

Public health, health systems and palliation planning for COVID-19 on an exponential timeline

A lockdown can substantially reduce epidemic size and flatten the curve, ensuring that health system capacity is not exceeded and economic recovery occurs sooner than with a phased approach

Exponential epidemic growth has been clearly demonstrated for coronavirus disease 2019 (COVID-19) in every country it has touched, with ascertained cases growing from 25 at the start of March in Australia to over 6000 cases 6 weeks later. For every ascertained case, there may be anywhere up to nine infections that are not detected.¹ This silent component of spread is likely driven by asymptomatic² or mild infection, especially in younger people. In countries which restrict testing to symptomatic high risk people only, there will be silent growth of undetected infection until the epidemic is large enough to be felt in the health system.³

The epidemic in China was largely localised through January 2020, with small numbers of imported cases in other countries. Following a lockdown on 23 January, it peaked on 5 February⁴ and has declined since. However, as the cases decreased in China, COVID-19 began surging in other countries by late February. Asian countries such as South Korea took an aggressive approach to testing and achieved control.⁵ In contrast, a more relaxed approach saw Europe becoming the new epicentre, followed by the United States,⁶ which had epidemic growth because of major testing failures. In Italy, Spain and parts of the US, health systems capacity has been exceeded, with resulting shortages of intensive care beds and ventilators.

Case fatality rates (CFRs) have varied globally, from 0.85% in South Korea to over 10% in Italy.⁷ Whether the CFR is 0.85% or 10%, this is orders of magnitude higher than seasonal influenza⁸ or even the 2009 influenza pandemic.⁹ Two factors influence CFR — testing and capacity to ventilate. More widespread testing will result in identification of mild and asymptomatic cases, as in South Korea, and a lower apparent CFR. Given respiratory failure is the leading cause of death from COVID-19, the inability to ventilate patients will drive the CFR up. In Germany, the number of intensive care unit (ICU) beds per head of population is 29.2 per 100 000 compared with 12.5 per 100 000 in Italy,¹⁰ so despite having a high number of cases, capacity has not been exceeded. In Italy and Spain, however, ICU capacity was exhausted. In contrast, in China, large hospitals were built in a matter of days to ensure that capacity to ventilate patients was not lost, keeping the CFR lower than in Italy. From this perspective, it is key that Australia flattens the curve to keep health system capacity available to ventilate every patient who needs it. We have 9.4 ICU beds per 100 000 population — less



than Italy — although Australian capacity has been expanded as part of COVID-19 preparedness.¹¹

R_0 and flattening the curve

Central to flattening the epidemic curve is R_0 , the basic reproductive number. R_0 is the number of secondary cases arising from one index case in a completely susceptible population. The epidemic threshold is defined mathematically as when R_0 exceeds 1, which creates conditions for an epidemic, although an epidemic may not always occur. If R_0 is less than 1, an epidemic cannot be sustained because one infectious case infects less than one other person on average, and infection will die out. The best estimates of R_0 for COVID-19 lie between 2 and 3.¹² Public health disease control strategies such as vaccination, social distancing and travel bans aim to reduce the R value to below 1, thereby stopping the epidemic. The R modified by such measures is manifested as flattening of the curve, which is dampening of the natural trajectory of the epidemic that would otherwise occur.

Herd immunity strategy — risks and no benefits

Closely related to R_0 is the concept of herd immunity. Herd immunity is a concept related largely to vaccination programs. It is the observation that when enough people are immune to an infection, even people who are non-immune are protected because the number of non-immune individuals is too small for infection to spread. Immunity can be gained by infection or by vaccination. Unless we can eradicate an infection, vaccination is the only way to control it long term. However, a range of non-pharmaceutical measures will also control epidemics, and can be used in the short to medium term to reduce the size of the

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epidemic, manage demand in the health system, and save as many lives as possible.

The required proportion of people in a population who need to be immune to induce herd immunity (H) is related to R_0 and calculated by the formula $H = 1 - (1/R_0)$.¹³ If we assume R_0 is 2.6, we need 61% of the Australian population to be immune to gain herd immunity for the remaining 39% of people. Therefore, any desire to “allow” some transmission (an idea floated by some experts in the United Kingdom and Australia) will only cause more disease and death without any benefit at infection rates < 60%.¹⁴ If > 60% of Australians were infected, we would have a worst-case scenario, endanger our health workers, and rapidly exhaust our health system capacity. Further, allowing transmission of COVID-19 would not get rid of the disease — it would cause recurrent, cycling epidemics of a mass scale, as seen with measles, mumps, rubella, smallpox and all other epidemic infectious diseases before vaccination. We would also see resulting high morbidity and mortality in older people, as 50% of the population is aged over 40 years. Younger people would also be affected. In the US, 36% of patients admitted to the ICU were aged 45–64 years and 12% were aged 20–44 years. Deaths in the US have been seen in all age groups above 18 years.⁶ Large studies also show that children can have severe disease or die — 50% had mild disease, 30% moderate disease and 6% critical illness.¹⁵ In one study, a child aged 10 months died.¹⁶ Young people and children tend to transmit respiratory infections most intensely in society because they have the highest contact rates.¹⁷ This means that mild or asymptomatic infection in young people could be a driver of epidemic growth. Many people live in multigenerational arrangements, so young people becoming infected could result in older people or people with chronic diseases becoming ill.

The Australian response

The Deputy Chief Medical Officer suggested, based on modelling, a worst case scenario of 15 million Australians infected and 150 000 deaths.¹⁸ We are a high income country of 26 million people, and it should be noted that in China, with nearly 1.4 billion people, even if true case numbers were 100 times greater than reported, less than 1% of their population was infected and 3298 people had died as of 23 March 2020.⁷ We may not be able to achieve China-style lockdowns, but surely we can control the disease enough to spare our health system and minimise morbidity and mortality. Modelling for Australia suggests we could run out of ICU beds if the epidemic trajectory remains unaltered.¹⁹

The protection of the health workforce is also key to our response. The other impact of health system overload is the infection of health workers, who are already vulnerable because of the failure to stockpile adequate personal protective equipment (PPE), thus further compromising the ability to respond. Studies have shown that viable severe acute respiratory syndrome coronavirus 2 can be found widely on surfaces and in the air 3 hours after aerosolisation,

highlighting the risk of airborne transmission.²⁰

This is supported by the finding of the virus in air outlet fans in the hospital room of an infected patient.²¹ It is therefore likely that transmission is multimodal, including respiratory and contact. In the US, critical PPE shortages forced health workers to use plastic garbage bags as gowns, with some workers dying. The US Centers for Disease Control and Prevention initially recommended respirators for health workers treating COVID-19, but as shortages worsened, downgraded this to surgical masks and even bandanas.²² We must flatten the curve to ensure that Australian health workers are not placed at risk by PPE shortages. Further, if hospital beds are full with COVID-19 patients and a large proportion of health workers are infected, the ability to treat other serious conditions like cardiovascular disease will be reduced.

Mass community palliative care

Another consequence of health system overload will be the need for community palliative care for patients with COVID-19 who are unable to access hospital care. While the potential for mass mortality is sometimes considered in major disaster plans, the issue of mass palliation is often neglected. In severe COVID-19 pneumonia, where respiratory support is not available there is a progressive decline of the patient until ultimate demise associated with severe hypoxaemia, cardiac failure, acute respiratory failure and sepsis. In the days and hours before death, however, the patient will usually suffer from progressive dyspnoea, chest pain and delirium, and will become progressively moribund and immobile.²³ Provision of equitable, compassionate, safe and dignified end-of-life care to people with COVID-19 who are unable to be offered life-saving critical care is fundamental to ensuring the integrity of the Australian social fabric, and the moral and mental welfare of potentially large swathes of the population. Up to 40% of older women and 22% of older men aged 80 years and over live alone (<https://aifs.gov.au/publications/nature-living-alone-australia>), complicating how to achieve what is necessary and right. Planning around the country for this worst case outcome is currently underway, but requires significant resources, personnel, government support and a national approach.

Short, sharp lockdown versus phased approach

The impact of interventions is generally seen one to two incubation periods from implementation. The flattening of the curve seen in Australia from 24 March probably reflects the impacts of rolling travel bans implemented from 5–10 March. However, New South Wales is the epicentre of infection in Australia, and the lapses in border control with the Ruby Princess and other cruise ships may have led to an increase in cases by mid-April. In light of this, a comprehensive lockdown including school closure buys time to scale up testing for when restrictions are lifted. A slow trickle of phased interventions and a “wait and see” strategy will leave us dealing with

COVID-19 in the health system for longer. For doctors, it is no consolation to hear that “we are not like Italy, Spain or the US”. All are high income countries that used a restricted testing strategy, unlike our Asian neighbours. The UK is probably the country whose approach has been most similar to ours. They are facing a strain on the National Health Service and shortages of PPE, despite confident assertions by authorities only weeks ago. The UK, like Australia, used restricted testing and did not test asymptomatic close contacts and other high risk groups.²⁴

To ensure that Australia continues to flatten the curve, social distancing is especially important because of asymptomatic transmitters of infection. Being unable to identify infectious cases makes disease control much harder. Until we have a vaccine, all we have available in the toolkit is social distancing and travel restrictions, along with isolation of sick people and quarantine of contacts and return travellers. The World Health Organization recommends school closure during a serious pandemic, and outlines the evidence showing that comprehensive, simultaneous social distancing measures and early school closure work better than phased or gradual measures.²⁵ China has demonstrated the feasibility of a short lockdown followed by phased lifting of restrictions. The Chinese epidemic curve⁴ shows the success of the lockdown, implemented in Wuhan on 3 January, while the epidemic was in the exponential growth phase with thousands of new cases a day. Within one incubation period, cases started to fall. China began lifting restrictions on 9 February, just over one incubation period from the lockdown. They have continued to gradually lift restrictions, from a more manageable baseline position of far fewer cases to track and contain, all within 8 weeks.

A lockdown is a temporary measure which can result in substantial reduction of epidemic size, more manageable case numbers and a flattening of the curve so that health system capacity is not exceeded and economic recovery can occur sooner. Lockdown can be relaxed safely in a phased manner, but must

be accompanied by extensive testing, including of asymptomatic high risk people such as close contacts, evacuees and people in institutional outbreak settings. To ensure all community cases are detected, any doctor should be able to exercise clinical judgement and order a test for COVID-19. Failure to test asymptomatic at-risk people and allow wider community testing will result in undetected transmission in the community and a bounce-back of the epidemic as lockdown restrictions are lifted. The only two countries to achieve sustained flattening of the curve to date are South Korea and China. South Korea has achieved this with more targeted, short lockdowns along with extensive testing.⁵

The risk of a phased and gradual approach is continued epidemic growth, potential failure of the health system, and a far longer road to recovery. We have examples of countries that have failed and succeeded, which can guide such a response. Epidemic control is time critical, because epidemics rise exponentially. There is no real choice available between jobs and lives — failing to save lives now will result in more net job losses and a longer recession. In addition to expanded testing, key strategies to accompany a lockdown must be a financial aid package that is accessible and leaves no person in need; a mental health and domestic violence package with outreach capability; aged care and disability support; and support for Aboriginal and Torres Strait Islander communities. Much of this is already being addressed by the government. Other needs may also become apparent, such as a communications and social engagement package; a physical fitness package; and identification of other vulnerable groups and required support to ensure the wellbeing of all Australians.

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