spread of COVID-19 and its impact on our healthcare system.¹⁴⁵ This helped guide the Government's decision making outlined in Chapter 2.

Mathematical models have since been used to estimate the effect of our combined lockdown measures, showing that delaying the lockdowns by a week would have resulted in a five-fold increase in total COVID-19 infections in Australia.¹⁴⁶ Others have been developed to forecast infection rates around the world.¹⁴⁷

Researchers at the University of Sydney also developed a microsimulation model which showed the levels of spatial distancing Australia would need to curtailing the rapid spread of the virus.¹⁴⁸

3.2 Grattan's microsimulation model of COVID-19 spread in Australia

Grattan Institute has developed a microsimulation model to assess the risks of lifting each of the existing restrictions. Our model estimates the effect of government policy decisions for school, work, and recreation on COVID-19 infection rates for individuals. It then aggregates these results for different geographic areas.

The starting point for our model is the Australian population, distributed in 'statistical areas' around the country.¹⁴⁹ People go to

¹⁴² Peng and Currie (2020)

¹⁴³ Ferguson et al (2020).

¹⁴⁴ Shearer et al (2020).

¹⁴⁵ Moss et al (2020).

¹⁴⁶ Marschner (2020).

¹⁴⁷ Phillips et al. (2020)

¹⁴⁸ Chang et al. (2020).

¹⁴⁹ Demographic data on 2,310 Australian statistical areas (SA2s) with populations of about 10,000 people, about the size of suburbs, is used from the 2016 Census: ABS (2016). See Appendix A.

work or school. They go to the shops, and to cafes and restaurants. At night, they go home; some to their families or housemates, others alone.

At each of these places, they come into contact with others. We calculate the number of people they interact with based on their setting. Workplace size is based on ABS business data; the size of schools is based on data from the Australian Curriculum, Assessment and Reporting Authority (ACARA).

We retrieve the location of shops, cafes, and restaurants from Google Places. Each person attends places in their area a pre-defined number of times – some people will go to the supermarket three times a week, for example, and others less so. The more people in an area going to the shops at a particular hour of the day will determine the number of interactions in these places.

We retrieve a person's household size and type from the ABS. A household of two adults and one child might, on a given day, interact with the people in two workplaces, one school, and a supermarket, before the three come home and interact with each other.

Each of these interactions carries risk of transmitting infections or being infected. These risks are determined by the likelihood of infection given an exposure to a case at home, school, work, or in the community (Section 3.3.2).

If a person is exposed to the virus and becomes infected, the virus will build up in their body for a number of days during their

incubation period until they start to show symptoms (Section 3.3.1).

They will start to shed and spread the virus to others they interact with during their infectious period, often before symptoms start to show, and will continue to do so until they no longer have the virus.

An infected person may remain without symptoms for the duration of their illness. Others will develop symptoms at the end of their incubation period. As the illness progresses, some will require hospital treatment, some in an ICU (Section 3.4). A small minority of these cases will die. This risk will change depending on a person's age.

The epidemiological characteristics of COVID-19 determine its spread and severity: the length of the incubation and infectious periods, the secondary attack rates, the severity or absence of symptoms, and the apparent difference in children compared to adults. These inputs into our model are discussed in the next section.

3.3 Epidemiological characteristics of COVID-19

A person who is exposed to COVID-19 and becomes infected takes time to develop symptoms during their incubation period. As the virus builds up, they can start to show symptoms and become ill.¹⁵⁰ A person with COVID-19 can be infectious before they develop symptoms and while they are symptomatic.

¹⁵⁰ World Health Organisation (2020c).

The type of interactions they have with others – indoors or outdoors, with physical contact or not, for a long time or short – will affect the number of people they infect, as will the number of such interactions.

These factors determine the spread of COVID-19 within the population. Our understanding of these factors and their effect on the spread of COVID-19 is explored in this section.

3.3.1 The incubation period

The time between becoming infected with the virus and developing symptoms is known as the incubation period.

The incubation period affects the speed of COVID-19 transmission from one person to the next. A longer incubation period means a longer time between a person becoming infected and realising they are infected. It is a key factor in determining quarantine lengths for people who may have been exposed to the virus, such as those with an infected housemate, or people coming from overseas.

Using patient interviews and contact tracing, researchers from around the world have estimated the incubation period of thousands of COVID-19 patients. Figure 3.1 shows the results from such studies.

Early studies from Wuhan observed incubation periods averaging about 6 days, with 95 per cent of people having an incubation period between 3 and 11 days.¹⁵¹ This range was supported by subsequent studies from around China in Shanghai,¹⁵² Zhejiang,¹⁵³ Shenzhen,¹⁵⁴ and Beijing.¹⁵⁵ Similar results for incubation periods were found in countries that were affected early, such as South Korea.¹⁵⁶

While some studies have shown a slightly longer average incubation period – between 7 and 9 days, shown in Figure 1 – meta-analysis of the literature suggests the true average is about 6.¹⁵⁷

As shown in Figure 3.1, some individuals have been observed with much longer incubation periods of 20 or 30 days.¹⁵⁸ But the vast majority – about 99 per cent – have incubation periods less than 15 days.¹⁵⁹

¹⁵¹ Backer et al. (2020); Lauer et al. (2020).

¹⁵² Lu et al. (2020).

¹⁵³ Qian et al. (2020).

¹⁵⁴ Bi et al. (2020).

¹⁵⁵ Tian et al. (2020).

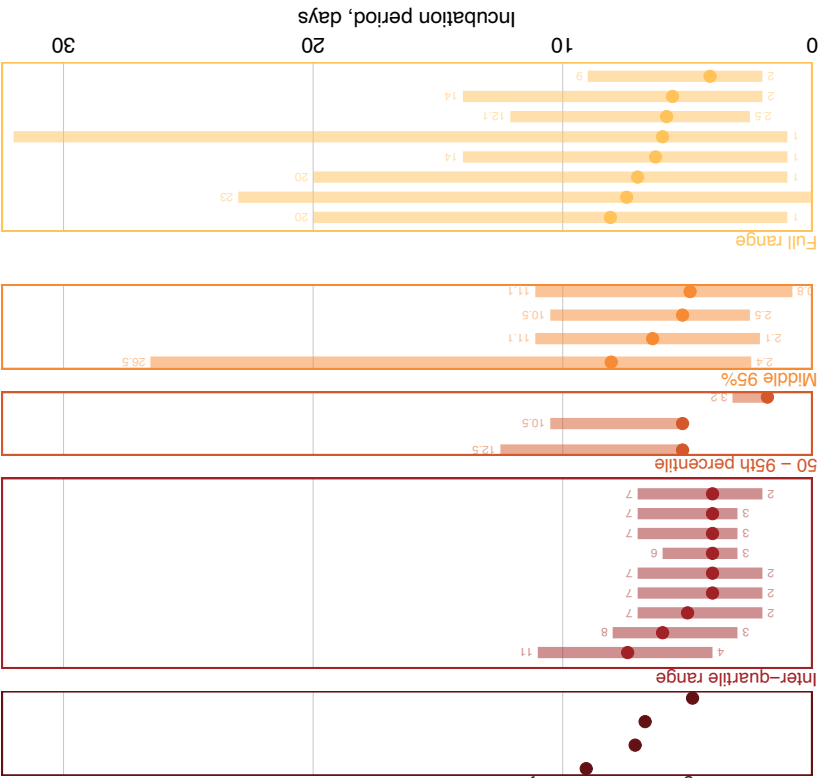
¹⁵⁶ Kong et al. (2020).

¹⁵⁷ McAloon et al. (2020).

¹⁵⁸ C. Qiu et al. (2020).

¹⁵⁹ Bar-On et al. (2020).

Figure 3.1: Incubation period
Observed incubation period statistics in studies since February
Studies showing mean/median only



¹⁶⁰ Ball (2020). The viral load is highest during the first week after the onset of symptoms: To et al. (2020).
¹⁶¹ World Health Organisation (2020e).

¹⁶² World Health Organisation (2020d). The virus can remain viable on most surfaces for hours: Bar-On et al. (2020); and on stainless steel and plastic for longer than three days: van Doremalen et al. (2020).
¹⁶³ Couch et al. (1966), p. 517.

3.3.2 How COVID-19 is spread

Viral load, viral shedding, and the infectious dose

As COVID-19 builds up in a person's body, their viral load – how much of the virus they have in their body – rises.¹⁶⁰ As this viral load builds up, people start to 'shed' the virus by expelling small particles through coughing, sneezing, and speaking.¹⁶¹ These viral particles can be passed from person to person directly, called 'droplet transmission', or can attach themselves to a surface to be picked up later, called 'contact transmission'.¹⁶²

Aerosol transmission – where the small droplets evaporate before they fall to the ground, leaving the dried-out virus to drift freely through the air¹⁶³ – is not yet a recognised as a source of transmission by the WHO. But evidence to date suggests it is

likely.¹⁶⁴ Aerosol transmission was confirmed for SARS-CoV-1, allowing the spread of disease over longer distances.¹⁶⁵ An aerosol of the SARS-CoV-2 virus has been observed in lab settings¹⁶⁶ and in hospitals in Wuhan.¹⁶⁷ This has consequences for precautions and restrictions: keeping 1.5m apart isn't effective if the virus can travel further.¹⁶⁸

The average number of these particles needed to start an infection in another person is called the infectious dose.¹⁶⁹ The higher the infectious dose, the less likely a disease is to spread.¹⁷⁰ The infectious dose for COVID-19 is not yet known.

For the virus to spread, a person carrying the it must build up a viral load. They then must shed viral particles that are picked up by another person, and the number of particles picked up must be greater than the infectious dose required for the virus to take.

A person's viral load builds up before they show symptoms, meaning they can start to shed the virus before they show symptoms. There is evidence of this pre-symptomatic transmission one-to-three days before symptom onset.¹⁷¹ This poses a particular problem: people without symptoms – and so who don't see a reason to self-isolate – spreading the virus.

Some people pass through the illness period showing few symptoms or none at all (see Section 3.4). These people can still spread the disease.¹⁷²

How many others does a person infect?

A disease's reproduction number – its R_0 – is the number of additional people each case infects, on average.¹⁷³ It is a useful statistic, but hides important facts about the spread of disease.¹⁷⁴ In reality, the distribution of individuals' infectiousness is highly skewed: some people will pass the virus on to nobody else, while others will pass it on to 10 people or more.¹⁷⁵

Examples of this were seen in early analysis of COVID-19 clusters in China, shown in Figure 3.2.¹⁷⁶ During a dinner in late January, one COVID-19 case infected the other eight people. During a larger gathering, a single person infected 10 others.

¹⁶⁴ Morawska and Cao (2020); Fineberg et al. (2020), pp. 19, 35-37.

¹⁶⁵ Li et al. (2005); Booth et al. (2005).

¹⁶⁶ van Doremalen et al. (2020)

¹⁶⁷ Yuan Liu et al. (2020)

¹⁶⁸ World Health Organisation (2020d). See also Yong (2020) for a discussion.

¹⁶⁹ See Geddes (2020).

¹⁷⁰ The infectious dose for COVID-19 is currently unknown but estimated to be low given it is very contagious: Geddes (2020).

¹⁷¹ He et al. (2020). Arons et al. (2020); Nishiura et al. (2020); Tindale et al. (2020); Tong et al. (2020);.

¹⁷² Emery et al. (2020).

¹⁷³ See Box 1 in Chapter 1.

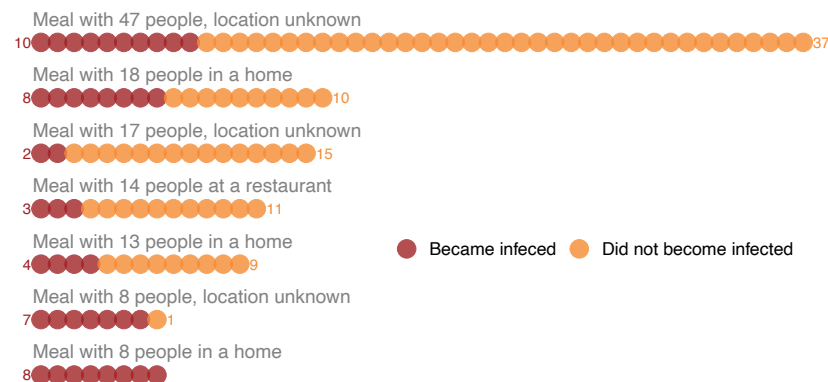
¹⁷⁴ Rossman (2020).

¹⁷⁵ Lloyd-Smith et al. (2005).

¹⁷⁶ Yang Liu et al. (2020). Using these clusters, the authors concluded that the secondary attack rate was between 27 and 44 per cent. However, this was an early study and the authors acknowledged the need for further research.

Figure 3.2: Super-spreading events

Spread of COVID-19 from meal-based clusters with secondary transmission in China



Source: Adapted from Table 1 of Liu et al (2020).

The skewed distribution of infectiousness isn't unique to COVID-19. It is a common feature of infectious diseases, including the measles, smallpox, SARS,¹⁷⁷ and MERS.¹⁷⁸

While research is evolving in this area, early analysis suggests that about 10 per cent of people are responsible for 80 per cent of COVID-19 spread.¹⁷⁹

¹⁷⁷ Lloyd-Smith et al. (2005).

¹⁷⁸ A. J. Kucharski and Althaus (2015).

¹⁷⁹ Endo et al. (2020).

¹⁸⁰ Bourouiba (2020).

¹⁸¹ Kupferschmidt (2020).

The goal of COVID-19 policies is to decrease the exposure of susceptible people to infected individuals,¹⁸⁰ and policy makers can exploit the fact that the virus is mostly passed on by highly infectious people at super-spreading events.¹⁸¹ This means shutting down high-risk events – removing the opportunity to have super-spreader events – can be highly effective. These policy decisions are discussed in Chapter 4.

Likelihood of becoming infected when exposed to the virus

The likelihood that a person will become infected when exposed to COVID-19 is called the 'secondary attack rate'.¹⁸² A higher secondary attack rate means the virus spreads to more people, and passes through the population more quickly.

Specific settings can pose greater risks of infection than others for COVID-19. These are settings that increase the likelihood of an infectious dose being passed from one person to another, like being indoors, sharing meals, or singing.¹⁸³

Knowing the secondary attack rate in the home is important in understanding the spread of COVID-19. Analysis of 391 clusters and their 1,286 contacts in Shenzhen, China, found that about 10 per cent of contacts in the home became infected, shown in Figure 3.3.¹⁸⁴

¹⁸² Center for Disease Control and Prevention (2020a).

¹⁸³ Read (2020).

¹⁸⁴ In a smaller study of 195 unrelated clusters from Guangzhou, researchers determined a household secondary attack rate of 19 per cent: Jing et al. (2020).

Young people were as likely as adults to be infected (see Section 3.4 for a discussion about children and COVID-19). Elderly people were significantly more likely to be infected.

Figure 3.3: Secondary attack rates in different demographics and settings



Source: Bi et al (2020).

3.4 Patient outcomes

3.4.1 Asymptomatic cases

Being asymptomatic means a person doesn't feel ill. But what is good for the individual can be detrimental to the group: they can spread the virus without knowing they have it.¹⁸⁵

The true proportion of people who do not show symptoms is not well understood. Under symptom-based testing – such as has been the policy in Australia until recently – asymptomatic cases are unlikely to be tested and diagnosed. Symptom-based testing tells us how many symptomatic people tested positive for COVID-19, rather than how many people *have* COVID-19. Tests are mostly done on people who appear sick, and asymptomatic people, by definition, do not appear sick.

To determine asymptomatic COVID-19 rates, people without symptoms need to be tested.¹⁸⁶ This happens in two scenarios: when all close contacts of a confirmed case are tested, and when a random sample of people is tested.

A random sample of the population was tested in Iceland. Among people who tested positive for COVID-19, about 40 per cent reported having no symptoms.¹⁸⁷ However, the authors of this study note that symptoms 'almost certainly' developed after

testing for some, so the true asymptomatic rate is likely to be lower.

A study of COVID-19 cases and their contacts found that about 20 per cent of cases were asymptomatic at the time of their positive test result.¹⁸⁸

Analysis of the people on the Diamond Princess – a cruise ship with an early outbreak of COVID-19 – showed a higher rate of asymptomatic cases. About three-quarters of confirmed cases were asymptomatic.¹⁸⁹ An assessment of another cruise-ship outbreak in South America found similar asymptomatic rates.¹⁹⁰ However, these high asymptomatic rates are likely overstated, with some pre-symptomatic people being incorrectly classified.¹⁹¹

3.4.2 Hospital and ICU rates

Some of the people who get sick will need care at a hospital, and a minority of those will require care in an ICU.

In its modelling for the Australian Government, the Doherty Institute provided estimates of hospitalisation and ICU rates, shown in Table 3.1.¹⁹² The severity of illness from COVID-19 is closely related to age, with older people suffering worse outcomes than younger people. The hospitalisation risk is almost zero for

¹⁸⁵ Ma et al. (2020).

¹⁸⁶ COVID-19 can also cause minor cold-like symptoms, increasing the difficulty of detecting the virus: Woelfel et al. (2020).

¹⁸⁷ Gudbjartsson et al. (2020).

¹⁸⁸ Bi et al. (2020).

¹⁸⁹ Emery et al. (2020).

¹⁹⁰ Ing et al. (2020).

¹⁹¹ Lewin (2020)

¹⁹² Moss R et al. (2020). See also Verity et al. (2020), table 3.

children, while 10-to-20 per cent of octogenarians will require an ICU bed.

Table 3.1: Hospitalisation and ICU rates

Age group	Hospitalisation rate, %	ICU rate, %
0 – 9	0.03 – 0.06	0.01 – 0.02
10 – 19	0.03 – 0.06	0.01 – 0.02
20 – 29	0.39 – 0.78	0.11 – 0.23
30 – 39	1.45 – 2.90	0.43 – 0.85
40 – 49	2.55 – 5.11	0.75 – 1.50
50 – 59	4.95 – 9.90	1.45 – 2.91
60 – 69	7.75 – 15.49	2.27 – 4.55
70 – 79	17.88 – 35.76	5.25 – 10.50
80+	32.97 – 65.94	9.68 – 19.36

Source: Moss et al (2020).

The expected use of hospitals and ICU facilities determines our healthcare system's capacity to cope with the COVID-19 pandemic.¹⁹³

¹⁹³ Duckett and Mackey (2020b); Duckett et al. (2020).

¹⁹⁴ Condit (2020).

3.4.3 Death

Understanding the mortality from COVID-19 is crucial in understanding the risk it poses to society. Two statistics are used to inform our understanding of the mortality danger of COVID-19.

The case fatality rate

The case fatality rate (CFR) is the 'ratio of the number of deaths divided by the number of confirmed cases of disease'.¹⁹⁴ This makes it a relatively simple number to calculate: take the number of people who have died from the disease and divide it by the number of cases.

On May 22 in Australia, for instance, there had been 100 deaths from 7,081 cases, meaning the CFR was 1.4 per cent.¹⁹⁵

Researchers looking at 43,000 cases in China concluded that the CFR was 1.38 per cent, similar to that in Australia.¹⁹⁶ They found that the case fatality rate, like demand for hospital and ICU beds, increased substantially with age.

While the CFR can provide a broad understanding of the mortality risk from COVID-19, it doesn't tell us exactly how dangerous the disease is. It misses some people: those who became infected but did not get tested, or did not have their test recorded. The CFR is therefore heavily influenced by the level of testing.

¹⁹⁵ Department of Health (2020i).

¹⁹⁶ Verity et al. (2020), table 1.

However, what we know about the CFR of COVID-19 shows that the risks are far higher for older people.

People aged 80 and have a CFR of about 15 per cent – 150 times higher than for people aged between 20 and 50. There are very few deaths among people aged below 20 years of age. Higher case fatality rates for older people are likely to be affected by underlying health conditions. In China, fewer than 1 per cent of people with no underlying health conditions died when they contracted of COVID-19, compared to 10 per cent of people with underlying cardiovascular disease.¹⁹⁷

Long-term residential-care facilities for older people are particularly likely to increase the case fatality risk. Between 30 and 50 per cent of all COVID-19 deaths in Europe, the US and Australia have been residents of long-term residential-care facilities.¹⁹⁸ Most residents are older and have underlying health problems, and the conditions of long-term care facilities are likely to promote the spread of infection.

The infection fatality rate

The infection fatality rate (IFR) is the number of deaths divided by the actual number of infections from a disease. This statistic

includes all people who were exposed and became infected, not just those who had their case recorded.

The benefit of the IFR is that it provides a clearer picture of mortality risk. An IFR of 1 per cent means that 1 per cent of people who become infected ultimately die, and so the risk of dying if you get the disease is 1 per cent.¹⁹⁹

But the IFR is more difficult to determine than the CFR because it requires knowing the actual number of infections in a population. This requires serology testing of SARS-CoV-2 antibodies (Section 3.3.2).

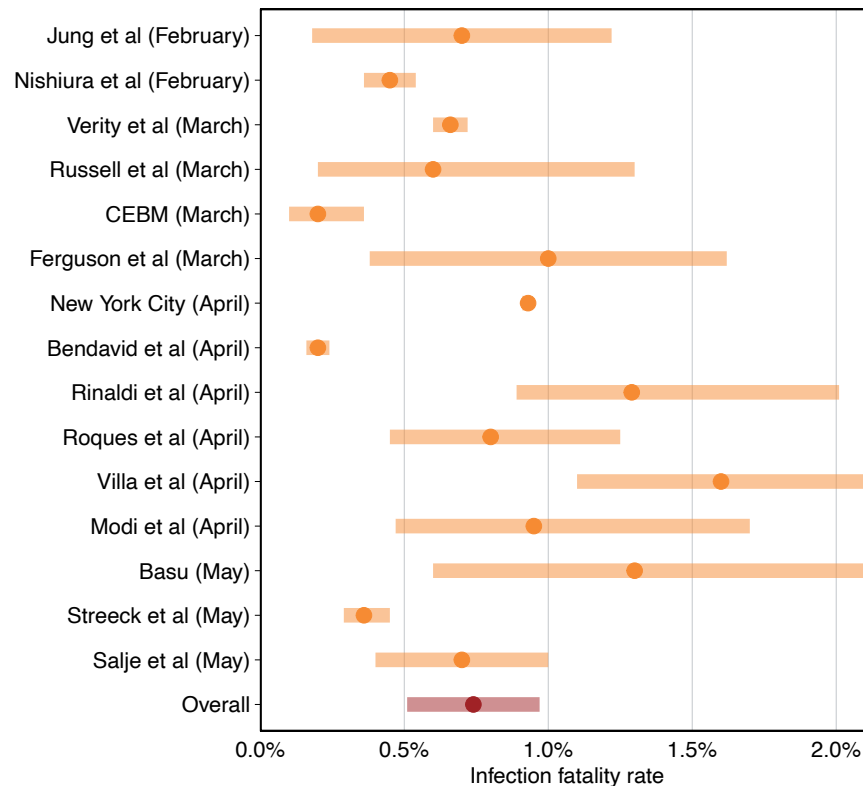
Figure 3.4 shows that current IFR estimates for COVID-19 suggest the rate is between 0.5 and 1 per cent, about 5-to-10 times higher than seasonal influenza.

¹⁹⁷ <https://ourworldindata.org/mortality-risk-covid#case-fatality-rate>

¹⁹⁸ See <https://www.ecdc.europa.eu/sites/default/files/documents/covid-19-long-term-care-facilities-surveillance-guidance.pdf> and <https://www.kff.org/health-costs/issue-brief/state-data-and-policy-actions-to-address-coronavirus>.

¹⁹⁹ On average.

Figure 3.4: Meta-analysis of COVID-19 infection fatality rates



Source: Meyerowitz-Katz and Merone (2020), figure 2.

3.5 COVID-19 appears to affect children differently

The understanding of COVID-19 described above is further complicated by the fact that there is still a lot we don't know about how the virus affects children.²⁰⁰

3.5.1 Prevalence of COVID-19 among children

Children of all ages can get COVID-19. There have been about three hundred confirmed cases of children with COVID-19 in Australia so far.

Evidence so far suggests many children with COVID-19 are symptom-free, meaning broad testing is needed to identify the children with the virus.²⁰¹

In Iceland, 10,800 asymptomatic people were tested for COVID-19 in mid-to-late March. About 0.8 per cent were positive.²⁰² Of the 848 children under 10 years of age, none had the virus; of the 1200 children aged 10-19, 0.4 per cent tested positive – half the rate of the adults.

In Germany, a COVID-19 lab processed 60,000 tests. Of the 2,200 children under 11, 2 per cent tested positive; of the 1,900 people aged 11-20, 4 per cent had the virus. About 22,000 adults aged 20-40 were tested over the same period, suggesting they were more likely to have symptoms. But only 5 per cent of them were positive for COVID-19, not much higher than the rate for the children.

²⁰⁰ See also Duckett & Mackey (2020).

²⁰¹ Kelvin and Halperin (2020); H. Qiu et al. (2020).

²⁰² Gudbjartsson et al. (2020).

In Shenzhen, China, a study of 391 cases and 1,286 of their close contacts found that children were ‘just as likely’ to contract the virus as adults under 50 (see Figure X).²⁰³ But a study of 195 clusters in Guangzhou concluded that children were less likely to become infected.²⁰⁴

That finding runs counter to analysis published a few days later, in which researchers examined the contact tracing information from Hunan, China.²⁰⁵ Contacts of COVID-19 positive patients were placed under medical observation for 14 days. Analysis concluded that children did have a lower risk of infection.

3.5.2 Children appear to spread COVID-19 less than adults

Children can pass on COVID-19 to adults and other children. But observational evidence so far has shown that they are less likely to spread the virus than adults. The World Health Organisation’s chief scientist Soumya Swaminathan says children ‘seem less capable of spreading the virus’ than adults.

At the beginning of the COVID-19 epidemic in Australia, the National Centre for Immunisation Research and Surveillance (NCIRS) studied 9 adult and 9 child cases of COVID-19 in 15 NSW schools.²⁰⁶ The study identified 832 ‘close contacts’, 735 of them children. One-third of this group were interviewed, tested with nasal swabs 5-to-10 days after contact, and had a blood sample examined for antibodies one month later.

One child in primary school tested positive on both the nasal swabs and for antibodies; and one child in high school tested positive for antibodies, but not on the initial nasal swab.

These cases happened in early March, before government recommendations for spatial distancing and lockdowns. Back then, Australia had done very little to reduce the spread of COVID-19. That two children out of 288 tested positive indicates that child-to-child transmission is possible, but it also suggests the rate of transmission is low.

The NSW study is in line with other observational studies. A study of an outbreak in the French Alps found that a symptomatic child had visited and had ‘close interactions’ in three schools without passing on the virus to anyone.²⁰⁷ The authors said this suggested ‘different transmission dynamics in children’.

A multinational study of 33 household clusters found that a child under 18 was the initiating contact (‘index case’) for three.²⁰⁸ The authors note that this is well below otherwise similar infections such as the H5N1 influenza virus, in which children are the index case about half the time.

²⁰³ Bi et al. (2020).

²⁰⁴ Jing et al. (2020).

²⁰⁵ Zhang et al. (2020).

²⁰⁶ National Centre for Immunisation Research and Surveillance and NSW Health (2020).

²⁰⁷ Danis et al. (2020).

²⁰⁸ Zhu et al. (2020).

In the Netherlands, the Ministry of Health studied 54 households with COVID-19 infections and found that while children did become infected, they were never the source of the spread.²⁰⁹

One thing we don't yet know is *why* an infected, symptomatic child would spread the disease less than an infected, symptomatic adult. A study of 3700 COVID-19 patients in Germany found there was no difference in the viral load between people in different age groups, including children.²¹⁰ Although these findings were challenged.²¹¹ This is still a developing area of research.

3.5.3 Children with COVID-19 are less likely to become severely ill, but we don't know whether they suffer long-term effects

We know that children with COVID-19 can become severely ill. But the available evidence strongly suggests they become severely ill at lower rates than adults.

A comprehensive study of 2,135 paediatric cases in China found more than half had mild (flu-like) symptoms at worst.²¹² About 40 per cent had moderate symptoms, such as pneumonia, frequent fever, and dry cough. The remaining 5 per cent were classified as

severe or critical, compared to 19 per cent of adults in China at the same time.

While the severe-illness rates for children with COVID-19 are low, the medium- and long-term effects are still unknown. The UK Health Secretariat has warned of a serious emerging syndrome affecting children, potentially related to COVID-19. There have been similar reports in Italy. Only time and regularly updated research will tell us how serious this is.

We do know that children can and do die from COVID-19.²¹³ There have been deaths of children in China,²¹⁴ the US,²¹⁵ the UK,²¹⁶ France,²¹⁷ and other countries with substantial outbreaks.

Death rates of children with COVID-19 are very low. But there are 4 million school children in Australia, meaning that in an outbreak, even a low death rate could translate into the deaths of many children.

²⁰⁹ National Institute for Public Health and the Environment (2020).

²¹⁰ Jones et al. (2020). However, re-analysis of this data suggests young children – under the age of 10 – might have a lower viral load than adults: McConway and Spiegelhalter (2020). This re-analysis was responded to with a subsequent re-release of the original study, which again found that there was no evidence to support the assertion that children carried a lower viral load: Jones et al. (2020), p 28.

²¹¹ McConway and Spiegelhalter (2020).

²¹² Dong et al. (2020). The number of asymptomatic cases is likely to be under-reported due to missed diagnoses.

²¹³ Ludvigsson (2020).

²¹⁴ Dong et al. (2020).

²¹⁵ CDC COVID-19 Response Team (2020).

²¹⁶ Public Health England (2020).

²¹⁷ Thiébaux and Lafaurie (2020).

3.6 Using known epidemiological characteristics of COVID-19 to model its spread

The information about COVID-19 has led us to use the following default parameters in our modelling, shown in Table 3.2 on the following page.

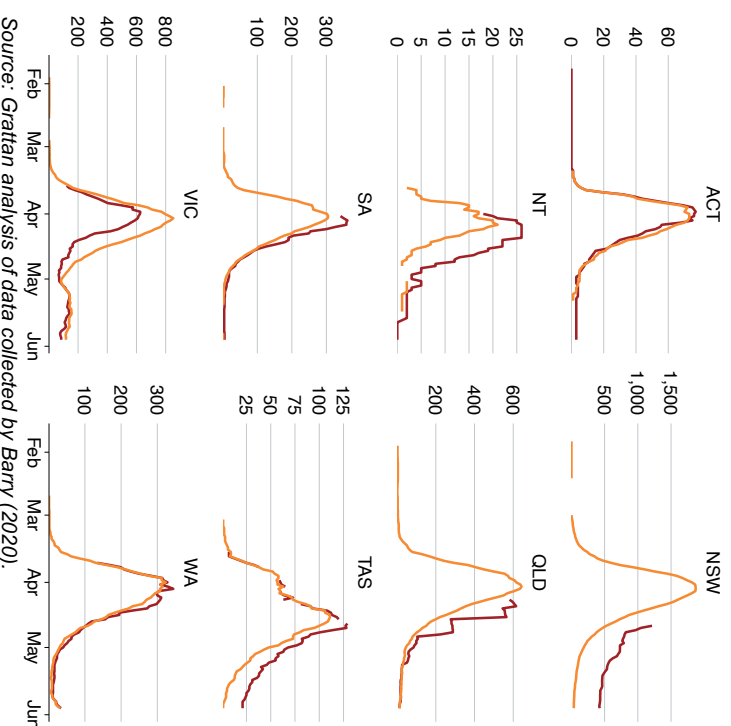
Table 3.3 shows the policy settings the model can explore, and their default values.

3.6.1 The number of active cases in the community is not known

COVID-19 spreads through an infected person to a susceptible person. To understand how it spread in the past, the number of infected people in the community needs to be known.

In the Australian context, this number is unknowable for three reasons. First, how long each COVID-19 case is infectious for is unknown. In most states, interviews are conducted in the weeks after a positive test result to determine whether a person is still infectious.²¹⁸ The national guidelines state that this must be at least 10 days since the positive test and after at least three days without symptoms.²¹⁹ But there is variation in how and when states record and report recovered, and therefore active, cases of COVID-19. Figure 3.5 shows

Figure 3.5: Imputed active cases
Number of active cases by state, **reported** and **imputed**



Source: Grattan analysis of data collected by Barry (2020).

²¹⁸ Inquiries by O'Brien et al. (2020) found that officials from ACT Health, Queensland Health, SA Health and WA Health interview patients after a positive test and assess them according to the national guidelines. Officials at NSW Health interview people three weeks after a positive test and record whether they have recovered; NSW Health (2020). Departments of Health in Victoria and

Tasmania have not made public how they assess patient recoveries: O'Brien et al. (2020).

²¹⁹ Communicable Diseases Network Australia and Department of Health (2020), p 16.

Second, there are cases of COVID-19 that go unrecognised and untested, and are therefore unrecorded. This is particularly true for people with little or no symptoms, who carry and can spread the virus, but may not know they have it.

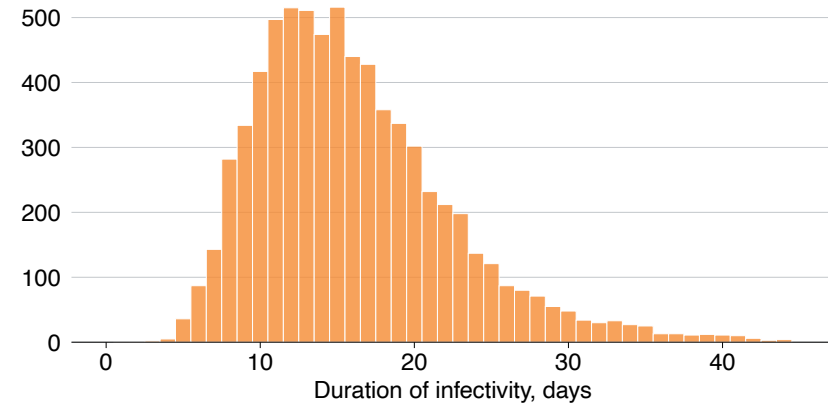
Third, a large proportion of Australia's COVID-19 cases came from overseas. From March 27, overseas arrivals have been quarantined for two weeks in hotels, meaning they are not in the community spreading the virus. But before March 27 they were asked to self-isolate in their homes. Exactly how many adhered to that policy, and how strictly they followed it, can't be determined.

To address these three issues, we model active cases in the community by:

- using data from April onwards;
- excluding overseas arrivals; and
- assuming that a person's illness duration is lognormal distributed around 15, shown in Figure 3.6.

Figure 3.6: Assumed distribution of infectivity

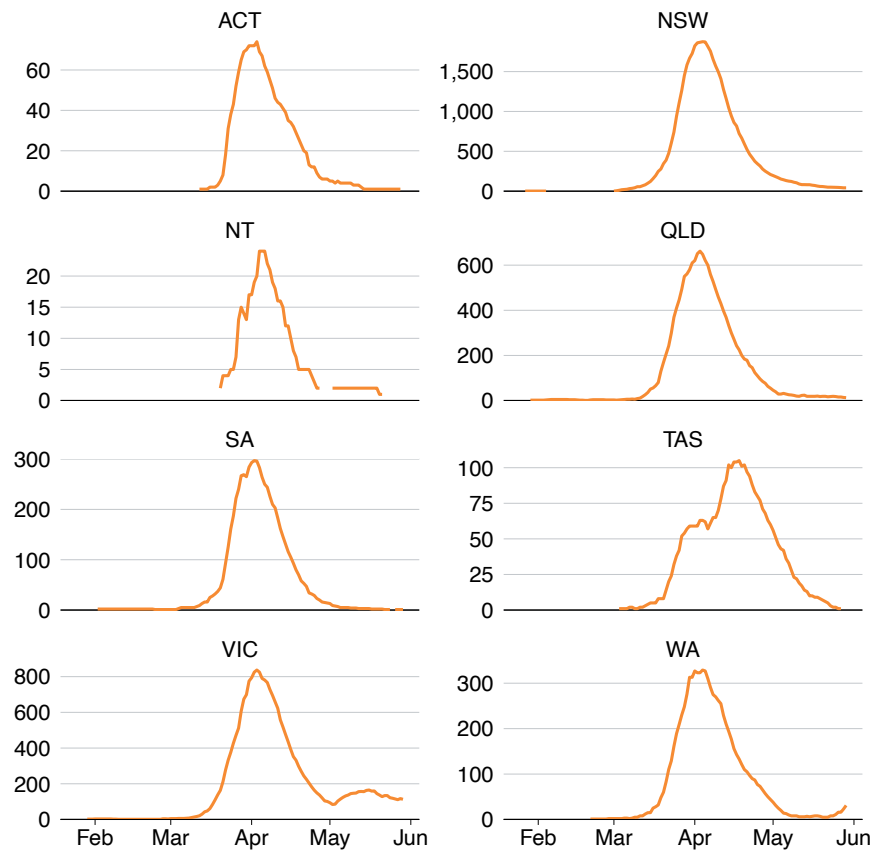
Number of observations from a sample of 7,100



These assumptions result in estimates for the number of active local cases in Australian states, shown in Figure 3.7. Most states and territories are at, or are close to, zero active cases. This means that regardless of most policy decisions – and depending on unquarantined overseas and international arrivals – they will manage to contain the virus.

The story is slightly different for Victoria and NSW, both of which still have a hundred or so active local cases. There are enough of these cases for policy settings and human behaviour to matter. If they open high risk settings too soon, or if their citizens do away with social distancing practices implemented to now, there is a substantial risk of outbreaks. These risks are explored in Chapter 4.

Figure 3.7: Imputed active local cases
Number of active local cases by state, imputed



Source: Grattan analysis.

3.6.2 Comparing simulation results with active cases

Figure 3.8 shows local active cases in NSW, Queensland and Victoria against 200 simulation runs using the default parameters in Tables 3.2 and 3.3.

Each simulation is shown as an orange line and represents a plausible path of active local COVID-19 cases in each of the states. With the epidemiological settings and the actual policy settings, the simulated results map relatively closely to the sharp decline in active cases seen in each of the states. The reduction, but not a complete stop, to new cases means the virus has lingered. Each of the states have maintained a low number of active cases from late April until the start of June.

But with active cases still lingering, and new cases still – as at June 1 – being detected on most days, it is only social distancing policies and behaviour that will prevent a resurgence.

Figure 3.8: Imputed active local cases
Active cases from **simulation runs** against **local active cases**

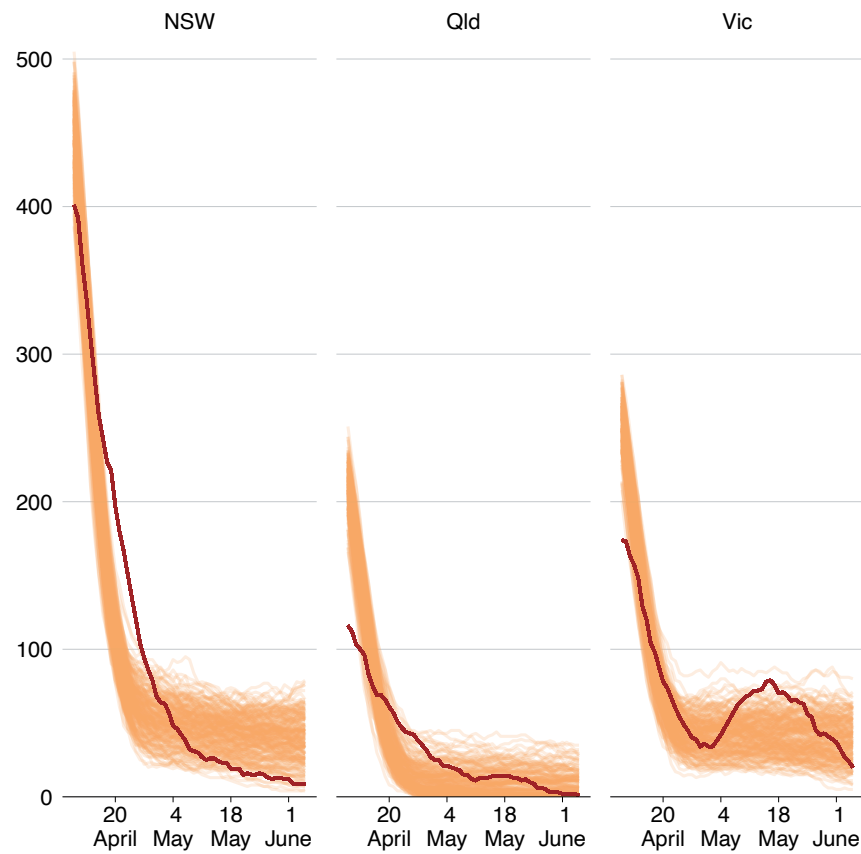


Table 3.2: Base epidemiology settings

The information about COVID-19 described above led us to use the following default parameters in our modelling.

Variable name	Default	Description
incubation_distribution	pois	One of 'pois', 'lnorm', and 'dirac', whether the incubation period is Poisson, log-normal, or constant.
incubation_mean	5	The intended average of the distribution must be positive, and a whole number for 'pois' and 'dirac'.
incubation_sigma	0.44	A measure of the spread of the distribution.
illness_distribution	pois	As for incubation.
illness_mean	15	As for incubation.
illness_sigma	1	As for incubation.
a_workplace_rate	0.07	The proportion of workplaces in which transmission between colleagues is possible.
a_household_rate	0.15	The proportion of households in which household transmission is possible.
a_schools_rate	0.07	The proportion of schools in which transmission between students is possible.
q_workplace	0.01	Daily transmission probability among workers of the same workplace.
q_household	0.05	Daily transmission probability among household members.
q_school	1/3000	Daily transmission probability among students of the same school.
q_school_grade	1/500	Daily transmission probability among students of the same school and same grade.
q_supermarket	1/500	Daily transmission probability among patrons of the same store at the same time.
resistance_threshold	400	The resistance required to not be infected, between 0 and 1000. A value of 0 means no one will be infected; a value of 1000 means everyone will.
p_asympto	0.48	The proportion of cases that are asymptomatic.
p_critical	0.02	The proportion of symptomatic patients that require ICU treatment.
p_death	0.01	The proportion of symptomatic patients who die.

Table 3.3: Base policy settings

Variable name	Default	Description
supermarkets_open	TRUE	Should supermarkets remain open?
schools_open	FALSE	Should schools remain open?
only_Year12	FALSE	If schools open, should they be restricted to Year 12 students only? No effect if schools_open = FALSE.
school_days_per_wk	1	Specifies how many days a week pupils attend school. By default, students attend full-time. Only applied after schools_open and only_Year12. In particular, has no effect if schools_open = FALSE and if only_Year12 = TRUE then all other students attend 0 times per week.
do_contact_tracing	TRUE	Should contact tracing occur? If FALSE households are not isolated if tested.
contact_tracing_days_before_test	0	The number of days after the end of the incubation period before the person gets tested.
contact_tracing_days_until_result	3	The number of days between a test and the result being known.
contact_tracing_only_symptomatic	TRUE	Is contact tracing only applied to symptomatic cases?
contact_tracing_success	0.9	The proportion of contacts successfully traced.
tests_by_state	Inf	The number of tests per day that states perform. First entry is the total tests available across Australia.
max_persons_per_supermarket	200	Maximum number of people allowed in a supermarket (within one hour i.e. concurrently).
age_based_lockdown	'None'	The ages (1-100) or a length-100 vector specifying the ages to be lockdown (as 1).
workplaces_open	FALSE	Are workplaces to be open? Can be FALSE or TRUE, or a number in [0, 1], the proportion of workplaces that remain open.
workplace_size_max	1	The maximum size of any workplace (we assume that everyone interacts on a single day).
workplace_size_beta, workplace_size_lmu, workplace_size_lsi	13, -1, -1	Parameters for the distribution of workplace sizes. _beta is the rate distribution for the geometric distribution; _lmu and _lsi are the parameters for the lognormal distribution.

4 Coming out of lockdown

The 'new normal' in Australia will include continued restrictions on international travel, public gatherings, public transport, schools, workplaces and community activities to prevent the transmission of COVID-19. Information on the likely effectiveness of infection control strategies is critical to plan and implement these measures.

Australia is progressively easing social distancing restrictions. Decisions on when and in which order should be informed by evidence.

Modelling generates information on how COVID-19 spreads and so helps policy makers identify measures to reduce the likelihood of transmission. Swift and accurate contract tracing will be crucial as students return to the classroom and workers return to the office.

Robust contact tracing systems will be vital in the new normal. Contact tracing seeks to rapidly identify and assess people who may have been exposed to a disease. By isolating people who may have been infected, chains of transmission can be broken, and outbreaks controlled.²²⁰

²²⁰ World Health Organization (2020a)

²²¹ See Adam J Kucharski et al. (2020); He et al. (2020); Hellewell et al. (2020); Fong et al. (2020).

²²² World Health Organization (2020a)

²²³ Leecaster et al. (2016) found that sensors recorded twice as many contacts occurring for 20 seconds or longer than self-reported contacts.

To be effective, a higher proportion of contacts need to be traced, and a high proportion of those identified contacts need to properly isolate.²²¹ This requires a dedicated contact tracing workforce, strong community engagement, and a system to collate and analyse data.²²² All Australian states and territories now have dedicated contact tracing teams to achieve this goal, potentially assisted by the COVIDSafe app to help overcome problems associated with manual contact tracing such as people not remembering, or misremembering, who they've had contact with.²²³ In the only known use of the app for contact tracing since its launch, health authorities in Victoria were able to identify one additional contact not remembered by the initial case.²²⁴

Contract tracing and isolation can be effective in controlling outbreaks if done well, and in conjunction with other measures. A key factor is getting cases early. If a contact of a confirmed case builds up a viral load of the virus and has time to spread the virus before they are notified by contact tracers to begin isolation – or if they are not identified as a contact at all – outbreaks can continue occur. The longer the period between infection and isolation, the more difficult it is to get an outbreak under control.²²⁵

SARS-CoV-2 mutates as it spreads. Identifying and comparing different strands of the virus using genomic testing provides researchers with information about possible lines of transmission, enabling them to quickly intervene to contain outbreaks.²²⁶ This

²²⁴ T. Taylor and Swan (2020).

²²⁵ Hellewell et al. (2020) used a stochastic transmission model to explore the effectiveness of contact tracing and isolation during COVID-19 outbreaks under different R0 scenarios. It found that in most scenarios, contact tracing and case isolation were enough to control an outbreak of COVID-19 within 3 months.

²²⁶ Caly et al. (2020).

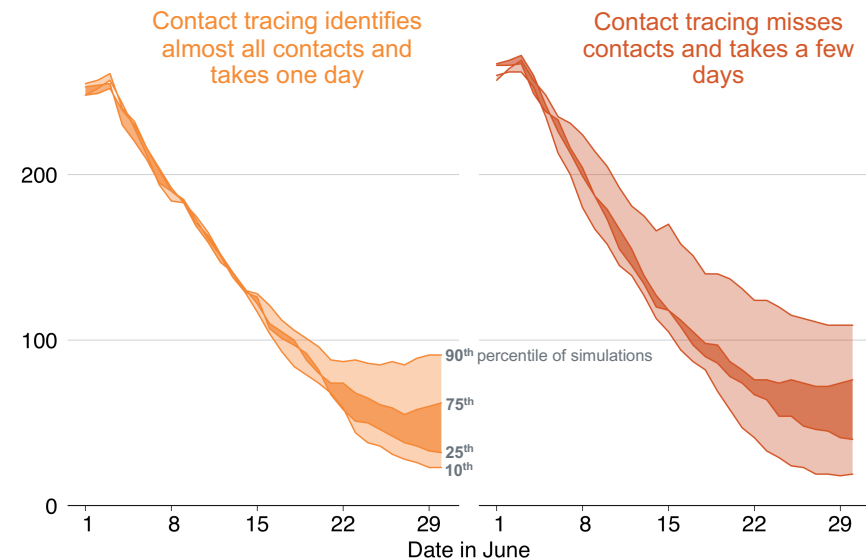
method has been used successfully Victoria, which has sequenced about three-quarters of the state's cases.²²⁷ It has also enabled identification of previously unknown clusters, and disentanglement of multiple clusters initially thought to be one.²²⁸

Robust contact tracing systems are essential if restrictions are lifted while the virus is still circulating in the community. If minor outbreaks occur, and can be managed through contact tracing, then governments can have more confidence about lifting restrictions. The big risk is if an outbreak occurs which overwhelms contact tracing capacity and results in igniting exponential spread of the virus through the community.

How COVID-19 can spread in Australia with different levels of contact tracing efficiency is explored in Figure 4.1. The left panel shows how cases might progress if contact tracing is nearly perfect and authorities are able to identify almost all contacts and doing so in just one day. The right panel shows the spread of outcomes if contact tracing is less efficient: if only 80 per cent of contacts are identified, and the process takes three days instead of one.

Figure 4.1: Efficient contact tracing reduces the risk of outbreaks

Active local COVID-19 cases in Australia



Source: Grattan's COVID-19 microsimulation model. 100 runs per scenario.

Contact tracing can reduce the risk of COVID-19 cases turning into outbreaks. But contact tracing and isolation efforts alone cannot prevent the spread of COVID-19.²²⁹ They must be combined with social distancing measures to increase the likelihood of controlling outbreaks.

²²⁷ Seemann et al. (2020).

²²⁸ Caly et al. (2020).

²²⁹ Adam J Kucharski et al. (2020); He et al. (2020).

4.1 Social distancing must be maintained in the community

Social distancing measures are designed to separate infected and uninfected people.²³⁰

Social distancing takes many forms. Keeping a 1.5 metre distance between people in public can reduce the likelihood that the droplets containing the virus are passed from one person to another.²³¹ Wearing masks can also help achieve the same goal, reducing the amount of the virus that is spread from an infected person.²³²

Reducing non-essential contact also takes away opportunities for the virus to spread. Limiting the amount of travel around the city and the number of non-essential visits to friends and family breaks transmission cycles, leading to fewer new cases in the following weeks.²³³

Where the virus has been shed by an infected person, washing hands, and wearing masks and protective equipment reduce the likelihood that enough of it will be picked up by a susceptible person.²³⁴ Combining these protective measures increases the likelihood of protection.²³⁵

Broad information campaigns about handwashing are important, but not sufficient, to change habits. Making handwash or sanitiser readily available and prominent increases use, as does signage.²³⁶

People tend to touch their face 10 to 20 times an hour, and this behaviour is difficult to change.²³⁷ A public health strategy that depends on people strictly abstaining from touching their face will probably fail.

Figure 4.2 shows three scenarios that demonstrate the risks of lapsing into pre-COVID-19 behaviour. The first panel shows Australia as it was throughout March, April and May: shops have restrictions on the number of people allowed inside at any one time, and people stayed at home if they feel sick and are kept their distance from one another when they were out. Here, cases are likely to continue their decline towards, but not reaching, zero active local cases.

²³⁰ Fineberg et al. (2020), p. 7.

²³¹ Cowling et al. (2020). See also Chapter 3.

²³² Prather et al. (2020); Long et al. (2020); Bartoszko et al. (2020). However, wearing masks does not remove the spread of the virus entirely: World Health Organisation (2020a). Wide-scale adoption of mask wearing is likely to be most effective: Eikenberry et al. (2020); Howard et al. (2020).

²³³ In the US, Sharkey and Wood (2020) find that a 1 per cent increase in distance travelled in the population leads to an 8.1 percent increase in new

cases per capita in the following week. A 1 per cent increase in non-essential visits leads to a 6.9 percent increase in new cases per capita in the following week. These findings were stronger in densely populated U.S. counties.

²³⁴ Jefferson et al. (2009)

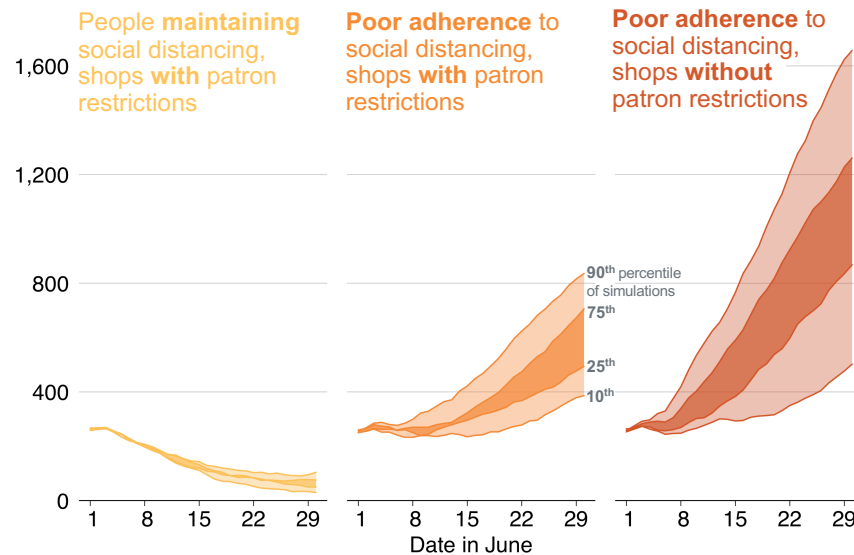
²³⁵ Jefferson et al. (2009)

²³⁶ Lunn et al. (2020)

²³⁷ Although there is substantial variation: Kwok et al. (2015).

Figure 4.2: Poor social distancing in open shops presents a severe risk

Active local COVID-19 cases in Australia



Source: Grattan's COVID-19 microsimulation model. 100 runs per scenario.

The second panel models a scenario the number of people allowed inside shops at any one time remains restricted, but people let down their guard and return to normal behaviour: hugging and shaking hands, and forgetting to wash them. Under

this scenario, the number of, active cases in the community start to rise.

The third panel models a scenario that maintains this poor adherence to social distancing and hand hygiene but also removes patron limits in shops. Under this scenario, with more opportunities to spread, the virus does so quickly.

The nature of the SARS-CoV-2 virus hasn't changed; our behaviour has. When interacting in the community, this behaviour is what prevents outbreaks. If Australians go back to a pre-COVID normal, the virus will spread quickly, and wildly, like it has elsewhere.

4.2 Reopening workplaces

A virus can move through a city via its workplaces. When people go to work, they travel to areas they otherwise wouldn't visit, and spend considerable time with people they otherwise wouldn't interact with. Closing workplaces reduced the spread of infection in previous pandemics.²³⁸

A May 2020 found that the social distancing measures were most effective with a staggered return to work in April (as compared to March).²³⁹

This study emphasises that a rushed lifting of restrictions would risk a second wave of infections but delaying the lifting of

²³⁸ See Ferguson et al. (2005).

²³⁹ Prem et al. (2020)

restrictions and easing people back to work slowly would reduce this risk.

To limit the spread of COVID-19 at work precautions should be taken to reduce the number of people interacting at the workplace, and to minimise the opportunity for virus transmission.

Reducing the number of people at a workplace means an infected person has fewer people they can spread the virus to. A staggered return to work with only a quarter of the workplace returning at first has been shown to be effective in analysis Wuhan.²⁴⁰

Similarly, having fewer people in an office space reduces contact.²⁴¹ This can be achieved by increasing the proportion of people who work from home on any given day by rotation, or limiting office time to essential activities.

Avoiding handshakes, minimising time spent in shared spaces and thorough cleaning, can reduce the risk of infection at a workplace.²⁴²

The Commonwealth Department of Health suggests people at work.²⁴³

- stop shaking hands;
- avoid non-essential meetings;
- put off large meetings to a later date;
- if possible, hold essential meetings outside in the open air;

- eat lunch at your desk or outside rather than in the lunch room;
- avoid non-essential travel.

The Department suggests employers:

- promote good hand, sneeze and cough hygiene;
- provide alcohol-based hand rub for all staff;
- regularly clean and disinfect surfaces that many people touch;
- open windows or adjust air conditioning for more ventilation;
- limit food handling and sharing of food in the workplace;
- promote strict hygiene whenever food is being prepared.

Figure 4.3 shows the effect of careful workplace reopening compared to a return to the pre-COVID-19 normal. As with shops, lots of people sharing a common space at work with minimal precautions against infection dramatically increases the risks of outbreaks that can lead to a second wave of mass infection.

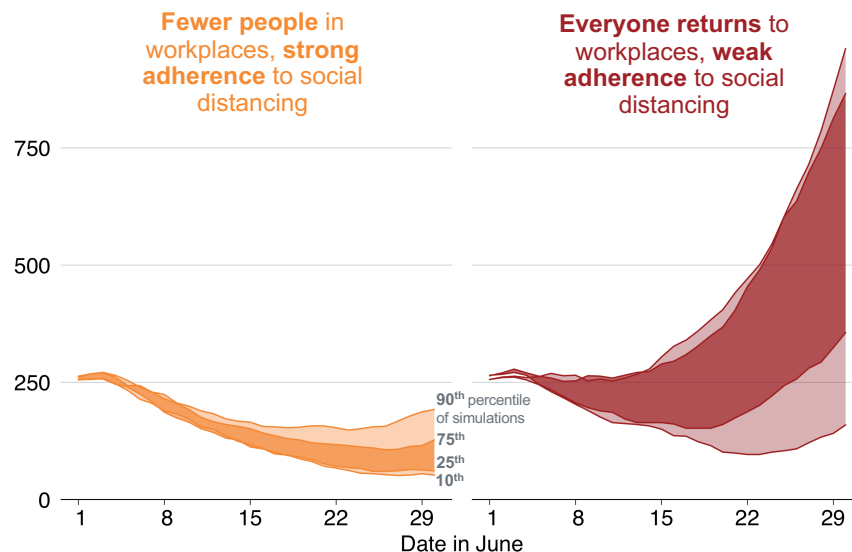
²⁴⁰ Prem et al. (2020). See also Cirrincione et al. (2020), section 3.1.

²⁴¹ Cirrincione et al. (2020); V. J. Lee et al. (2020).

²⁴² Some of these workplace containment measures are outlined in Cirrincione et al. (2020), sections 3.1 and 3.2.

²⁴³ Department of Health (2020j)

Figure 4.3: Reopening workplaces could pose big risks
Active local COVID-19 cases in Australia



Source: Grattan's COVID-19 microsimulation model. 100 runs per scenario.

Figure 4.3 also shows the range of different potential outcomes. The right-hand panel shows that with good luck, there is still a potential of relatively low spread, but with bad luck the virus could get out of control again. Different decision makers will emphasise

the optimistic outcome, while others will focus on the potential pessimistic one, depending on their risk tolerance and the other contextual factors they take into account (such as the short-term benefits to popularity or the economy from opening up).

4.3 Reopening schools

By the end of March, more than 100 countries had implemented national school closures.²⁴⁴ Closing schools can limit contacts between people and households, giving a virus less scope to spread.²⁴⁵ But for millions of working parents in Australia, having kids at home from school is a significant burden.²⁴⁶ It also disrupts the education of children, particularly those preparing for exams. It is a potential restriction to the spread of COVID-19 with substantial costs to society.

The literature on the effectiveness of school closures on the transmission of coronavirus diseases, including COVID-19, found minimal effectiveness. Modelling of the COVID-19 outbreak in Wuhan suggests that school closures led to a small reduction in transmission.²⁴⁷ In Hong Kong and Singapore, closing schools did not appear to have an impact on transmission of COVID-19.²⁴⁸

There is evidence that closing schools has slowed the spread of other diseases. A study looking at influenza transmission amongst children in France found closing schools during a pandemic

²⁴⁴ Viner et al. (2020).

²⁴⁵ Ferguson et al. (2020), p. 16.

²⁴⁶ Wood and Mackey (2020).

²⁴⁷ Prem et al. (2020)

²⁴⁸ Viner et al. (2020). There were few studies that could separate the effectiveness of school closures from other concurrent social distancing measures.

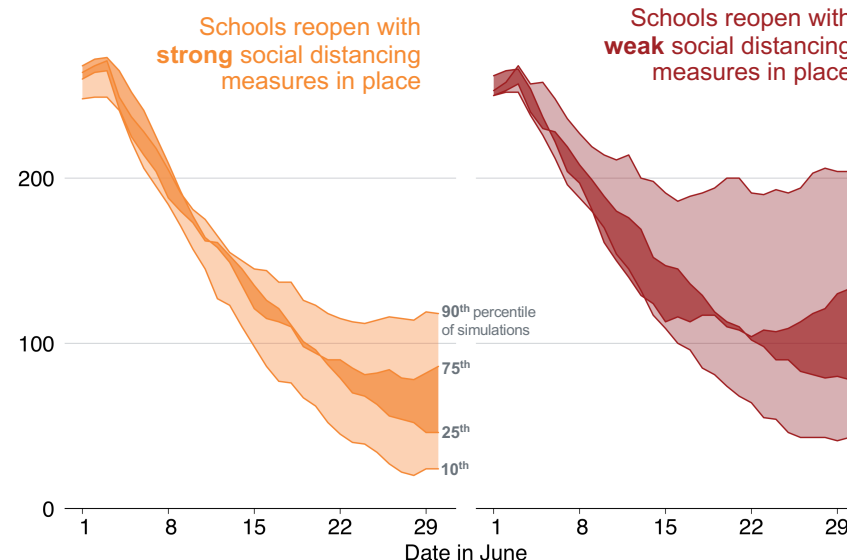
reduces spread in both children and adults.²⁴⁹ Modelling of influenza in South-East Asia,²⁵⁰ Australia,²⁵¹ Europe,²⁵² the United States²⁵³ and elsewhere²⁵⁴ has also shown the effectiveness of school closures.

But where the attack rate of other influenza viruses on children was high,²⁵⁵ children appear less likely to get and spread COVID-19 (see Section 3.5). Low infection rates of children mean that the impact of closing schools is likely to be minimal.²⁵⁶

School kids interact with their classmates most, and with children in other grades less. Analysis of the in-school interactions of school children found that kids interact with between 30 and 60 people during a school day, with interactions lasting between 20 and 50 minutes.²⁵⁷ And while the rates appear to be low, COVID-19 does spread to and from children.

For these reasons, the outcomes in Figure 4.4 are less dramatic than those with loose restrictions at work or in the community. If schools are open and put in place practices to reduce the likelihood of transmission, the risks of outbreaks is still relatively low. If schools are less careful – if transmission is more likely in the classroom or in the playground – this risk rises. But as schools are quick to close on the discovery of a new case – as is modelled in both panels of Figure 4.4 – outbreaks are likely to be contained.

Figure 4.4: Opening schools presents a risk of outbreaks
Active local COVID-19 cases in Australia



Source: Grattan's COVID-19 microsimulation model. 100 runs per scenario.

²⁴⁹ Cauchemez et al. (2008)

²⁵⁰ Ferguson et al. (2005), p. 212.

²⁵¹ Kelso et al. (2009).

²⁵² Hens et al. (2009).

²⁵³ Halloran et al. (2008).

²⁵⁴ Fong et al. (2020), table 1; Rashid et al. (2015).

²⁵⁵ See for example Neuzil et al. (2002).

²⁵⁶ Ferguson et al. (2020), p. 15-16.

²⁵⁷ Guclu et al. (2016), table 2. See also Leecaster et al. (2016).

4.4 Major events

Cancelling major events was the first action taken within Australia to prevent the spread of COVID-19.²⁵⁸ The logic behind this decision is sensible: stopping tens-of-thousands of people gathering in the same place for a football game or music festival removes millions of potential contacts and chances to transmit the virus.

Mass gatherings have been the source of outbreaks for other viruses.²⁵⁹ A systematic review on mass gatherings and respiratory disease in the US between 2005 to 2014 found that more than half of outbreaks occurred at fairs and at children's camps.²⁶⁰

The nature of the major event is crucial in assessing its risk. A seven-day cruise with shared indoor spaces and meals pose an obvious risk, as was seen throughout the COVID-19 crisis.²⁶¹ But few outbreaks were detected at sporting events, which are often held outside with ample ventilation and limited social mixing.²⁶²

The major concern with major events is that outbreaks in these settings can overwhelm our contact tracing capacity. Recalling all the people that you had contact with at a dinner party is one thing; doing the same when you have been on a crowded train to a crowded stadium is another. Outbreaks that involve major events

are difficult to contact trace, meaning isolating all the people who have potentially become infected is impossible.

4.5 How Australia should move forward

Through decisive policy action and effective collective action, Australia finds itself in a fortunate position. But we are not out of danger yet, and must make ourselves comfortable in a new normal of restrictions and behaviour change.

The new normal will have to be in place for an extended period. At best a vaccine may be available for widespread use sometime in the first half of 2021. But, despite the unprecedented international effort, there is no certainty this will happen.

4.5.1 While there are few active COVID-19 cases in Australia

Testing contact tracing and isolation and a graduated lifting of lockdown restrictions are likely to maintain a low rate of infection in Australia for an extended period – given the very effective initial period of restriction. But with low rates of infection, initially, perceptions of risk will decrease, and spatial distancing and hygiene measures are less likely to be maintained.

It is therefore important, while there are active COVID-19 cases in Australia, that structural measures to control rates of infection over the longer term are put in place.

²⁵⁸ See Chapter 2.

²⁵⁹ Abubakar et al. (2012)

²⁶⁰ Rainey et al. (2016). Most of the outbreaks at camps were of Swine Flu in children in 2009.

²⁶¹ Ebrahim and Memish (2020)

²⁶² Rainey et al. (2016)

Even with structural measures in place, it is likely there will be ongoing outbreaks and clusters. The capacity and effectiveness of contact tracing will be critical to prevent wider spread and a return to exponential growth.

Workplaces should be re-opened slowly, with as many people continuing to work from home as possible to minimise the number of people interacting.

At workplaces, there needs to be continued health messaging about social distancing and hygiene, like minimising time spent in shared spaces like kitchen and avoiding touching. What we have shown in our modelling is the importance of individual behaviour – the risk of opening workplaces will depend on how workplaces are opened and how people behave in the workplace. Social distancing in workplaces is crucial. Government guidelines for businesses should be clear, and their implementation should be monitored.

When there is an infection within a workplace, rigorous contact tracing, testing and isolation must be implemented. Workers who show symptoms linked to COVID-19 must not be allowed in the workplace, and must be supported to continue their work from home where possible, or through Government support.

Schools should remain open with social distancing policies in place to reduce risk of outbreaks before detection. If a case is detected in a school, schools should be closed, and rigorous contact tracing implemented.

People in the community must continue to take social distancing precautions, including wearing masks in high risk situations. As

fewer COVID-19 cases are reported and risk perceptions are lowered, people must be reminded about their social distancing responsibilities. Clear provision of hand sanitiser must remain the norm.

Policies that govern patron spacing limits in shops should be maintained if local transmission of COVID-19 continues in particular cities. The onus should be on the employer or owner of the workplace, café, or shop, to be aware of the risks, to have developed a safe opening plan informed by resources from government health authorities, and to enforce the plan. The onus is on public health authorities to be clear about what a good safe opening plan looks like for employers and owners.

The transition from lockdown to a new normal will take some months to stabilise as new information emerges from experience. As structural measures to manage infection are put in place, new patterns of personal behaviour are likely to follow. It will be important that there is an effective communication campaign to support, encourage and reinforce these changes.

4.5.2 Dealing with a second wave

While there are active cases of COVID-19 in Australia, there is still a possibility of a second wave. The risk of a second wave is higher if policies and behaviour return to normal too soon.

State governments must actively monitor cases in local areas. They must be prepared to act decisively to control major outbreaks. Exactly how they will act in the case of a major outbreak must be determined in advance by the relevant public

health authority, and should be communicated clearly with the public before outbreaks occur.

Local lockdowns should be considered, but the mechanics – the threshold of cases for a lockdown, who can enter and exit the affected area, what happens to workplaces and schools and workplaces – must be communicated with the public in advance of outbreaks occurring. This will ensure the public and local authorities know what to expect and how to react. It will also remind the public of the risks of COVID-19 spread: if it remains, and if there is an outbreak, lockdown will have to return.

4.5.3 When there are no active COVID-19 cases in Australia

When there are no active cases in the community – a feat achieved by New Zealand on 8 June – more of life can return to normal. Capacity constraints on workplaces, shops and hospitality can be removed. People can start to move freely within and between states.

Some people with COVID-19 have remained infective long after their diagnosis, and well after a 14 or 21 day cut-off. Testing must remain a routine part of life even after Australia declares itself COVID-19-free. If local cases are identified, contact tracers must be at the ready, and widespread testing should restart in affected areas.

The rest of the world is still a long way from control of COVID-19, and Australia must make sure it does not import new cases. Current mandatory quarantining of international arrivals must remain in place. Commonwealth should maintain and enforce safety guidelines for new arrivals as updated information about

the virus and new technology to assess infectivity of individuals is developed.

Quarantine exemptions could be made with other countries, like New Zealand, that also have no active COVID-19 cases and that have effective international arrival practices in place.

5 Transitioning to a new normal

All Australians were affected by the coronavirus pandemic. For most, it was just the irksome restrictions as spatial distancing was used to drive down new cases. For many, it involved a loss of income. For some, it was mourning the death of a loved one, with the grieving made all the more painful by restrictions on the number of people who could attend the funeral.

The health system changed too. It embraced new ways of working because of the need to protect patients and staff from infection. Elective procedures were cancelled and health professionals took on new roles. The coronavirus pandemic caused massive changes in the way health services were provided. Disruptive change²⁶³ -- advocated by many for decades but often assigned to the too-hard basket -- was implemented rapidly. Changes occurred across most parts of the health system, and were often embraced by consumers and providers alike.

It wasn't all smooth sailing. Coordination wasn't good enough and had to be built. Public health planning wasn't strong enough at the regional level. Primary care wasn't ready or properly supported to deliver the required front line services. Telehealth wasn't ready and defaulted to telephone calls. Home care and home monitoring was not well prepared or well integrated with primary or tertiary care. The private and public hospital systems were not integrated. Rapid solutions to all these problems had to be found.

²⁶³ Christensen, *et al.* (2009)

We are only part the way through the response to the pandemic and its consequences. The expected wave of post-pandemic mental illness has not yet hit the system.

The experience of health care during the pandemic highlight the issues we need to address for a more effective, efficient, and equitable health system. In this chapter, we discuss what a 'new normal' should look like. It is not clear yet that this experience will contribute to a 'new normal', but it would be a tragedy if lessons weren't learned. We argue that Australia should not 'snap back' to the old order, but rather that the changes that occurred during the pandemic should inform what happens during the recovery period and beyond. The recession makes it more imperative to take actions now that will create a health system that provides better and more efficient care for patients. This will require changes to funding and governance.

The process for change

Retaining some of the changes that were made during the lockdown is a no-brainer. But even so-called no-brainers require some thought. Almost every consumer and health professional has a story to tell about what worked and what didn't. Stewards of the system -- the funders and the regulators -- will also have their perspectives on how things worked, aware of the unintended or perverse consequences of policies implemented rapidly during the pandemic. All this knowledge should be tapped to design a better system, and this requires effective overarching change management processes.

States and territories, and the Commonwealth Government, should establish participatory processes to plan the transition to the new normal. These processes may be a special-purpose review committee²⁶⁴ or build on the task groups set up to manage the pandemic.²⁶⁵ Whatever the structure, there should be opportunities for consumers and professionals to be involved.

COVID-19 appeared on the scene quickly, and there was a lack of evidence initially about what it was, its epidemiology, and how to treat it. The Commonwealth Government established a 'Rapid Research Information Forum' to provide evidence-based advice on topics such as the efficacy of serological tests and whether people can be reinfected.²⁶⁶ This evidence-based approach should be carried over into the new normal. In particular, any policy changes should be informed by evidence about the impact on the most vulnerable.²⁶⁷

There are seven key areas where pandemic-related policy changes or identifiable weaknesses provide lessons for the future: telehealth; out-of-hospital care; the primary care system; the interaction between the public and private hospital systems; supply chains; public health preparedness; and overall system planning and coordination.

²⁶⁴ Such as Queensland has established, and in which Stephen Duckett participates.

²⁶⁵ This latter is the approach adopted by South Australia.

²⁶⁶ Rapid Research Information Forum (2020a); Rapid Research Information Forum (2020b).

²⁶⁷ Pineda and Corburn (2020); Wang and Tang (2020); Smith and Judd (2020); The Lancet (2020); Ahmad, *et al.* Ibid.

5.1 Improving access through telehealth

Primary care played a crucial role in the preparations to fight coronavirus, stepping up without adequate supplies of personal protective equipment, facing changing guidance on who to test, where and when, and despite initial hits to practice revenue.²⁶⁸ There was a silver lining for consumers: the introduction of telehealth, which should now become a permanent feature of health care in Australia.

Starting in mid-March 2020, the Government drip-fed changes to facilitate telehealth in primary care. Two groups of items were introduced: one for video-conference consultations, and one for telephone consultations if video was not available.

Telehealth has been advocated for decades as a way of enhancing access to care for people living in rural and remote Australia.²⁶⁹ But telehealth has faced numerous barriers,²⁷⁰ not least equivocal Commonwealth government support,²⁷¹ and poor internet connectivity in rural and remote Australia.²⁷² Take-up was low.²⁷³

Telehealth should not be seen as a simple substitute for a face-to-face consultation, although it can do that. In the new normal, health professionals and their patients need to assess when

²⁶⁸ This section draws on Duckett (2020d).

²⁶⁹ Bradford, *et al.* (2016); Wells (1976).

²⁷⁰ Jang-Jaccard, *et al.* (2014).

²⁷¹ Yellowlees (2001).

²⁷² Broadband for the Bush Alliance (2018); Park, *et al.* (2019).

²⁷³ Wade, *et al.* (2014).

telehealth should be the preferred medium because of the nature of the presenting problem, distance to be travelled and other factors.. The ‘digital divide’ means that a patient’s digital and health literacy will need to be assessed in customising care.²⁷⁴

Telehealth consultations are part of the broader opportunities in virtual health services. This includes remote imaging services, online secondary consultations, electronic scripts, remote monitoring, online team coordination and electronic health records.²⁷⁵ The COVID-19 experience shows that the opportunities for virtual health can and should be expanded to improve patient outcomes and experiences.

The pandemic telehealth items initially did not include secondary consultations – discussions between a specialist and a general practitioner without the patient present. This service currently attracts no additional remuneration for either party, but should be expanded as part of a virtual health world.

Telehealth is prone to a ‘woodwork effect’ -- where demand comes out of the woodwork when a new benefit is available.²⁷⁶ The risks of over-servicing,²⁷⁷ misuse by some providers with predatory business models,²⁷⁸ and fraud are real,²⁷⁹ but the benefits of telehealth are undeniable. However, especially in the context of increasing prevalence of chronic disease, telehealth items should enhance continuity of care,²⁸⁰ which benefits

patients and reduces costs,²⁸¹ and not further fragment the primary care system.

New telehealth items ought to have been introduced long ago. It is a tragedy that it took a pandemic to get the policy ball rolling. The issue becomes how to ensure new items are not abused; for that reason, the COVID-19 items may not be suitable for the new normal.

The Australian College of Rural and Remote Medicine has published a set of standards which could be used as a basis for developing revised items.²⁸² These standards include 11 core principles, one of which is:

The integrity and therapeutic value of the relationship between client and health care practitioner should be maintained and not diminished by the use of telehealth technology. Telehealth must enhance the existing clinician patient relationship (not fragment it). Telehealth arrangements should complement existing services (where available), build on rural workforce and referral patterns to avoid further service fragmentation, and address practicalities of coordination, scheduling and support from the patient’s perspective to improve their continuity of care.

²⁷⁴ Velasquez and Mehrotra (2020).

²⁷⁵ Fera, *et al.* (2020)

²⁷⁶ Sprague (2014).

²⁷⁷ Viney and Haas (1998); Van Gool, *et al.* (2002).

²⁷⁸ Knibbs (2020a); Knibbs (2020b)

²⁷⁹ United States. Department of Justice (2019); United States. Department of Health and Human Services. Office of Inspector General (2018); Faux and Grain (2020).Rajda and Paz (2019)

²⁸⁰ Including continuity of care between medical practitioners and pharmacists

²⁸¹ Pereira Gray, *et al.* (2018); Bazemore, *et al.* (2018)

²⁸² Australian College of Rural and Remote Medicine (2020).

Although framed for rural and remote practise, this principle is relevant to telehealth delivery anywhere. In line with that principle, specifically that telehealth ‘must enhance the existing clinician patient relationship’, new telehealth items should be limited to patients with an established relationship to a practice such as having at least half of their primary care visits in the past year being to that practice.²⁸³ In the case of people over the age of 70, telehealth should be limited to the practice in which the patient is enrolled.²⁸⁴

The current items specify that telephone consultations are supposed to happen only if video is not available. Yet during the pandemic telehealth, at least in general practice, was primarily by telephone. After the pandemic, it may be appropriate for a limit to be imposed so that no more than half of a practice’s telehealth consultations are by telephone but such a limit should await evidence as to the most beneficial balance for patients and providers.²⁸⁵ Telehealth items should be bulk-billed, and subject to strict electronic verification requirements.²⁸⁶

During the pandemic the structuring of the telehealth items mirrored face-to-face items. In the new normal there might be quite different tiering, splitting the standard consultation item into

two or three items as there can be more accurate automatic verification of consultation length.

Telehealth is particularly useful in mental health care.²⁸⁷ Unfortunately, during the pandemic spatial isolation often converted into social isolation, and this created anxiety and psychological distress for many.²⁸⁸ After the pandemic, there will be a surge in demand for mental health services,²⁸⁹ and this will put still more pressure on an already overloaded mental health system.²⁹⁰ As with primary care, new technologies may help meet this future demand.²⁹¹

Telehealth may have perverse effects too. Although a boon for rural and remote patients, if wider access to telehealth reduces viability – or trust in – specialists who are based in regional centres it may be a net negative. Policies which limit telehealth access in a way which promotes continuity of care may reduce the risk to rural specialty practice.

²⁸³ Practices should be able to contract with specialist telehealth providers for out-of-hours care, and it may also be appropriate to allow practice nurses to provide telehealth services for the practice.

²⁸⁴ In England all patients need to enrol with a general practice. The current payment contract between the NHS and general practice requires a phased expansion of telehealth including that at least one quarter of consultations should be digitally – and this before the pandemic see Iacobucci (2019)

²⁸⁵ Outcome Health (2020b) proposed a system-wide target of 50 per cent of telehealth consultations to use video by 2021.

²⁸⁶ Faux and Grain (2020). Anecdotal evidence suggests telehealth is more efficient for providers, including by reducing no-shows.

²⁸⁷ This section draws on Hickie and Duckett (2020).

²⁸⁸ Australian Bureau of Statistics (2020); Biddle, *et al.* (2020).

²⁸⁹ Reger, *et al.* (2020); Outcome Health (2020a); Brown, *et al.* (2020). Torjesen (2020)

²⁹⁰ Duckett and Swerissen (2020).

²⁹¹ Torous, *et al.* (2020).

5.2 Encouraging outreach and telehealth with new primary care funding models

Australia has taken the first hesitant steps towards new primary medical care funding arrangements, with an enrolment fee for people aged 70+ announced in the 2019 Budget.²⁹² More steps should be taken, to improve the continuity of patient care.

During the pandemic, staff in some Victorian community health centres made more 'outreach' phone calls to vulnerable patients, to motivate and encourage them, and to advise them on how to manage their condition.²⁹³ This type of practice should be encouraged and facilitated with a new funding model.

Australia's GP fee-for-service funding approach inhibits new practice models.²⁹⁴ Australia still has a very doctor-centric primary care system, reinforced by our Medicare system, based as it is on fee-for-service remuneration principally of medical practitioners. This puts barriers in the way of practices using staff from other professions as part of the treatment team.

There was an important contrast between the testing strategies in England compared to Australia in the early stages of the pandemic.²⁹⁵ Nurse-led drive-through testing was established in London more than a fortnight before an equivalent strategy was adopted in Australia. The UK response was possible only

because of a systematic strategy over years to focus GP time on patients who most require the diagnostic and treatment skills of a GP, and to encourage the community to seek advice about when a visit to a GP was really necessary.

Minimising GP visits is not a good business proposition for private GPs in Australia, because they get paid on a fee-for-service basis: the more patients through the door, the more revenue for the practice. But minimising GP visits makes a lot of sense in the UK, where the payment system for GPs is more sophisticated: they are paid an overall fee to manage a patient's care plan.

Payment strategies which encourage the most appropriate health professional to be involved in the care are required before practices can start to redesign their workflows.

Using nurses and other staff to help plan the care of patients with chronic conditions can improve patient care and increase system efficiency.²⁹⁶ Using non-specialist health workers, supported by digital technology, could also improve the care of people with mental health problems.²⁹⁷

The Commonwealth Government should review the barriers in the Medicare Benefit Schedule to practices forming their workforce to ensure they deliver high-quality care more efficiently.

²⁹² Durham (2019).

²⁹³ Innovative ways to provide alcohol and drug services were also required Dunlop, *et al.* (2020)

²⁹⁴ Duckett, *et al.* (2013).

²⁹⁵ This section draws on Duckett (2020a).

²⁹⁶ Vasi, *et al.* (2020).

²⁹⁷ Naslund, *et al.* (2019).

Funding needs to move from the fee-for-service model towards a ‘blended’ model that combines fee-for-service, capitation, and commissioning for primary care.²⁹⁸ The overarching framework for agreements should be negotiated between the Commonwealth and the profession. Agreements for individual practices should be negotiated and monitored by Primary Health Networks on behalf of local regions and communities.

Of course, changing funding arrangements is notoriously difficult – after all, every dollar of health expenditure is a dollar of income.²⁹⁹ But the widespread public support for some of the changes during the pandemic may give governments the spine and cover to push ahead with change.³⁰⁰

5.3 Improving convenience and access with expanded out-of-hospital care

New ‘virtual hospitals’ were planned as part of the pandemic response.³⁰¹ A huge variety of telehealth and telemonitoring approaches were introduced very rapidly.³⁰² In this section we argue that all this should become part of a new ‘business as usual’.

²⁹⁸ Oliver-Baxter (2015).

²⁹⁹ Reinhardt (2012).

³⁰⁰ This discussion has been about primary care. However, public hospitals should make it easier for outpatient consultations, especially follow-up consultations, to be provided by telehealth. Post-surgery follow-up by telehealth has been shown to be safe and effective, provide significant savings to patients and health care systems, and be acceptable to both patients and providers. For more on outpatient reform see Duckett (2020c).

Hospital-in-the-home is a well-established and effective alternative to in-patient care for many conditions.³⁰³ Rehabilitation in the home, or as an out-patient, has been shown to be just as effective as in-patient rehabilitation for appropriately selected patients.³⁰⁴

COVID-19 had a very significant impact on residential care, accounting for about 30 per cent of deaths in Australia and 30 – 50 per cent world-wide. The pandemic caused many nursing homes (residential aged care facilities) to go into lock-down and reduce visitors and transfers in and out for hospital care. There is now well-established evidence of the benefits of hospitals providing additional support to residential aged care facilities, including via telehealth,³⁰⁵ to reduce the number of hospital admissions.³⁰⁶

States should expand hospital-in-the-home and rehabilitation-in-the-home services, and outreach into residential aged care facilities.³⁰⁷ States with plans to expand public hospital bricks and mortar should review those to assess to what extent out-of-hospital and telehealth expansion might obviate the need for some of these builds.

³⁰¹ Mannix (2020); Sweet (2020).

³⁰² Wosik, *et al.* (2020).

³⁰³ Caplan, *et al.* (2012); Kansagara, *et al.* (2016).

³⁰⁴ Schilling, *et al.* (2018).

³⁰⁵ Hui, *et al.* (2001).

³⁰⁶ Chan, *et al.* (2018); Testa, *et al.* (2019); Carter, *et al.* (2019).

³⁰⁷ Importantly, hospital in the home services may need to be tailored to be culturally appropriate for all communities: Brett *et al.* (2017).

Telemonitoring is an important aspect of hospital-in-the-home.³⁰⁸ It reduces costs,³⁰⁹ and appears not to reduce quality of care for the most vulnerable.³¹⁰

More telemonitoring will require viable business models, either through new Medicare Benefit Schedule items, again perhaps linked to enrolled patients, or as part of hospital outreach, with costs shared between the Commonwealth and states under public hospital funding arrangements, as a non-admitted service.³¹¹

5.4 Improving efficiency by connecting public and private and managing elective procedures better

Public hospitals were transformed during the pandemic as they responded to an anticipated tsunami of demand.³¹² Beds were freed up as a near total shutdown of elective procedures was ordered. This latter strategy increased average total waiting times for surgery, and created a 'care debt' of delayed procedures, most of which will need to be performed in the future. This section discusses how this 'care debt' may be addressed.

Using private hospitals better

The private hospital system took a battering during the pandemic. Private hospitals were effectively closed for a month, and their viability may be under pressure. But the pandemic showed that it was possible to integrate public and private. Every

state and territory negotiated contracts for private hospitals to provide 'overflow' care in case public hospitals were overwhelmed.

Unemployment has risen, which may cause people to reflect on whether they can afford to maintain their private health insurance. Funds' cash position has been improved by the slow-down in elective procedures, and in visits to health professionals covered by general (extras) insurance. But if younger people, hit hard by increased unemployment, decide to drop their insurance, the industry's 'death spiral' will accelerate.³¹³ Fewer people insured will mean less demand for private hospitals from private patients.

States should consider negotiating long-term contracts with private hospitals, so that procedures can be performed in these hospitals to help clear the elective surgery backlog. States should also consider this strategy to meet future demand for elective procedures.

Managing demand for elective procedures

If there is to be increased public contracting of private care, it needs to be equitably managed.

A properly managed elective procedures system should have three key elements:

³¹⁰ Jennett, *et al.* (2003).

³¹¹ For example, as a 'clinical monitoring service'.

³¹² This section draws on Duckett (2020b).

³¹³ Duckett and Nemet (2019a); Duckett and Cowgill (2019).

³⁰⁹ Michaud, *et al.* (2018).

- there should be a consistent process for assessing a patient's need for the procedure, and ranking that patient's priority against others;
- the team performing the procedure, and caring for the patient afterwards, should be highly experienced in the procedure; and
- the procedure should be performed at an efficient hospital or other facility, so the cost to the health system is as low as possible.

Unfortunately, Australia sometimes fails on all three measures.

There is no consistent assessment process across hospitals. Even different surgeons in the same hospital seeing the same patient sometimes make different recommendations about the need for a procedure. This means a patient lucky enough to be seen by surgeon A may be assigned to category 2, but the same patient seen by surgeon B might be assigned to category 3 and so have to wait longer. A patient's gender or level of education sometimes seems to have an inappropriate effect on categorisation decisions.³¹⁴

Assessment is a core skill of specialists and there will always be legitimate variation in recommendations for treatment to take

account the individual circumstances of each patient. However, the point here is to ensure that variations in assessment and prioritisation reflect patient-specific factors and are evidence-based.

States should develop agreed assessment processes for high-volume procedures, such as knee and hip replacements and cataract operations, and reassess all patients on hospital waiting lists. Reassessment could be done remotely using telehealth.

Standardised care paths improve care and equity

Specialists in each area should be invited to develop evidence-based criteria for setting priorities and for developing agreed care paths.³¹⁵ The care paths should cover pre-surgery care (e.g. what diagnostic tests should be done, what non-surgical treatments should be tried before the procedure),³¹⁶ and post-surgery care both in-hospital and at home.³¹⁷ Standardised care paths, such as the New South Wales Agency for Clinical Innovation's Osteoarthritis Chronic Care Program³¹⁸ have been shown to lead to better outcomes and reduced admission rates.³¹⁹

A substantial proportion of patients in even the most specialised medical centres can be treated according to a standardised care path.³²⁰ Care paths should be developed by multidisciplinary

³¹⁴ Smirthwaite, *et al.* (2016).

³¹⁵ Referring clinicians should also be consulted to help build support for a centralised system Breton, *et al.* (2020)

³¹⁶ Schoch and Adair (2012); Stute, *et al.* (2018); Glasgow, *et al.* (2020).

³¹⁷ Care paths should also specify who might do what as part of workforce reform, see Erhun, *et al.* (2020).

³¹⁸ New South Wales. Agency for Clinical Innovation (2020)

³¹⁹ Deloitte Access Economics (2014)

³²⁰ Cook, *et al.* (2014).

teams, to ensure non-medical treatments are appropriately considered.³²¹

Private health insurers should be empowered to participate in funding diversion options, so patients are able to have their rehabilitation at home rather than in a hospital bed.³²²

A new, coordinated, single waiting list priority system in each state would enable all patients to know where they stand.³²³ A patient on the top of the list would be offered the first available place, regardless of whether it was closest to their home. They could refuse the offer, without losing their place in the queue, if they wanted to wait for a closer location of to be treated by a team that they have a relationship with.³²⁴ Queueing theory suggests that a single waiting list will lead to shorter average waiting times overall.³²⁵ And 'single-entry' models appear to improve patient care.³²⁶

The single waiting list should include both regional and metropolitan patients, to ensure as much as possible that city patients do not get faster treatment than people in regional and remote areas, or vice versa. The system should be further centralised in metropolitan areas. The full range of elective procedures should not be re-established in every hospital.³²⁷ Some surgeons would need to be offered new appointments if

elective surgery in their specialty was no longer being performed at the hospital where they previously had their main appointment.

Patients with private health insurance can opt to be treated as a private patient in a public hospital. So the waiting list should include public and private patients, to prevent private patients gaining faster admission to public hospitals.

5.5 Improving health system readiness by better planning

Australia's health system preparedness was put to the test during the COVID-19 pandemic. Despite Australia's largely successful response to the pandemic to date, the crisis has exposed some key weaknesses in governance, capacity, surveillance, and post-pandemic planning.

5.5.1 Governance

Australia's pandemic preparedness regime – at a national and local level, and across health and non-health sectors (see Chapter 1) – helped guide Australia's response to the COVID-19 crisis. But some of the arrangements made and decisions taken were outside Australia's existing pandemic preparedness plans, because the existing regime did not adequately address the scale of the crisis. This meant the governance approach tended to be

³²¹ Standardised care paths would also help ensure smoother transition from primary care (general practice) to secondary care (hospitals) and back again.

³²² Duckett and Nemet (2019b).

³²³ A similar proposal has been advanced for Canada, termed a 'single entry model', see Urbach and Martin (2020).

³²⁴ Or a particular surgeon or medical proceduralist if they are to be treated privately.

³²⁵ Breton, *et al.* (2020)

³²⁶ Damani, *et al.* (2017).

³²⁷ We have discussed the benefits of concentrating procedures in high volume centres in a previous report Duckett and Nemet (2019b)

reactive, and this contributed to mixed messaging (see Chapter 2) and a slower-than-ideal government response.

The *Australian Health Management Plan for Pandemic Influenza*,³²⁸ most recently revised in 2019, did not contemplate the scale of the COVID-19 pandemic. The operational plan included a simplistic phased response (Initial Action Stage, Targeted Action Stage, and Stand-down Stage), which did not include the possibility of harsh measures such as international border closures, or mandatory self-isolation and quarantining of individuals. The plan assumed a ‘business as usual’ approach to governance, designating the Council of Australian Governments (COAG) to lead national cooperation. Instead, the Prime Minister created the novel ‘National Cabinet’ during the peak of the COVID-19 crisis, to enable a nimbler national response.

The *Australian Health Sector Emergency Response Plan for COVID-19*,³²⁹ released in February 2020, was adapted from the 2019 *Australian Health Management Plan for Pandemic Influenza*. But the 2020 plan was less comprehensive than the 2019 plan and failed to take account of the different constitutional responsibilities of the Commonwealth Government and the states.

Reviews of the responses to the pandemic have already been established by the Senate and several state parliaments. The shortcomings of the initial governance approaches to the COVID-19 pandemic will be considered in those reviews identifying lessons learned into Australia’s pandemic preparedness arrangements for the future.

³²⁸ Department of Health (2019b).

³²⁹ Department of Health (2020b).

5.5.2 Capacity

State governments took significant steps to reduce demand on, and increase capacity in, the health system during the crisis. Governments suspended non-urgent elective surgeries and prepared to partner with private hospitals. Specific primary care practices were designated as COVID clinics, albeit slowly, to protect health workers and ensure routine health services could continue. State public health units were quickly expanded to enable comprehensive testing and widespread contact tracing (e.g. in Victoria, the contact tracing team was increased from 57 people to 1000 people).³³⁰

But the pandemic exposed the Commonwealth Government’s inability to quickly increase health system capacity. State governments have boots-on-the-ground capability that enables them to quickly boost capacity; the Commonwealth Government does not. The Commonwealth announced on 11 March that it would establish 100 GP testing clinics (in addition to state testing clinics). But these clinics were not fully operational until two months later, after the crisis had peaked.

As highlighted in Section 2.2.1, the National Medical Stockpile did not have adequate supplies,³³¹ and governments were too slow to secure additional personal protective equipment (PPE) and testing kits. As a consequence, there was a temporary shortage in supply of testing kits and PPE during the peak of the crisis, hampering the health system’s capabilities.

³³⁰ Preiss and McMillan (2020)

³³¹ Senate. Select Committee on COVID-19 (2020); McCauley (2020)

Governments were also slow to boost the number of intensive care units (ICUs), despite exponential growth in case numbers and clear projections that ICUs could be overwhelmed in the absence of tight lockdowns.³³² By the time ICU capacity was significantly increased, case numbers had begun to decline and so the additional capacity has not been used.³³³

Governments struck problems when trying to acquire more ventilators and PPE, substantially increase clinical and nursing staff, and quickly boost supplies of medications.³³⁴

The health system's ability to boost capacity quickly in a crisis is becoming increasingly important.³³⁵ Not only are the risks of pandemics potentially increasing (see Section 1.1), but there are increased health risks from droughts, heatwaves, bushfires, floods, and other natural disasters, exacerbated by climate change.³³⁶

Australia needs better public health planning, with clear roles and responsibilities for the Commonwealth and state governments. In particular, states need to review their ICU strategies to prepare for

surges in demand.³³⁷ These strategies should include plans for rapid access to PPE supplies through improved supply chains (see Section 5.6). A workforce strategy should enable quicker training of health workers, potential quick regulatory changes to create a surge workforce, allow students to be brought into the workforce early or allow expanded scopes of practise,³³⁸ and deployment of workers from less-affected regions.

5.5.3 Surveillance

The pandemic exposed weaknesses in Australia's disease reporting system. Through the first few months of the crisis, each state government operated independently when collecting and reporting on confirmed COVID-19 cases.

Australia's preparedness regime should include a national surveillance strategy for the collection, analysis, and reporting of data at a national level.³³⁹ Quick and accurate reporting of data would help decision makers, improve testing regimes, and provide clearer information to the community.

³³² This problem has been noted for a long time. It was highlighted, for example, in a 2004 Australian Government research paper on Australia's capacity to respond to an infectious disease outbreak: Brew and Burton (2004).

³³³ Similarly, many hospitals continued to hold beds and staff available for a surge of admissions well after lock-down restrictions were being lifted.

³³⁴ Litton et al. (2020).

³³⁵ Or to prioritise necessary activity. We have discussed in a previous report the issue of low-value care Duckett, *et al.* (2015).

³³⁶ CSIRO and Bureau of Meteorology (2018). See also Duckett, *et al.* (2014), Section 1.6.

³³⁷ This was also recommended in the review of Australia's health sector response to pandemic (H1N1) 2009. It recommended that governments develop a health sector surge capacity strategy to address the anticipated increase in demand for health services during a pandemic, and the need to sustain provision for long periods: Department of Health and Ageing (2011). See also: Litton et al. (2020).

³³⁸ Tonkin and Fletcher (2020).

³³⁹ This was also recommended in the review of Australia's health sector response to pandemic (H1N1) 2009 (recommendation 8): Department of Health and Ageing (2011).

5.5.4 Post-pandemic planning

Australia's pandemic preparedness regime fails to recognise that the end-state is not 'back to normal', but a 'new normal'. The secondary health effects of a pandemic, such as mental health and alcohol and drug use effects, should be incorporated into pre-pandemic planning. The final stage of a pandemic plan should not be 'stand down' but should incorporate management of these conditions which arise during and after the immediate crisis.

5.5.5 Public health preparedness lessons

Australia needs to review its public health preparedness, to ensure the lessons learned from this pandemic are embedded in national and state health emergency planning. This will ensure a better response to any potential second-wave outbreak of COVID-19 infections, and to any future outbreak of a new infectious disease or other crisis events. Australia's preparedness regime should ensure sufficient flexibility to enable the response to be adapted to the specific nature of any future crisis.³⁴⁰

³⁴⁰ This was a key recommendation in the review of Australia's health sector response to pandemic (H1N1) 2009 (recommendation 1): Department of Health and Ageing (2011).

³⁴¹ Whoriskey (2009).

³⁴² Betcheva, *et al.* (2020).

5.6 Increasing the resilience of the health system through supply chain reform

The pandemic created shortages of essential equipment as supply chains fractured. In this section we propose supply chain reforms to tackle the identified problems.

The supply chain mantra for the past few decades has been 'just-in-time'. The most efficient supply chain was thought to be where no -- or close to no -- stock was held by the company, and deliveries would be made if and when new stock was required.

But the just-in-time strategy assumes a resilient supply chain and, with many products sourced from China, this proved not to be the case during the pandemic. COVID-19 exposed the 'interlocking fragility of globalisation',³⁴¹ as production and delivery times grew longer and a global surge in demand increased competition for critical items such as personal protective equipment.³⁴²

Building supply chain resilience does not mean abandoning the just-in-time strategy, but it does require more attention to the risks of not holding stock,³⁴³ and to building organisational resilience to be able to manage supply chain risks.³⁴⁴ State supply agencies should review the vulnerability of their supply chains and build 'intrinsic' resilience by making the demand side of the chain more sustainable.³⁴⁵

³⁴³ Balancing the cost of holding stock against the cost of smaller, more frequent orders, Duckett (1987).

³⁴⁴ ShakirUllah, *et al.* (2016).

³⁴⁵ Briano, *et al.* (2009); Sáenz and Revilla (2014).

Building a more really resilient supply chain will involve a combination of strategies, including:

- giving a greater price premium to local supply and manufacture;³⁴⁶
- rewriting contracts to increase obligations on suppliers to ensure continuity of supply;³⁴⁷
- increasing product standardisation across the health system to allow easier substitution of products and to reduce the cost of inventory;³⁴⁸
- increasing flexibility by spreading the supply chain across more than one supplier;³⁴⁹
- ensuring that the national stockpile is reviewed regularly to ensure it contains the right mix of products (for example, the Australian stockpile at the start of the pandemic included masks but not gowns).

A resilient supply chain also needs skilled procurement offices that can quickly establish links to alternative sources of supply if the supply chain breaks.³⁵⁰

³⁴⁶ We are not recommending that the old ‘defence industries argument’ for tariff protection Corden (1958). Australia’s supply chain will always involve significant reliance on imports, especially from the United States McVicar and Iles (2020).

³⁴⁷ The New Zealand pharmaceuticals and prosthesis purchaser, PHARMAC, has adopted this strategy.

³⁴⁸ Sheffi (2005).

5.7 Bringing it all together with integrated regional planning and system management

Australia’s health care system worked differently during the pandemic. Ossified structures and processes were swept away when it became clear that without dramatic action, hospitals would have been overwhelmed by mid-April.³⁵¹ Vested interests lost a lot of their power and a new era of Commonwealth-state relations dawned as the national interest trumped petty squabbling.³⁵²

In this section we propose reforms to Australia’s dysfunctional federal system to improved on-the-ground coordination.

The upgrading of the meeting between the Prime Minister and state and territory leaders – from a fractious talkfest convened at the whim of the Prime Minister and known as COAG (the Council of Australian Governments), to a ‘national cabinet’ meeting at least once a week – was a critical advance.

Constitutional responsibility for dealing with the pandemic is split between the Commonwealth – essentially responsible for border control including international quarantine, the economy, and taking a lead on primary care – and the states and territories, responsible for public health including lockdown rules, emergency management, and management of public hospitals and schools.

³⁴⁹ Ibid.

³⁵⁰ The Commonwealth Department of Health replied on a private group to procure additional testing kits during a pandemic.

³⁵¹ Duckett and Mackey (2020).

³⁵² This section draws on Duckett (2020 (in press)).

The national cabinet was therefore essential if there were to be even a semblance of consistency across the country.

Under normal circumstances, the Commonwealth uses its greater fiscal power to push its agenda. Commonwealth ministers can and did opine at length about what the lockdown provisions ought to be, or whether schools should open, but the decision makers on both of these critical issues were state and territory leaders accountable to their own electorates. This is despite the Commonwealth's declaring a state of emergency under its *Biosecurity Act*.³⁵³ If the Prime Minister and Commonwealth ministers were to exercise any influence, a structured forum needed to be created, and it was.

National cabinet may have worked so well because it was a meeting of equals, each with their sovereign responsibilities, with the state and territory leaders not mere supplicants looking for Commonwealth largess.

The pandemic also highlighted a consequence of the development of a 'market state', at the national level.³⁵⁴ As a consequence of this hollowing out of direct service delivery and the mantra of 'steering not rowing',³⁵⁵ the Commonwealth Department of Health operates primarily to fund states or private businesses – it performs almost no direct service delivery and it has only limited capacity to coordinate local activity. During the

pandemic it used the Primary Health Networks as local coordinating agencies, including for distributing masks, but the PHNs are intentionally small and operate as 'commissioning' rather than delivery agencies.

In contrast, the states and territories run things, most notably public hospitals. They have public health staff who could be deployed to perform contact tracing. The states and territories quickly mobilised their services to respond to the pandemic. They were quicker than the Commonwealth to establish new testing and treatment clinics and reprioritise hospital work.

The contrast between the Commonwealth – which relies on markets to effect its policy objectives – and states - which have more hierarchical relationships with public hospitals – was stark.³⁵⁶ When asked to jump by states, public hospitals said how high? When the Commonwealth asked services to jump, the response was often how much will you pay me?³⁵⁷

This difference in broad strategy and favoured modes of interacting hindered the speed with which the Commonwealth could respond on the ground to the new health care challenge compared to the states.

A grand realignment of responsibilities of the Commonwealth and states is regularly proposed but it patently has not been achieved.

³⁵³ The powers of that Act are constrained to be within the areas of Commonwealth responsibility in the Constitution. The Commonwealth Minister made only two declarations using his emergency powers under the *Biosecurity Act*, one relating to a ban on cruise ships and the other on overseas travel. See Maclean and Elphick (2020).

³⁵⁴ Robison (2006); Knafo, *et al.* (2019); Knafo (2019).

³⁵⁵ Osborne and Gaebler (1992).

³⁵⁶ For a discussion of the benefits of markets compared to hierarchies see the work of Nobel Laureate Oliver Williamson e.g. Williamson (1975).

³⁵⁷ Le Grand (2020).

In its absence, PHNs play a role in integrating regional planning and system management.

There is currently little regional planning and coordination of primary care services, even for services funded under programmatic rather than fee-for-service funding. Where the Commonwealth funds agencies, it does so in tightly defined 'silos'. State-funded services have to adapt whenever a new Commonwealth silo is created. There is no agreed policy framework between the Commonwealth and the states for the range, scope, and eligibility of primary care services, nor for their funding and regulation or governance and management.

It is common for both levels of government to fund the same service types for the same populations, with little reference to one another. Community mental health services, alcohol and drug services, community health services, and general practices are required adhere to different service models, funding arrangements, and accountability and reporting requirements. This leads to confusion, duplication, and inefficiency, and creates gaps which people in need fall through.

There is no overarching set of agreements between the states and territories to define the role of PHNs. PHNs have limited budgets, authority, and capacity to plan, coordinate, and influence the development of primary care. As a result, in practice, the primary care system is largely unmanaged.

This needs to change. The good news is that some of the architecture required is already in place.³⁵⁸ Both levels of

government are committed to bilateral agreements to improve care and reduce hospital admissions for people with complex and chronic conditions. The states have agreed to work with the Commonwealth in selected regions on issues such as planning, coordination, information sharing, education, and pooled funding. Initiatives to improve primary care have already begun in some states. These arrangements need to be supplemented by an overarching policy that pulls the Commonwealth and pushes the states towards improvement in every part of Australia.

Primary care agreements should be struck between the Commonwealth and each state. Agreements should specify the investment the Commonwealth and the state will make to improve primary care for patients. Targets for reducing hospital admissions should be set. Performance should be monitored and the Commonwealth, the state, and the PHN held accountable for progress.

As part of the new Commonwealth-state agreements, specific tripartite agreements should be struck with every PHN around Australia. These should specify funding and results targets, and commit the Commonwealth, the state, and the PHN to specific local system changes to improve patient care and reduce potentially preventable hospital admissions. These tripartite agreements should provide a new basis for cooperation between Commonwealth and state governments, helping to overcome the disjunctions caused by Australia's fractured federalism.

PHNs have played a central role in delivering the Commonwealth's pandemic measures at the local level, but until

³⁵⁸ This section draws on Duckett, *et al.* (2017).

now their importance has not been recognised. In future they will need to be strengthened, more closely integrated with state public health and acute services, and freed from some of the bureaucratic shackles that constrained them before to the pandemic.

6 References

- ABS. (2016, July 12). Statistical Area Level 2 (SA2). Retrieved May 23, 2020, from [https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/bySubject/1270.0.55.001~July 2016~Main Features~Statistical Area Level 2 \(SA2\)~10014](https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/bySubject/1270.0.55.001~July%2016~Main%20Features~Statistical%20Area%20Level%20(SA2)~10014)
- Abubakar, I., Gautret, P., Brunette, G. W., Blumberg, L., Johnson, D., Pomeroy, G., ... Khan, A. S. (2012, January). Global perspectives for prevention of infectious diseases associated with mass gatherings. *The Lancet Infectious Diseases*. [https://doi.org/10.1016/S1473-3099\(11\)70246-8](https://doi.org/10.1016/S1473-3099(11)70246-8)
- Andersen, K. G., Rambaut, A., Ian Lipkin, W., Holmes, E. C., and Garry, R. F. (2020). The proximal origin of SARS-CoV-2. *Nature Medicine*, 26, 450–455. <https://doi.org/10.1038/s41591-020-0820-9>
- Armocida, B., Formenti, B., Ussai, S., Palestra, F., and Missoni, E. (2020). The Italian health system and the COVID-19 challenge. *The Lancet Public Health*, 5, e253. [https://doi.org/10.1016/S2468-2667\(20\)30074-8](https://doi.org/10.1016/S2468-2667(20)30074-8)
- Arons, M. M., Hatfield, K. M., Reddy, S. C., Kimball, A., James, A., Jacobs, J. R., ... Jernigan, J. A. (2020). Presymptomatic SARS-CoV-2 Infections and Transmission in a Skilled Nursing Facility. *New England Journal of Medicine*, NEJMoa2008457. <https://doi.org/10.1056/NEJMoa2008457>
- Australian Institute of Health and Welfare. (2015). *Australian Burden of Disease Study: Impact and causes of illness and death in Australia*. <https://doi.org/10.25816/5ebca2a4fa7dc>
- Backer, J., Klinkenberg, D., and Wallinga, J. (2020). The incubation period of 2019-nCoV infections among travellers from Wuhan, China. *Eurosurveillance*. <https://doi.org/10.1101/2020.01.27.20018986>
- Ball, J. (2020). Expert reaction to questions about COVID-19 and viral load. Retrieved May 20, 2020, from <https://www.sciencemediacentre.org/expert-reaction-to-questions-about-covid-19-and-viral-load/>
- Bar-On, Y. M., Flamholz, A., Phillips, R., and Milo, R. (2020). Sars-cov-2 (Covid-19) by the numbers. *ELife*, 9. <https://doi.org/10.7554/eLife.57309>
- Bartoszko, J. J., Farooqi, M. A. M., Alhazzani, W., and Loeb, M. (2020). Medical masks vs N95 respirators for preventing COVID-19 in healthcare workers: A systematic review and meta-analysis of randomized trials. *Influenza and Other Respiratory Viruses*, irv.12745. <https://doi.org/10.1111/irv.12745>
- Bi, Q., Wu, Y. Y., Mei, S., Ye, C., Zou, X., Zhang, Z., ... Feng, T. (2020). Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: a retrospective cohort study. *The Lancet Infectious Diseases*. [https://doi.org/10.1016/S1473-3099\(20\)30287-5](https://doi.org/10.1016/S1473-3099(20)30287-5)
- Booth, T. F., Kournikakis, B., Bastien, N., Ho, J., Kobasa, D., Stadnyk, L., ... Plummer, F. (2005). Detection of Airborne Severe Acute Respiratory Syndrome (SARS) Coronavirus and Environmental Contamination in SARS Outbreak Units. *The Journal of Infectious Diseases*, 191(9), 1472–1477. <https://doi.org/10.1086/429634>

- Bourouiba, L. (2020, March 26). Turbulent Gas Clouds and Respiratory Pathogen Emissions: Potential Implications for Reducing Transmission of COVID-19. *JAMA - Journal of the American Medical Association*. American Medical Association. <https://doi.org/10.1001/jama.2020.4756>
- Brett, J., Dawson, A., Ivers, R., Lawrence, L., Barclay, S., and Conigrave, K. (2017). Healing at Home: Developing a Model for Ambulatory Alcohol “Detox” in an Aboriginal Community Controlled Health Service. *Faculty of Science, Medicine and Health - Papers: Part A*. <https://doi.org/10.18357/ijih11201716906>
- Brew, N., and Burton, K. (2004). *Critical but stable: Australia’s capacity to respond to an infectious disease outbreak*. Parliament of Australia. Retrieved from https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/pubs/rp/rp0405/05rp03
- Britton, T., Ball, F., and Trapman, P. (2020). The disease-induced herd immunity level for Covid-19 is substantially lower than the classical herd immunity level. *Cornell University*. Retrieved from <http://arxiv.org/abs/2005.03085>
- Caly, L., Druce, J., Roberts, J., Bond, K., Tran, T., Kostecki, R., ... Catton, M. G. (2020). Isolation and rapid sharing of the 2019 novel coronavirus (SAR-CoV-2) from the first patient diagnosed with COVID-19 in Australia. *Medical Journal of Australia*, 212(10), 459–462. <https://doi.org/10.5694/mja2.50569>
- Cameron, E. E., Nuzzo, J. B., and Bell, J. A. (2019). *GHS Index: Global Health Security Index*. Retrieved from <https://www.ghsindex.org/wp-content/uploads/2019/10/2019-Global-Health-Security-Index.pdf>
- Cauchemez, S., Valleron, A. J., Boëlle, P. Y., Flahault, A., and Ferguson, N. M. (2008). Estimating the impact of school closure on influenza transmission from Sentinel data. *Nature*, 452(7188), 750–754. <https://doi.org/10.1038/nature06732>
- CDC COVID-19 Response Team. (2020). *Coronavirus Disease 2019 in Children — United States, February 12–April 2, 2020*. Atlanta. Retrieved from <https://www.cdc.gov/coronavirus/2019-ncov/downloads/pui-form.pdf>.
- Center for Disease Control and Prevention. (2020a). Measures of Risk. Retrieved May 19, 2020, from <https://www.cdc.gov/csels/dsepd/ss1978/lesson3/section2.html>
- Center for Disease Control and Prevention. (2020b). Serology Testing for COVID-19 at CDC. Retrieved May 23, 2020, from <https://www.cdc.gov/coronavirus/2019-ncov/lab/serology-testing.html>
- Centers for Disease Control and Prevention. (2017, December 6). SARS Basics Factsheet. Retrieved June 5, 2020, from <https://www.cdc.gov/sars/about/fs-sars.html>
- Centers for Disease Control and Prevention. (2019). 1918 Pandemic (H1N1 virus). *Centers for Disease Control and Prevention*, 160(12). <https://doi.org/10.1093/aje>
- Chang, S. L., Harding, N., Zachreson, C., Cliff, O. M., and Prokopenko, M. (2020). *Modelling transmission and control of the COVID-19 pandemic in Australia*.
- Cirrincione, L., Plescia, F., Ledda, C., Rapisarda, V., Martorana, D., Moldovan, R. E., ... Cannizzaro, E. (2020). COVID-19 Pandemic: Prevention and protection measures to be adopted at the

- p>workplace.
- Sustainability (Switzerland)*
- , 12(9), 3603.
-
- <https://doi.org/10.3390/SU12093603>
- Coates, B. (2020, March 30). COVID-19: New OECD estimates suggest a 22% hit to Australia's economy. *The Conversation*. Retrieved from <https://grattan.edu.au/news/new-oecd-estimates-suggest-a-22-hit-to-australias-economy/>
- Communicable Diseases Network Australia, and Department of Health. (2020). *Coronavirus Disease 2019 (COVID-19) CDNA National Guidelines for Public Health Units*.
<https://doi.org/10.1101/2020.02.07.937862v1.full.pdf>
- Condit, R. (2020, April 5). Infection Fatality Rate – A Critical Missing Piece for Managing Covid-19. Retrieved May 22, 2020, from <https://www.virology.ws/2020/04/05/infection-fatality-rate-a-critical-missing-piece-for-managing-covid-19/>
- Couch, R. B., Cate, T. R., Douglas, R. G., Gerone, P. J., and Knight, V. (1966). Effect of route of inoculation on experimental respiratory viral disease in volunteers and evidence for airborne transmission. *Bacteriological Reviews*, 30(3), 517–531.
<https://doi.org/10.1128/membr.30.3.517-529.1966>
- Cowling, B. J., Ali, S. T., Ng, T. W. Y., Tsang, T. K., Li, J. C. M., Fong, M. W., ... Leung, G. M. (2020). Impact assessment of non-pharmaceutical interventions against coronavirus disease 2019 and influenza in Hong Kong: an observational study. *The Lancet Public Health*, 5(5), e279–e288. [https://doi.org/10.1016/S2468-2667\(20\)30090-6](https://doi.org/10.1016/S2468-2667(20)30090-6)
- Crooks, K., Casey, D., and Ward, J. S. (2020). First Nations people leading the way in COVID-19 pandemic planning, response and management. *Medical Journal of Australia*.
https://doi.org/10.5694/MJA____
- CSIRO and Bureau of Meteorology. (2018). *State of the Climate 2018*. Retrieved from <http://www.bom.gov.au/state-of-the-climate/>
- Cunningham, M. (2020a, March 19). Coronavirus Australia: Lives at risk as Victorians lie about overseas travel in order to see GPs. *The Sydney Morning Herald*. Retrieved from <https://www.smh.com.au/national/lives-at-risk-as-victorians-lie-about-overseas-travel-in-order-to-see-gps-20200318-p54bdg.html>
- Cunningham, M. (2020b, April 13). Coronavirus Australia: Critically ill patients risk their lives to avoid hospital visits. *The Age*. Retrieved from <https://www.theage.com.au/national/critically-ill-patients-risk-their-lives-to-avoid-hospital-visits-20200413-p54jb3.html>
- Daley, J. (2020, March 20). The case for Endgame C: stop almost everything, restart when coronavirus is gone. *The Conversation*. Retrieved from <https://theconversation.com/the-case-for-endgame-c-stop-almost-everything-restart-when-coronavirus-is-gone-134232>
- Daley, J., and Duckett, S. (2020, April 13). "It's worth a shot": Australia's endgame must be total elimination of COVID-19. *The Sydney Morning Herald*. Retrieved from <https://grattan.edu.au/news/australias-endgame-must-be-total-elimination-of-covid-19/>
- Danis, K., Epaulard, O., Bénét, T., Gaymard, A., Campoy, S., Bothelo-Nevers, E., ... Team, I. (2020). Cluster of coronavirus disease 2019 (Covid-19) in the French Alps, 2020. *Clinical Infectious Diseases*. <https://doi.org/10.1093/cid/ciaa424>
- Dawood, F. S., Iuliano, A. D., Reed, C., Meltzer, M. I., Shay, D. K., Cheng, P. Y., ... Widdowson, M. A. (2012). Estimated global

- mortality associated with the first 12 months of 2009 pandemic influenza A H1N1 virus circulation: A modelling study. *The Lancet Infectious Diseases*, 12(9), 687–695.
[https://doi.org/10.1016/S1473-3099\(12\)70121-4](https://doi.org/10.1016/S1473-3099(12)70121-4)
- Delamater, P. L., Street, E. J., Leslie, T. F., Yang, Y. T., and Jacobsen, K. H. (2019). Complexity of the basic reproduction number (R_0). *Emerging Infectious Diseases*, 25(1), 1–4.
<https://doi.org/10.3201/eid2501.171901>
- Department of Health. (2010). How does a pandemic develop? Retrieved May 12, 2020, from <https://www1.health.gov.au/internet/main/publishing.nsf/Content/about-pandemic-how-develop>
- Department of Health. (2011). History of pandemics. Retrieved May 12, 2020, from <https://www1.health.gov.au/internet/main/publishing.nsf/Content/about-pandemic-history#1918>
- Department of Health. (2019a). *Australian Health Management Plan*. Retrieved from <https://ecdc.europa.eu/en/publications-data/guide-public-health-measures-reduce->
- Department of Health. (2019b). *Australian Health Management Plan for Pandemic Influenza*. Retrieved from [https://www1.health.gov.au/internet/main/publishing.nsf/Content/519F9392797E2DDCCA257D47001B9948/\\$File/w-AHMPPI-2019.PDF](https://www1.health.gov.au/internet/main/publishing.nsf/Content/519F9392797E2DDCCA257D47001B9948/$File/w-AHMPPI-2019.PDF)
- Department of Health. (2020a). Australian COVID-19 cases by source of infection. Retrieved June 2, 2020, from <https://www.health.gov.au/resources/australian-covid-19-cases-by-source-of-infection>
- Department of Health. (2020b). *Australian Health Sector Emergency Response Plan for Novel Coronavirus (COVID-19)*. Retrieved from <https://www.health.gov.au/resources/publications/australian-health-sector-emergency-response-plan-for-novel-coronavirus-covid-19>
- Department of Health. (2020c). *Coronavirus (COVID-19) at a glance for 1 June 2020*.
- Department of Health. (2020d). COVID-19 Temporary MBS Telehealth Services. Retrieved June 2, 2020, from <http://www.mbsonline.gov.au/internet/mbsonline/publishing.nsf/Content/Factsheet-TempBB>
- Department of Health. (2020e). *Modelling the current impact of COVID-19 in Australia*. Retrieved from <https://www.health.gov.au/sites/default/files/documents/2020/04/modelling-the-current-impact-of-covid-19-in-australia.pdf>
- Department of Health. (2020f). *Novel coronavirus (COVID-19) Information for Clinicians: Frequently Asked Questions*. Retrieved from <https://www.health.gov.au/sites/default/files/documents/2020/03/coronavirus-covid-19-information-for-clinicians.pdf>
- Department of Health. (2020g, April 30). Coronavirus at a glance: 30 April 2020. Retrieved June 1, 2020, from <https://www.health.gov.au/sites/default/files/documents/2020/04/coronavirus-covid-19-at-a-glance-30-april-2020.pdf>
- Department of Health. (2020h, May 1). Coronavirus at a glance: 1 May 2020. Retrieved June 1, 2020, from <https://www.health.gov.au/sites/default/files/documents/2020/05/coronavirus-covid-19-at-a-glance-1-may-2020.pdf>

- Department of Health. (2020i, May 22). Current status. Retrieved May 22, 2020, from <https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert>
- Department of Health. (2020j, May 29). Physical distancing for coronavirus (COVID-19). Retrieved May 31, 2020, from <https://www.health.gov.au/news/health-alerts/novel-coronavirus-2019-ncov-health-alert/how-to-protect-yourself-and-others-from-coronavirus-covid-19/physical-distancing-for-coronavirus-covid-19#at-work>
- Department of Health and Ageing. (2011). *Australia's Health Sector Response to Pandemic (H1N1) 2009*. Retrieved from [https://www1.health.gov.au/internet/publications/publishing.nsf/Content/review-2011-l/\\$File/lessons_identified-oct11.pdf](https://www1.health.gov.au/internet/publications/publishing.nsf/Content/review-2011-l/$File/lessons_identified-oct11.pdf)
- Deslandes, A., Berti, V., Tandjaoui-Lambotte, Y., Alloui, C., Carbonnelle, E., Zahar, J. R., ... Cohen, Y. (2020). SARS-CoV-2 was already spreading in France in late December 2019. *International Journal of Antimicrobial Agents*, 106006. <https://doi.org/10.1016/j.ijantimicag.2020.106006>
- DeWitte, S. N. (2014). Mortality risk and survival in the aftermath of the medieval Black Death. *PLoS ONE*, 9(5). <https://doi.org/10.1371/journal.pone.0096513>
- Dickens, B. L., Koo, J. R., Wilder-smith, A., and Cook, A. R. (2020). Institutional, not home-based, isolation could contain the COVID-19 outbreak. *The Lancet*, 6736(20), 1–2. [https://doi.org/10.1016/S0140-6736\(20\)31016-3](https://doi.org/10.1016/S0140-6736(20)31016-3)
- Docherty, A. B., Harrison, E. M., Green, C. A., Hardwick, H. E., Pius, R., Norman, L., ... Semple, M. G. (2020). Features of 16,749 hospitalised UK patients with COVID-19 using the ISARIC WHO Clinical Characterisation Protocol. *MedRxiv*, 2020.04.23.20076042. <https://doi.org/10.1101/2020.04.23.20076042>
- Doelitzsch, C. (2020, March 30). Global study about COVID-19: Dalia assesses how the world ranks their governments' response to the pandemic. *Dalia Research*. Retrieved from <https://daliaresearch.com/blog/dalia-assesses-how-the-world-ranks-their-governments-response-to-covid-19/>
- Dong, Y., Mo, X., and Hu, Y. (2020). Epidemiology of COVID-19 Among Children in China. *Pediatrics*, 145(6), 20200702. <https://doi.org/10.1542/peds.2020-0702>
- Dowdle, W. R. (1998). The principles of disease elimination and eradication. *Bulletin of the World Health Organisation*, 76(2), 23–25. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2305684/pdf/bullwho00391-0020.pdf>
- Duckett, S. (2020a). COVID-19: There are only two options from here. One is more deadly - Grattan Institute. *Australian Financial Review*. Retrieved from <https://grattan.edu.au/news/covid-19-there-are-only-two-options-from-here-one-is-more-deadly/>
- Duckett, S. (2020b, April 30). Why Australia's coronavirus wars have only just begun. *Financial Review*. Retrieved from <https://www.afr.com/politics/federal/why-australia-s-corona-wars-have-only-just-begun-20200430-p54oo1>
- Duckett, S., and Mackey, W. (2020a). How children get and transmit COVID-19 is still a mystery. [https://doi.org/10.1016/S1473-3099\(20\)30236-X](https://doi.org/10.1016/S1473-3099(20)30236-X)
- Duckett, S., and Mackey, W. (2020b, March 24). As more Australians

- get COVID-19, will we have enough hospital beds? Retrieved May 22, 2020, from <https://blog.grattan.edu.au/2020/03/as-more-australians-get-covid-19-will-we-have-enough-hospital-beds/>
- Duckett, S., and Mackey, W. (2020c, April 6). Is the COVID-19 glass half full or half empty? *Grattan Blog*. Retrieved from <https://blog.grattan.edu.au/2020/04/is-the-covid-19-glass-half-full-or-half-empty/>
- Duckett, S., and Mackey, W. (2020d, April 27). Why we've downloaded the COVIDSafe app. *Grattan Blog*. Retrieved from <https://blog.grattan.edu.au/2020/04/why-weve-downloaded-the-covidsafe-app/>
- Duckett, S., Stobart, A., and Mackey, W. (2020, April 1). If coronavirus cases don't grow any faster, our health system will probably cope. *The Conversation*. Retrieved from <https://theconversation.com/if-coronavirus-cases-dont-grow-any-faster-our-health-system-will-probably-cope-135214>
- Ebrahim, S. H., and Memish, Z. A. (2020). COVID-19 – the role of mass gatherings. *Travel Medicine and Infectious Disease*, 34. <https://doi.org/10.1016/j.tmaid.2020.101617>
- Eikenberry, S. E., Mancuso, M., Iboi, E., Phan, T., Eikenberry, K., Kuang, Y., ... Gumel, A. B. (2020). To mask or not to mask: Modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. *Infectious Disease Modelling*, 5, 293–308. <https://doi.org/10.1016/j.idm.2020.04.001>
- Eisenberg, J. (2020, February 5). R0: How scientists quantify the intensity of an outbreak like coronavirus and predict the pandemic's spread. *The Conversation*. <https://doi.org/10.3201/eid2501.171901>
- Emery, J. C., Russell, T. W., Liu, Y., Hellewell, J., Pearson, C. A., working group, -nCoV, ... Quilty, B. J. (2020). The contribution of asymptomatic SARS-CoV-2 infections to transmission - a model-based analysis of the Diamond Princess outbreak. *Preprint*.
- Endo, A., Abbott, S., Kucharski, A. J., and Funk, S. (2020). Estimating the overdispersion in COVID-19 transmission using outbreak sizes outside China. *Wellcome Open Research*, 5, 67. <https://doi.org/10.12688/wellcomeopenres.15842.1>
- Epstein, P. R. (2001, July 1). Climate change and emerging infectious diseases. *Microbes and Infection*. Elsevier Masson SAS. [https://doi.org/10.1016/S1286-4579\(01\)01429-0](https://doi.org/10.1016/S1286-4579(01)01429-0)
- Fan, V., Jamison, D., and Summers, L. (2016). The Inclusive Cost of Pandemic Influenza Risk. *National Bureau of Economic Research*. <https://doi.org/10.3386/w22137>
- Ferguson, N. M., Cummings, D. A. T., Cauchemez, S., Fraser, C., Riley, S., Meeyai, A., ... Burke, D. S. (2005). Strategies for containing an emerging influenza pandemic in Southeast Asia. *Nature*, 437(7056), 209–214. <https://doi.org/10.1038/nature04017>
- Ferguson, N. M., Laydon, D., Nedjati-Gilani, G., Imai, N., Ainslie, K., Baguelin, M., ... Ghani, A. C. (2020). Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. <https://doi.org/10.25561/77482>
- Fineberg, H. V., Andersen, K. G., Bassett, M. T., Bedford, T., Benjamin, G. C., Besser, R. E., ... Walt, D. R. (2020). *Rapid Expert Consultations on the COVID-19 Pandemic: March 14, 2020-April 8, 2020*. Washington. <https://doi.org/10.17226/25784>
- Fogel, D. B. (2018). Factors associated with clinical trials that fail and

- opportunities for improving the likelihood of success: A review. *Contemporary Clinical Trials Communications*, 11, 156–164. <https://doi.org/10.1016/j.conctc.2018.08.001>
- Fong, M. W., Gao, H., Wong, J. Y., Xiao, J., Shiu, E. Y. C., Ryu, S., and Cowling, B. J. (2020). Nonpharmaceutical Measures for Pandemic Influenza in Nonhealthcare Settings-Social Distancing Measures. *Emerging Infectious Diseases*, 26(5), 976–984. <https://doi.org/10.3201/eid2605.190995>
- Frydenberg, J. (2020a, May 3). National Accounts Q&A, Parliament House, Canberra. *Treasurer of the Commonwealth of Australia*. Retrieved from <https://ministers.treasury.gov.au/ministers/josh-frydenberg-2018/transcripts/national-accounts-qa-parliament-house-canberra>
- Frydenberg, J. (2020b, May 5). Address to the National Press Club. *Treasurer of the Commonwealth of Australia*. Retrieved from <https://ministers.treasury.gov.au/ministers/josh-frydenberg-2018/speeches/address-national-press-club>
- Gabriela, M., Gomes, M., Aguas, R., Corder, R. M., King, J. G., Langwig, K. E., ... Penha-Goncalves, C. (2020). Individual variation in susceptibility or exposure to SARS-CoV-2 lowers the herd immunity threshold. *MedRxiv*, 2020.04.27.20081893. <https://doi.org/10.1101/2020.04.27.20081893>
- Geddes, L. (2020). Does a high viral load or infectious dose make covid-19 worse? Retrieved May 20, 2020, from <https://www.newscientist.com/article/2238819-does-a-high-viral-load-or-infectious-dose-make-covid-19-worse/#ixzz6MwwHGhMI>
- Global Preparedness Monitoring Board. (2018). GPMB: About us. Retrieved May 15, 2020, from <https://apps.who.int/gpmb/about.html>
- Global Preparedness Monitoring Board. (2019). *A world at risk: Annual report on global preparedness for health emergencies*. Retrieved from <http://apps.who.int/iris>
- Gopinath, G. (2020, April 20). The Great Lockdown: Worst Economic Downturn Since the Great Depression – IMF Blog. Retrieved May 14, 2020, from <https://blogs.imf.org/2020/04/14/the-great-lockdown-worst-economic-downturn-since-the-great-depression/>
- Gorbalenya, A. E., Baker, S. C., Baric, R. S., de Groot, R. J., Drosten, C., Gulyaeva, A. A., ... Ziebuhr, J. (2020). The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nature Microbiology*, 5(4), 536–544. <https://doi.org/10.1038/s41564-020-0695-z>
- Gruen, D. (2020, May 27). New mortality statistics and other information to measure COVID-19 impacts. Retrieved June 2, 2020, from <https://www.abs.gov.au/websitedbs/d3310114.nsf/home/ABS+Media+Statements+-+New+mortality+statistics+and+other+information+to+measure+COVID-19+impacts>
- Guclu, H., Read, J., Vukotich, C. J., Galloway, D. D., Gao, H., Rainey, J. J., ... Cummings, D. A. T. (2016). Social contact networks and mixing among students in K-12 Schools in Pittsburgh, PA. *PLoS ONE*, 11(3). <https://doi.org/10.1371/journal.pone.0151139>
- Gudbjartsson, D. F., Helgason, A., Jonsson, H., Magnusson, O. T., Melsted, P., Norddahl, G. L., ... Stefansson, K. (2020). Spread of SARS-CoV-2 in the Icelandic Population. *New England Journal of Medicine*, NEJMoa2006100. <https://doi.org/10.1056/NEJMoa2006100>
- Halloran, M. E., Ferguson, N. M., Eubank, S., Longini, I. M., Cummings,

- D. A. T., Lewis, B., ... Cooley, P. (2008). Modeling targeted layered containment of an influenza pandemic in the United States. *Proceedings of the National Academy of Sciences*, 105(12), 4639–4644. <https://doi.org/10.1073/pnas.0706849105>
- He, X., Lau, E. H. Y., Wu, P., Deng, X., Wang, J., Hao, X., ... Leung, G. M. (2020). Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nature Medicine*. <https://doi.org/10.1038/s41591-020-0869-5>
- Hellewell, J., Abbott, S., Gimma, A., Bosse, N. I., Jarvis, C. I., Russell, T. W., ... Eggo, R. M. (2020). Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. *The Lancet Global Health*, 8(4), e488–e496. [https://doi.org/10.1016/S2214-109X\(20\)30074-7](https://doi.org/10.1016/S2214-109X(20)30074-7)
- Hens, N., Ayele, G. M., Goeyvaerts, N., Aerts, M., Mossong, J., Edmunds, J. W., and Beutels, P. (2009). Estimating the impact of school closure on social mixing behaviour and the transmission of close contact infections in eight European countries. *BMC Infectious Diseases*, 9. <https://doi.org/10.1186/1471-2334-9-187>
- Hitch, G. (2020, May 22). JobKeeper numbers cut by 3 million after Federal Government reveals accounting bungle in coronavirus stimulus program. *ABC News*. Retrieved from <https://www.abc.net.au/news/2020-05-22/jobkeeper-numbers-cut-by-3-million-businesses-accounting-bungle/12277488>
- Hollingsworth, T. D., Klinkenberg, D., Heesterbeek, H., and Anderson, R. M. (2011). Mitigation Strategies for Pandemic Influenza A: Balancing Conflicting Policy Objectives. *PLoS Computational Biology*, 7(2), e1001076. <https://doi.org/10.1371/journal.pcbi.1001076>
- Horne, N. (2020, April 2). COVID-19 and parliamentary sittings. *Parliament of Australia*. Retrieved from https://www.aph.gov.au/About_Parliament/Parliamentary_Departments/Parliamentary_Library/FlagPost/2020/April/COVID-19_and_parliamentary_sittings
- Houston, C. (2020, March 25). Coronavirus Australia: COVID-19 infected couple return to Melbourne from Aspen, do not self-isolate. *The Age*. Retrieved from <https://www.theage.com.au/national/victoria/wealthy-couple-return-from-skiing-with-coronavirus-then-do-not-self-isolate-20200325-p54du5.html>
- Howard, J., Huang, A., Li, Z., Tufekci, Z., Zdimal, V., Westhuizen, H.-M. van der, ... Rimoim, A. W. (2020). Face Mask Against COVID-19: An Evidence Review. *British Medical Journal*, (April), 1–8. <https://doi.org/10.20944/preprints202004.0203.v1>
- Hughes, J. M., Wilson, M. E., Pike, B. L., Saylor, K. E., Fair, J. N., Lebreton, M., ... Wolfe, N. D. (2010). The Origin and Prevention of Pandemics. *Emerging Infections*, 50, 1636–1640. <https://doi.org/10.1086/652860>
- Hunt, G. (2020a, January 25). First confirmed case of novel coronavirus in Australia. *Department of Health*. Retrieved from <https://www.health.gov.au/ministers/the-hon-greg-hunt-mp/media/first-confirmed-case-of-novel-coronavirus-in-australia>
- Hunt, G. (2020b, April 20). Australians embrace telehealth to save lives during COVID-19. *Minister for Health Media*. Retrieved from <https://www.greghunt.com.au/australians-embrace-telehealth-to-save-lives-during-covid-19/>
- Hunt, G. (2020c, May 13). Opening of 100th COVID-19 GP-led

- respiratory clinic. *Department of Health*. Retrieved from <https://www.health.gov.au/ministers/the-hon-greg-hunt-mp/media/opening-of-100th-covid-19-gp-led-respiratory-clinic>
- Ing, A. J., Cocks, C., and Green, J. P. (2020). COVID-19: in the footsteps of Ernest Shackleton. *Thorax*, thoraxjnl-2020-215091. <https://doi.org/10.1136/thoraxjnl-2020-215091>
- Jefferson, T., Del Mar, C., Dooley, L., Ferroni, E., Al-Ansary, L. A., Bawazeer, G. A., ... Rivetti, A. (2009). Physical interventions to interrupt or reduce the spread of respiratory viruses: Systematic review. *BMJ (Online)*, 339(7724), 792. <https://doi.org/10.1136/bmj.b3675>
- Jing, Q.-L., Liu, M.-J., Yuan, J., Zhang, Z.-B., Zhang, A.-R., Dean, N. E., ... Yang, Y. (2020). Household Secondary Attack Rate of COVID-19 and Associated Determinants. *MedRxiv*. <https://doi.org/10.1101/2020.04.11.20056010>
- Johns Hopkins Coronavirus Resource Center. (2020). COVID-19 Map. Retrieved June 4, 2020, from <https://coronavirus.jhu.edu/map.html>
- Jones, T. C., Mühlemann, B., Veith, T., Zuchowski, M., Hofmann, J., Stein, A., ... Christian Drosten, P. (2020). *An analysis of SARS-CoV-2 viral load by patient age*.
- Kahn, J. (2020). We've never made a successful vaccine for a coronavirus before. This is why it's so difficult. Retrieved May 7, 2020, from <https://www.abc.net.au/news/health/2020-04-17/coronavirus-vaccine-ian-frazer/12146616>
- Katz, R. (2009). Use of revised international health regulations during influenza A (H1N1) epidemic, 2009. *Emerging Infectious Diseases*, 15(7), 1165. <https://doi.org/10.3201/eid1508.090665>
- Kelly, H. (2011). The classical definition of a pandemic is not elusive. *Bulletin of the World Health Organization*, 89(7), 540–541. <https://doi.org/10.2471/BLT.11.088815>
- Kelly, H., Peck, H. A., Laurie, K. L., Wu, P., Nishiura, H., and Cowling, B. J. (2011). The Age-Specific Cumulative Incidence of Infection with Pandemic Influenza H1N1 2009 Was Similar in Various Countries Prior to Vaccination. *PLoS ONE*, 6(8), e21828. <https://doi.org/10.1371/journal.pone.0021828>
- Kelso, J. K., Milne, G. J., and Kelly, H. (2009). Simulation suggests that rapid activation of social distancing can arrest epidemic development due to a novel strain of influenza. *BMC Public Health*, 9(1), 117. <https://doi.org/10.1186/1471-2458-9-117>
- Kelvin, A. A., and Halperin, S. (2020). COVID-19 in children: the link in the transmission chain. *The Lancet Infectious Diseases*. [https://doi.org/10.1016/S1473-3099\(20\)30236-X](https://doi.org/10.1016/S1473-3099(20)30236-X)
- Kikwete, J. M., Calmy-Rey, M., Amorinm, C., Natalegawa, R. M. M. M., Phumaphi, J., and Shah, R. (2016). Report of the High-Level Panel on the Global Response to Health Crises, 01747(February).
- Knaus, C. (2020, March 17). Coronavirus: Australian doctors report “unacceptable” shortages of protective equipment. *The Guardian*. Retrieved from <https://www.theguardian.com/world/2020/mar/17/coronavirus-australian-doctors-report-unacceptable-shortages-of-protective-equipment>
- Kong, I., Park, Y., Woo, Y., Lee, J., Cha, J., Choi, J., ... Kim, U. (2020). Early epidemiological and clinical characteristics of 28 cases of coronavirus disease in South Korea. *Osong Public Health and Research Perspectives*, (1), 8–14.

- <https://doi.org/10.24171/j.phrp.2020.11.1.03>
- Kucharski, A. J., and Althaus, C. L. (2015). The role of superspreading in middle east respiratory syndrome coronavirus (MERS-CoV) transmission. *Eurosurveillance*, 20(25), 14–18. <https://doi.org/10.2807/1560-7917.ES2015.20.25.21167>
- Kucharski, Adam J, Klepac, P., Conlan, A. J. K., Kissler, S. M., Tang Mmath, M., Fry Phd, H., ... Edmunds, W. J. (2020). *Effectiveness of isolation, testing, contact tracing and physical distancing on reducing transmission of SARS-CoV-2 in different settings: a mathematical modelling study*.
- Kupferschmidt, K. (2020). Why do some COVID-19 patients infect many others, whereas most don't spread the virus at all? *Science*. <https://doi.org/10.1126/science.abc8931>
- Kwok, Y. L. A., Gralton, J., and McLaws, M. L. (2015). Face touching: A frequent habit that has implications for hand hygiene. *American Journal of Infection Control*, 43(2), 112–114. <https://doi.org/10.1016/j.ajic.2014.10.015>
- Lai, J., Ma, S., Wang, Y., Cai, Z., Hu, J., Wei, N., ... Hu, S. (2020). Factors Associated With Mental Health Outcomes Among Health Care Workers Exposed to Coronavirus Disease 2019. *JAMA Network Open*, 3(3), e203976. <https://doi.org/10.1001/jamanetworkopen.2020.3976>
- Lauer, S. A., Grantz, K. H., Bi, Q., Jones, F. K., Zheng, Q., Meredith, H., ... Lessler, J. (2020). The incubation period of 2019-nCoV from publicly reported confirmed cases: estimation and application. *MedRxiv*, 2020.02.02.20020016. <https://doi.org/10.1101/2020.02.02.20020016>
- Lawler, E. (2020, February 10). \$2 Million Immediate Tourism Resilience Plan for the Northern Territory. *Northern Territory Government Newsroom*. Retrieved from <http://newsroom.nt.gov.au/mediaRelease/31959>
- Lazzerini, M., Barbi, E., Apicella, A., Marchetti, F., Cardinale, F., and Trobia, G. (2020). Delayed access or provision of care in Italy resulting from fear of COVID-19. *The Lancet Child and Adolescent Health*, 4(5), e10–e11. [https://doi.org/10.1016/S2352-4642\(20\)30108-5](https://doi.org/10.1016/S2352-4642(20)30108-5)
- Le Grand, C. (2020, May 20). Coronavirus Australia: COVID-19 testing refused by pathology groups at height of pandemic. *The Sydney Morning Herald*. Retrieved from <https://www.smh.com.au/national/pathology-groups-threatened-covid-19-test-ban-at-height-of-pandemic-20200520-p54uva.html>
- Lee, N., and McGeer, A. (2020). The starting line for COVID-19 vaccine development. *Lancet (London, England)*, 0(0). [https://doi.org/10.1016/S0140-6736\(20\)31239-3](https://doi.org/10.1016/S0140-6736(20)31239-3)
- Lee, V. J., Chiew, C. J., and Khong, W. X. (2020). Interrupting transmission of COVID-19: lessons from containment efforts in Singapore. *Journal of Travel Medicine*. Retrieved from <https://academic.oup.com/jtm/article/27/3/taaa039/5804843>
- Leecaster, M., Toth, D. J. A., Pettey, W. B. P., Rainey, J. J., Gao, H., Uzicanin, A., and Samore, M. (2016). Estimates of social contact in a middle school based on self-report and wireless sensor data. *PLoS ONE*, 11(4). <https://doi.org/10.1371/journal.pone.0153690>
- Lewin, E. (2020, June 2). Asymptomatic COVID-19 rate could be 'much higher' than previously thought. Retrieved June 2, 2020, from <https://www1.racgp.org.au/newsgp/clinical/asymptomatic-covid-19->

- rate-could-be-much-higher-th#.XtXf65dqu5A.twitter
- Li, Y., Huang, X., Yu, I. T. S., Wong, T. W., and Qian, H. (2005). Role of air distribution in SARS transmission during the largest nosocomial outbreak in Hong Kong. *Indoor Air*, 15(2), 83–95. <https://doi.org/10.1111/j.1600-0668.2004.00317.x>
- Lindahl, J. F., and Grace, D. (2015). The consequences of human actions on risks for infectious diseases: a review. *Infection Ecology & Epidemiology*, 5(1), 30048. <https://doi.org/10.3402/iee.v5.30048>
- Litton, E., Bucci, T., Chavan, S., Ho, Y. Y., Holley, A., Howard, G., ... Pilcher, D. (2020). Surge capacity of intensive care units in case of acute increase in demand caused by COVID-19 in Australia. *Medical Journal of Australia*, 212(10), n/a-n/a. <https://doi.org/10.5694/mja2.50596>
- Liu, Yang, Eggo, R. M., and Kucharski, A. J. (2020, March 14). Secondary attack rate and superspreading events for SARS-CoV-2. *The Lancet*, p. e47. [https://doi.org/10.1016/S0140-6736\(20\)30462-1](https://doi.org/10.1016/S0140-6736(20)30462-1)
- Liu, Yuan, Ning, Z., Chen, Y., Guo, M., Liu, Y., Gali, N. K., ... Lan, K. (2020). Aerodynamic Characteristics and RNA Concentration of SARS-CoV-2 Aerosol in Wuhan Hospitals during COVID-19 Outbreak. *MedRxiv*. <https://doi.org/10.1101/2020.03.08.982637>
- Lloyd-Smith, J. O., Schreiber, S. J., Kopp, P. E., and Getz, W. M. (2005). Superspreading and the effect of individual variation on disease emergence. *Nature*, 438(7066), 355–359. <https://doi.org/10.1038/nature04153>
- Long, Y., Hu, T., Liu, L., Chen, R., Guo, Q., Yang, L., ... Du, L. (2020). Effectiveness of N95 respirators versus surgical masks against influenza: A systematic review and meta-analysis. *Journal of Evidence-Based Medicine*, jebm.12381. <https://doi.org/10.1111/jebm.12381>
- Lowe, P. (2020). An Economic and Financial Update. Retrieved May 14, 2020, from <https://www.rba.gov.au/speeches/2020/sp-gov-2020-04-21.html>
- Lu, H., Ai, J., Shen, Y., Li, Y. Y., Li, T., Zhou, X., ... Zhang, W. (2020). A descriptive study of the impact of diseases control and prevention on the epidemics dynamics and clinical features of SARS-CoV-2 outbreak in Shanghai, lessons learned for metropolis epidemics prevention. *MedRxiv*, 2020.02.19.20025031. <https://doi.org/10.1101/2020.02.19.20025031>
- Ludvigsson, J. F. (2020). Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults. *Acta Paediatrica*. <https://doi.org/10.1111/apa.15270>
- Lunn, P. D., Belton, C. A., Lavin, C., McGowan, F. P., Timmons, S., and Robertson, D. A. (2020). Using Behavioral Science to help fight the Coronavirus. *Journal of Behavioral Public Administration*, 3(1), 1–15. <https://doi.org/10.30636/jbpa.31.147>
- Ma, S., Zhang, J., Zeng, M., Yun, Q., Guo, W., Zheng, Y., ... Yang, Z. (2020). Epidemiological parameters of coronavirus disease 2019: a pooled analysis of publicly reported individual data of 1155 cases from seven countries. *MedRxiv*, 2020.03.21.20040329. <https://doi.org/10.1101/2020.03.21.20040329>
- Madhav, N., Oppenheim, B., Gallivan, M., Mulembakani, P., Rubin, E., and Wolfe, N. (2017). Pandemics: Risks, Impacts, and Mitigation. In *Disease Control Priorities, Third Edition (Volume 9): Improving Health and Reducing Poverty* (pp. 315–345). The World Bank.

- https://doi.org/10.1596/978-1-4648-0527-1_ch17
- Marschner, I. C. (2020). Back-projection of COVID-19 diagnosis counts to assess infection incidence and control measures: analysis of Australian data. *Epidemiology and Infection*, 148, e97. <https://doi.org/10.1017/S0950268820001065>
- McAloon, C. G., Collins, A., Hunt, K., Barber, A., Byrne, A., Butler, F., ... More, S. J. (2020). The incubation period of COVID-19: A rapid systematic review and meta-analysis of observational research. *MedRxiv*, 2020.04.24.20073957. <https://doi.org/10.1101/2020.04.24.20073957>
- McCauley, D. (2020, April 25). No gowns, visors, gloves: national medical stockpile to be reviewed. *The Sydney Morning Herald*. Retrieved from <https://www.smh.com.au/politics/federal/no-gowns-visors-gloves-national-medical-stockpile-to-be-reviewed-20200424-p54mxk.html>
- McConway, K., and Spiegelhalter, D. (2020, May 26). Is SARS-CoV-2 viral load lower in young children than adults? Jones et al provide evidence that it is (in spite of their claims to the contrary). Retrieved May 27, 2020, from https://medium.com/@d_spiegel/is-sars-cov-2-viral-load-lower-in-young-children-than-adults-8b4116d28353
- McKibben, W. J., and Sidorenko, A. A. (2006). *Global Macroeconomic consequences of pandemic influenza*. Retrieved from <https://www.brookings.edu/wp-content/uploads/2016/06/200602.pdf>
- Morawska, L., and Cao, J. (2020, June 1). Airborne transmission of SARS-CoV-2: The world should face the reality. *Environment International*. Elsevier Ltd. <https://doi.org/10.1016/j.envint.2020.105730>
- Morrison, S. (2020a, March 3). Press Conference Australian Parliament House, ACT - 3 March 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/press-conference-australian-parliament-house-act-6>
- Morrison, S. (2020b, March 11). \$2.4 Billion health plan to fight COVID-19. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/24-billion-health-plan-fight-covid-19>
- Morrison, S. (2020c, March 19). Border Restrictions - 19 March 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/border-restrictions>
- Morrison, S. (2020d, March 20). Update on coronavirus measures - 20 March 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/update-coronavirus-measures-0>
- Morrison, S. (2020e, March 25). National COVID-19 Coordination Commission. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/national-covid-19-coordination-commission>
- Morrison, S. (2020f, March 29). \$1.1 billion to support more mental health, Medicare and domestic violence services. *Prime Minister Media Releases*. Retrieved from <https://www.pm.gov.au/media/11-billion-support-more-mental-health-medicare-and-domestic-violence-services-0>
- Morrison, S. (2020g, March 29). National Cabinet Statement - 29 March 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/national-cabinet-statement>
- Morrison, S. (2020h, April 16). Update on coronavirus measures - 16 April 2020. *Prime Minister of Australia Media*. Retrieved from

- <https://www.pm.gov.au/media/update-coronavirus-measures-160420>
- Morrison, S. (2020i, April 26). COVIDSafe: New app to slow the spread of coronavirus. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/covidsafe-new-app-slow-spread-coronavirus>
- Morrison, S. (2020j, May 8). Update on Coronavirus measures - 8 May 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/update-coronavirus-measures-08may20>
- Morrison, S. (2020k, May 15). Update on coronavirus measures - 15 May 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/update-coronavirus-measures-15may20>
- Morrison, S. (2020l, May 29). Press Conference - Australian Parliament House, ACT - 29 May 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/press-conference-australian-parliament-house-act-29may20>
- Morrison, S., and Frydenberg, J. (2020). Press Conference - Australian Parliament House, ACT - 14 May 2020. *Prime Minister of Australia Media*. Retrieved from <https://www.pm.gov.au/media/press-conference-australian-parliament-house-act-14may20>
- Moss R, Wood J, Brown D, Shearer F, Black, A., Cheng AC, ... McVernon J. (2020). *Modelling the impact of COVID-19 in Australia to inform transmission reducing measures and health system preparedness*. Melbourne.
- Murphy, B. (2020, March 13). Chief Medical Officer update on coronavirus testing. *RACGP*. Retrieved from <https://www1.racgp.org.au/newsgp/professional/chief-medical-officer-update-on-coronavirus-testin>
- National Centre for Immunisation Research and Surveillance, and NSW Health. (2020). *COVID-19 in schools-the experience in NSW Overview*.
- National Incident Room Surveillance Team. (2020). *Communicable Diseases Intelligence 2019 - COVID-19, Australia: Epidemiology Report 16: Reporting week ending 23:59 AEST 17 May 2020*. <https://doi.org/10.33321/cdi.2020.44.45>
- National Institute for Public Health and the Environment. (2020). *Children and COVID-19*. Retrieved from <https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19>
- National Institutes of Health. (2007). *Understanding Emerging and Re-emerging Infectious Diseases*. National Institutes of Health (US). Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK20370/>
- Neuzil, K. M., Hohlbein, C., and Zhu, Y. (2002). Illness Among Schoolchildren During Influenza Season. *Archives of Pediatrics & Adolescent Medicine*, 156(10), 986. <https://doi.org/10.1001/archpedi.156.10.986>
- Nickol, M. E., and Kindrachuk, J. (2019). A year of terror and a century of reflection: Perspectives on the great influenza pandemic of 1918-1919. *BMC Infectious Diseases*, 19(1). <https://doi.org/10.1186/s12879-019-3750-8>
- Nishiura, H., Linton, N. M., and Akhmetzhanov, A. R. (2020). Serial interval of novel coronavirus (COVID-19) infections. *International*

- Journal of Infectious Diseases*, 93, 284–286.
<https://doi.org/10.1016/j.ijid.2020.02.060>
- NSW Government. (2020, April 22). Special Commission of Inquiry: Ruby Princess. *NSW Government*. Retrieved from <https://www.nsw.gov.au/covid-19/special-commission-of-inquiry-ruby-princess>
- NSW Health. (2020, May 31). NSW COVID-19 case statistics - up to 8pm, 31 May 2020. Retrieved June 1, 2020, from <https://www.health.nsw.gov.au/Infectious/covid-19/Pages/stats-nsw.aspx>
- O'Brien, J., Barry, D., Macali, A., Urquhart, J., Monteiro, C., and Byrne, A. (2020). Coronavirus (COVID-19) in Australia. Retrieved May 1, 2020, from <https://www.covid19data.com.au/>
- Ochmann, S., and Roser, M. (2017, November 9). Polio. *Our World in Data*. Retrieved from <https://ourworldindata.org/polio>
- Palaszczyk, A., and Jones, K. (2020, February 23). Palaszczyk Govt launches tourism initiative in country music capital. *The Queensland Cabinet and Ministerial Directory*. Retrieved from <http://statements.qld.gov.au/Statement/2020/2/23/palaszczyk-govt-launches-tourism-initiative-in-country-music-capital>
- Peng, C., and Currie, D. (2020, June 1). Can modelling the COVID-19 outbreak really predict its future? Retrieved June 1, 2020, from <https://www.themandarin.com.au/134695-can-modelling-the-covid-19-outbreak-really-predict-its-future/>
- Phillips, B., Makin, M., and Felzmann, U. (2020, May 29). Coronavirus 10-day forecast. Retrieved May 31, 2020, from <https://covid19forecast.science.unimelb.edu.au/>
- Prather, K. A., Wang, C. C., and Schooley, R. T. (2020). Reducing transmission of SARS-CoV-2. *Science*, eabc6197.
<https://doi.org/10.1126/science.abc6197>
- Preiss, B., and McMillan, A. (2020, April 4). Coronavirus Australia: Victoria reports eighth coronavirus death as woman in her 70s succumbs as virus tracing team ramped up to 1000. *The Age*. Retrieved from <https://www.theage.com.au/national/victoria/victoria-reports-eighth-coronavirus-death-as-virus-tracing-teams-boosted-20200404-p54h1s.html>
- Prem, K., Liu, Y., Russell, T. W., Kucharski, A. J., Eggo, R. M., Davies, N., ... Klepac, P. (2020). The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. *The Lancet Public Health*, 5(5), e261–e270. [https://doi.org/10.1016/S2468-2667\(20\)30073-6](https://doi.org/10.1016/S2468-2667(20)30073-6)
- Public Health England. (2020, April 23). Coronavirus (COVID-19): Using data to track the virus. Retrieved May 1, 2020, from <https://publichealthmatters.blog.gov.uk/2020/04/23/coronavirus-covid-19-using-data-to-track-the-virus/>
- Qian, G.-Q., Yang, N.-B., Ding, F., Ma, A. H. Y., Wang, Z.-Y., Shen, Y.-F., ... Chen, X.-M. (2020). Epidemiologic and Clinical Characteristics of 91 Hospitalized Patients with COVID-19 in Zhejiang, China: A retrospective, multi-centre case series. *QJM: An International Journal of Medicine*.
<https://doi.org/https://doi.org/10.1093/qjmed/hcaa089>
- Qiu, C., Xiao, Q., Liao, X., Deng, Z., Liu, H., Shu, Y., ... Da, L. (2020). Transmission and clinical characteristics of coronavirus disease 2019 in 104 outside-Wuhan patients, China. *MedRxiv*, 2020.03.04.20026005.

- <https://doi.org/10.1101/2020.03.04.20026005>
- Qiu, H., Wu, J., Hong, L., Luo, Y., Song, Q., and Chen, D. (2020). Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study. *The Lancet Infectious Diseases*. [https://doi.org/10.1016/S1473-3099\(20\)30198-5](https://doi.org/10.1016/S1473-3099(20)30198-5)
- RACGP. (2020, May). RACGP survey reveals strong take up of telehealth but face to face consultations still available. *RACGP*. Retrieved from <https://www.racgp.org.au/gp-news/media-releases/2020-media-releases/may-2020/racgp-survey-reveals-strong-take-up-of-telehealth>
- Rafiq, D., Batool, A., and Bazaz, M. A. (2020). Three months of COVID-19: A systematic review and meta-analysis. *Reviews in Medical Virology*. <https://doi.org/10.1002/rmv.2113>
- Rainey, J. J., Phelps, T., and Shi, J. (2016). Mass Gatherings and Respiratory Disease Outbreaks in the United States – Should We Be Worried? Results from a Systematic Literature Review and Analysis of the National Outbreak Reporting System. *PLOS ONE*, 11(8), e0160378. <https://doi.org/10.1371/journal.pone.0160378>
- Randolph, H. E., and Barreiro, L. B. (2020). Herd Immunity: Understanding COVID-19. *Immunity*, 52(5), 737–741. <https://doi.org/10.1016/j.immuni.2020.04.012>
- Raper, A. (2020, April 18). NSW breast cancer screening service suspended to free up doctors in fight against coronavirus pandemic. *ABC News*. Retrieved from <https://www.abc.net.au/news/2020-04-18/nsw-breast-cancer-screening-service-suspended-due-to-coronavirus/12160264>
- Rashid, H., Ridda, I., King, C., Begun, M., Tekin, H., Wood, J. G., and Booy, R. (2015). Evidence compendium and advice on social distancing and other related measures for response to an influenza pandemic. *Paediatric Respiratory Reviews*, 16(2), 119–126. <https://doi.org/10.1016/j.prrv.2014.01.003>
- Read, R. (2020). Choir practice turns fatal. Coronavirus is to blame - Los Angeles Times. *Los Angeles Times*, March 29. Retrieved from <https://www.latimes.com/world-nation/story/2020-03-29/coronavirus-choir-outbreak>
- Rossmann, J. (2020). Coronavirus: is the R number still useful? Retrieved May 20, 2020, from <https://theconversation.com/coronavirus-is-the-r-number-still-useful-138542>
- Ryan, B., and Florance, L. (2020, March 8). Coronavirus COVID-19 mask shortages mean GPs are shopping at hardware stores for supplies - ABC News. *ABC News*. Retrieved from <https://www.abc.net.au/news/2020-03-05/coronavirus-covid-19-gps-cant-get-face-masks/12023752>
- Saunders-Hastings, P. R., and Krewski, D. (2016). Reviewing the history of pandemic influenza: Understanding patterns of emergence and transmission. *Pathogens*, 5(4). <https://doi.org/10.3390/pathogens5040066>
- Seemann, T., Lane, C., Sherry, N., Duchene, S., Silva, A. G. da, Caly, L., ... Howden, B. P. (2020). Tracking the COVID-19 pandemic in Australia using genomics. *MedRxiv*, 2020.05.12.20099929. <https://doi.org/10.1101/2020.05.12.20099929>
- Senate Select Committee on COVID-19. (2020a, April 23). Australian Government's response to the COVID-19 pandemic - 23 April 2020. *Proof Committee Hansard*. Canberra. Retrieved from

- <https://parlinfo.aph.gov.au/>
- Senate Select Committee on COVID-19. (2020b, May 5). Australian Government's response to the COVID-19 pandemic - 5 May 2020. Retrieved May 22, 2020, from <https://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=ld%3A%22committees%2Fcommsen%2F8e0eeacd-c687-45fa-92ce-2c969b8f1931%2F0000%22>
- Sharkey, P., and Wood, G. (2020). *The Causal Effect of Social Distancing on the Spread of SARS-CoV-2. Preprint.*
- Simonsen, L., Spreeuwenberg, P., Lustig, R., Taylor, R. J., Fleming, D. M., Kroneman, M., ... Viboud, C. (2013). Global Mortality Estimates for the 2009 Influenza Pandemic from the GLaMOR Project: A Modeling Study. *PLoS Medicine*, 10(11). <https://doi.org/10.1371/journal.pmed.1001558>
- Singh, K., and Mehta, S. (2016). The clinical development process for a novel preventive vaccine: An overview. *Journal of Postgraduate Medicine*, 62(1), 4–11. <https://doi.org/10.4103/0022-3859.173187>
- Slessor, C. (2020, April 11). Clinical trial to test if tuberculosis vaccine can be used to boost immunity against COVID-19 - ABC News. *ABC News*. Retrieved from <https://www.abc.net.au/news/2020-04-11/trial-to-test-if-tuberculosis-vaccine-boosts-covid-19-immunity/12142230>
- Swerissen, H. (2020, April 14). What now? It depends on the chance of an effective coronavirus vaccine - Grattan Institute. *Croakey*. Retrieved from <https://grattan.edu.au/news/what-now-it-depends-on-the-chance-of-an-effective-coronavirus-vaccine/>
- Taylor, J. (2020a, May 6). Covidsafe app is not working properly on iPhones, authorities admit. Retrieved May 31, 2020, from <https://www.theguardian.com/world/2020/may/06/covidsafe-app-is-not-working-properly-on-iphones-authorities-admit>
- Taylor, J. (2020b, May 24). How did the Covidsafe app go from being vital to almost irrelevant? Retrieved May 30, 2020, from <https://www.theguardian.com/world/2020/may/24/how-did-the-covidsafe-app-go-from-being-vital-to-almost-irrelevant>
- Taylor, N. P. (2020, May 22). AstraZeneca's COVID-19 vaccine enters phase 2/3 clinical trial. *FierceBiotech*. Retrieved from <https://www.fiercebiotech.com/biotech/astrazeneca-s-covid-19-vaccine-enters-phase-2-3-clinical-trial>
- Taylor, T., and Swan, N. (2020, May 28). Has the COVIDSafe app been worth it? Retrieved May 31, 2020, from <https://www.abc.net.au/radio/programs/coronacast/has-the-covidsafe-app-been-worth-it/12292620>
- Terrill, M. (2020, May 1). We kept our distance before the COVID decrees: phone data reveals Australians' goodwill. *The Sydney Morning Herald*. Retrieved from <https://www.smh.com.au/national/we-kept-our-distance-before-the-covid-decrees-phone-data-reveals-australians-goodwill-20200430-p54oho.html>
- Thanh Le, T., Andreadakis, Z., Kumar, A., Gómez Román, R., Tollefsen, S., Saville, M., and Mayhew, S. (2020). The COVID-19 vaccine development landscape. *Nature Reviews Drug Discovery*. <https://doi.org/10.1038/d41573-020-00073-5>
- The Lancet. (2020). COVID-19: protecting health-care workers. *The Lancet*, 395(10228), 922. [https://doi.org/10.1016/S0140-6736\(20\)30644-9](https://doi.org/10.1016/S0140-6736(20)30644-9)

- Thiébaux, A., and Lafaurie, L. (2020). Coronavirus victims: who dies, at what age, with what disease? Retrieved May 1, 2020, from <https://sante.journaldesfemmes.fr/fiches-maladies/2622115-coronavirus-victime-france-age-mort-deces-qui-en-meurt-jeunes-touches/>
- Tian, S., Hu, N., Lou, J., Chen, K., Kang, X., Xiang, Z., ... Zhang, J. (2020). Characteristics of COVID-19 infection in Beijing. *Journal of Infection*, 80(4), 401–406. <https://doi.org/10.1016/j.jinf.2020.02.018>
- Tindale, L., Coombe, M., Stockdale, J. E., Garlock, E., Lau, W. Y. V., Saraswat, M., ... Colijn, C. (2020). Transmission interval estimates suggest pre-symptomatic spread of COVID-19. *MedRxiv*, (February), 2020.03.03.20029983. <https://doi.org/10.1101/2020.03.03.20029983>
- To, K. K. W., Tsang, O. T. Y., Leung, W. S., Tam, A. R., Wu, T. C., Lung, D. C., ... Yuen, K. Y. (2020). Temporal profiles of viral load in posterior oropharyngeal saliva samples and serum antibody responses during infection by SARS-CoV-2: an observational cohort study. *The Lancet Infectious Diseases*, 20(5), 565–574. [https://doi.org/10.1016/S1473-3099\(20\)30196-1](https://doi.org/10.1016/S1473-3099(20)30196-1)
- Tong, Z. D., Tang, A., Li, K. F., Li, P., Wang, H. L., Yi, J. P., ... Yan, J. B. (2020). Potential Presymptomatic Transmission of SARS-CoV-2, Zhejiang Province, China, 2020. *Emerging Infectious Diseases*, 26(5), 1052–1054. <https://doi.org/10.3201/eid2605.200198>
- Tonkin, A., and Fletcher, M. (2020, May 18). COVID-19: regulators flex to support Australia's pandemic response. Retrieved May 27, 2020, from <https://insightplus.mja.com.au/2020/19/covid-19-regulators-flex-to-support-australias-pandemic-response/>
- Torales, J., O'Higgins, M., Castaldelli-Maia, J. M., and Ventriglio, A. (2020). The outbreak of COVID-19 coronavirus and its impact on global mental health. *International Journal of Social Psychiatry*, 002076402091521. <https://doi.org/10.1177/0020764020915212>
- van Doremalen, N., Bushmaker, T., Morris, D. H., Holbrook, M. G., Gamble, A., Williamson, B. N., ... Munster, V. J. (2020, April 16). Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *The New England Journal of Medicine*. NLM (Medline). <https://doi.org/10.1056/NEJMc2004973>
- Varga, Z., Flammer, A. J., Steiger, P., Haberecker, M., Andermatt, R., Zinkernagel, A. S., ... Moch, H. (2020). Endothelial cell infection and endotheliitis in COVID-19. *The Lancet*, 395(10234), 1417–1418. [https://doi.org/10.1016/S0140-6736\(20\)30937-5](https://doi.org/10.1016/S0140-6736(20)30937-5)
- Verity, R., Okell, L. C., Dorigatti, I., Winskill, P., Whittaker, C., Imai, N., ... Ferguson, N. M. (2020). Estimates of the severity of coronavirus disease 2019: a model-based analysis. *The Lancet Infectious Diseases*. [https://doi.org/10.1016/S1473-3099\(20\)30243-7](https://doi.org/10.1016/S1473-3099(20)30243-7)
- Viner, R. M., Russell, S. J., Croker, H., Packer, J., Ward, J., Stansfield, C., ... Mbbbs, J. W. (2020). Review School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *Lancet Child Adolesc Health*, 4(5), 397–404. [https://doi.org/10.1016/S2352-4642\(20\)30095-X](https://doi.org/10.1016/S2352-4642(20)30095-X)
- Wang, C., Liu, L., Hao, X., Guo, H., Wang, Q., Huang, J., ... Wu, T. (2020). Evolving Epidemiology and Impact of Non-pharmaceutical Interventions on the Outbreak of Coronavirus Disease 2019 in Wuhan, China. *MedRxiv*, 2020.03.03.20030593. <https://doi.org/10.1101/2020.03.03.20030593>
- Williamson, O. E. (1975). *Markets and Hierarchies: Analysis and Antitrust Implications: A Study in the Economics of Internal*

Organization.

- Woelfel, R., Corman, V. M., Guggemos, W., Seilmaier, M., Zange, S., Mueller, M. A., ... Wendtner, C. (2020). Clinical presentation and virological assessment of hospitalized cases of coronavirus disease 2019 in a travel-associated transmission cluster. *MedRxiv*, 2020.03.05.20030502. <https://doi.org/10.1101/2020.03.05.20030502>
- Wood, D., Emslie, O., and Blane, N. (2020, April 2). COVID-19: What the states and territories are spending. *Grattan Blog*. Retrieved from <https://blog.grattan.edu.au/2020/04/covid-19-what-the-states-and-territories-are-spending/>
- Wood, D., Griffiths, K., and Blane, N. (2020, April 7). COVID-19: Where the Federal Government's \$194 billion is going. *Grattan Blog*. Retrieved from <https://blog.grattan.edu.au/2020/04/covid-19-where-the-federal-governments-194-billion-is-going/>
- Wood, D., and Mackey, W. (2020). As long as it's done right, a staged return to school makes good sense. *The Sydney Morning Herald*.
- Woodley, M. (2020, January 23). RACGP - Should suspected coronavirus patients present to general practice? *NewsGP*. Retrieved from <https://www1.racgp.org.au/newsgp/clinical/should-suspected-coronavirus-patients-present-to-g>
- World Health Organisation. (2016, May 11). Ebola data and statistics. Retrieved June 5, 2020, from <https://apps.who.int/gho/data/view ebola-sitrep ebola-summary-latest?lang=en>
- World Health Organisation. (2018). HIV/AIDS. *WHO*. Retrieved from <https://www.who.int/gho/hiv/en/>
- World Health Organisation. (2020a). *Advice on the use of masks in the community, during home care and in healthcare settings in the context of the novel coronavirus (COVID-19) outbreak*. Retrieved from [https://www.who.int/publications-detail/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-\(2019-ncov\)-outbreak](https://www.who.int/publications-detail/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak)
- World Health Organisation. (2020b). Coronavirus. Retrieved May 7, 2020, from https://www.who.int/health-topics/coronavirus#tab=tab_1
- World Health Organisation. (2020c). *Coronavirus disease 2019 (COVID-19) Situation Report-73*. <https://doi.org/10.3201/eid2606.200239>
- World Health Organisation. (2020d). Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. Retrieved May 23, 2020, from <https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations#.XoEhmfFVIAU.twitter>
- World Health Organisation. (2020e). Q&A on coronaviruses (COVID-19). Retrieved May 20, 2020, from <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-coronaviruses>
- World Health Organisation. (2020f, January 5). Pneumonia of unknown cause – China. *WHO*. Retrieved from <https://www.who.int/csr/don/05-january-2020-pneumonia-of-unknown-cause-china/en/>
- World Health Organisation. (2020g, January 23). Statement on the meeting of the International Health Regulations (2005) Emergency

- Committee regarding the outbreak of novel coronavirus 2019 (n-CoV) on 23 January 2020. *WHO Newsroom*. Retrieved from [https://www.who.int/news-room/detail/23-01-2020-statement-on-the-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/23-01-2020-statement-on-the-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov))
- World Health Organisation. (2020h, May 30). Draft landscape of COVID-19 candidate vaccines. *WHO*. Retrieved from <https://www.who.int/who-documents-detail/draft-landscape-of-covid-19-candidate-vaccines>
- World Health Organization: Regional Office for the Eastern Mediterranean. (2020). MERS situation update, January 2020. Retrieved May 14, 2020, from <http://www.emro.who.int/pandemic-epidemic-diseases/mers-cov/mers-situation-update-january-2020.html>
- World Health Organization. (2012). SARS (Severe Acute Respiratory Syndrome). Retrieved May 14, 2020, from <https://www.who.int/ith/diseases/sars/en/>
- World Health Organization. (2019). Middle East respiratory syndrome coronavirus (MERS-CoV). Retrieved May 14, 2020, from [https://www.who.int/news-room/fact-sheets/detail/middle-east-respiratory-syndrome-coronavirus-\(mers-cov\)](https://www.who.int/news-room/fact-sheets/detail/middle-east-respiratory-syndrome-coronavirus-(mers-cov))
- World Health Organization. (2020a). Contact tracing in the context of COVID-19, 2019(May), 1–7. Retrieved from <https://www.who.int/publications-detail/contact-tracing-in-the-context-of-covid-19>
- World Health Organization. (2020b, January 30). Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). Retrieved May 22, 2020, from [https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-\(2005\)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-\(2019-ncov\)](https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov))
- World Health Organization. (2020c, February 11). Key considerations for repatriation and quarantine of travellers in relation to the outbreak of novel coronavirus 2019-nCoV. Retrieved May 22, 2020, from <https://www.who.int/news-room/articles-detail/key-considerations-for-repatriation-and-quarantine-of-travellers-in-relation-to-the-outbreak-of-novel-coronavirus-2019-ncov/>
- Wu, F., Zhao, S., Yu, B., Chen, Y.-M., Wang, W., Song, Z.-G., ... Zhang, Y.-Z. (2008). A new coronavirus associated with human respiratory disease in China. *Nature*, 579, 265–269. <https://doi.org/10.1038/s41586-020-2008-3>
- Wu, P., Fang, Y., Guan, Z., Fan, B., Kong, J., Yao, Z., ... Hoven, C. W. (2009). The psychological impact of the SARS epidemic on hospital employees in China: Exposure, risk perception, and altruistic acceptance of risk. *Canadian Journal of Psychiatry*, 54(5), 302–311. <https://doi.org/10.1177/070674370905400504>
- Xiang, Y. T., Yang, Y., Li, W., Zhang, L., Zhang, Q., Cheung, T., and Ng, C. H. (2020). Timely mental health care for the 2019 novel coronavirus outbreak is urgently needed. *The Lancet Psychiatry*, 7(3), 228–229. [https://doi.org/10.1016/S2215-0366\(20\)30046-8](https://doi.org/10.1016/S2215-0366(20)30046-8)
- Yamey, G., Schäferhoff, M., Aars, O. K., Bloom, B., Carroll, D., Chawla, M., ... Whiting, E. (2017). Financing of international collective action for epidemic and pandemic preparedness. *The Lancet Global Health*, 5(8), e742–e744. <https://doi.org/10.1016/S2214->

109X(17)30203-6

- Yong, E. (2020). Is the Coronavirus Airborne? Should We All Wear Masks? - The Atlantic. Retrieved May 20, 2020, from <https://www.theatlantic.com/health/archive/2020/04/coronavirus-pandemic-airborne-go-outside-masks/609235/>
- Zhang, S., Diao, M. Y., Yu, W., Pei, L., Lin, Z., and Chen, D. (2020). Estimation of the reproductive number of novel coronavirus (COVID-19) and the probable outbreak size on the Diamond Princess cruise ship: A data-driven analysis. *International Journal of Infectious Diseases*, 93, 201–204. <https://doi.org/10.1016/j.ijid.2020.02.033>
- Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., ... Shi, Z.-L. (2012). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*, 579, 270–275. <https://doi.org/10.1038/s41586-020-2012-7>
- Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., ... Tan, W. (2020). A novel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine*, 382(8), 727–733. <https://doi.org/10.1056/NEJMoa2001017>