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In Practice

The value of universal screening for COVID-19 cases on cruise ships during outbreaks

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Key points

- This case series of universal screening for coronavirus disease 2019 (COVID-19) on cruise ships experiencing an outbreak shows there is likely to be significant under-detection of cases on board
- These cases are likely to be in elderly passengers who may unknowingly spread COVID-19 to medically vulnerable communities on their return, highlighting the importance of all passengers taking precautions when interacting with others post-disembarkation
- On cruise ships experiencing a COVID-19 outbreak, universal screening remains an important tool to reduce the spread of infection

Abstract

Objectives: To describe the impact of universal screening for coronavirus disease 2019 (COVID-19) on passengers on cruise ships docking in Sydney, Australia, during 2022 that experienced a significant outbreak of COVID-19.

Type of program or service: Cruise ship disease surveillance

Methods: Case series, based on analysis of cruise ship voyages where universal screening of passengers was requested by a NSW health authority and undertaken by the cruise ship.

Results: Of 111 voyages in 2022, three fit the definition for this study. Universal screening during these voyages resulted in the detection of up to 1.8 times the number of existing COVID-19 cases, increasing attack rates of the three voyages from 14% to 24%; 13% to 28%; and 3% to 8% respectively. Case demographics showed an even gender distribution, with a majority 70 years or older. Asymptomatic case percentage ranged from 2% to 54%, with age and gender not associated with symptomatic status. Almost all cases were reported as being fully vaccinated. Genomic testing of cases showed multiple lineages of COVID-19 circulating in all three voyages.

Lessons learnt: Public health authorities, the cruise industry and passengers should be aware that a large number of unidentified cases of COVID-19 may disembark from a cruise ship that has experienced a large outbreak of the virus. These cases can seed the infection into vulnerable communities. Universal screening as part of the response to a significant outbreak will help identify cases and limit the spread of COVID-19.

Introduction

In response to the coronavirus disease 2019 (COVID-19) pandemic, the Australian Government placed a ban on international cruise ships entering Australian ports on 18 March 2020.[1] On 17 April 2022 this ban expired, with the first passenger cruise docking in the port of Sydney on 4 June 2022. By 31 December 2022, 111 cruise ships had docked in Sydney, carrying a total of 243 518 passengers.

While mitigation measures have reduced the risk of COVID-19, cruise ships remain a risk setting for transmitting COVID-19 infection. Cruise ships may contain high population densities, with common areas presenting challenges for physical distancing. Passengers can be onboard for weeks to months and may disembark at multiple locations during the voyage, while new passengers and crew join the ship from diverse geographical locations.[2] Two studies that examined the spread of COVID-19 on cruise ships suggested that decreased population density, routine universal surveillance testing, daily screening of individuals for COVID-19 symptoms and reduction in the number of ports visited reduce the spread of COVID-19. At the same time, participation in events such as excursions or other group activities increases the risk of infection.[3,4] Seeding of COVID-19 from cruise ships into a country's population was shown in the early days of the pandemic[5], and while an argument can be made about the current endemic nature of COVID-19, the evolution of new COVID-19 variants reinforces the importance of preventing ongoing seeding.[3] Peer-reviewed reporting on the underdiagnosis of COVID-19 cases on cruise ships during outbreaks is limited. However, one study in which universal polymerase chain reaction (PCR) screening was undertaken determined 81% of COVID-19 cases to be asymptomatic.[6]

The resumption of cruising in Australia in 2022 was contingent on the cruise ship industry agreeing to comply with conditions. Two key documents were developed: *Eastern Seaboard and Western Australian Cruising Protocols*[7] and the *Communicable Disease Network of Australia (CDNA) National Guidelines for Cruising in Australia*.[2] Both these documents outlined expectations and standards for the cruise ship industry in preventing, reporting and controlling COVID-19 outbreaks on cruise ships docking in Australian ports. [2,7] These guidelines required a range of pre-boarding and on-board measures, including passenger vaccination, symptom screening and testing, mask use, physical distancing, free medical care and isolation of COVID-19 cases. They documented control measures cruise ships needed to take if COVID-19 case numbers escalated. This could include COVID-19 rapid antigen testing (RAT) of the entire ship's population (universal screening).

Part of the reporting process outlined in the CDNA *National Guidelines for Cruising in Australia* involved the ship's medical team completing an MS Excel template list of all cases of respiratory and gastrointestinal illness on board the vessel. The list must be provided to the local health authority of the next Australian port where the ship docks.

In the state of New South Wales (NSW), a ship could be requested to undertake universal screening of all passengers and/or crew if the ship had or was likely to have, greater than 3% of the population with active COVID-19 and had increasing case numbers in the preceding days. This investigation aims to examine the impact of this recommendation in terms of case identification and outbreak control. While the CDNA guidelines were rescinded in August 2023, this case series may be used to inform future policy in this area. Of the 111 cruise ship voyages entering the port of Sydney in 2022, this paper reports on the three voyages that undertook universal COVID-19 RAT screening at the request of local health authorities.

Methods

Data were collected from line lists submitted to NSW Health by cruise ships within 24 hours prior to docking at Sydney ports. These line lists include age, gender, COVID-19 vaccination status, date of symptom onset (left blank if asymptomatic), severe disease (Y/N), COVID-19 test date, COVID-19 result, and reason for the test (symptomatic, close contact, screening, pre-embarkation) for all cases on the ship. COVID-19 vaccination status includes fully vaccinated (completed primary course of any Therapeutic Goods Administration [TGA]-approved or recognised COVID-19 vaccine), and booster (subsequent dose after a completed primary course of any TGA approved or recognised COVID-19 vaccine).

Passenger case data were extracted from these line lists, and descriptive and chi-squared statistical testing was undertaken in MS Excel and SPSS v28.0.1.1. All case demographics and health status were based on cumulative case numbers within 24 hours of docking in Sydney (end of voyage). Voyages 1 and 2 conducted universal screening at one time point, while voyage 3 performed universal screening at two time points. Calculatons included:

- Attack rates were calculated at three (voyages 1 and 2) or four (voyages 3) time points: prior to the day of surveillance testing; the day(s) of surveillance testing; and at the end of voyage.
- Attack rates were based on the cumulative case numbers before the day of surveillance testing; up to and including the day of surveillance testing; and at the end of voyage, using the total passenger population as the denominator.
- Percentage increase post surveillance was calculated as the number of cases identified on the day of surveillance testing by the cumulative case number before the day of surveillance testing.

- Asymptomatic percentage was calculated as the number of cases that did not have a "date of symptom onset" recorded for the voyage, divided by the total number of cases.
- Screening asymptomatic percentage was calculated as the number of cases in which the reason for testing was "screening" on the day of universal screening, and there was no "date of symptom onset" recorded, divided by all cases in which the reason for testing was "screening" on the day of universal screening.
- Passenger case numbers per day for each voyage were extracted to construct epidemic curves.
- A chi-squared test for independence with Yates' continuity correction was undertaken to examine the associations between age (< 70 or ≥ 70 years) and gender and symptomatic status (symptomatic/asymptomatic).

Between 10 and 20 case samples per voyage underwent genomic testing. Genomic testing was undertaken at laboratories accredited for the task.

Results

The male-to-female ratio for COVID-19 cases was close to 1 for all three voyages, with a large proportion of cases in passengers > 70 years old. Table 1 details the demographics, health status, attack rates, asymptomatic proportions, case percentage increase post universal testing and genomic testing results from each of the three voyages. Figures 1 to 3 show the epidemic curves on each cruise, with the days on which universal testing took place shown by the purple bar. The number of people on board diagnosed with COVID-19 following universal testing increased by between 36% and 178% (Figures 1–3). Age and gender were not associated with symptomatic status (age χ^2 $p = 0.096$ [voyage 1], $p = 0.250$ [voyage 2], $p = 0.672$ [voyage 3]; gender χ^2 $p = 0.972$ [voyage 1], $p = 0.208$ [voyage 2], $p = 0.533$ [voyage 3]).

Discussion

We found that undertaking universal surveillance testing during an escalating outbreak of COVID-19 on board a cruise ship may detect up to 1.8 times the number of existing cases. As shown in each epidemic curve, universal testing reset the expected trajectory of the outbreak by identifying cases that would have either gone undetected or may have been detected later if symptoms developed. When early detection of cases is accompanied by effective isolation, outbreak size can be reduced.[8] Nevertheless, the number detected is likely to be an underestimate of the true number of cases due to surveillance using RAT, which is known to have variable sensitivity in detecting cases, especially asymptomatic cases.[9] At least half the cases were in people aged 70 years or older, a known risk factor for COVID-19 health complications. Despite this, no case was reported as having severe disease, which may partly be explained by the fact that almost all cases had received full COVID-19 vaccination plus a booster. However, it is not known if these cases developed complications post-disembarkation.

If universal screening had not occurred in these cases, there would have been many passengers with undiagnosed COVID-19 disembarking. Despite NSW Government advice that all disembarking passengers consider whom they visit in the week after they disembark from their cruise and avoid contact with people at higher risk of severe illness, being aware of infection may make cases more likely to comply with these measures.[10] Given that most cases were in people aged over 70 years, this caution is particularly important, as they may be more likely to live or mingle with other older people on their return from a cruise.

Genomic testing revealed that all three voyages contained multiple lineages of the Omicron variant, consistent with the profile of lineages circulating in the Australian community during this period. This contributes to an outbreak in two ways. Firstly, multiple lineages suggest seeding onboard has occurred from various sources, so the initial number of cases onboard is numerous. Secondly, passengers are exposed to multiple lineages to which they may have differing immunity, leaving them more vulnerable to infection.

Truly asymptomatic COVID-19 cases in the community were estimated at 18% in 2020.[11] Modelling showed that the Diamond Princess cruise ship – which docked in Yokohama, Japan in 2020 with with 634 people having tested positive for COVID-19) – had a similar asymptomatic proportion of cases (18%), after adjusting for the pre-symptomatic proportion of asymptomatic cases.[12] It is, however, lower than the 81% asymptomatic cases reported on another cruise in the same period.[6] The proportions of RAT-detected asymptomatic cases range from 2% to 54% for the Omicron variant. Several factors could have led to changes in the asymptomatic proportions. Firstly, asymptomatic cases were only tested once for voyages 1 and 2 and twice for voyage 3. Therefore, some asymptomatic infections could have resolved before the surveillance testing or developed afterwards, or current infections may have not been detected, resulting in false negative results using RAT swab testing.[9] Offsetting this is the unaccounted pre-symptomatic cases within the asymptomatic case numbers. Further, the evolution of the pandemic, including the build-up of hybrid immunity, may have increased the proportion of asymptomatic or mildly symptomatic cases compared to 2020.

Response and measurement bias could also have affected the asymptomatic proportion. For voyages 1 and 3 it is possible that most of the cases identified via universal screening were asymptomatic and that by default the testing date was wrongly entered as the onset date. For voyage 2, some cases might have been

Figure 1. Epidemic curve on voyage 1[a]

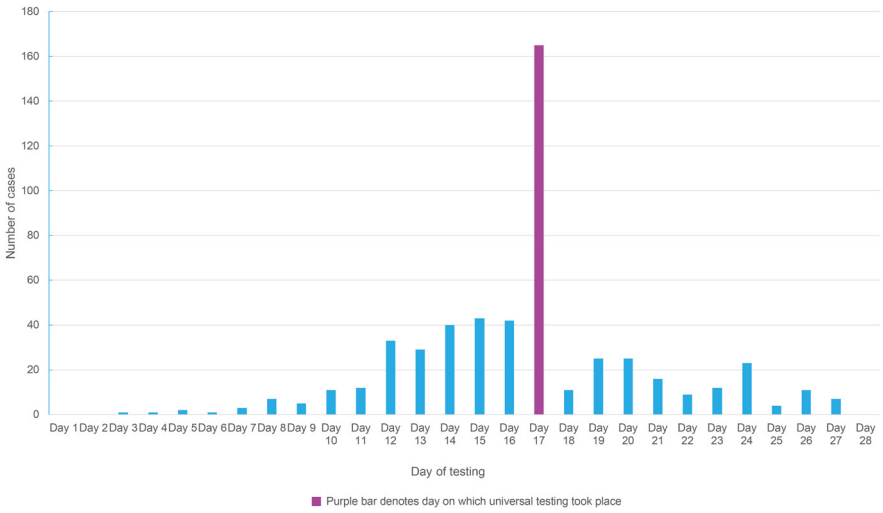


Figure 2. Epidemic curve on voyage 2[a]

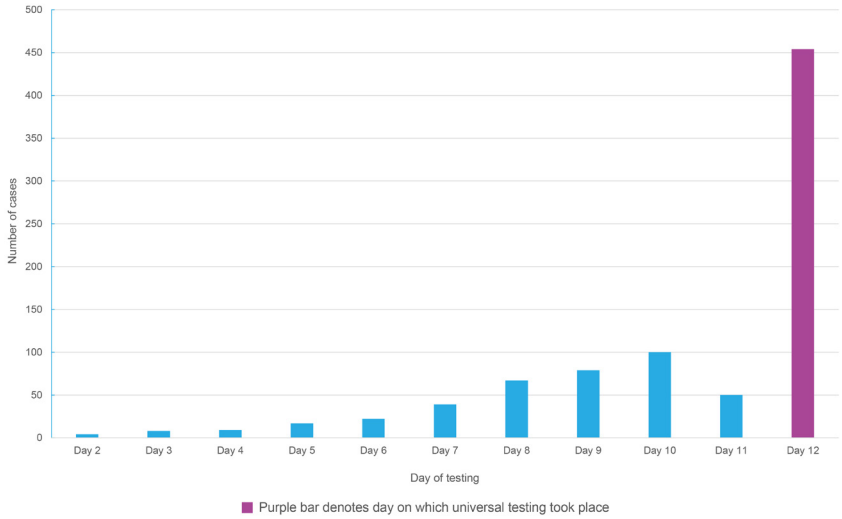
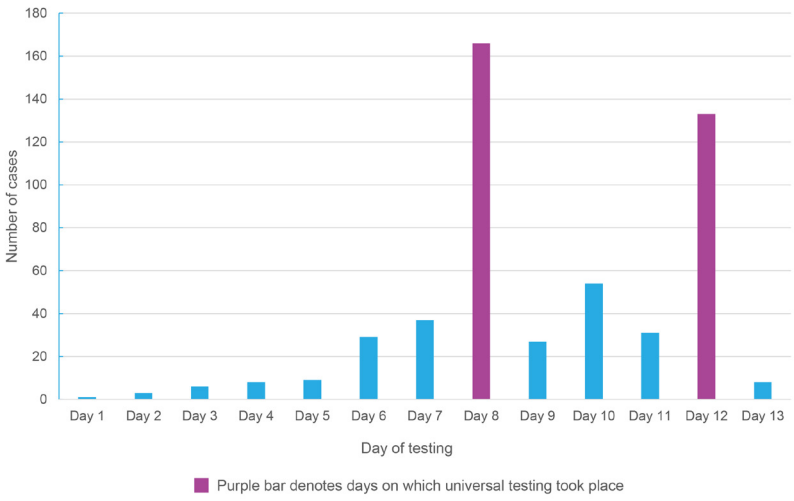


Figure 3. Epidemic curve on voyage 3[a]



[a] Days shown represent total days of cruise duration

Table 1. Voyage statistics and genomic testing results

Voyage		1	2	3
		n (%)	*n* (%)	*n* (%)
Total passengers[a]		*1657*	*3066*	*3174*
Total cases: end of voyage		*538*	*849*	*512*
Case demographics and health status	Male cases[b]	*245* (46)	*384* (45)	*246* (48)
	≥ 70 years old.	*414* (77)	*451* (53)	*310* (61)
	Fully vaccinated	*538* (100)	*849* (100)	*509* (99)
	COVID-19 booster	*538* (100)	*849* (100)	*499* (97)
	Severe disease	*0* (0)	*0* (0)	*0* (0)
Cumulative attack rate	Prior to day of surveillance	*230* (14)	*395* (13)	*93* (3)
	Day of surveillance	*395* (24)	*849* (28)	*259* (8)
	End of voyage	*538* (32)	*849* (28)	*512* (16)
Asymptomatic	End of voyage	*10* (2)	*459* (54)	*86* (17)
Screening asymptomatic – 1st day of surveillance	Asymptomatic screened cases	*0*	*447*	*31*
	Total screened cases	*149* (0)	*451* (99)	*166 (19)*
Screening asymptomatic – 2nd day of surveillance[c]	Asymptomatic screened cases	n/a	n/a	*51*
	Total screened cases	n/a	n/a	*123* (41)
Case percentage increase post -surveillance	First round	(72)	(115)	(178)
	Second round	n/a	n/a	(36)
Genomic testing	Cases	*10*	*15*	*20*
	Variant	Omicron	Omicron	Omicron
	Lineages	BA.5.2.1 BA.5.2.6 BQ.1.3	BA.5.1 BA5.2 BA.5.2.25 BN.1 BQ.1.1 BR.2 XBC.1	BA2.75.3 BA.5.2 BA.5.2.1 BQ.1 BQ.1.1 BQ.1.23 BR.2 BR.2.1

[a] Total passengers exclude those who were COVID-19 positive at the start of the cruise
[b] No unspecified gender was recorded
[c] Voyage 3 undertook 2 days of surveillance
n/a = not applicable

falsely counted as asymptomatic if the onset dates were not recorded. However this possibility appears unlikely. For voyages 1 and 3 not all onset dates recorded were the same as the testing date, and for voyage 2, some onset dates were recorded for cases, showing that some consideration was given to the proper recording of onset dates across the three voyages. The difference in the proportions of asymptomatic cases between voyages could also be explained by the capacity of medical staff to interview patients and record their onset date. Voyage 2 had three times more cases than voyages 1 and 3, and likely less time for interview and data entry.

It could be hypothesised that those cases who undertook screening should be asymptomatic, given that if they were genuinely symptomatic, they should have self-reported to the cruise medical centre for COVID-19 assessment. Therefore, the high rate of screened cases that reported being symptomatic on voyages 1 and 3 is surprising. A possible explanation for these rates could be the mild nature of the symptoms reported and the impost of being isolated for 5 days in the cabin if positive being a disincentive to seek testing, but passengers went on to declare symptoms once they tested positive (or not in the case of voyage 2). One of the major findings in a

qualitative study on Australian attitudes to cruising was the disincentive of perceived increased financial and time costs from the risk of lockdowns or quarantine onboard.[13]

As our focus is on the risk of COVID-19 to the often medically vulnerable passenger cohort and their community exposures post disembarkation, we have limited our analysis to passengers. However, we acknowledge COVID-19 outbreaks also impact crew, who may be a source of passenger infection.

Conclusions

Public health authorities should be aware of the potential large number of unidentified cases of COVID-19 infection that may disembark from a cruise ship that has had an extensive outbreak onboard. Infected passengers are likely to be elderly and may expose other older adults. As Australia reduces COVID-19 control measures, universal screening during large outbreaks on cruise ships will help identify these cases and, when used early in the voyage, limit the spread of COVID-19.

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Competing interests

None declared.

Author contributions

AC developed the concept and led the drafting of the paper. All authors contributed to the surveillance program design and editing of the paper.

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