

1 **High attack rate of SARS-CoV-2 B.1.1.529 among two-dose vaccinated populations in two**
2 **indoor entertainment setting outbreaks**

3
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18 **Running title:** High SARS-CoV-2 Omicron attack rate

19 **Main Point (40 words):** SARS-CoV-2 Omicron attack rates of >50% were found in two outbreaks in
20 indoor entertainment venues among 2-dose vaccinated populations. Our findings demonstrate the
21 importance of non-pharmaceutical public health measures in addition to vaccination to prevent virus
22 transmission.

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1

2 **Abstract**

3 We estimated attack rates of SARS-CoV-2 B.1.1.529 (Omicron) infection among people attending a
4 nightclub and a graduation ball where >95% had at least 2 vaccine doses. Attack rates were
5 295/535(55.1%) and 102/189(54.0%) respectively (mean: 5 days post-event). At the ball, attack rates
6 increased with time since vaccination: 12.5% among those vaccinated 1-2 months previously; 68.0%
7 among those vaccinated 3+ months previously; such differences were not found at the nightclub.
8 Recent vaccination prevents Omicron infection, but is time and setting-dependent, emphasising the
9 importance of non-pharmaceutical public health measures in addition to vaccine booster doses to
10 maximise protection in high-risk contexts.

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12 Keywords: COVID-19, SARS-CoV-2, Omicron, outbreak, vaccination

13

1 **Introduction**

2 The SARS-CoV-2 Omicron variant of concern (VOC) was first detected in Australia on 23 November
3 2021.¹ Immediately prior to Omicron introduction, very low and stable case numbers of the Delta VOC
4 were recorded (~5 per 100,000) in Australia.² At the time of Omicron VOC introduction, Australia's
5 population had a high reliance on vaccine-induced immunity with a low infection rate since 2020
6 (cumulatively 8/1000; n~200,000 cases in total)² but very high rates of vaccination (85.5% of those
7 over age 16 having received 2 doses of COVID-19 vaccines nationally, and 92% in the state of New
8 South Wales [NSW]).³

9 The first large Australian outbreaks of the Omicron VOC occurred in the city of Newcastle, NSW
10 (population 167,000)⁴. Prior, Delta VOC cases had reached a nadir on 6 December 2021,⁵ with three
11 cases in Newcastle that day. At the time of the outbreaks, entertainment venues were required to
12 ensure that all attendees checked in with a smartphone app to enable contact tracing, and provided
13 evidence of completed primary COVID-19 vaccination with an approved vaccine⁶, however, no mask
14 wearing requirements or density limits were in place.

15 The two outbreaks in entertainment venues occurred on: 1) 8 December 2021 in a nightclub holding a
16 themed event characterised by dancing, singing and drinking alcohol and; 2) 10 December 2021 at a
17 ball for graduating medical students and medical school faculty at the Newcastle Exhibition Centre.

18 The likely index cases at the nightclub were two males infected with Omicron in one of the country's
19 first outbreaks, a boat party in Sydney on 3rd December 2021; at the graduation ball at least one of the
20 attendees had also been at the nightclub two days prior. The nightclub consisted of interlinked rooms,
21 with limited external windows and internal common areas of 1000m² with approximately 1 person per
22 2.5 square-meters at peak occupancy. The exhibition hall is a large (1195 square meter) indoor
23 venue.

24 We aimed to estimate attack rates of Omicron infection and differences according to vaccination
25 status in these relatively high-density entertainment venues.

1 **Methods**

2 Data on people who attended the two outbreak venues were obtained from lists reported to the NSW
3 Ministry of Health for contact tracing. Lists included individuals' names, and where available their date
4 of birth, information on whether they were tested for SARS-CoV-2, if they had a laboratory confirmed
5 polymerase chain reaction (PCR) positive test for SARS-CoV-2, and if S-gene target failure (SGTF)
6 was identified or whole genome sequencing (WGS) confirmation of the Omicron VOC was reported.
7 Data up to 12 days following the events were linked deterministically to the Australian Immunisation
8 Register (AIR) to obtain COVID-19 vaccination records. The AIR is a national register documenting
9 vaccination of people in Australia. Reporting of COVID-19 vaccines to the Register has been
10 mandatory since February 2021, prior to COVID-19 vaccine roll-out in Australia.⁷ Individuals were
11 classified as up to date with vaccination if they had received at least 2 doses of a COVID-19 vaccine
12 reported in the AIR at least 14 days prior to the exposure date. For people who did not link to a record
13 of vaccination, a manual checking process was used to validate if a record of vaccination existed.
14 Individuals who did not have a link to a vaccination record in the AIR nor were found on manual check
15 to have a record were presumed unvaccinated.

16 Individuals who attended the nightclub, but had no SARS-CoV-2 test recorded, had limited identifying
17 information to enable linkage to AIR. Vaccination status was therefore not reported for this group and
18 they were not included in analyses.

19 To assess severity of infection, all individuals identified with SARS-CoV-2 were also matched to
20 hospitalisation data to determine if they were admitted to a hospital following their diagnosis.

21 For each outbreak, attack rates for SARS-CoV-2 infection were estimated overall and according to
22 number of vaccine doses received, vaccine brand, and by time since receipt of the second vaccine
23 dose.

24 This report was part of routine public health management; no ethical risks were identified by the NSW
25 Population and Health Services Research Ethics Committee.

1 Results

2 There were 664 individuals recorded as attending the nightclub and 189 as attending the graduation
3 ball.

4 Of the 664 at the nightclub, 535 (80.6%) had at least 1 PCR test for SARS-CoV-2 recorded by day 12.
5 Of those tested 295 (55.1%) had SARS-CoV-2 infection based on PCR testing at a mean of 5.5 days
6 (median 5) following the event. Of these, all isolates that had additional WGS were Omicron; 150 had
7 WGS-confirmed SARS CoV2 B.1.1.529, a further 65 were considered probable Omicron based on
8 SGTF and for the remaining 80 SGTF was not reported.

9 Of those tested from the nightclub, the average age was 21.5 years (standard deviation [SD] 4.1;
10 range 18-50 years). Most (508/535; 95.0%) had received at least 2 valid doses of a COVID-19
11 vaccine, 6 (1.1%) received 3 valid doses, 7 (1.3%) received 1 valid dose; and 20 (3.7%) did not match
12 to an AIR record of vaccination on linkage or manual check and were assumed to be unvaccinated.
13 For their primary vaccine series, the majority (64.8%, n=333) had received the Pfizer/Comirnaty
14 vaccine, 32.3% (n=166) had received AstraZeneca and 2.9% (N=15) had received Moderna/Spikevax.
15 Among those with at least 2 valid doses, the mean (median) time since receipt of the last vaccine dose
16 was 73.6 days (63 days).

17 Table 1 shows characteristics of individuals testing positive (cases) or negative following the event
18 and Figure 1A shows attack rates according to vaccination status. There were no clear differences in
19 attack rates based on the brand, number of vaccines received nor time since vaccination.

20 Of the 189 at the exhibition centre graduation ball, 102 (54.0%) were confirmed to have SARS-CoV-2
21 based on PCR testing on average 4.4 days (median 4) following the event (27 had WGS-confirmed
22 SARS CoV2 B.1.1.529, 44 SGTF and for 33 SGTF was not reported).

23 The average age of people at the ball was slightly older than the nightclub: 26.5 years (SD 9.8; range
24 16-64 years). Almost all (185/189; 97.9%) had received at least 2 valid doses of a COVID-19 vaccine
25 with 34 (18.3%) receiving 3 valid doses; only 3 (1.6%) did not match to an AIR record of vaccination.

1 For their primary vaccine series, the majority (82.8%, n=154) had received the Pfizer/Comirnaty
2 vaccine, 14.5% (n=27) had received AstraZeneca and 2.7% (n=5) had received Moderna/Spikevax.
3 Among those who had at least 2 valid doses, the mean (median) time since receipt of the last dose of
4 vaccine was longer than for people at the nightclub at 101.8 days (87 days). This was likely due to
5 earlier and prioritised access to vaccination among people at the ball who were either older or
6 graduating medical students.

7 Table 1 shows age and vaccination status among those who tested positive (cases) or negative
8 following the event. The attack rate by age among those aged ≥ 30 years was lower compared to those
9 aged < 30 years: 31.4% (11/35) versus 59.1% (91/154); $p < 0.001$. Figure 1B shows attack rates
10 according to vaccination status with little difference by brand and number of doses. However, at the
11 ball, among those receiving 2 doses, there was a clear gradient of lower attack rates among those
12 who had been vaccinated more recently.

13 The proportions of cases who presented to a hospital emergency department (ED) in the two weeks
14 following the outbreaks was 2.0% (6/295) from the nightclub and 2.9% (3/102) from the ball. Those
15 with an ED presentation were aged between 20-34 years and none were hospitalised for their COVID-
16 19 infection. Of those presenting to the ED, 2/6 from the nightclub were not vaccinated and the other
17 4/6 had 2 vaccine doses. Of those who attended the ball all 3 had at least 2 vaccine doses.

18 Discussion

19 In two SARS-CoV-2 Omicron VOC outbreaks in indoor entertainment venues in Australia, with no
20 mask wearing or density limits, and close contact activity, a high force of infection was observed
21 among mostly two dose vaccinated young adults. In the high-risk nightclub environment, two doses of
22 either Pfizer, AstraZeneca or Moderna COVID-19 vaccines administered an average of 2 months prior
23 had poor effectiveness against infection with the Omicron VOC. In the medical graduation ball, where
24 two doses of COVID-19 vaccines had been administered on average 3 months earlier, the secondary
25 attack rate was similar to the nightclub, however there was a clear trend towards lower attack rates
26 with more recent vaccine receipt.

1 The effectiveness of vaccines is influenced by biological, host and environmental factors. Our study
2 characterises two unique outbreaks in relatively crowded indoor environments with limited mitigation
3 measures in place, and activities conducive to virus transmission, such as energetic dancing, drinking,
4 close face-to-face contact in mostly small poorly ventilated rooms with few external open windows
5 occurred (particularly in the nightclub). Our findings suggest that in such environments, non-
6 pharmaceutical public health measures⁸ are needed in addition to at least two doses of the COVID-19
7 vaccine to reduce infection risk from the Omicron VOC. Indeed, at the graduation ball where there was
8 a seated dinner and then dancing afterwards; the difference in attack rates between the older and
9 younger people may reflect the strong influence of different behavioural factors in these indoor
10 entertainment settings.

11 Recent population-based vaccine effectiveness studies all show poor effectiveness of two doses of the
12 current COVID-19 vaccines, based on the ancestral SARS-CoV-2 spike protein, against the Omicron
13 VOC with some studies showing little effectiveness^{9,10} regardless of timing of vaccine administration.
14 Other studies have found that 2 doses are effective in the first few months following administration but
15 that effectiveness wanes substantially afterwards.^{11,12} All studies suggested that a third dose after 2
16 primary doses improved protection but that the absolute level of protection against Omicron infection
17 varies.

18 As most people in these outbreaks had received 2 doses of vaccine it was difficult to examine vaccine
19 effectiveness, however we did not find that receipt of a third dose in these settings significantly
20 reduced the risk of infection compared to 2 doses of vaccine; this was unexpected given that all those
21 classified as receiving 3 valid doses had received them between 2-5 weeks earlier. Almost all
22 recipients of third doses had received 3 doses of the Pfizer/Comirnaty vaccine, except three
23 individuals who received alternate schedules (who all tested negative). However, given the small
24 numbers it is difficult to draw conclusions on the effect of different combinations of primary courses
25 and third doses against infection with Omicron with varying combinations shown to provide protection
26 in other studies.¹¹

1 Limitations include that findings from these selected outbreaks are not generalisable to all social
2 contexts.¹³ We had limited data on potential confounders including reasons for third dose receipt and
3 detail of individuals' risk behaviours in the venues. Not all individuals recorded as attending the
4 nightclub were tested which may misrepresent the true event attack rate and some attendees at both
5 the nightclub and graduation ball may have also attended other events following the initial outbreak
6 and prior to being asked to isolate, therefore, the estimated attack rates do not necessarily represent
7 a single exposure event. At the graduation ball most attendees were healthcare workers, which may
8 have moderately increased their potential for exposure to SARS-CoV-2, but this was unlikely given
9 term had finished and the Omicron VOC had only emerged. There is potential for misclassification of
10 vaccination data however all records that did not match to the Register were manually checked.
11 Finally, not all SARS-CoV-2 isolates were confirmed as Omicron, but about 70% of those in each
12 setting had either WGS or the indicative SGTF reported.

13 The SARS-CoV-2 Omicron VOC resulted in very high attack rates in these indoor events following
14 introduction to Australia, in a population with high two-dose primary vaccination (with mRNA and viral
15 vector vaccines). This unique outbreak assessment reinforces that to prevent mass transmission
16 events, particularly in high-risk indoor settings, public health and social measures in addition to
17 COVID-19 vaccination are required. Furthermore, there is a need to improve protection through
18 additional vaccination strategies, including booster doses and potentially via development of Omicron-
19 specific vaccines.

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21 **Declarations:** All authors have no conflicts of interest to declare

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1 **Table 1:** Vaccination status and age in COVID-19 cases and those testing negative in indoor (nightclub and
 2 graduation ball) venue outbreaks at commencement of the SARS-CoV-2 Omicron wave in Newcastle Australia,
 3 December 2021.

	Nightclub		Graduation ball	
	Case	Test negative	Case	Test negative
Total	295 (55.1%)	240 (44.9%)	102 (54.0%)	87 (46.0%)
Characteristics				
Age in years, mean (SD)	21.4 (3.7)	21.6 (4.5)	25.1 (3.6)	28.1 (13.8)
Age in years, median (range)	21 (18-50)	20 (18-48)	24 (16-42)	24 (16-64)
Age <30 years (%)	287 (97.3%)	227 (94.6%)	91 (89.2%)	63 (72.4%)
By vaccination status				
Valid doses received [^]				
No vaccination	10 (3.4%)	10 (4.2%)	3 (2.9%)	0 (0%)
Doses received - 1 (%)	1 (0.3%)	6 (2.5%)	0 (0%)	1 (1.1%)
Doses received - 2 (%)	281 (95.3%)	221 (92.1%)	81 (79.4%)	70 (80.5%)
Doses received - 3 (%)	3 (1.0%)	3 (1.3%)	18 (17.7%)	16 (18.4%)
At least 2 doses (%)	284 (96.3%)	224 (93.3%)	99 (97.1%)	86 (98.9%)
By primary course vaccine brand				
Pfizer (%)	173 (60.7%)	160 (69.9%)	84 (84.9%)	70 (80.5%)
AstraZeneca (%)	102 (35.8%)	64 (28.0%)	15 (15.2%)	12 (13.8%)
Moderna (%)	10 (3.5%)	5 (2.2%)	0 (0%)	5 (5.8%)
15-45 Among those with 2+ doses[†]				
Days since last vaccine dose, mean (SD)	73.1 (39.1)	74.2 (36.9)	120.9 (67.3)	79.9 (56.9)
Time since dose 2 in days, mean (SD)				
Pfizer	82.8 (49.9)	84.8 (46.8)	169.3 (52.4)	137.5 (73.2)
AstraZeneca	66.6 (20.0)	69.2 (19.6)	132.5 (39.9)	97.3 (39.3)
Moderna	33.2 (6.7)	31.2 (2.6)	-	81.8 (88.0)

Time since dose 2 excl those with 3 valid doses				
<1 month	8 (2.8%)	4 (1.8%)	0	0
1-2 months	127 (44.7%)	88 (39.3%)	3 (3.7%)	21 (30.0%)
2-3 months	99 (34.8%)	88 (39.3%)	12 (14.8%)	18 (25.7%)
3+ months	47 (16.7%)	41 (18.6%)	66 (81.5%)	31 (44.3%)

1 % for age and vaccination status are column percentages

2 ^Valid dose means dose 2 or 3 must have been given at least 14 days prior to exposure

3 †For the 6 at the nightclub who received 3 doses, the mean time since their 3rd dose was 26.2 days (range 15-
4 37) whilst for the 34 at the ball who received 3 doses, the mean time since their 3rd dose was 28.0 days (range
5 15-45).

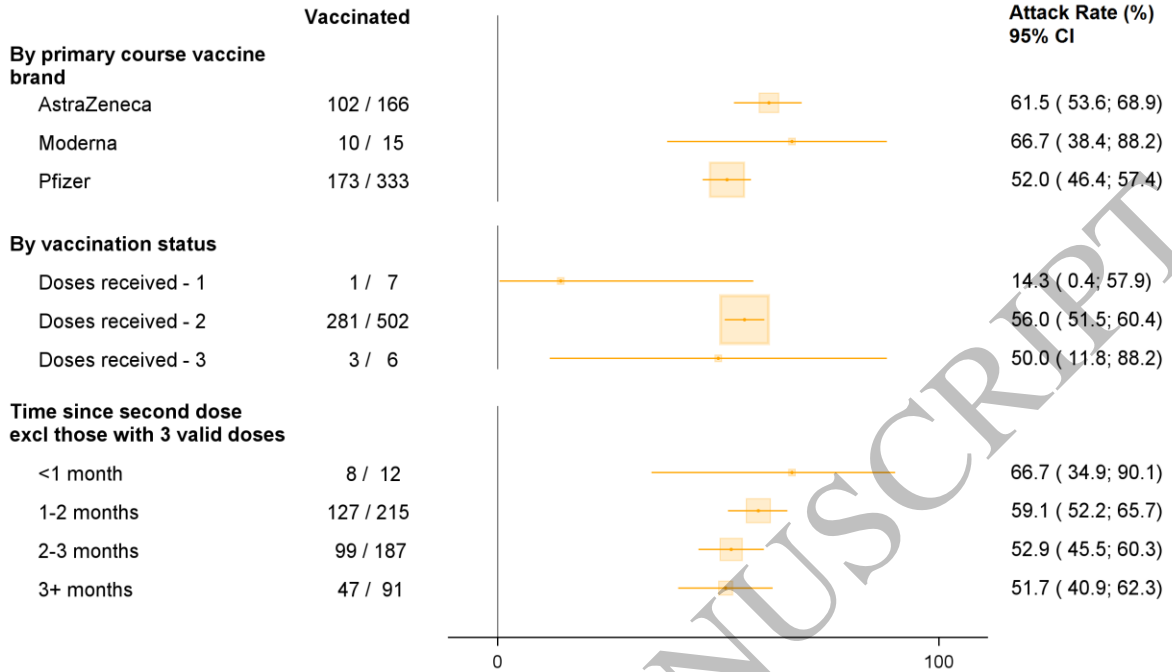
6 **Legends**Figure 1: Attack rates of SARS-CoV-2 Omicron variant in a) the nightclub and b) the graduation ball
7 venues according to dose, brand and timing of second vaccine dose, Newcastle Australia, December 2021.

8 Footnote: NC=Not calculated

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a) Nightclub



b) Graduation Ball

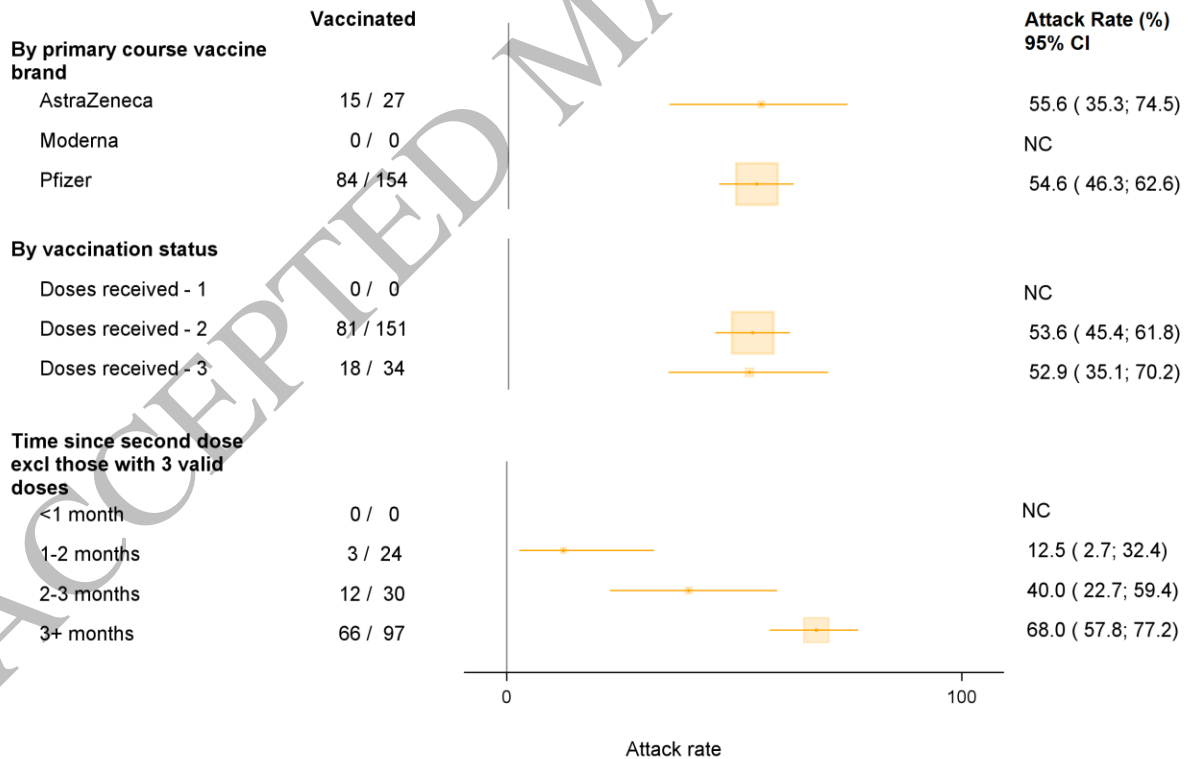


Figure 1
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