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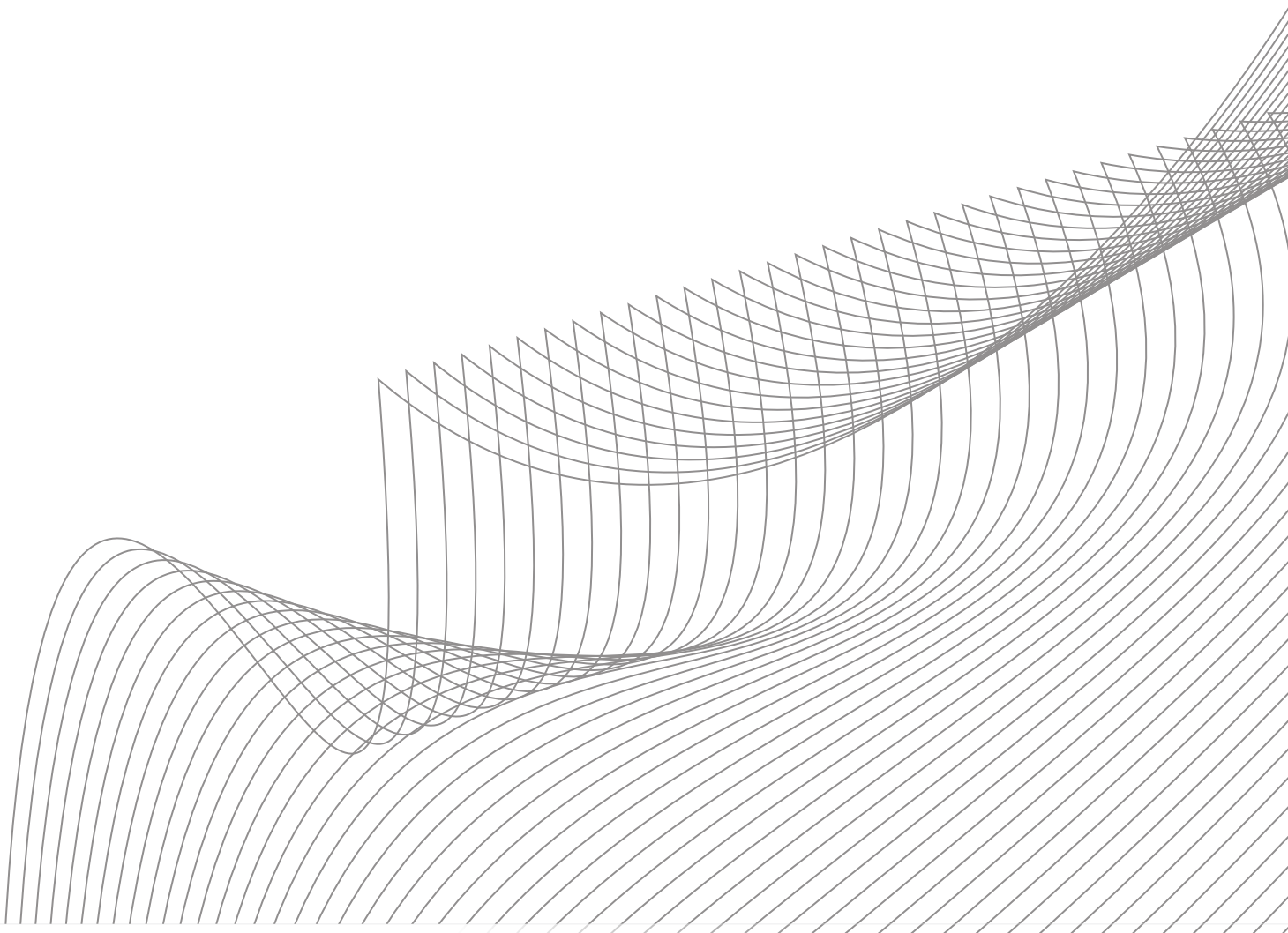

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Original article

Pens down: An outbreak of the B.1.617.2 SARS-CoV-2 variant in an Australian high school, August 2021

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Abstract

Background

Little is known about the transmission dynamics of the B.1.617.2 (Delta) variant of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) among children and young adolescents. We investigated an outbreak in an Australian high school, with limited public health mitigation measures in place, to understand the school activities associated with transmission, and the role of young adolescents in spreading SARS-CoV-2.

Methods

All 1,164 school attendees were monitored for SARS-CoV-2 infection through their mandated 14-day quarantine period. A cohort study design was used to investigate the effect of contact with the index case in different classes on the transmission of SARS-CoV-2, and the effect of vaccination among household contacts on becoming infected by SARS-CoV-2.

Results

There were 48 outbreak cases, including 14 students and one teacher who likely acquired their infection at the school. Attack rates among students in the index case's classes ranged from 0% to 45%. The greatest risk of infection for students in the same grade attending a class with the index case were from the drama class (risk ratio, RR: 111.6; 95% confidence interval (95% CI): 14.88–837.19) and the personal development, health, and physical education class (RR: 7.45: 95% CI: 2.27–24.44). The overall household attack rate was 57%, and household contacts who were not fully vaccinated were 2.9 times more likely (95% CI: 1.07–7.87) to become cases than were effectively-vaccinated household contacts.

Conclusion

Children can play an important role in the transmission of the Delta variant of SARS-CoV-2 within schools and at home. Transmission in this outbreak was largely associated with active, practical lessons that had close contact between students. This study demonstrates that the absence of public health and social measures in a low-incidence context resulted in the rapid spread of coronavirus disease 2019 (COVID-19) within an educational setting. These findings reinforce the role of public health and social measures and vaccinations to reduce airborne transmission and to enable a safe face-to-face learning environment.

Keywords: COVID-19; SARS-CoV-2; schools; risk factors; outbreak; contact tracing; adolescent; child; transmission; classroom

Introduction

After 16 months of no known local transmission in the Australian Capital Territory (ACT), the first locally-acquired coronavirus disease 2019 (COVID-19) case of 2021 was notified to the ACT Health Directorate (ACT Health) on 12 August 2021. This prompted a territory-wide stay-at-home order and the closure of the ACT's schools. A mask mandate was introduced for all persons aged 12 years and over; non-essential services were closed; schools were closed; and home-based learning was introduced for ACT students.[1] On 15 August 2021, ACT Health was notified of a high school student with a positive reverse transcription polymerase chain reaction (RT-PCR) test result for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

While infectious, the student attended a local public high school serving 1,079 students aged 12–16 years (grades 7–10), with 114 staff. Students were grouped into different classes for each subject and attended multiple classrooms through the school day. The school had been operating face-to-face learning for the 2021 school year and masks were not required for staff or students. Public health and social measures across ACT schools focused on hand hygiene promotion and on increased frequency of cleaning services. At the time of this outbreak, people aged 29 years and younger were not eligible for a COVID-19 vaccination.[2]

The index case became symptomatic on 12 August 2021 with a sore throat and fever, undertook a RT-PCR test on 14 August 2021 and was notified to ACT Health on 15 August 2021. The student was considered infectious while symptomatic and for three days before symptom onset. From Monday 9 August to Thursday 12 August 2021 during this infectious period they had attended school, which was considered a high-risk setting.[3] Genomic sequencing on 17 August 2021 confirmed that the student case was infected with the B.1.617.2 (Delta) variant. This outbreak investigation documents the transmission of the B.1.617.2 variant of SARS-CoV-2 from a single student to others in a classroom setting. In this report, we describe the investigation, the epidemiological characteristics of the outbreak, and the risk factors associated with transmission at the high school.

Methods

A school-associated case was defined as a person with a positive RT-PCR test for SARS-CoV-2 who attended the high school between 9 August 2021 and 12 August 2021. A household-associated case was defined as a person who received a positive RT-PCR test for SARS-CoV-2 and who was a household contact of an outbreak case. All people who attended the school campus any day between 9 August 2021 and 12 August 2021 were considered close contacts of the index case and were required to quarantine for 14 days after their exposure date, and to be tested immediately and on days 5 and 13 of quarantine, or upon the development of symptoms. The household contacts of the close contact attendees were considered secondary contacts and were required to quarantine for 14 days and to get tested if they developed symptoms of COVID-19.[4] A household close contact was defined as a person residing in the same dwelling as an outbreak case during their infectious period.

All cases in this outbreak were interviewed to ascertain their symptomology, potential exposures, and vaccination status. A breakthrough infection was defined as a confirmed case who had received two doses of COVID-19 vaccine at least 14 days prior to symptom onset.

A cohort study design was used to investigate the effect of contact with the index case in different classes on the transmission of SARS-CoV-2. The cohort included all students in the same grade as the index case who attended the high school between Monday 9 August and Thursday 12 August 2021. Only students in the same grade as the index case were included, as students from other year groups could not be enrolled in the index case's classes. Exposure was defined as attending a class with the index case for any length of time. The outcome was defined as

having a positive RT-PCR test. Data on exposure were collected through interviews using a standard questionnaire, with the case and their legal guardian, to ascertain movements and activities at school, and through reviewing school timetables. All attendees were followed up until 14 days after their last exposure date at the school. Data was collected and managed using REDCap electronic data capture tools hosted at ACT Health.[5,6]

Attack rates were calculated for attendees and non-attendees for each class attended by the index case. Relative risk (RR) and associated 95% confidence intervals (95% CI) were calculated for students in the same grade as the index case, to examine the association between attending different classes and becoming a confirmed COVID-19 case. Staff members were excluded from these analyses. The effect of being fully vaccinated on becoming infected by SARS-CoV-2 was examined by calculating attack rates and relative risk for household contacts of outbreak cases. For the purposes of the relative risk calculations, fully vaccinated was defined as receiving two doses at least 14 days before the start of the infectious period for the first case in the household. Results of hypothesis testing were considered statistically significant where confidence intervals did not include 1 and *p* values were less than 0.05. Statistical analysis was conducted in *R* version 4.1.1.

Whole genomic sequencing was conducted by the Australian National University on behalf of ACT Health, with lineage assigned using Phylogenetic Assignment of Named Global Outbreak Lineages (PANGOLIN) nomenclature.[i]

The investigation formed part of a public health emergency response under the *ACT Public Health Act 2010;* therefore, ethics approval was not required. This investigation is covered by the Australian National University Human Research Ethics Committee (Protocol 2017/909) standing approval for outbreak investigations involving staff and students.

Results

Outbreak associated cases

Fifteen students who had not attended the school campus between 9 August and 12 August 2021 were excluded. A total of 110 out of 114 (96.5%) staff members and 1,054 out of 1,064 (99.1%) included students were tested for SARS-CoV-2 during the quarantine period.

Overall, there were 48 outbreak cases. Sixteen cases were school-associated and were likely to have acquired their infection from the index case at the school, including one staff member and fifteen students. A further five students who attended the school were assessed as likely to have acquired their infection as a household close contact of an infectious sibling who also attended the high school, based on their time of symptom onset. A further 27 household contacts were notified as confirmed COVID-19 cases. The key characteristics of the cases are summarised in Table 1. The median age of the cases was 15 years (IQR: 13–40 years) and 63% of cases (30/48) were female. There were no hospitalisations or deaths.

Forty-two samples from this outbreak were sequenced, and six were unable to be sequenced. All sequenced samples were the B.1.617.2 (Delta) variant and were within two single nucleotide polymorphisms (SNPs) of the index case's sequence.

An epidemic curve of the outbreak by symptom onset date is shown in Figure 1. One school-associated case reported the same symptom onset date as the index case. The genomic analysis indicated that this secondary case was closely related, but not identical and suggests the transmission event may have occurred earlier in the index case's infectious period. Further, this second student did not share their genomic

i https://cov-lineages.org/.

Table 1: Characteristics of cases associated with the B.1.617.2 high school outbreak (n = 48), Australian Capital Territory, August 2021

Characteristic	School associated[a]	Household associated	Total
Total	**16**	**32**	**48**
Sex			
Male	4	14	18
Female	12	18	30
Age group (years)			
0–9	—	3	3
10–19	15	13	28
20–29	1	—	1
30–39	—	3	3
40–49	—	9	9
50+	—	4	4
Indigenous status			
Aboriginal and Torres Strait Islander people	1	—	1
Non-Indigenous people	15	31	46
Not stated	—	1	1
Country of birth			
Australia	15	22	38
Overseas	1	9	10
Vaccination status			
Not age eligible	16	16	31
Unvaccinated	—	6	6
1 dose	—	5	5
2 doses	—	5	5
2 doses > 14 days before onset	—	3	3

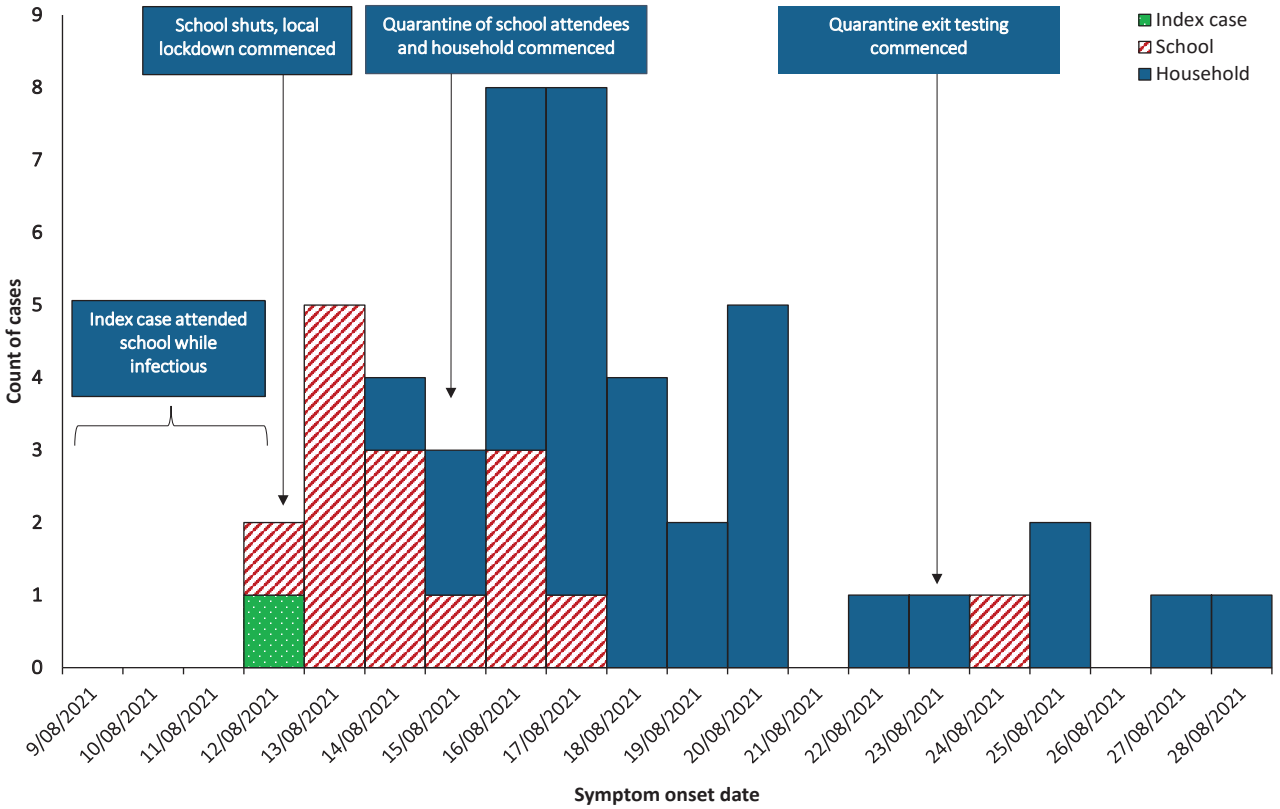
a Includes the index case, students who likely acquired their infection at school, and the staff member case.

sequence with any other school-associated cases, suggesting only one index case was present in this outbreak.

Among the 14 age-eligible cases, six were unvaccinated, three had received one dose, and five cases had received two doses. Three of the latter were breakthrough infections.

All but one case reported at least one COVID-19 symptom throughout their infection. The remaining case was asymptomatic through their infection. The most commonly-reported symptoms among child and adult cases were cough (83%; 40/48), runny or blocked nose (81%; 39/48), and headache (79%; 38/48) (Figure 2). A greater proportion of adult cases than child cases reported alteration of taste or smell; muscle or joint pain; diarrhoea; shortness of breath; or chest pain.

Figure 1: Epidemic curve of COVID-19 cases associated with the B.1.617.2 outbreak (n = 48), by symptom onset date,[a] Australian Capital Territory, August 2021



a Specimen collection date was used for cases that remained asymptomatic throughout their infection.

Transmission events

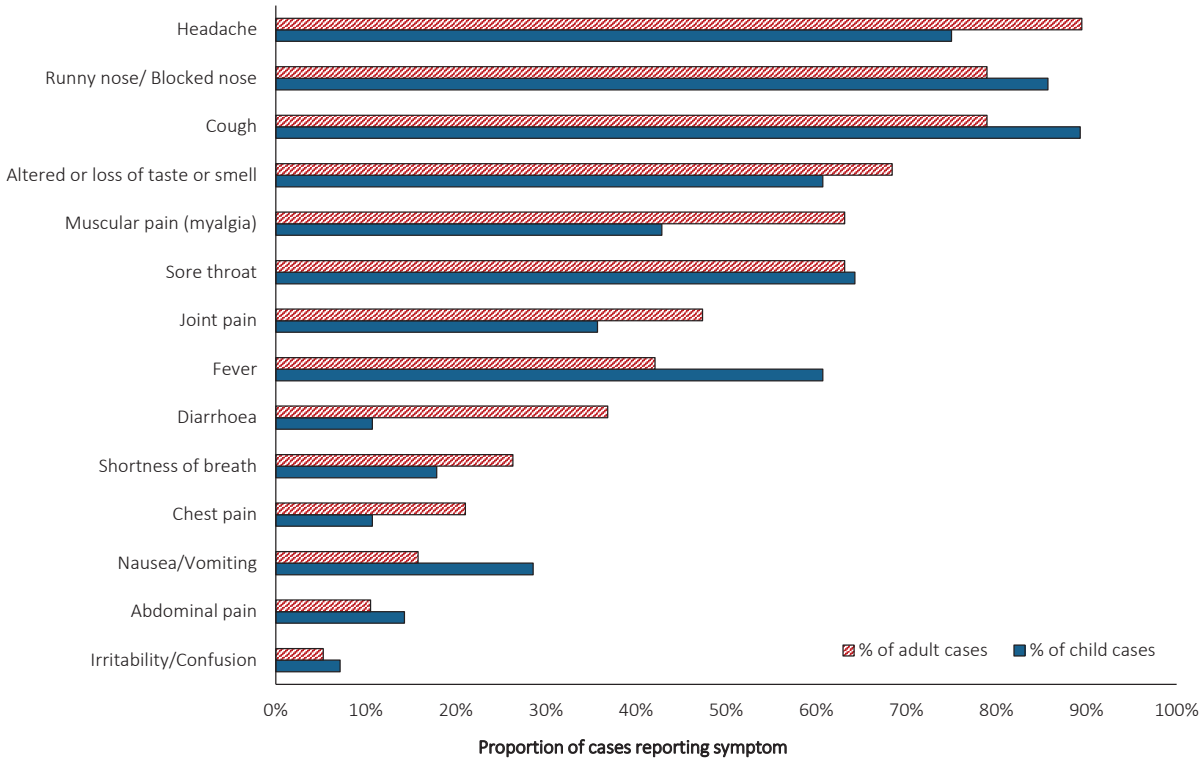
Based on the findings of the case interview and genomic analysis, the source of the index case's infection was identified as a theatre group rehearsal at a community hall the weekend before onset.

School transmission

The in-school transmission events associated with this outbreak are shown in Figure 3. Ten of the 14 school-acquired cases (71%) were in the same grade as the index case and had attended at least one class together. Four of these students attended multiple classes with the index case. The attack rates for the eight classes that the index case attended ranged between 0% and 45% (median: 3.2%) (Table 2). All lessons were indoors.

The highest attack rate was seen in the drama class, where nine of the 20 classmates of the index case were confirmed outbreak cases. This practical class had three timetabled indoor lessons during 9–12 August 2021 and involved small groups in close contact preparing short performances and the class sitting together as an audience. Risk of infection for students attending drama class was over one hundred times the risk for students in the same grade who did not attend this class (95% CI: 14.88–837.19; $p < 0.001$). Three student cases attended a personal development, health, and physical education (PDHPE) class with the index case for three lessons during 9–12 August 2021. All three practical lessons involved indoor physical activity, social mixing and close contact between students, and using the change rooms before and after class. Students in the PDHPE class were seven times more likely to be cases (RR 7.45; 95% CI: 2.27–24.44; $p < 0.001$) than were students who did not attend the class. The teacher of this class was also a confirmed outbreak case.

Figure 2: Symptom profile of child and adult COVID-19 cases associated with the B.1.617.2 high school outbreak (n = 48),[a] Australian Capital Territory, August 2021



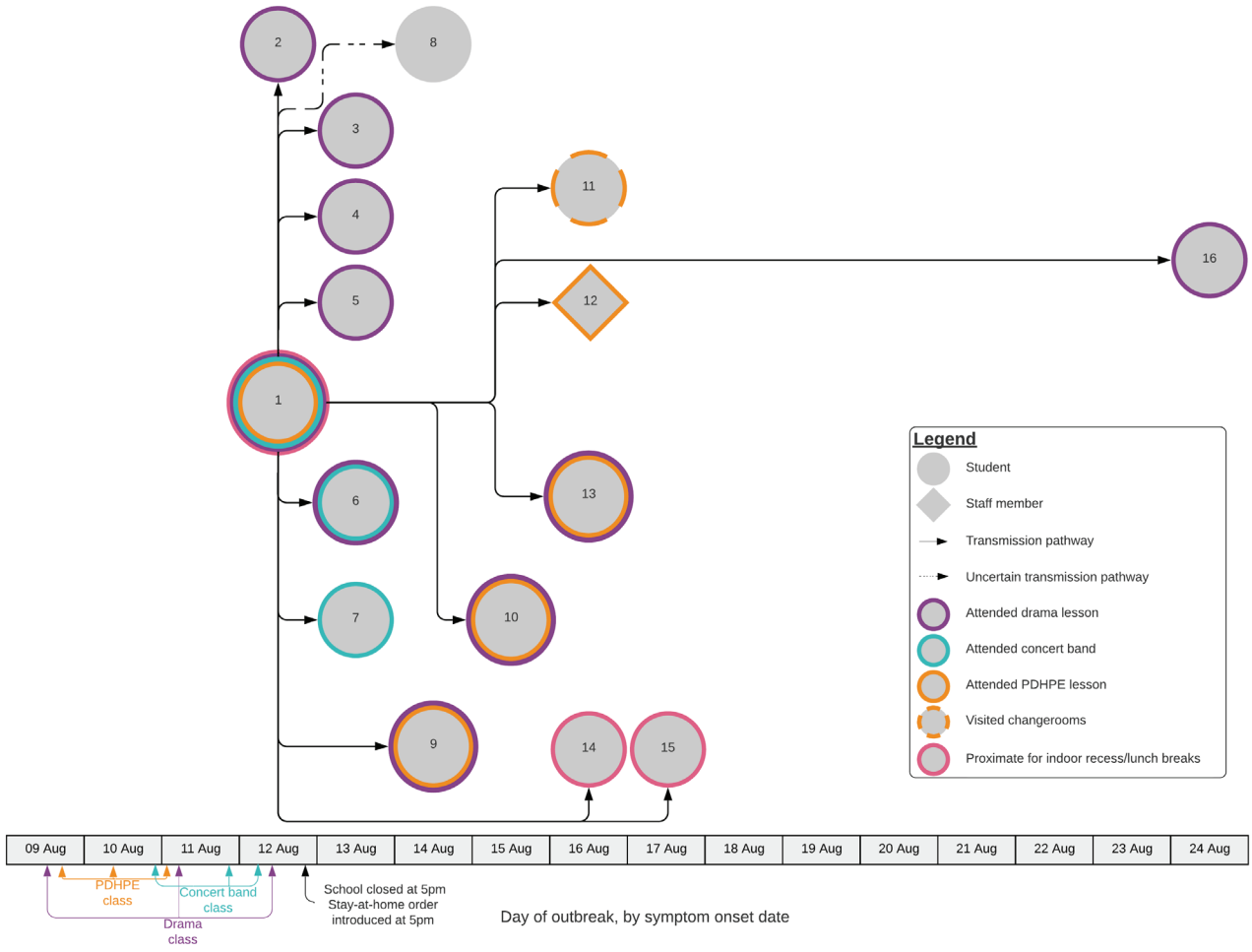
a One case reported remaining asymptomatic through their infection.

Two student cases attended a concert band rehearsal with the index case for two lessons during 9–12 August 2021. These lessons involved students playing brass and woodwind instruments and were conducted indoors in a dedicated music performance space. The risk of transmission in this class was not statistically significant (RR: 0.54; 95% CI: 0.12–2.48; p = 0.418). Two student cases also attended home group and a science class with the index case; however, these cases also attended the drama class.

Four school-associated cases were in a different grade to the index case. None of these four cases reported social interactions or timetabled classes with the index case, or with each other, and no likely sources of infection outside the educational setting were identified. Genomic analysis confirmed these four cases shared the same sequence as the index case. One of these four cases reported three timetabled practical PDHPE lessons with a different teacher at the same time as the index case, and both cases reported using the change rooms before and after each lesson. Although the lessons were conducted in different areas of the school, the repeated use of the change rooms may have provided an opportunity for transmission between the index case and this student.

Two additional students reported sitting near the index case for recess and lunch periods during 9–12 August 2021. The seating area was indoors and an informal setting enabled students to move freely. There was potential for the virus to have been transmitted to students during the lunch and recess periods in this shared space. One student case had an unclear source of exposure. This student had practical PDHPE lessons timetabled directly after the index case on three days; however, they reported using different change rooms and a different PDHPE teacher.

Figure 3: Likely transmission tree of school-associated COVID-19 cases associated with the B.1.617.2 high school outbreak (n = 16), by symptom onset date,[a] Australian Capital Territory, August 2021[b]



a Specimen collection date used for cases that remained asymptomatic throughout their infection.

b Note: This figure only includes school-associated cases. Household associated cases have been excluded.

c PDHPE: Personal development, health, and physical education.

Household transmission

Household size ranged from three to six people with a median of four residents. Twelve school-associated cases led to onward transmission within their household. Household attack rates ranged from 33% to 100% of household contacts and the overall attack rate among household contacts was 57% (30/56). Three school-associated cases did not lead to onward transmission at home. The median household size was the same for households with transmission (four residents) and households with no transmission (four residents).

The relative risk of a household contact becoming a COVID-19 case was 2.9 times higher (95% CI: 1.07–7.87; $p = 0.003$) among household contacts who were not fully vaccinated than among those who had received two doses of COVID-19 vaccine at least 14 days before the infectious period of the outbreak case (Table 3).

The outbreak was declared over on 12 September 2021, fourteen days after the notification of the final household-associated case.

Table 2: Attack rates and relative risk of COVID-19 among students in different classes, B.1.617.2 high school outbreak, Australian Capital Territory, August 2021 (n = 258)

Class	Student cases who attended the class	Student non-cases who attended the class	AR	Student cases who did not attend the class	Student non-cases who did attend the class	RR	*p* value	95% CI
Home group	2	18	10%	8	240	3.10	0.124	0.70–13.63
PDHPE[a]	4	18	18%	6	240	7.45	< 0.001	2.27–24.44
History and social sciences	0	24	0%	10	234	—	—	—
Science	1	24	4%	9	234	1.08	0.941	0.14–8.18
Drama	9	11	45%	1	247	111.6	<0.001	14.88–837.19
English	0	21	0%	10	237	—	—	—
Concert band	2	83	2.4%	8	175	0.54	0.417	0.12–2.48
Maths	0	25	0%	10	233	—	—	—

a PDHPE: Personal development, health, and physical education.

Table 3: The risk of transmission to household contacts (n = 52) by vaccination status among cases associated with the B.1.617.2 high school outbreak, Australian Capital Territory, August 2021

Vaccination status[a]	Case	Negative contact	Total	AR	RR
Fully vaccinated	3	9	12	25%	2.9[b]
Not fully vaccinated	29	11	40	73%	
Total	**32**	**20**	**52**		

a For this analysis, fully vaccinated was defined as receiving 2 doses > 14 days before the start of the infectious period for of the first case in the household.

b 95% CI: 1.07–7.87; $p = 0.003$.

Discussion

This high school outbreak demonstrates the transmission of the Delta variant of COVID-19, in an education setting with limited mitigation measures in place, during a period of low incidence. Masks were not worn during indoor lessons and public health and social measures in place had focused on surface cleaning and hand hygiene. These conditions promoted transmission among young adolescents in class and have been associated with in-school transmission in other COVID-19 outbreaks.[7–14]

Transmission in this outbreak was largely associated with active, practical lessons that had close contact between students. The drama, PDHPE and concert band classes all involved activities—including students mingling throughout the room, raised voices, physical activity, and playing musical instruments—with greater aerosol-generating potential than did quietly sitting at a desk. Transmission of SARS-CoV-2 has been documented in PDHPE classes in other jurisdictions,[8,9,15,16] and in classes and extracurricular activities with raised voices from teachers and students.[7,11,17,18] These activities may explain why transmission occurred in these classes and not during didactic lessons, where students are more often passive listeners as a teacher gives a lecture. Practical lessons are core components to student learning and safe

face-to-face learning will require adherence to public health and social measures, such as mask wearing among staff and students, and conducting practical lessons outdoors where feasible.

Although schools and students were previously considered to play limited roles in transmission for ancestral strains of SARS-CoV-2 in Australia and internationally,[19–22] this investigation suggests that new variants may have greater potential for transmission within educational settings. Investigations of outbreak of the B.1.617.2, B.1.1.57 (Alpha), and B.1.1.159 (Omicron) variants within schools have found higher attack rates compared to ancestral strains, and more frequent student-to-student and student-to-staff transmission.[7,11,21,23–26] The introduction of mask wearing in high schools and of vaccinations for children have been shown to reduce attack rates of the B.1.617.2 variant compared to ancestral SARS-CoV-2 in schools elsewhere in Australia,[21] demonstrating the value of public health and social measures to reduce transmission.

It is evident from this outbreak investigation that children experience symptoms and can play an important role in the transmission of the B.1.617.2 variant of COVID-19, particularly when limited public health mitigation measures are in place. Only one child case (2%) in this outbreak reported no symptoms. This is a lower proportion of asymptomatic cases than in previously-reported symptom profiles among children with B.1.617.2 infection.[27–32] The household attack rate in this outbreak indicates the potential for increased transmissibility of the Delta variant compared with other variants.[33–38]

The findings of this outbreak investigation are subject to some limitations. Firstly, not every student and staff member was recorded in ACT Health's quarantine database or had testing records identified. This may have resulted in under-ascertainment of cases. Further, the exact number of household contacts of staff and students is unknown, limiting our understanding of the extent of those impacted by the outbreak. Secondly, while all cases were able to be interviewed, the school-specific interviews took place up to two weeks after last attending the school campus. Recall bias may have affected the quality of data collected; the recall was particularly low for the use of toilets and attending non-timetabled areas of the school such as the library or the office. Thirdly, six cases were unable to have their samples sequenced to confirm their lineage and relatedness to other outbreak associated cases. Despite these limitations, these findings demonstrate transmission between young adolescents in an educational setting.

The transmission events in this outbreak demonstrate that the absence of public health and social measures in a low prevalence setting resulted in rapid spread in an educational setting. Promoting vaccination among eligible populations; mask wearing during class; improving indoor ventilation; encouraging outdoor rest periods and lessons (especially for practical classes); physical distancing of students; and staying home when symptomatic all remain crucial components to limit transmission and to enable a safe face-to-face learning environment for children and school staff.

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