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Short report

Vaccine breakthrough infections in a highly-vaccinated Australian population during a SARS-CoV-2 Delta outbreak

Meru Sheel, Tze Vun Voo, Nevada Pingault, Timothy S Sloan-Gardner, Alexandra Marmor, Martyn D Kirk, Vanessa Johnston, Kerryn Coleman

Abstract

Over 80% of residents in the Australian Capital Territory were fully vaccinated within 10 weeks of a SARS-CoV-2 Delta variant outbreak. Of the outbreak's 1,545 cases, 10% were breakthrough infections. The incidence of infections among fully- and partially-vaccinated people was 98.5% and 90% lower, respectively, than for unvaccinated people.

Keywords: COVID-19 breakthrough infections, Australian Capital Territory, COVID-19, outbreak, SARS-CoV-2 Delta, vaccination

Study setting

After more than a year of zero cases of community-acquired coronavirus disease 2019 (COVID-19), the Australian Capital Territory (ACT) recorded its first locally-acquired case due to infection from SARS-CoV-2 Delta variant on 12 August 2021. To limit transmission, the ACT introduced a series of public health and social measures, including a strict lockdown wherein people were only allowed to leave home for five essential reasons: essential shopping; care giving; seeking healthcare; essential work; and outdoor exercise. Mask use was required for all instances of leaving the house.¹

In February 2021, the ACT commenced a COVID-19 vaccination program using Cominarty and Vaxzevria vaccines for residents aged ≥ 12 years. In line with Australia's national vaccine roll-out, the program initially prioritised high-risk groups for infection or severe disease, including health workers and people aged ≥ 70 years.² At the start of the Delta outbreak, 50.2% of ACT residents aged ≥ 12 years (183,051/364,321) had received one dose of either vaccine and 26.5% (96,601/364,321)

had received two doses. Here we report data on SARS-CoV-2 infections in fully-vaccinated and one-dose-vaccinated persons in a setting of high epidemic control.

Methods

In the ACT, a confirmed COVID-19 case required laboratory evidence of SARS-CoV-2 infection demonstrated by nucleic acid testing of combined oropharyngeal and deep nasal swabs.³ We verified vaccination status from the Australian Immunisation Register (AIR). We excluded cases with missing or invalidated records on the AIR database. Population denominator data was sourced from the ACT's Treasury and Economic Development Directorate projection for June 2021. For population denominator data on vaccinated persons, vaccination coverage data were extracted at the end of each week if they reported the ACT as their residence at the time of vaccination. The population was restricted to those aged ≥ 12 years and resident within the ACT based on the Statistical Local Area. Unvaccinated populations were estimated by subtracting the vaccinated population from the total population of the ACT.

Table 1: Classification of confirmed COVID-19 cases as per immunisation history, Australian Capital Territory, 2021.

Case category	Definitions for vaccination status of confirmed cases
Breakthrough	COVID-19 diagnosed \geq 14 days after second dose of COVID-19 vaccine.
2 doses < 14 days	COVID-19 diagnosed < 14 days after second dose of COVID-19 vaccine.
1 dose	COVID-19 diagnosed \geq 21 days after first dose of COVID-19 vaccine.
1 dose < 21 days	COVID-19 diagnosed < 21 days after first dose of COVID-19 vaccine.
Unvaccinated	COVID-19 in a person with no documented proof on AIR of COVID-19 vaccination.
Partial	COVID-19 in a person in one of the '2 doses < 14 days'; '1 dose'; or '1 dose < 21 days' categories

Public health staff interviewed all cases to determine demographic details and to identify close contacts, movements and outcomes of illness, including symptom details and timing. We defined the 'diagnosis date' of cases as the date of first symptom onset or specimen date collection where onset date was unavailable.

We classified cases into five categories based on the time interval between the diagnosis date and the last dose of a vaccine (Table 1). An additional category of partially vaccinated was included if a confirmed case had received one dose of the vaccine independent of the time interval or two doses < 14 days prior to diagnosis date. We used Stata 15 to estimate incidence rate ratios for infection amongst fully-vaccinated persons (breakthrough infections) compared to partially-vaccinated and unvaccinated persons, after adjusting for age group using negative binomial regression.

Results

The ACT recorded 1,578 cases of the Delta variant of SARS-CoV-2 between 12 August and 17 October 2021. In response to the outbreak, the ACT population rapidly achieved \geq 80% two-dose coverage for persons aged \geq 12 years, with \geq 95% one-dose COVID-19 vaccine coverage (Figure 1). As of 17 October 2021, vaccination status was validated for 97.9% (1,545/1,578) of confirmed COVID-19 cases associated with the ACT outbreak. We identified 9.5% of cases (147/1,545) as breakthrough infections; a further 4.9% of cases (75/1,545) had received one

dose of a COVID-19 vaccine (Table 2) 21 days or more before the diagnosis date. Overall, 21.9% (338/1,545) were partially vaccinated. Fourteen persons received a vaccine dose after being diagnosed with COVID-19.

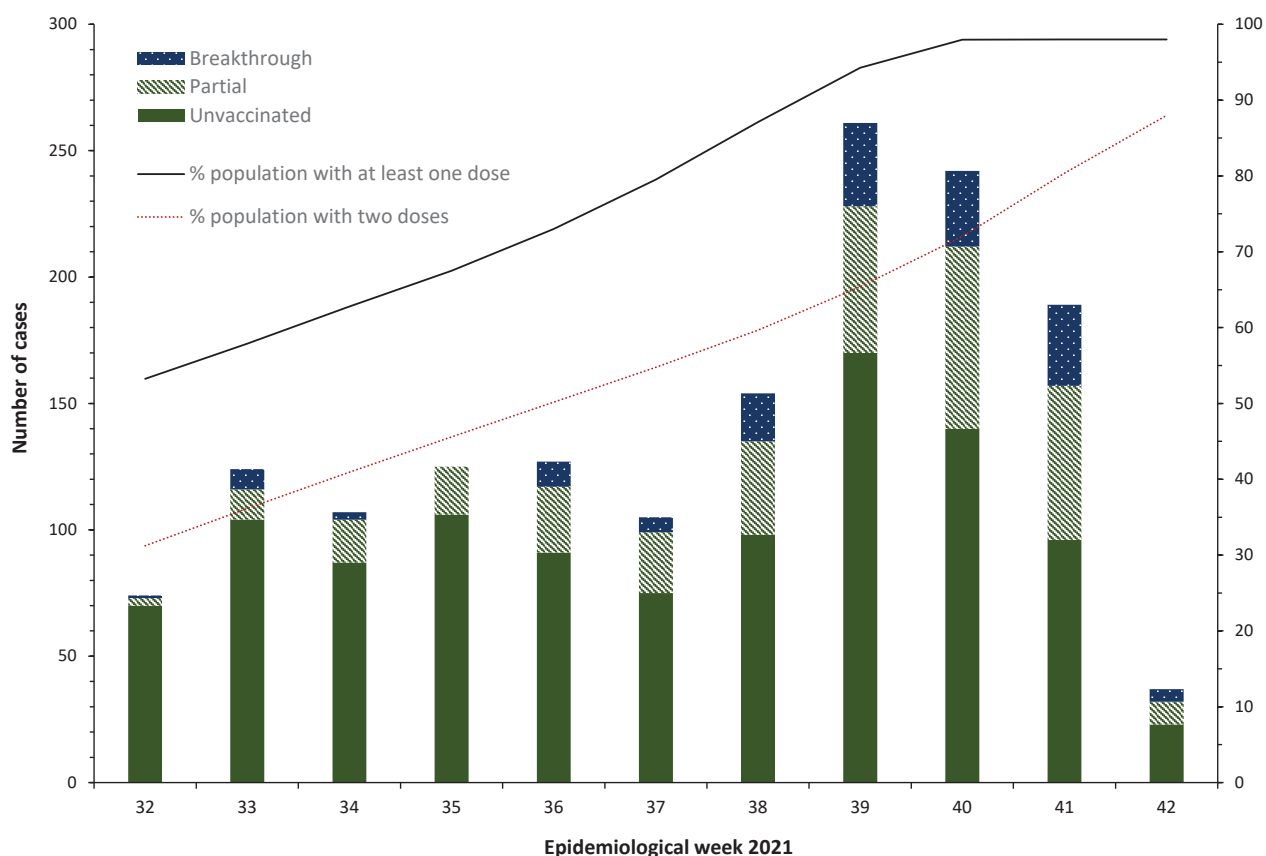
In total, 7.0% of cases (108/1,545) were hospitalised for any reason during their COVID-19 illness, of which 3.7% (4/108) were breakthrough infections, compared with 76.9% of hospitalised cases (83/108) who were unvaccinated, and 19.4% (21/108) who were partially vaccinated.

The median time from receipt of the second dose to breakthrough infection was 48 days (range 14–185 days).

Most breakthrough infections occurred through transmission within households (57.1%; 84/147) and within long-term care facilities (9.5%; 14/147); these are high-risk settings due to extended close contact and high viral exposure. Of all breakthrough infections, 9.5% (14/147) were in healthcare workers, including aged care workers.

In the ACT, after adjusting for age, the incidence of infections among fully vaccinated cases was 98.5% lower than for unvaccinated cases (incident rate ratio, IRR: 0.015; 95% confidence interval [95% CI]: 0.009–0.024). The incidence of COVID-19 in partially-vaccinated people was 90% lower than for unvaccinated persons (IRR: 0.10; 95% CI: 0.067–0.156).

Figure 1: Numbers of COVID-19 cases and COVID-19 vaccination coverage, Australian Capital Territory, 11 August 2021 – 17 October 2021



Discussion and conclusion

In the ACT, early intervention with extensive public health and social measures along with a rapid roll-out and high uptake of COVID-19 vaccines resulted in suppression of the COVID-19 outbreak associated with the Delta SARS-CoV-2 variant. Breakthrough infections accounted for 10% of all cases, but the risk of COVID-19 in fully-vaccinated persons was dramatically lower. Only 2.7% of people with breakthrough infections (4/147) were hospitalised. In the ACT, it was important to note that the relationship between incidence and vaccination status may be confounded by ability or willingness to comply with public health measures, such as community-wide lockdown. Emerging international evidence during the Delta surge suggested that fully vaccinated persons remained at risk of SARS-CoV-2, but the incidence and severity varied on individual immune responses, and by setting and level of community transmission.⁴ In England, during

the peak of Delta surge in June-July 2021, the prevalence of SARS-CoV-2 amongst vaccinated persons was 0.40% (n = 55,962) compared with 1.21% amongst unvaccinated persons (n = 15,135).⁵

The lower incidence of COVID-19 in partially-vaccinated persons highlights the benefits of a single dose of vaccine against COVID-19. At the population level, these findings supported a rapid roll-out of the vaccine along with public health and social measures including contact tracing in outbreak settings. In the outbreak setting, the emphasis on maximising one-dose coverage was critical.

The majority of breakthrough infections occurred in households and long-term care facilities, which is expected given the force of infection and the regular exposure to an infected person in residential settings.^{6,7} Data from the United Kingdom, examining transmission and viral kinetics, found that individuals with

Table 2: Characteristics of persons with documented SARS-CoV-2 infection after vaccination compared with infection in those who were not vaccinated,^a Australian Capital Territory, 11 August 2021 – 17 October 2021

	Breakthrough N (%)	Two doses < 14 days N (%)	One dose N (%)	One dose < 21 days N (%)	Unvaccinated N (%)	Total N (%)
Total	147 (9.5)	51 (3.3)	75 (4.9)	212 (13.7)	1,060 (68.6)	1,545 (100)
Age						
< 12 years	0 (0)	0 (0)	0 (0)	0 (0)	272 (25.7)	272 (17.6)
12–15 years	0 (0)	3 (5.9)	2 (2.7)	15 (7.1)	93 (8.8)	113 (7.3)
16–29 years	22 (15)	17 (33.3)	23 (30.7)	74 (34.9)	338 (31.9)	474 (30.7)
30–39 years	24 (16.3)	9 (17.6)	16 (21.3)	60 (28.3)	176 (16.6)	285 (18.4)
40–49 years	31 (21.1)	9 (17.6)	11 (14.7)	39 (18.4)	109 (10.3)	199 (12.9)
50–59 years	35 (23.8)	8 (15.7)	11 (14.7)	18 (8.5)	37 (3.5)	109 (7.1)
≥ 60 years	35 (23.8)	5 (9.8)	12 (16)	6 (2.8)	35 (3.3)	93 (6.0)
Sex						
Male	79 (53.7)	30 (58.8)	23 (30.7)	103 (48.6)	486 (45.8)	721 (46.7)
Female	68 (46.3)	21 (41.2)	52 (69.3)	109 (51.4)	574 (54.2)	824 (53.3)
Indigenous status^b						
Aboriginal and Torres Strait Islander	8 (5.4)	1 (2)	5 (6.7)	22 (10.4)	139 (13.1)	175 (11.3)
Non-Indigenous	138 (93.9)	50 (98)	70 (93.3)	190 (89.6)	914 (86.2)	1362 (88.2)
Experienced symptoms^c						
Yes	120 (81.6)	42 (82.4)	58 (77.3)	177 (83.5)	892 (84.2)	1289 (83.4)
No	20 (13.6)	9 (17.6)	14 (18.7)	32 (15.1)	152 (14.3)	227 (14.7)
Hospitalised^d						
Yes	4 (2.7)	6 (11.8)	4 (5.3)	11 (5.2)	83 (7.8)	108 (7)
No (including unavailable)	143 (97.3)	45 (88.2)	71 (94.7)	201 (94.8)	977 (92.2)	1,437 (93)

a Diagnosis date of cases was defined as first symptom onset date, or as specimen date when onset date was unavailable.

b Data unavailable on eight cases.

c Data unavailable on 29 cases.

d Includes hospitalisations due to and with COVID-19.

breakthrough infections had peak viral load similar to unvaccinated cases, but had faster mean rate of viral load decline.⁸ The secondary attack rate within households exposed to the Delta variant was 25% (95% CI: 18–33%) for fully vaccinated persons, compared to 38% (95% CI: 24–53%) in unvaccinated persons.⁸

We did not observe any notable trend between time-from-vaccine and breakthrough infections,

but this may be due to the small numbers of breakthrough infections. Examining breakthrough infections over time is important due to concerns about waning immunity, particularly among healthcare workers and the immunocompromised.⁹ While most breakthrough infections occurred in high-risk transmission settings of households, we were unable to

examine the immune status of household contacts that did not become cases, which will be important for future studies.

Rapid wide-scale vaccination played a critical role in reducing the risk of COVID-19 transmission in the ACT during an outbreak of the Delta variant of SARS-CoV-2.

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