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Title	Failures of quarantine systems for preventing COVID-19 outbreaks in Australia and New Zealand

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Failures of quarantine systems for preventing COVID-19 outbreaks in Australia and New Zealand

Abstract

Objectives: To identify COVID-19 quarantine system failures in Australia and New Zealand.

Design, setting, participants: Observational epidemiological study of travellers in managed quarantine in Australia and New Zealand, to 15 June 2021.

Main outcome measures: Number of quarantine system failures, and failure with respect to numbers of travellers and SARS-CoV-2-positive travellers.

Results: We identified 22 quarantine system failures in Australia and ten in New Zealand to 15 June 2021. One failure initiated a COVID-19 outbreak that caused more than 800 deaths (the Victorian "second wave"); nine lockdowns were linked with quarantine system failures. The failure risk was estimated to be 5.0 failures per 100 000 travellers passing through quarantine and 6.1 (95% CI, 4.0–8.3) failures per 1000 SARS-CoV-2-positive travellers. The risk per 1000 SARS-CoV-2-positive travellers was higher in New Zealand than Australia (relative risk, 2.0; 95% CI, 1.0–4.2).

Conclusions: Quarantine system failures can be costly in terms of lives and economic impact, including lockdowns. Our findings indicate that infection control in quarantine systems in Australia and New Zealand should be improved, including vaccination of quarantine workers and incoming travellers, or that alternatives to hotel-based quarantine should be developed.

Summary box

The known: Australia and New Zealand have repeatedly eliminated community transmission of SARS-CoV-2. These countries have primarily used hotel-based quarantine for citizens returning from overseas. The quality of quarantine processes has improved, but the risks of virus transmission within hotels and escape into the community remain high.

The new: Australia and New Zealand had 32 COVID-19-related quarantine system failures to 15 June 2021: five failures per 100 000 returning travellers or six failures per 1000 SARS-CoV-2-positive travellers.

The implications: Quarantine systems are being required to manage increasing proportions of returning travellers infected with SARS-CoV-2. Improved monitoring and quality of quarantine systems are needed.

New Zealand and some Australian states have repeatedly eliminated community transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).[1] The two countries have primarily used hotel-based quarantine for citizens returning from overseas, requiring 14 days of quarantine, as well as polymerase chain reaction (PCR)-based virus testing and mask use in shared spaces, such as common exercise areas (in New Zealand, but not in most Australian states).

Adapting hotels for quarantine purposes exploits a resource otherwise underused during the coronavirus disease 2019 (COVID-19) pandemic, given the decline in international travel. However, the major disadvantage of hotel-based quarantine is that shared spaces and inappropriate ventilation[2] probably render it less effective than purpose-built facilities. Moreover, the consequences of escape of the virus from quarantine (eg, via infected facility workers) may be more severe, given the higher population density in the urban areas where the hotels are located.

On 13 June 2021, the rolling 7-day mean number of administered COVID-19 vaccine doses was 0.46 per 100 people in Australia and 0.31 per 100 people in New Zealand.[3] However, as two doses of the vaccines used are required, these numbers do not indicate the number of people who are fully vaccinated. Most border workers in Australia and New Zealand have been fully vaccinated; in New Zealand, more than 56 000 doses had been administered to border workers by 28 March 2021.[4] All hotel quarantine workers in Victoria who have face-to-face contact with returned travellers had received first vaccine doses by the first week of April 2021.[5]

In view of the limitations of hotel quarantine, we estimated the failure risk of quarantine systems in New Zealand and Australia with respect to the spread of COVID-19 into the community.

Methods

We defined a quarantine system failure as infection with SARS-CoV-2 of a border or health worker, or of a person in the community with a link to the quarantine and isolation system. This definition included people infected in hospital by someone transferred from a quarantine facility (ie, infected persons for whom the 14-day quarantine process had not ended), but did not include virus transmission between returned persons within quarantine facilities.

During 6 January – 23 June 2021, we searched government websites in both countries, including state-specific websites in Australia, to identify outbreaks and border control failures associated with quarantine systems. When an outbreak source was uncertain (eg, the Auckland outbreak in August 2020[6]), we used the best available information to determine whether it was a quarantine failure. Decisions to label an incident a quarantine system failure were confirmed by all authors.

We calculated failure risk (with 95% confidence intervals [CIs]) per 100 000 travellers who passed through quarantine facilities during 1 April 2020 (Australia) or 17 June 2020 (New Zealand) – 15 June 2021; we also calculated the risk per 1000 SARS-CoV-2-positive people who passed through these facilities in this time. The 95% CIs were calculated as $(1.96 * \sqrt{n})(P/d)$, where n = number of hotel quarantine failures, P = population size for rate (100 000 or 1000), and d = number of travellers or SARS-CoV-2-positive people. The starting dates for the analysis correspond in each country to those of the first positive test in a quarantine facility. We calculated risk for New Zealand, Australia, the eight Australian states and territories, and for both countries combined.

For New Zealand, we analysed Ministry of Business Innovation and Employment data for travellers passing through the quarantine system[7] and Ministry of Health data on SARS-CoV-2-positive people.[8] For Australia, we analysed overseas arrivals data (Australian Bureau of Statistics)[9] and Department of Health data.[10]

Ethics approval

Our analysis of publicly available data did not require formal ethics review.

Results

We identified 22 quarantine system failures in Australia, in one instance initiating an outbreak that caused more than 800 deaths (the Victorian "second wave"); eight lockdowns were linked with quarantine system failures. We identified ten quarantine system failures in New Zealand; one initiated an outbreak that caused three deaths and a lockdown (Box 1; online Supporting Information).

For Australia and New Zealand combined, there were 5.0 failures per 100 000 travellers in quarantine (one per 20 156 travellers) and 6.1 failures per 1000 SARS-CoV-2-positive travellers in quarantine (one per 163 infections) (Box 1). This equates to quarantine system failures leading to one lockdown response per 71 665 travellers, and about one COVID-19-related death per 803 quarantined travellers.

In New Zealand, there were 10.5 (95% confidence interval [CI], 4.0–17 failures) per 1000 SARS-CoV-2-positive travellers in quarantine; in Australia, there were 5.2 (95% CI, 3.0–7.3) failures per 1000 SARS-CoV-2-positive travellers (relative risk, New Zealand *v* Australia: 2.0; 95% CI, 1.0–4.2) (Box 1).

Discussion

We identified 32 of quarantine system failures in Australia and New Zealand to 15 June 2021. The higher failure rate per SARS-CoV-2-positive traveller in New Zealand than in Australia could reflect lower quality quarantine measures, but perhaps also greater detection of infections among border workers by testing over a longer period.

Given the low number of failures, our estimates are subject to chance variations. But we may also have underestimated their number, as not all failures will have led to detectable chains of community transmission. Genomes for the first 649 viral isolates in New Zealand indicated that only 19% of virus introductions resulted in more than one additional case of infection.[12] Counting border system failures is therefore sensitive to how they are identified and defined, and increased testing — for example, testing people after leaving quarantine on day 16 is now typical in Australia — may now detect failures that would formerly have been missed.

The risk of quarantine failure in New Zealand and Australia may increase, as the proportion of infected returning travellers is rising because of global intensification of the pandemic and the greater infectivity of newer SARS-CoV-2 variants.[13] Indeed, transmission within quarantine hotels has been documented.[14-16]

Measures have been undertaken that may reduce the risk, including the vaccination of quarantine workers. In New Zealand, the vaccination of border workers with the Pfizer–BioNTech vaccine began in February 2021, and by 11 June it was reported that all managed isolation and quarantine workers had been fully vaccinated.[17] However, more than 1600 other frontline border workers (eg, those working at ports or as aircrew) were still unvaccinated at the end of June 2021.[18]

While vaccination of quarantine workers and other border staff was a priority during the first phase of the national vaccine rollout in Australia, information on how many had been vaccinated was not published. In some states, it was reported in April that all border staff had been required to undergo vaccination earlier in 2021.[5,19]

Full vaccination of frontline border workers may have prevented some quarantine system failures. However, vaccination does not eliminate the risk of transmitting or being infected with SARS-CoV-2, although a moderate degree of protection is likely. For example, vaccine efficacy with respect to symptomatic COVID-19 was 67% more than 14 days after the second AstraZeneca vaccine dose,[20] while a later study reported that clinical vaccine efficacy for preventing symptomatic nucleic acid amplification test (NAAT)-positive infection was 70% for the Alpha variant and 82% for other lineages more than 14 days after the second dose.[21] Infection rates were reduced by 70% in people who had received two doses of the Moderna vaccine (asymptomatic and symptomatic cases),[22] and by 95% with the Pfizer/BioNTech vaccine (national surveillance data in Israel).[23] Studies in other primates suggests that the peak level and duration of infectivity are reduced in animals vaccinated against but nonetheless infected with SARS-CoV-2.[24]

Increased testing of quarantine workers[25] will identify some quarantine failures before they lead to community outbreaks. Other improvements in quarantine systems include better security, requiring mask wearing inside quarantine facilities, reducing access to shared spaces, and improving personal protective equipment (PPE) use by workers.[26,27]

Better or purpose-built quarantine facilities in rural locations would both avoid the greater risk of close community contacts associated with central business district hotels and that of within-building spread by inappropriate ventilation systems. There have been no quarantine failures at the Howard Springs facility near Darwin, a success that was cited in the June 2021 announcement of the construction of a purpose-built quarantine facility in Victoria.[28] Other infection prevention and control measures, including PPE, will remain important in all quarantine facilities.

The most direct way to substantially reduce the risk of SARS-CoV-2 escaping quarantine is to reduce the number of arriving travellers from areas with high infection levels, as New Zealand and Australia did temporarily for travel from India and other high risk countries in April 2021.[29] Beyond this measure, a range of other improvements in arrangements and processes could be considered (Box 2).

Limitations

The cause of some COVID-19 outbreaks is uncertain (eg, Auckland, August 2020[6]) and there was imprecision in traveller numbers for Australia, as some people moved between states on domestic flights, and this was not captured in the data we analysed. Additionally, COVID-19 case numbers are often provisional because of reclassifications of false positive results and duplications. We did not assess the change in quarantine system failures over time because of the relatively small number of failure events. The risk of system failures is probably highly dynamic as traveller volumes, infection rates, and quarantine processes change, and as vaccination rates for border workers and in the community increase. The number of deaths per failure was almost entirely attributable to the second wave in Victoria, and therefore should not extrapolated to future failures.

Conclusions

We identified 32 COVID-19 quarantine failures in Australia and New Zealand to 15 June 2021. Quarantine system failures can be costly in terms of lives and economic impact. Hotel-based quarantine needs to be improved or alternative approaches developed.

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Box 1. Quarantine system failures in Australia and New Zealand, from the time of first identified SARS-CoV-2 infection in quarantine to 15 June 2021

	Numbers in quarantine facilities			Failure risk	
Jurisdiction	**Failures**	**Travellers**	**SARS-CoV-2-positive travellers**	**Per 100 000 travellers passing through quarantine**	**Per 1000 SARS-CoV-2-positive travellers (95% CI)***
New Zealand and Australia	32	644 982	5206	5.0 (3.2–6.7)	6.1 (4.0–8.3)
New Zealand (17 June 2020 – 15 June 2021)	10	145 759	955†	6.9 (2.6–11)	10 (4.0–17)
Australia (1 April 2020 – 15 June 2021)					
All jurisdictions	22	499 223	4251	4.4 (2.6–6.2)	5.2 (3.0–7.3)
Australian Capital Territory	0	988	26	—	—
Queensland	3‡	111 805	724	2.7	4.1
New South Wales	9	218 457	1907	4.1	4.7
Northern Territory§	0	16 378	153	—	—
South Australia	2	20 524	351	9.7	5.7
Tasmania	0	1287	21	—	—
Victoria¶	5	83 904	550	6.0	9.1
Western Australia	3	45 880	519	6.5	5.8

CI = confidence interval.

* Numbers at state/territory level were too small for calculation of meaningful 95% CIs.

† Excludes nine SARS-CoV-2-positive people without overseas travel history.[7]

‡ Includes two at a hospital during the quarantine process.

§ Includes one non-hotel facility (former workers' camp).[11]

¶ Flights to Victoria were suspended during 14 February – 25 March 2021 following a quarantine failure linked with use of a nebuliser in a quarantine facility, leading to 22 infections (the "Holiday Inn cluster"). Flights to Victoria were also suspended during 2 July – 6 December 2020 (the "second wave").

Box 2. Policy and operational options for reducing the risk of SARS-CoV-2 transmission by travellers to Australia and New Zealand, with proposed prioritisation

Policy option	**Description**	**Priority**
1. Cap or suspend travel from countries with high infection rates	The Australian and New Zealand governments have the legal powers to reduce the numbers of incoming travellers by restricting the rights of their citizens to return from countries very high incidence rates on public health grounds.	Top priority

2. Pre-departure testing, with or without quarantine	Expand existing requirements for pre-departure testing to further source countries. Pre-departure testing could include both polymerase chain reaction (PCR) testing within 72 hours of departure and rapid testing immediately before departure, to identify infected persons who start shedding virus in the 72 hours preceding departure. Such arrangements are considered legally acceptable. Pre-departure quarantine (for one week) would provide additional assurance, preferably in an airport hotel in a transport hub where New Zealand and Australian officials are permitted to check quality processes. If this is impractical, incoming travellers could be asked (via the passenger booking system) to self-quarantine as strictly as possible during the week before travel.	Top priority
3. Pre-departure vaccination	Make travel contingent on providing evidence of full vaccination. This measure assumes that vaccination at least partially reduces the risk of transmission.	Uncertain
4. Use passenger booking systems to reduce infection risk	Require passengers to declare pre-departure COVID-19 precautions when booking quarantine facility accommodation prior to travel. A booking system is operating in New Zealand and could be adopted in Australia.	High priority
5. Increase in-flight precautions	Explore means for reducing risk of in-flight infection, as documented on a flight to New Zealand,[30] by more stringent enforcement of mask wearing in airports and during flights, and the use of higher efficacy masks (although fit can be critical to the level of protection) or double masking. The United States Centers for Disease Control found that a medical procedure mask blocked 56.1%, a cloth mask 51.4% of particles ejected by a simulated cough dummy; a cloth mask over a medical procedure mask (double masking) blocked 85.4% of particles. Double masking of the dummy reduced the cumulative exposure of an unmasked receiver dummy by 82.2%; if the source was unmasked and the receiver fitted with a double mask, cumulative exposure was reduced by 83.0%. When both source and receiver were double masked, the cumulative exposure of the receiver was reduced by 96.4%.[31] A laboratory study (in people) that compared the fitted filtration efficiency (FFE) of commonly available masks worn singly, doubled, or in combination found that adding a second medical procedure mask improved mean FFE from 55% to 66%, and wearing a procedure mask under a cloth face covering improved overall FFE from 66% to 81%, probably by reducing leakage between mask and skin.[32] These findings may not fully reflect real world double masking, but suggest that it may reduce both the risk from infected people and the exposure of uninfected persons. Minimising talking during eating and drinking, and improved ventilation and spacing during flights might also be worthwhile.	High priority
6. Reduce infection risk in airports and transit hubs	Minimise the risk of cross-infection at departure airports and transit hubs by enforcing physical distancing and mask use.	Medium priority
7. Improve local transport	Ensure sufficient physical distancing of travellers on arrival and in transit to quarantine (eg, reduced shuttle capacity); higher efficacy masks or double masking could be required.	Medium priority

8. Shift to discrete quarantine units	Shift some or all quarantine facilities to rural military bases or camps where discrete units (eg, mobile homes or caravans) could be spatially separated, allowing natural ventilation and eliminating shared indoor spaces. The Howard Springs facility, a converted workers' camp in the Northern Territory,[11] is a successful model. If spaces were limited, these facilities could be used for travellers from the highest risk countries.	High priority
9. Restrict hotel quarantine in large cities to travellers at low risk of being infected	Reserve large city hotel quarantine for lowest risk category travellers, and send those in higher risk categories to hotels in smaller cities. Airport access and the risk associated with additional travelling need to be considered.	High priority
10. Expand PCR testing of saliva of facility workers and travellers	Expand daily PCR testing of saliva from facility workers to all facilities in both countries. This could also be considered for all travellers, possibly in combination with current testing regimens. In light of the greater transmissibility of new SARS-CoV-2 variants, testing all workers in border-associated occupations (including catering and laundry service staff) at least twice per week should be considered. Documentation of negative test results should replace self-report systems as an occupational requirement for all border workers.	High priority
11. Require vaccination of quarantine staff	Vaccinating all frontline quarantine workers would be particularly valuable should it prove to reduce transmission.	April 2021: nearing completion in some jurisdictions
12. Cohorting of travellers	All arriving travellers on a flight should enter the same quarantine facility, capacity permitting. This approach, introduced in New Zealand in late April 2021,[7] reduces cross-infection within facilities.	Medium priority
13. Upgrade processes at quarantine facilities	Eliminate shared spaces (no shared exercise areas or smoking areas) to ensure no mixing of residents during the day. Ventilation could be improved, using only rooms with external windows or balconies.	Medium priority
14. Prosecute rule breaking in quarantine facilities	Enforce quarantine facility rules more rigorously. Rule breaking, relatively common in New Zealand facilities,[33] led to no prosecutions during 2020.	Medium priority
15. Improve conditions for quarantine staff	Improve working conditions for quarantine facility staff to minimise overwork (which may increase risk of PPE failures) and prohibit workers take part-time jobs elsewhere. Staffing inadequacies in New Zealand facilities were a concern as late as February 2021.[34,35] Some Australian states have banned frontline quarantine staff from having second jobs.[36]	High priority
16. Improve management of travellers who smoke	Introduce measures to reduce need of nicotine-dependent travellers to smoke in designated areas during travel and in managed quarantine (eg, nicotine replacement treatment as requirement for travel).	Medium priority
17. Add post-quarantine control measures	Introduce a post-quarantine period of home quarantine to reduce risk of local transmission by people with undetected infections (ie, those with exceptionally long incubation periods or cross-infection during quarantine). Post-quarantine testing could be used to detect such infections.	Medium priority

18. Mandatory digital contact tracing tools	Require quarantine workers to use digital tools (eg, Bluetooth function of COVID-19 smartphone apps) to facilitate contact tracing in case of border failure. Travellers could be required to use such technologies for two weeks after completing quarantine. Travellers could also use these tools during quarantine, as facilities are sometimes evacuated because of fire alarms and burst water pipes.	Medium priority

COVID-19 = coronavirus disease 2019; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2.