Maximizing the probability that the 6-week lock-down in Victoria delivers a COVID-19 free Australia

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Appendix: 1 (specific to this paper – more details at SRN 3588074 2020)

Victoria is the unlucky state in a lucky country. Most other states and territories, except for NSW, have achieved elimination of community transmission of the pandemic virus SARS-CoV-2 (28 or more days of no locally acquired cases where the source is unknown).

The situation in NSW is mixed and precarious. On the one hand, NSW has a current outbreak of 40 cases (as of 16 July) linked to the Crossroads Hotel outbreak in Casula. On the other hand, until 16 July there had only been three locally acquired cases of SARS-CoV-2 infection with no known source in the preceding 28 days suggesting NSW was on the cusp of elimination [1] – but three cases have been reported on 16 July with no obvious link to the current outbreak.[2] If NSW successfully contains this outbreak, it may resume its prior trajectory towards the elimination of local transmission, leaving Victoria isolated as the only state with community transmission.

It seems highly unlikely that states and territories that have eliminated local transmission will relinquish their status by freely opening borders and engaging with Victoria (and NSW if community transmission remains). Australia going forward as two separate systems (six or seven states and territories having eliminated the virus, one or two not) is a significant concern. Both the Victorian economy (comprising 23.7% of Australia's economy [3]) and the wider Australian economy will be adversely impacted for a long period due to the public health measures necessary to prevent and control recurrent outbreaks arising from resurgent community transmission.

There are three general strategic policy responses to the challenge of COVID-19: elimination, suppression, and mitigation (or herd immunity). No response is free of economic, social and health harms – rather, it is about minimising harm.[4] Society has largely rejected a mitigation response due to the high morbidity and mortality inherent (e.g. if 60% of the population were infected the number of deaths may exceed 100,000 under current case fatality rates [5]). We argue that explicitly pushing towards a strategy of elimination across all of Australia is optimal given where we are at and what we know.

Elimination strategy

We know from New Zealand (NZ; population 5.0 million)[6] and Taiwan (23.8 million)[7] that elimination of community transmission is achievable in island jurisdictions, both having no reported community transmission for over two months as of 10 July.[8] The advantage of elimination is that despite international border closures or strict quarantine, citizens can go about life with a near-normal functioning of their society and economy.

Elimination has challenges. First, there is the extra effort to achieve it – and the fact that aiming to achieve elimination does not guarantee success. Second, having achieved elimination, there would be the constant risk of the virus re-entering due to quarantine breaches. This is evident from the two quarantine hotels in Melbourne that leaked cases of SARS-CoV-2 infection. However, if we learn from experience, there is no reason why the quarantine of arrivals to a country cannot be made near-perfectly secure with the appropriate processes and resources.

How sustainable a COVID-19 free nation with tight border controls is in the very long term is unclear, especially when international tourism begins to be resurrected in the rest of the world. If an effective vaccine does not arrive in the next year or so, then at some point a COVID-19 free country may choose to pivot away from maintaining elimination towards suppression or mitigation. This could involve the easing of border restrictions and the return of disease spread but where the mortality and morbidity

burden is substantially lessened through improved treatments and social mechanisms to protect the elderly and vulnerable (e.g. good ring-fencing of rest-homes). The point now, though, is that living in a state or country that has achieved elimination is a far better option than suppression in the short- to medium-term, compared to the high likelihood of recurrent outbreaks precipitating recurrent lock-downs with attendant social and economic disruption. For example, NZ used a more stringent lock-down that Australia in March to April 2020 (Supplementary Figure 1), rapidly achieved elimination, and its economy appears to have bounced back more strongly than Australia's, at least on the measure of payroll job estimates (Supplementary Figure 2). So too, COVID-19 free Australian states and territories (e.g., Queensland) are benefiting economically, enabling the re-opening of business activity and hosting of national sporting teams and fixtures such as the AFL.

Is elimination achievable with a six-week lock-down?

Lock-downs are effective for pandemic control.[9,10] Our case for an explicit elimination strategy in Victoria, now, is that given the State is in lock-down for six-weeks there is only a marginal cost of 'going hard' with a rigorous public health response that increases the probability of achieving elimination. But is elimination achievable within six-weeks?

We examined four policy scenarios using an agent-based model, a type of micro-simulation of individuals. The model accurately reflects the prior experience of both NZ and Australia [11], and in this paper, we have adapted it to Victoria (including the case counts up to 14 July) (see Appendix for details). The four policy approaches were:

1. Standard, reflecting the first Australian lock-down (calibrated in), with key parameters including 85% of people observing physical distancing; of those observing physical distancing, they do so 85% of the time; 30% of adult workers are essential workers; 93% of people asked to isolate doing so; 20% uptake of COVID-Safe App; but no closure of schools and no mask-wearing.
2. Standard plus masks at 50%, above plus 50% of people wearing masks when in crowded indoor environments.
3. Stringent with masks at 50%, schools closed and essential workers restricted to 20% of workers, otherwise as above.
4. Stringent with masks at 90%, above with mask use increased to 90%.

Figure 1 shows the percentage likelihood of elimination in Victoria, defined as the date of clearance of infection by the last case. The observable moment of 28 days without a locally acquired case with no known contact follows by about another two weeks.

Under the 'Standard' policy approach, there is no chance that all infected people will have cleared their SARS-CoV-2 infection by 19 August (six-weeks after lock-down started). The probabilities for the other three policy approaches are 5% for 'Standard plus masks at 50%'; slightly more at about 7% for 'Stringent with masks at 50%'; and nearly 50% for 'Stringent plus masks at 90%'. As an important aside, as we have updated these model runs in the week since lockdown began, the curves have been shifting to the right due to the ongoing high numbers of daily cases. If Victoria gets on top of the current outbreak, these probabilities may improve, and the curves shift to the left – but also vice versa. We will update these models on a regular basis.

Undertaking simulation modelling of SARS-CoV-2 policy options is challenging and the uncertainties are still large. Nevertheless, our results lend weight to the proposition that elimination is achievable, and that mandatory wearing of masks can greatly assist its chances.

A ten-point plan to maximize the chance of elimination in Victoria

Box 1 gives enhancements to the stay-at-home orders used in the first lock-down, that should see an increased probability of elimination being achieved. The first and critical point is leadership. Victoria's Premier Daniel Andrews (and indeed all State and Territory Premiers) should explicitly declare 'elimination' as the goal. This should be accompanied by increased transparency and target-setting including the appointment of an expert advisory group in order to increase trust in the process. An explicit goal will more likely avert a public clamouring for premature opening up again as case-numbers fall and will recognise that these investments will have greater health and economic payoffs in the future.

Since the second lock-down in Victoria was announced (Tuesday 7 July), progress with aspects of this ten-point plan has already been made with the closure of schools (other than for year 11 and 12, and special needs students), encouragement to wear masks in indoor environments (though we argue this needs to be mandatory), and commitments to improve contact tracing capacity.

Conclusion

We argue that Melbourne and Victoria should not waste the opportunity this lock-down presents. By learning from the lessons on social and preventive measures to lower SARS-CoV-2 transmissibility,[9,10,12,13] and specifically the lessons from NZ,[4] Taiwan and six of the eight Australia States and Territories that have achieved elimination, Victoria can increase its chances of also eliminating community transmission.

There is the risk of failure – we cannot guarantee that our ten-point plan will achieve elimination, we cannot guarantee high compliance in measures by the Victoria population if a more stringent lock-down was imposed, and if the outbreak in NSW restarts community transmission then both NSW and Victoria will need to have elimination strategies for Australia to eliminate. But we argue that it would be a bigger failure to not enhance the probability of elimination by augmenting the current lock-down now. Our work and those of others who have independently considered the alternatives consistently demonstrates that elimination is possible, and if achieved optimal for health and long-term for the economy.[4,14-16]

Finally, we can only make estimates as to what the future holds. If a timely vaccine does not arrive, or treatments greatly improve, then for Australia to fully reintegrate with the rest of the world there may be a need to pivot to suppression and then mitigation. But we argue this is a decision better reserved for the future as the disease evolves and our knowledge improves; an Australia with no community transmission of SARS-CoV-2 in the near-term will be better and stronger for it.

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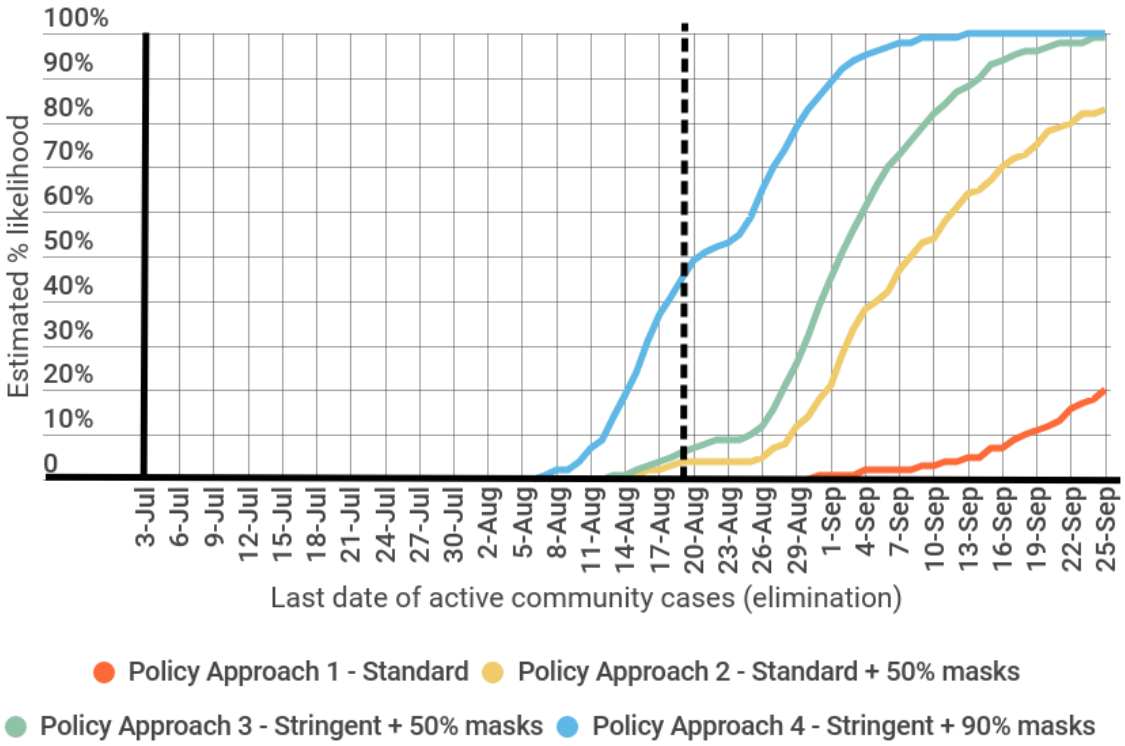
Figure 1: Percentage likelihood of elimination of community transmission in Victoria (date of last case clearing their SARS-CoV-2 infection) across 1000 Monte Carlo simulations in an agent-based SEIR model.



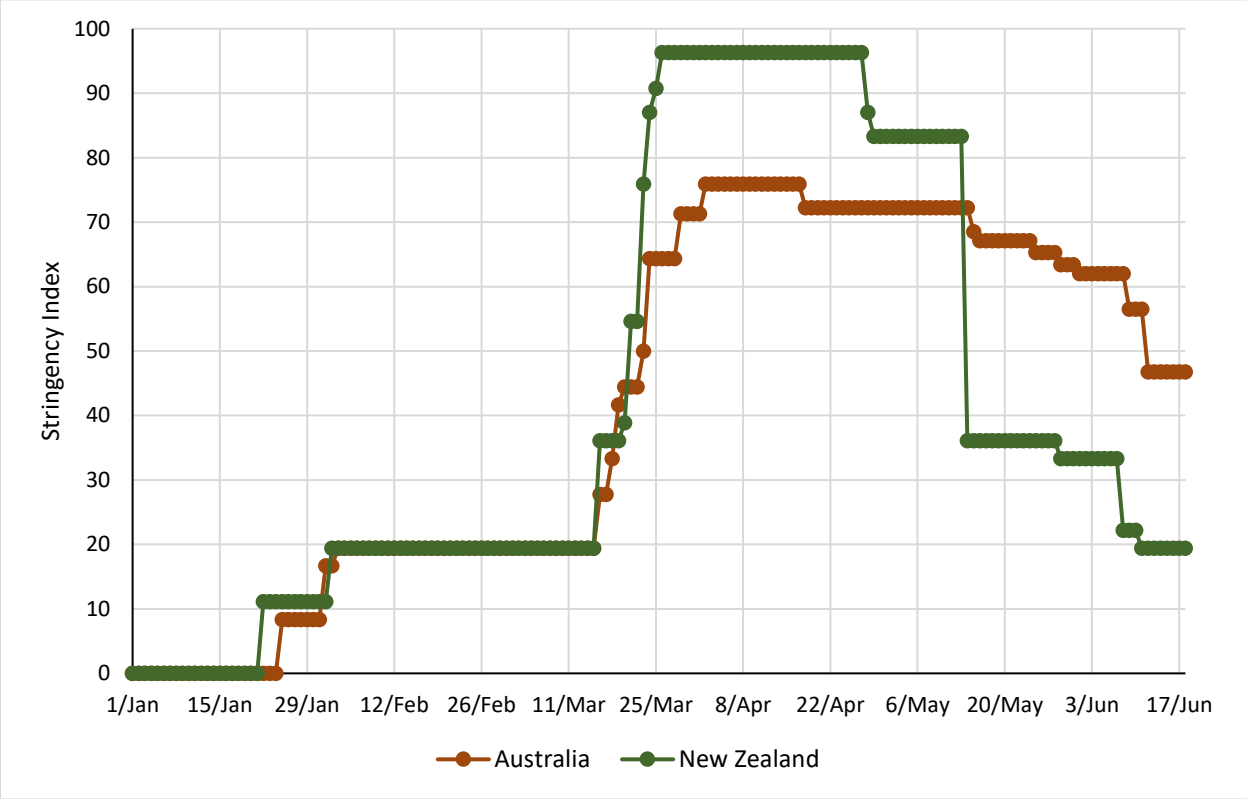
Textbox

Box 1: A ten-point plan to maximize the chance of successful elimination of community transmission of SARS-CoV-2 in Victoria, leveraging the six-week lock-down from 9 July 2020

1. **Strong and decisive leadership with strategic clarity.** An explicit goal of elimination should be articulated, learning from the NZ experience (i.e. Prime Minister Ardern, Ministers and senior officials).[17] A clear set of targets for loosening of policies needs to be articulated, so citizens know what will likely happen – when.
2. **Convene an expert advisory group** of experts in the elimination strategy and SARS-CoV-2 public health response, reporting weekly to the Victorian Chief Health Office (CHO), with the agenda, papers and minutes made publicly available.
3. **Close all schools.** Whilst children do not usually suffer severe illness from SARS-CoV-2, the SARS-CoV-2 virus still transmits between children and staff in schools.[18] Accordingly, schools need to close until such time as the daily rate of SARS-CoV-2 infection without a known source falls beneath a target set by the CHO.
4. **Tighten the definition of essential shops to remain open**. Supermarkets and chemists need to remain open. However, department stores, hardware stores, and such like should be closed. A staged re-opening based on set target levels of daily numbers of SARS-CoV-2 infection without a known source should then be implemented, so long as mask-wearing by both staff and patrons is mandatory, as is hand sanitizer use on entry and exit from stores.
5. **Require mask wearing by Melbournians in indoor environments where 1.5 meter physical distancing cannot be ensured**, like supermarkets, and (especially) public transport. Whilst no panacea, the wearing of masks reduces the chance of infected people spreading the virus.[9]
6. **Tighten the definition of essential workers and work**. There is currently a loose definition of who is an essential worker and what is essential work; this needs urgent tightening – for example, as per the NZ definitions used in their level 4 lock-down.[19]
7. **Require mask wearing by essential workers** whenever they are in close contact with people other than those in their immediate 'household bubble'.
8. **Ensure financial and other supports to businesses, community and other groups most affected by more stringent stay-at-home and lock-down requirements.** Enhancements, targeted where warranted, to programs such as JobKeeper and JobSeeker.
9. **Further strengthen contact tracing** to ensure the majority of notifications (and their close contacts) are interviewed within 24 hours of the index case notification and placed in isolation if necessary. The use of smart phone and digital adjuncts needs to be improved, be that for initial contact tracing (i.e. COVID Safe App; or South Korean style use of telecoms data) or monitoring of adequacy of isolation (e.g. text message follow-up, GPS monitoring, or electronic bracelets).
10. **Extend suspension of international arrivals into Victorian quarantine and divert resources.** To allow a stronger focus on elimination within Victoria, extend the suspension of international arrivals to Victoria. Quarantine capacity can be redeployed for isolation of Melbournians infected with SARS-CoV-2 (and potentially high-risk close contacts) where those people do not have satisfactory home environments for self-isolation.

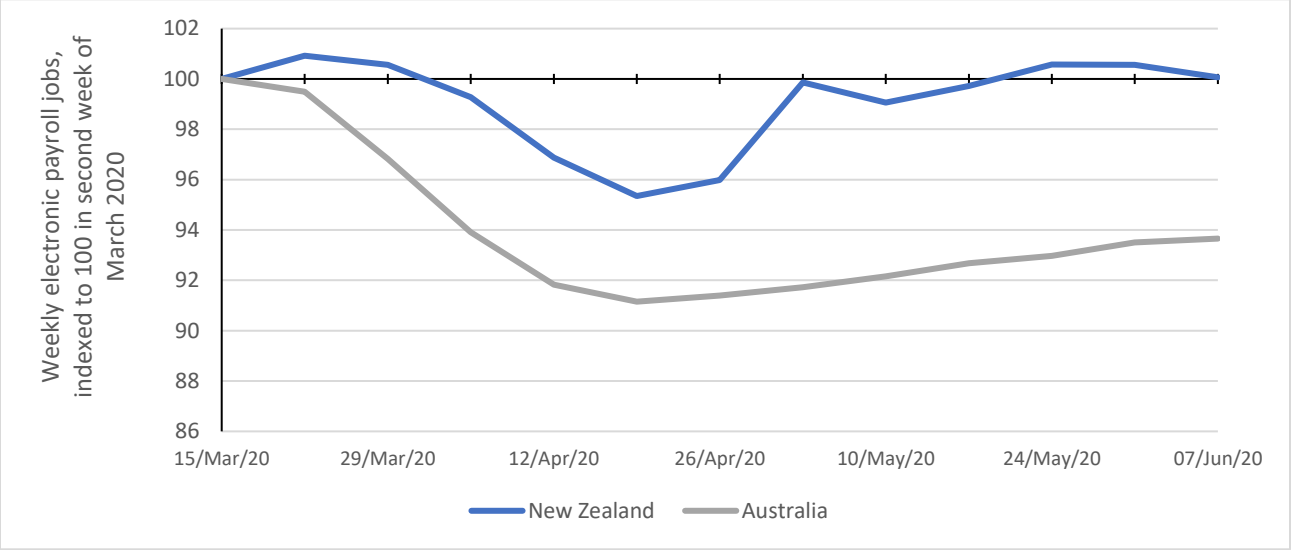
Supplementary Figures

Supplementary Figure 1: Oxford COVID-19 Government Response Tracker Stringency Index for pandemic control by time for Australia and New Zealand



Data from an Oxford led collaboration that scores all nation's responses including components of testing, contact tracing, stay-at-home requirements, and school closures.[20] A more stringent lock-down approach has been shown to reduce future infection case-loads.[21] Unfortunately, data for Australia are not available by State and Territory.

Supplementary Figure 2: Preliminary weekly electronic payroll jobs estimates for Australia and New Zealand



Sources: ABS [22] and Statistics New Zealand.[22] Payroll jobs count the number of employer-employee relationships. Estimates have a 17-day time lag from reference week for Australia, and a 27-day time lag from reference week for New Zealand, to improve accuracy.

Appendix: Model description, for "Maximizing the probability that the 6-week lock-down in Victoria delivers a COVID-19 free Australia"

Individual agents making up a synthetic population representing the Victorian population were modelled. Agents move and interact based on stochastic processes and/or in response to policies reflecting government-imposed restrictions. Their aggregate behaviour, experiences (e.g., of infection and recovery) and actions were used to assess the effect of SARS-CoV-2 disease progression and suppression strategies across the Victorian population. Specifically, we estimated the median date of elimination in Victoria. Elimination was defined here as no active cases, which differs from that observable in the real-world as the model user has perfect knowledge of active cases in the synthetic population – i.e., there is no need to wait for the lapse of multiple incubation or illness periods[1].

Because it is underpinned by stochastic processes, we report results from 1000 model runs conducted for 100 simulated days. All programming, documentation, data and details related to the calculations, estimations and assumptions are available for download from the online repository (https://bit.ly/2XI3v3z) as is a full and detailed description of the model following the principles of the Overview, Design concepts and Details (ODD)[2] standard protocol for ABMs. Parameters used in the model under policies 1-4 (1. Standard, 2. Standard + 50% masks, 3. Stringent + 50% masks, 4. Stringent + 90% masks) are set out in Table 1.

Table 1. Parameter estimates and 'agent' characteristics most relevant to current paper used in the ABM [2] (for a full details, see https://bit.ly/30eblSi).

Key Parameters	Parameter Estimates (Policies 1, 2, 3, 4)
Physical distancing (% of people limiting movement and maintaining a distance of 1.5m in pubic) [3]	85%
Physical distancing - time (% of time that people successfully maintain a distance of 1.5m (Aus)) [3]	85%
Proportion of essential workers¥	30% of working age-people in standard conditions 1 and 2, 20% of working aged in stringent conditions 3 and 4
Mean incubation period (days, log-normal)[4]	m = 5.1, sd = 1.5
Mean illness period (days, log-normal)[5]	m = 20.8, sd = 2
Mean adherence with isolation of infected cases (%, beta distribution (28,2)) ¥	m = 0.93, sd = 0.05
Super-spreaders as a proportion of infected population¥¥	10%
Number of days after infection that new cases are publicly reported ¥	6
Date of case simulation initialisation (Day 0)	July 8th, 2020
Days from case 0 to policy enactment	1 (July 9th, 2020)
Asymptomatic cases (% of cases) [1,5]	20%
Infectiousness of asymptomatic cases vs symptomatic cases (per contact) [6]	33%
Schools shutdown policy enacted	False (policies 1 and 2), True (policies 3 and 4)
Proportion of people wearing face-masks during interactions outside the home	0% (policy 1), 50% (policies 2 and 3), 90% (policy 4)
Reduction in transmission risk per contact for people wearing face-masks ¥¥¥	80%[7]

Compliance with isolation orders ¥	95%
Seeded cases	An initial volume of 1200 active cases was seeded into the model on day 0, followed by 7 days of 150 new cases representing infections gained prior to lockdown to reflect lag in testing and reporting.
COVID-Safe App Uptake	20% of population, reducing track and trace time by 1/2

Agent Characteristics	**Definition**
Infection status	Infected, susceptible, recovered, deceased
Time now	The number of days (integer) since an infected person first became infected with SARS-CoV-2
Age-range	The age-bracket (categorical) of the person, calibrated to census data deciles from 0 to 100.
Risk of death	The overall risk of death (float) for each person based on their age-profile
Location	The current location of the simulated person (agent) in the model interface
Pace	The speed at which the person moves around the environment – higher speeds resulted in more close contact with other people (agents) in the model
Heading	The direction of travel of the person at the current time-step. In conjunction with the scaling approach, the heading variable was used to create local communities and control interaction between and across communities
Contacts	A count (integer) of contacts the person (agent) had interacted with in the past day as they moved within the model's environment

¥ Assumed parameter based on expert opinion
¥¥ 10% of the population potentially transmit infections widely through occasional travel to random locations.
¥¥¥ The source paper reports an adjusted odds ratio of 0.15 for a systematic review of observational studies. Given possible residual confounding, and to be conservative, we used 80% rather than 85%.

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