Evidence check

28 October 2020

Rapid evidence checks are based on a simplified review method and may not be entirely exhaustive, but aim to provide a balanced assessment of what is already known about a specific problem or issue. This brief has not been peer-reviewed and should not be a substitute for individual clinical judgement, nor is it an endorsed position of NSW Health.

Second spike in COVID-19 cases

Evidence check question

What are the contributing factors of a second spike in COVID-19 cases?

In brief

- Epidemiology reports in Australia highlight COVID-19 notifications by week of diagnosis, with timing of key public health measures. Prior to the second wave in Victoria, there was a start of easing of restrictions in select states and territories on 27 April.(1)
- A global overview of second waves found three distinct time periods in the data. Cases rose to mid-April, plateaued till mid-May then rose again. Almost all the slopes in these three time periods were statistically significant. Deaths followed a similar pattern.(2)
- Common factors that were linked to a second spike in countries included imported cases,(3-8) negligent hotel quarantine program,(9) easing lockdown measures,(1, 10-14) relaxation of social distancing practices,(3, 10, 12, 14-18) especially among young people, and mass gatherings or events.(17, 19-21)
- Singapore and Japan saw a second spike in March after initially curtailing the first spike in COVID-19 cases. This was mainly driven by imported cases from European and North American countries(4, 6-8) and community transmission among foreign migrant workers living in dormitories in Singapore.(6, 22) In several jurisdictions including Hong Kong, China, Nepal and Vietnam, imported cases prompted new waves of outbreak.(11)
- Japan experienced a further surge in cases in August, which was attributed to the lack of scrutiny and transparency from the government, inadequate testing, lack of efficient digital reporting system and a domestic tourism campaign.(18)
- In Malaysia, the second surge in cases was associated with clusters originating from religious and other gatherings.(21) In Vietnam, almost half of new cases during the second wave were found in the hospital setting.(23) Easing of social distancing and leisure activities of young people were associated with second waves in South Korea, Hong Kong and Iran.(3, 10, 15)
- Two major provinces in South Korea experienced a resurgence in cases after easing lockdown measures, with the majority of new clusters associated with nightclubs, religious facilities, sports clubs, and indoor promotional events.(17, 20) The second wave had a higher proportion of asymptomatic cases than the first wave, especially among the 20-39 age group. This could be

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due to extensive contact tracing and testing among this age group in investigating clusters originating from leisure-venues and workplaces. This age group may otherwise delay testing or have lower rates of screening.(17)

- European countries that had seen a sustained decline in cases after an initial peak started to experience a spike, which was attributed to easing of lockdown measures, relaxation of social distancing practices, increased number of testing,(24) younger people continuing to engage in social gatherings,(16) two mass events,(12, 19) and delays in implementing locally coordinated, culturally appropriate and accessible public health interventions.(25)
- An analysis of the second wave of COVID-19 in 26 countries found that the second wave of infections was mainly among younger age groups and the rate of spread increased with the rise of temperature.(26) A second analysis article found that the second wave had a lower case fatality rate than the first wave.(27)

Limitations

There is limited peer-reviewed or pre-peer reviewed literature on the contributing factors of 'second wave' or 'second spike' of COVID-19. There is no a formal or clear definition of what constitutes as a 'second wave' of COVID-19.(28, 29). The terms 'second wave', 'second spike', 'resurgence' and 'second peak' were used interchangeably in the existing literature without a clear distinction between those concepts. There is no clear consensus on whether an exponential increase in localised infections constitutes a 'second wave' or the localised spike is among multiple peaks within 'one big wave' or 'sporadic outbreaks'.(30-32) The pandemic is still evolving and the empirical evidence on this topic is still developing. Currently, the existing literature on this topic generally lacks depth in their analysis. Testing rates can affect the measurement of different waves, and treatments have evolved over the course of the pandemic. These factors are not always described in publications but play an important role in interpretation.

Background

In Australia, Victoria experienced a spike in COVID-19 cases which started from mid-June and peaked in mid-August.(33) Local media sources reported that the new outbreak could have been originated from the hotel quarantine program.(9, 34, 35) Family gatherings were also mentioned as a significant source of transmission.(36) A royal commission into the hotel quarantine program is currently underway.(9)

Globally, many countries have experienced a surge in COVID-19 cases after an initial decline or a steady low incidence rate.(27) Recent articles suggest that in the absence of herd immunity acquired through either vaccination or natural infection, the virus is likely to persist and pose a resurgence threat.(37-39) Mathematical modelling studies had predicted that with extensive testing of symptomatic individuals, effective contact tracing, and quarantine measures, it could be possible to curtail a spike in infections even with relaxation of lockdown measures such as reopening schools and economic activities.(40, 41) Behavioural, social and public health measures such as enhanced testing and contact tracing, continued emphasis on social distancing, hand hygiene and personal protection, stringent border control, robust quarantine measures, and strategic preparedness and response plans are recommended to mitigate the risk of subsequent spikes.(3, 17, 37, 42-44)

Methods (Appendix 1)

PubMed and Google searches were conducted on 10 September and 13 October 2020. Only peer-reviewed or pre-peer-reviewed literature were included. Studies reporting on mathematical or simulated modelling or hypothetical scenario analysis were excluded.

Results

Table 1

Source	Summary
Peer-reviewed sources	
COVID-19 Australia: Epidemiology Report 26 COVID-19 National Incident Room Surveillance Team 2020(1)	• Epidemiology report for COVID-19 in Australia. • Graph showing COVID-19 notifications by week of diagnosis, with timing of key public health measures. • Prior to the second wave on 27 April, select states and territories began easing of restrictions. • At the start of the second wave in Victoria on 1 July, the state implemented lockdowns on 'hot spot' suburbs, and by 8 July the NSW-VIC border was closed and stage 3 lockdown of Melbourne and Mitchell Shire.
The Deadly Cost of Ignorance: The Risk of Second Wave of COVID-19 Zali, et al. 2020(10)	• Letter on a second wave in Iran. • Nearly a month and a half since the first infection (8 April), reopening gradually began and social activities resumed. • The highest number of confirmed cases was recorded on 4 June. • The National COVID-19 Combat Committee reports on people's attitude about COVID-19 and sanitation protocols. The report found that the percentage of people who respected sanitation protocols were 61% and 25% in April and June respectively.
Mass Events Trigger Malta's Second Peak After Initial Successful Pandemic Suppression Cuschieri, et al. 2020(19)	• Study reports on a second wave in Malta. • After the first wave, only four positive cases were reported over the successive 15 days. • There were two major mass events (a hotel pool party with approximately 800 people and an annual Catholic Saint feast celebration), which saw a rise in community transmission and daily cases rise to two-digit figures. • Despite initial cases among young adults, within weeks there was a small spill off on the more elderly population observed.
The second wave of COVID-19 in a tourist hotspot in Vietnam Vuong, et al. 2020(23)	• Study reports on a second wave in Vietnam. • After 99 days without any further local cases following the first wave, a second wave of COVID-19 started in a major hospital in Da Nang, Vietnam. • About half of all SARS-CoV-2 cases were found in the hospital setting (49.4%), with Da Nang Hospital as the epicentre of the outbreak (251 cases, 45.6%).

Source	Summary
Peer-reviewed sources	
Lessons Learned from the Re-emergent COVID-19 Cases in Areas of Long Reported No Community Transmission Ibrahim, et al. 2020(11)	• Narrative article. • In several jurisdictions (Hong Kong, China, Nepal, Vietnam), after a period of stability, imported cases have prompted new waves of outbreak. • Many are linked to illegal immigration. • Stricter border controls and contact tracing are advocated.
Stringent containment measures without complete city lockdown to achieve low incidence and mortality across two waves of COVID-19 in Hong Kong Wong, et al. 2020(3)	• Aggressive escalation of border control correlated with the reduction of the reproduction number (R_t) from 1.35 to 0.57 and 0.92 to 0.18 and aversions of 450 and 1,650 local infections during the first and second waves, respectively. • Implementing COVID-19 tests for overseas returners correlated with an upsurge of asymptomatic case detection, and shortened containment delay in the second wave. • Medium-sized cluster events in the first wave were mainly due to family gatherings, and those in the second wave were from leisure activities among young people. • Containment delay was associated with older age, male gender and local cases, and saw significant improvement in the second wave compared with the first wave (average: 6.8 vs 3.7 days).
Malta tourism losses due to second wave of COVID-19 Grech, et al. 2020(12)	• Descriptive account of two waves in Malta. • The second wave occurred after measures limiting gatherings were lifted, permitting two mass gatherings to take place. • Authors reiterates the value of the WHO criteria for relaxing restrictions.
Covid-19: Leaders warn of "full blown second surge" as hospital admissions rise Iacobucci 2020(45)	• A BMJ news article. • The article warns the UK National Health Service will face a second surge without urgent action. • On 8 October there were 3,044 patients in hospital in England with coronavirus, up from 1,995 a week ago on 1 October. 8 October was the highest number of daily cases since 22 June.
Spatial variability in reproduction number and doubling time across two waves of the COVID-19 pandemic in South Korea, February to July 2020	• Study reports on a second wave in South Korea. • South Korea experienced two spatially heterogenous waves of COVID-19 in March and June. • The easing of the social distancing measures resulted in the second wave.

Source	Summary
Peer-reviewed sources	
Shim, et al. 2020(15)	
COVID-19: A global and continental overview of the second wave and its (relatively) attenuated case fatality ratio Grech, et al. 2020(2)	• Publicly available data for daily new cases and deaths from December 2019 to September 2020 was obtained from Our World in Data website and analysed with Pearson correlation. • There three distinct time periods exhibited in the data. • Cases rose to mid-April, plateaued till mid-May then rose again. Almost all the slopes in these three time periods were statistically significant. • Deaths followed a similar three-part pattern, with values lagging circa one week after new cases and a middle time period when deaths decreased, with all periods exhibiting significant slopes. • At a continent level, for new cases, Asia rose steadily, Europe is increasing again, the Americas and Africa are declining. Deaths follow a similar pattern. • Oceania shows a bimodal pattern, with a first and second wave of cases shortly followed by deaths in a similar pattern.
Covid-19 in Australia: most infected health workers in Victoria's second wave acquired virus at work Smith August 2020(9)	• A news article on BMJ about Australia. • Melbourne, Australia experienced a second wave of COVID-19 outbreak in July 2020. • An inquiry into the COVID-19 hotel quarantine in Victoria is currently underway. Early hearings of the inquiry revealed that the Victorian government contracted private security firms to guard the hotels. However, security guards from those firms only received a 30-minute online infection control training. Local news and social media reported that some security guards might have been in intimate contact with quarantined hotel residents. There were also reports that they were either not provided with personal protective equipment or were not wearing the protective equipment appropriately. There was a lack of medical oversight at the hotels and security guards who contracted the virus from the quarantined travellers took it back to their families and communities. • Genomic sequencing of the second wave virus revealed that 99.8% of the transmission could be traced back to three clusters originating from the hotel quarantine.
Inverted Covariate Effects for First versus Mutated Second Wave Covid-19: High Temperature Spread Biased for Young	• Visual graph examination of the characteristics and determinants of first and second waves of COVID-19 in 26 countries. • Compared to the spread rate of the first wave, which decreased with the rise of temperature, the second wave spread rate

Source	Summary
Peer-reviewed sources	
Seligmann, et al. August 2020(26)	increased with temperature. Authors hypothesise that this could be due to population tendency to stay inside in cold temperature. • Compared to the first wave, which mainly infected the elderly, the second wave mainly affected the younger age groups. • Compared to the first wave, second wave COVID-19 strains had lower spread rates.
Decreased Case Fatality Rate of COVID-19 in the Second Wave: a study in 53 countries or regions Fan, et al. September 2020(27)	• This article analyses data from 54 countries that experienced a second wave of outbreak. • The second wave had a lower fatality rate (CFR, rates of death among reported cases) than the first wave in 43 countries, which may indicate decreasing severity of the pandemic. • Authors hypothesise that the decrease in case fatality rate could be due to the most vulnerable having died in the first wave, or countries were better prepared for the next wave, or transmission shifting to the younger age group.
Covid-19: Social irresponsibility of teenagers towards the second wave in Spain Murilo-Llorente and Perez-Bermejo August 2020(16)	• A letter to the editor from Spain. • The resurge in COVID-19 cases were mainly attributed to the social irresponsibility of young people, who continued to engage in social activities in nightclubs and pubs and hold private parties.
Early lessons from a second COVID-19 lockdown in Leicester, UK Nazareth, et al. July 2020(25)	• A correspondence letter from Leicester, UK. • Leicester, UK experienced a second spike in cases in June 2020, and new cases were concentrated in areas with a high proportion of people from minority ethnic backgrounds. • The information on an ongoing spike in cases, which were reflected in the data collected at Pillar 2 level (swab testing in the community), was not communicated to the local health organisations in a timely manner. This resulted in delays in the implementation of locally coordinated, culturally appropriate and accessible public health interventions.
Epidemiology and control of two epidemic waves of SARS-CoV-2 in South Korea	• A pre-peer-review article from South Korea. • South Korea experienced two COVID-19 epidemic waves: first from 19 January to 19 April 2020 and second from 20 April to 11 August 2020. • In early February, South Korea implemented strict social distancing and public health measures. Those measures resulted

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Peer-reviewed sources	
Ryu, et al. September 2020(17)	in a gradual decline in case numbers and effective reproductive number R_t after a peak in the third week of February. • After relaxing the strict social distancing measures on 6 May, both the case numbers and R_t resurged, with the former peaking in late May and early June and the latter peaking on 11 May. • The new infections during the second wave were mainly driven by local transmission, rather than being imported cases. • The most frequent type of clusters during both the first and second waves was the religious gatherings. • Reopening of schools and resuming work activities may have contributed to the second spike in cases. • The second wave had a higher proportion of asymptomatic cases than the first wave, especially among the 20-39 age group. This could be due to extensive contact tracing and testing among this age group in investigating clusters originating from workplaces and leisure-venues. This age group may otherwise delay testing or have lower rates of screening. • Efficient social distancing measures, along with extensive contact tracing, especially among asymptomatic cases, were recommended to mitigate the risk of subsequent waves of the epidemic.
Spatial and temporal variability in the transmission potential of COVID-19 in South Korea including the second wave in the greater Seoul area, February to July 2020 Shim and Chowell August 2020(20)	• A pre-peer-review article from South Korea. • Seoul and Gyeonggi provinces experienced two waves of COVID-19, with the second wave peaking in the first two weeks of June 2020. • The South Korean government eased social distancing restrictions on 6 May after the first wave. Schools reopened from mid-May. • A new cluster emerged from nightclubs that marked the start of a second spike in the Seoul area in late May. Later, new clusters were associated with a holiday weekend, religious facilities, a call centre, a sports club, promotional events by a health product retailer, and door-to-door salespeople. • The second spike in cases in Gyeonggi area that started to develop in late May were associated with clusters originating from religious facilities, a warehouse, a call centre, a hospital, nightclubs, promotional events by a health product retailer, door-to-door sales and a sports facility. • The second waves in two provinces in South Korea were attributed to the easing of social distancing measures, especially in high population density areas.

Source	Summary
Peer-reviewed sources	
The Annals and the Medical Narrative of Singapore Oh, et al. March 2020(4)	• An editorial from Singapore. • The second spike in the COVID-19 cases was attributed to the return travellers or visitors from countries such as the USA, UK, Italy and other European countries.
Monitoring respiratory infections in covid-19 epidemics Chan, et al. May 2020(5)	• An analysis article from Hong Kong, China. • The second wave of COVID-19 was primarily driven by returning residents from the European countries and the USA.
Perspectives on COVID-19 from Singapore: Impact on ESKD Care and Medical Education Coffman, et al. August 2020(6)	• A perspectives article from Singapore. • The second wave of COVID-19, which started in early March 2020, was primarily driven by the returning residents from Europe, North America and other countries. • In late March, cases started to rise among foreign national workers living in dormitories.
Socioeconomic factors influencing COVID-19 spread in Japan: Virus importation and domestic transmission during the first two waves Bassino and Ladmiral, July 2020(7)	• A pre-peer-review article from Japan. • Citing findings from haplotype analysis of virus genome by the National Institute for Infectious Diseases (NIID), the second wave which started from mid-March 2020 and peaked on 12 April was attributed to imported cases from European and North American countries. The majority of imported cases were citizens or long-term residents of Japan. • Insufficient testing capacity at international airports was cited as a contributing factor.
Why does Japan have so few cases of COVID-19? Iwasaki and Grubaugh May 2020(8)	• A commentary article from Japan. • The second spike in COVID-19 cases was attributed to the returning travellers from Europe.
Resurgence of covid-19 in Japan Shimizu, et, al. August 2020(18)	• An editorial from Japan. • Japan experienced a surge in cases in early August after experiencing an earlier surge in mid-March. • Authors argue the following could have contributed the surge in cases.

Source	Summary
Peer-reviewed sources	
	○ Lack of scrutiny and transparency from the government, which dismantled the expert committee comprised of key discipline experts in June 2020 ○ The government launched a domestic tourism campaign in July 2020. ○ Inadequate testing capacity ○ Lack of efficient digital reporting system.
COVID-19 outbreak in Malaysia: Actions taken by the Malaysian government Shah, et al. May 2020(21)	• A situation analysis article from Malaysia. • Malaysia experienced a second wave in COVID-19 cases in early March 2020. • The second wave of cases mainly originated from two clusters, one was from contacts of a confirmed case who visited five different meetings and gatherings, and the other was related to a large religious gathering in a mosque attended by a positive case.
COVID-19 resurgence in Iran Devi, June 2020(13)	• A report from Iran. • The second wave of COVID-19 started in early May after the country experienced a gradual drop in cases from early April. The increase in cases was attributed to the easing of lockdown measures, as well as increased testing capacity.
Characteristics and Outcomes of COVID-19 Patients During Initial Peak and Resurgence in the Houston Metropolitan Area Vahidy, et al. August 2020(14)	• A research letter from the Houston, US. • A second surge in COVID-19 cases started on 16 May 2020, which was two weeks after the phased state-wide reopening. • An analysis of electronic health records of COVID-19 cases showed that the increase during surge 2, especially among low socioeconomic and younger population groups, can be related to the following factors. ○ Phased reopening ○ Increased testing ○ Return to work and relaxation of preventative practices.

Appendix 1

PubMed search terms (searched on 10 September 2020)

("second wave"[title/abstract] or "second spike" [title/abstract] or "second surge"[title/abstract] or "second rise" [title/abstract] or "re-emerge*"[title/abstract] or "resurge*"[title/abstract]) AND (2019-nCoV[title/abstract] or nCoV*[title/abstract] or covid-19[title/abstract] or covid19[title/abstract] or "covid

19"[title/abstract] or "coronavirus"[MeSH Terms] or "coronavirus"[title/abstract] or sars-cov-2[title/abstract] or “severe acute respiratory syndrome coronavirus 2”[Supplementary Concept]) AND (2020/01/01:3000/12/31[Date - Publication])

The search was re-run on the 13 October 2020.

Google and grey literature search terms

Second wave/second spike/ resurgence/ and COVID-19

References

1. COVID-19 Australia: Epidemiology Report 26: Fortnightly reporting period ending 27 September 2020. Communicable Diseases Intelligence (2018). 2020;44.
2. Grech V, Cuschieri S. COVID-19: A global and continental overview of the second wave and its (relatively) attenuated case fatality ratio. Early Human Development. 2020:105211.
3. Wong MCS, Ng RWY, Chong KC, Lai CKC, Huang J, Chen Z, et al. Stringent containment measures without complete city lockdown to achieve low incidence and mortality across two waves of COVID-19 in Hong Kong. BMJ Glob Health. 2020;5(10).
4. Oh VM, Seet RC. Editorial. The Annals and the Medical Narrative of Singapore. 2020;49(3).
5. Chan KH, Lee P-w, Chan CY, Lam KBH, Ho P-l. Monitoring respiratory infections in covid-19 epidemics. BMJ (Clinical research ed). 2020;369.
6. Coffman TM, Chan CM, Choong LH-L, Curran I, Tan HK, Tan CC. Perspectives on COVID-19 from Singapore: Impact on ESKD Care and Medical Education. Journal of the American Society of Nephrology. 2020;31(10):2242-2245.
7. Bassino J-P, Ladmiral G. Socio-Economic Factors Influencing COVID-19 Spread in Japan; Evidence from the Second Wave (March-May 2020). 2020 July.
8. Iwasaki A, Grubaugh ND. Why does Japan have so few cases of COVID-19? EMBO Molecular Medicine. 2020;12(5):e12481.
9. Smith P. Covid-19 in Australia: most infected health workers in Victoria's second wave acquired virus at work. BMJ (Clinical research ed). 2020;370:m3350.
10. Zali A, Ashrafi F, Ommi D, Behnam B, Arab-Ahmadi M. The Deadly Cost of Ignorance: The Risk of Second Wave of COVID-19. Asia Pac J Public Health. 2020:1010539520957809.
11. Ibrahim Y, Raut A, Varney J, Sidhu A, Dong V, Nguyen TH. Lessons Learned from the Re-emergent COVID-19 Cases in Areas of Long Reported No Community Transmission. Clin Infect Dis. 2020.
12. Grech V, Cuschieri S, Balzan M, Grech P, Fabri S, Gauci C. Malta tourism losses due to second wave of COVID-19. Early human development. 2020:105208.
13. Devi S. COVID-19 resurgence in Iran. Lancet (London, England). 2020;395(10241):1896.
14. Vahidy FS, Drews AL, Masud FN, Schwartz RL, Askary BB, Boom ML, et al. Characteristics and Outcomes of COVID-19 Patients During Initial Peak and Resurgence in the Houston Metropolitan Area. Jama. 2020.
15. Shim E, Tariq A, Chowell G. Spatial variability in reproduction number and doubling time across two waves of the COVID-19 pandemic in South Korea, February to July 2020. Int J Infect Dis. 2020.
16. Murillo-Llorente MT, Perez-Bermejo M. Covid-19: Social irresponsibility of teenagers towards the second wave in Spain. Journal of epidemiology. 2020.
17. Ryu S, Noh E, Ali ST, Kim D, Lau EH, Cowling BJ. Epidemiology and Control of Two Epidemic Waves of SARS-CoV-2 in South Korea. Available at SSRN 3687061. 2020.
18. Shimizu K, Wharton G, Sakamoto H, Mossialos E. Resurgence of covid-19 in Japan. BMJ (Clinical research ed). 2020;370:m3221.
19. Cuschieri S, Balzan M, Gauci C, Aguis S, Grech V. Mass Events Trigger Malta's Second Peak After Initial Successful Pandemic Suppression. Journal of Community Health. 2020:1-8.

20. Shim E, Chowell G. Spatial and temporal variability in the transmission potential of COVID-19 in South Korea including the second wave in the greater Seoul area, February to July 2020. medRxiv : the preprint server for health sciences. 2020:2020.07.21.20158923.
21. Shah AUM, Safri SNA, Thevadas R, Noordin NK, Rahman AA, Sekawi Z, et al. COVID-19 outbreak in Malaysia: Actions taken by the Malaysian government. International Journal of Infectious Diseases. 2020;97:108-16.
22. Das D, Zhang J. Pandemic in a smart city: Singapore's COVID-19 management through technology & society. Urban Geography. 2020:1-9.
23. Vuong NM, Le Quyen NT, Tra DT, Do Van T, Tuan NQ, Co DX, et al. The second wave of COVID-19 in a tourist hotspot in Vietnam. J Travel Med. 2020.
24. Eurosurveillance editorial team. Rapid risk assessment from ECDC: Resurgence of reported cases of COVID-19 in the EU/EEA, the UK and EU candidate and potential candidate countries. Euro Surveill. 2020;25(26).
25. Nazareth J, Minhas JS, Jenkins DR, Sahota A, Khunti K, Haldar P, et al. Early lessons from a second COVID-19 lockdown in Leicester, UK. The Lancet. 2020;396(10245):e4-e5.
26. Seligmann H, Iggui S, Rachdi M, Vuillerme N, Demongeot J. Inverted Covariate Effects for First versus Mutated Second Wave Covid-19: High Temperature Spread Biased for Young. Biology. 2020;9(8).
27. Fan G, Yang Z, Lin Q, Zhao S, Yang L, He D. Decreased Case Fatality Rate of COVID-19 in the Second Wave: a study in 53 countries or regions. Transboundary and emerging diseases. 2020.
28. Middleton J, Lopes H, Michelson K, Reid J. Planning for a second wave pandemic of COVID-19 and planning for winter : A statement from the Association of Schools of Public Health in the European Region. International Journal of Public Health. 2020:1-3.
29. Department of Health. Chief Medical Officer's press conference about COVID-19 on 22 June 2020 Canberra: Australian Government Department of Health; 2020. Available from: https://www.health.gov.au/news/chief-medical-officers-press-conference-about-covid-19-on-22-june-2020.
30. Moghadas SM, Fitzpatrick MC, Sah P, Pandey A, Shoukat A, Singer BH, et al. The implications of silent transmission for the control of COVID-19 outbreaks. Proc Natl Acad Sci U S A. 2020;117(30):17513-5.
31. The Centre for Evidence-Based Medicine. Covid 19 – Epidemic 'Waves'. Oxford: CEBM, University of Oxford; 2020. Available from: https://www.cebm.net/covid-19/covid-19-epidemic-waves/.
32. Beaumont P, Graham-Harrison E. 'One big wave' – why the Covid-19 second wave may not exist. The Guardian. 2020.
33. Victoria State Government Health and Human Services. Victorian coronavirus (COVID-19) data 2020. Available from: https://www.dhhs.vic.gov.au/victorian-coronavirus-covid-19-data.
34. Taylor J. Hotel quarantine linked to 99% of Victoria's Covid cases, inquiry told. The Guardian. 2020.
35. Schneiders B. How hotel quarantine let COVID-19 out of the bag in Victoria. The Age. 2020.
36. Lessons for Australia from Melbourne's COVID-19 spike [press release]. Canberra: Australian Government Department of Health; 2020. Available from: https://www.health.gov.au/news/lessons-for-australia-from-melbournes-covid-19-spike.

37. Moghnieh R, Abdallah D, Bizri AR. COVID-19: Second Wave or Multiple Peaks, Natural Herd Immunity or Vaccine-We Should be Prepared. Disaster Medicine and Public Health Preparedness. 2020:1-18.
38. Chavkin W, Nelson K, Swerdlow L. COVID-19 Second Wave Public Health Policy Recommendations. New York: Columbia University Mailman School of Public Health; 2020.
39. Geard N, Wood J. What causes a 'second wave' of disease outbreak? The Conversation; 2020. Available from: https://theconversation.com/coronavirus-what-causes-a-second-wave-of-disease-outbreak-and-could-we-see-this-in-australia-134125.
40. Panovska-Griffiths J, Kerr CC, Stuart RM, Mistry D, Klein DJ, Viner RM, et al. Determining the optimal strategy for reopening schools, the impact of test and trace interventions, and the risk of

occurrence of a second COVID-19 epidemic wave in the UK: a modelling study. The Lancet Child & Adolescent Health. 2020;4(11):817-827.
41. Aleta A, Martín-Corral D, Piontti APY, Ajelli M, Litvinova M, Chinazzi M, et al. Modeling the impact of social distancing, testing, contact tracing and household quarantine on second-wave scenarios of the COVID-19 epidemic. medRxiv; 2020.
42. Bazzell B, Wagner D, Durant KM, Callahan B. Insights on developing a field hospital formulary and medication distribution process in preparation for a second surge of COVID-19 cases. American Journal of Health-System Pharmacy. 2020; 77(21):1763-1770.
43. Xu S, Li Y. Beware of the second wave of COVID-19. Lancet (London, England). 2020;395(10233):1321-2.
44. Baqaee D, Farhi E, Mina M, Stock JH. Policies for a second wave. Brookings Papers on Economic Activity. 2020.
45. Iacobucci G. Covid-19: Leaders warn of "full blown second surge" as hospital admissions rise. BMJ. 2020;371:m3941.