

SARS-CoV-2 infections and public health responses in schools and early childhood education and care centres in Victoria, Australia: An observational study

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Summary

Background The epidemiology of SARS-CoV-2 in children is an important consideration for control measures. To inform the safe re-opening of Victorian schools and early childhood education and care (ECEC) in late 2020, a detailed analysis of local data was undertaken.

Methods Data on all Victorian SARS-CoV-2 confirmed cases, their close contacts, and ECEC/school events from the first case in Victoria to the end of the third school term (25/01/2020 – 18/09/2020) were analysed. We compared temporal and geographic trends in cases linked to ECEC/school events and community cases; and describe events with onward transmission by age of first case, and public health actions.

Findings Victoria recorded 20,049 SARS-CoV-2 cases during the study period. In total, 1,691 cases and 18,423 contacts were linked to 339 events in ECEC/schools. Many (n=224, 66.1%) events had no evidence of onward transmission, and most (96.5%) involved <10 cases. Onward transmission was more common when the first case was older: when first case was aged 0-5 years, 14.1% events involved additional cases, compared to 30.5% (6-12 years), 33.3% (13-15 years), 42.9% (16-18 years), and 39.1% when the first case was an adult. ECEC/schools were closed within a median of one day (IQR 0-2) from laboratory notification of the first case.

Interpretation Mitigation measures and rapid responses prevented most SARS-CoV-2 cases in ECEC/schools from becoming outbreaks in Victoria in 2020. As new variants emerge and vaccination coverage increases, ECEC/school mitigation strategies should be tailored to local community transmission and educational level.

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Introduction

SARS-CoV-2 is generally a mild illness in children.¹ However, the indirect effects from the public health measures, especially the educational impacts related to school closures and the socio-economic impact of COVID-19 on families, are disproportionately adverse for children. School closures affect children's and parent's mental health, and increase behavioural and developmental concerns.¹⁻⁵

Given the varied implementation of system wide school closures across the world and the detrimental unintended effects on children during the pandemic, there is an imperative to understand SARS-CoV-2 transmission dynamics in different educational settings. Children and adolescents get infected with and transmit SARS-CoV-2 but the degree to which they transmit seems to be age dependent, with adolescents transmitting to a similar degree as adults and younger children transmitting less than older adolescents and adults.⁶ Understanding this further can inform the safe reopening of schools and early childhood services, and whether this should vary by school year level.

In Australia during 2020, most SARS-CoV-2 cases (74%) occurred in the state of Victoria.⁷ In Victoria, the first wave peaked in March to April 2020 with a maximum of 106 daily cases.⁸ A much larger second wave began in early June 2020 and was suppressed by the

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Research in Context

Evidence before this study

We searched Medline for articles published from 01 January 2020 to 10 December 2020 that reported on SARS-CoV-2 outbreaks in educational facilities. Our search term included variants of "SARS-CoV-2" or "COVID-19" and "school" or "early years" or "kindergarten" or "education" and was restricted to English language studies. There is conflicting evidence about the degree to which children transmit SARS-CoV-2 and the role of children in outbreaks in early childhood education and care (ECEC) settings and schools. Evidence suggests that younger children transmit less than older adolescents and adults. Most evidence comes from single site outbreaks, with limited large scale surveillance data.

Added value of this study

We analysed all SARS-CoV-2 notifications in Victoria, Australia to the end of the third school term (n=20,049), and the associated cases in ECEC and school settings (n=1691). SARS-CoV-2 events (when a case attended ECEC or school while infectious) were infrequent when community transmission was low and schools were closed to most students. As community transmission rose, the number of ECEC and school events also increased. In most events only one case was detected, and when outbreaks did occur, most were small (<10 cases). Outbreaks were more common when the first case was an adolescent or an adult, and they were uncommon when the first case was a young child. Prompt public health responses likely helped to prevent onward transmission.

Implications of all the available evidence

In 2020, cases of SARS-CoV-2 in ECEC and schools appeared to be largely a consequence, rather than a cause, of increased transmission in the broader community. These data show that transmission in schools and ECEC settings can be controlled with mitigation measures and timely testing, tracing and isolation when community incidence is low to moderate. The harms of prolonged school closures are substantial. Where possible, ECEC and schools should be prioritised for operation, with community measures, particularly vaccination, in place to reduce community transmission. Additional facility-level risk mitigation can be implemented to protect staff and students.

end of September 2020.^{9,10} For periods during both waves, schools were closed for onsite learning to most students, and only children of permitted essential workers and vulnerable families could attend. At some points, some year levels were permitted to attend face-to-face while other year levels learned remotely. Early childhood education and care (ECEC) remained open throughout most of the second wave,

but was closed during the most stringent restrictions in Greater Melbourne from early August to mid-September 2020.¹⁰

Throughout 2020, evidence emerged from many settings regarding the adverse effects of school closures on children and families, including in Victoria^{11–13}. It was vital that the safe re-opening of ECEC and schools was prioritised and planned as SARS-CoV-2 transmission declined. Hence, the Victorian Department of Health and Human Services (DHHS) and the Department of Education (DET) requested an analysis of the 2020 ECEC and school outbreak data.

In this study, we described cases and events in ECEC/schools; assessed the association between the age of the first case and the occurrence of outbreaks; described temporal and geographic trends in cases linked to ECEC/school events and community cases; and described the public health responses to these events in Victorian schools and ECEC.

Methods

Site

In 2020, Australia had a population of 25.6 million people. Victoria is the second most populous state in Australia with a population of 6.6 million,¹⁴ of whom 5.1 million people reside in metropolitan Melbourne, the state capital. The state is divided into 79 local government areas (LGAs) of which 31 are in Greater Melbourne and 48 are in regional Victoria.¹⁵

Public health measures

A detailed summary of public health responses in Victoria to SARS-CoV-2 epidemic can be found in the Supplementary Table 1, including details on school and ECEC closures. In brief, throughout 2020, Victoria implemented various physical distancing and other measures to limit community transmission, including 'lockdowns' of varying stringency in both the first and second wave. Included in the restrictions at various timepoints were limitations on which children were permitted to attend ECEC and school onsite (Supplementary Table 1).¹⁶

Victoria operated a test, trace, and isolate program after the first case of COVID-19 was reported in late January. In brief, testing was initially restricted to those with both epidemiological criteria and symptoms of COVID-19; testing criteria were expanded during 2020 to include symptoms only (without known contact with an infectious case), and asymptomatic testing in some circumstances (for example close contacts). SARS-CoV-2 testing is available free of charge through public hospitals, primary care services, and 'pop up' testing sites in public spaces. Several nucleic acid tests (RT-PCR) on oropharyngeal and nasal swab samples have been approved for diagnosis of SARS-CoV-2 in Australia; rapid point-of-care diagnostic tests and serology were

not routinely used for diagnosis in Australia in 2020.¹⁶ Victorian laboratories were required by law to report all test results (positive, negative, or equivocal) to DHHS, who interviewed positive cases, provided directions about isolation, and traced close contacts.

In 2020, close contacts were defined as individuals who were with a case while infectious for at least 15 minutes face to face or at least two hours in an enclosed space, however in some events the definition of close contacts was expanded. Close contacts were required to quarantine for 14 days after last exposure to an infectious case. Case and contact management protocols were iteratively updated in response to emerging evidence. From May 2020, all close contacts were encouraged to undergo RT-PCR testing on day 11 of their quarantine period, regardless of symptoms.

Cases were interviewed by DHHS staff (contact tracers), with the parents of minors interviewed depending on the age of the child. If a case had attended an ECEC setting or a school during their infectious period (beginning two days prior to symptom onset or first positive test, as per DHHS definitions), this triggered public health action.

Public health response to an ECEC or school event

The DET managed ECEC and school public health responses in collaboration with DHHS and maintained records of key dates and activities in the public health response. All ECEC settings and schools that recorded an event were temporarily closed while investigations and public health actions were undertaken. Public health actions were managed by an education setting outbreak response team at DHHS/DET. Actions included an 'infectious clean' of the facility, and notifying staff and students who met the close contact definition of their quarantine requirements. An infection prevention and control (IPC) team (the "Outbreak Squad") visited some facilities to assess IPC standards and provide risk mitigation advice. ECEC settings and schools were required to remain closed until re-opening advice was received from DHHS.

Data sources

The Public Health Event Surveillance System (PHESS) operated by the DHHS in Victoria was used for this analysis and was supplemented with additional data from the outbreaks management systems and DET. These confidential data were collected under the *Public Health and Wellbeing Act*, and as such cannot be made available to third parties.

Definitions

An 'event' was defined as any instance of a person with SARS-CoV-2 infection attending an ECEC or school during their infectious period, which triggered a public

health response. Events were further classified as 'complex cases' (either a single case, or multiple cases from the same household) or an 'outbreak' (two or more cases from different households), consistent with DHHS definitions.

The 'first case' is the staff member, student, or person attending the facility with the earliest onset date. If multiple cases had the same earliest onset date in an event, they were jointly classified as the first cases in that event. The 'onset date' was calculated as two days prior to the start of symptoms in symptomatic cases, or two days prior to specimen collection of first positive swab in asymptomatic cases, consistent with DHHS definitions. 'Contacts' are those who were potentially exposed during the event, but did not develop disease or test positive for SARS-CoV-2.

Data analysis

The study period spanned three complete school terms for 2020: from 25 January (confirmation of the first SARS-CoV-2 case in Victoria, immediately before the start of school term 1) to 18 September 2020 (the last day of school term 3 in Victoria).

We describe SARS-CoV-2 cases in Victoria during the study period, including their demographic and clinical characteristics, and geographic locations. LGAs were used for geographic mapping as these are the standard geographic unit of reporting for SARS-CoV-2 in Victoria. Descriptive statistics were calculated regarding confirmed cases and contacts linked to events in ECEC and schools, including demographic data and their relationships to the event site (staff, student, household member, or 'other' such as visitors or social contacts). Hospitalisations among cases linked to ECEC and schools were enumerated.

The percentage of events that became outbreaks was calculated stratified by the age of the first identified case in a staff member or a student. Risk ratios for outbreak occurrence were calculated using adults aged 19 years or older as the reference group, and a chi-squared test for trend was undertaken to test for a statistically significant association between the age group of the first case and the percentage of events which became outbreaks. The median number (and interquartile range, IQR) of cases and contacts associated with each outbreak was calculated and compared according to the age group of the first case. The occurrence of events relative to the timing of different restrictions was described.

The geographic distribution of cases linked to events in schools and ECEC was compared to the distribution of other cases, according to the case's residential address. In Victoria, government schools are legally required to preferentially enroll students residing within their catchment, which is often within the same LGA.¹⁷

Analyses were stratified by educational setting and by age group. Educational settings included ECEC

providers, primary schools, secondary schools, ‘mixed’ level schools (e.g. Prep-12, Prep-9, “Prep” being the first year of primary school in Australia), and schools for children with special needs (‘specialist schools’). Children were stratified into age groups which correspond to attendance at ECEC and schools: 0-5 years (ECEC), 6-12 years (primary school), and 13-18 years (secondary school). We further stratified adolescents into 13-15 years and 16-18 years, because attendance for senior high school students was prioritized in some periods of 2020, and because transmission from older and younger adolescents may differ.

Public health actions were described. Outbreak management records included the date that a case in the ECEC provider or school was first identified, the date the facility was notified of the requirement to close, and dates of contact tracing, completing the infectious clean, and permission to reopen. We report the median (and IQR) number of days between laboratory notification of the first case and facility closure, the number of days facilities remained closed, and the median number of close contacts for each event. Additionally, data are stratified by the size of the event (complex case, outbreak with 2-4, 5-9, 10+ staff or student cases).

Data were cleaned in PHESS prior to analysis. Data management, analysis and visualization was performed in Stata and R.

SARS-CoV-2 surveillance data is routinely collected, analysed, and reported for public health purposes under Victoria’s *Public Health and Wellbeing Act* and this analysis was commissioned by DHHS and DET to inform policy and practice. Research ethical approval was therefore not required for this study.

Role of the funding source

The Department of Health and Human Services (now the Department of Health), Victorian Government funded the study. The funder collected the data, identified key research questions of policy relevance, assisted with data analysis and interpretation, and supported the publication of the results.

Results

SARS-CoV-2 infections in Victorian children

There were 20,049 confirmed SARS-CoV-2 infections in Victoria from the first case (25 January 2020) until 18 September 2020 (the end of term 3 in Victoria). Of these, 8.2% of infections were in children aged 0-12 years, 6.0% were in adolescents aged 13-18 and 85.8% were in adults over 18 years old. Compared to adults, children and adolescents were more likely to be asymptomatic at the time of testing (35.5% of cases aged 0-5 years, 39.4% aged 6-12 years, 23.5% aged 13-18 years, and 15.5% aged 19 years and older). Most cases (93%) occurred in Greater Melbourne.

SARS-CoV-2 cases linked to ECEC and schools

There were 339 events at ECEC settings or schools. Among all these events, 224 (66.1%) were complex cases (with a single case or multiple cases from a single household recorded) and 115 (33.9%) were outbreaks (Table 1). Of the 115 outbreaks, 103 (89.6%) involved less than 10 cases in staff and students.

Of the 12 outbreaks involving 10 or more cases, three occurred in ECEC settings, two occurred in primary schools, two in mixed level schools, four occurred in secondary schools, and one occurred in a specialist school. There was one very large outbreak in the community linked to a mixed level school which ultimately involved 208 cases. Events in secondary schools accounted for the greatest numbers of cases and contacts, and specialist schools the fewest (Table 1). Outbreaks were more common in mixed level and secondary schools, and less common in ECEC, primary schools and specialist schools.

There were 1,691 confirmed cases linked to ECEC and schools, comprising 8.4% of all cases in Victoria during the study period. This includes second and third generation cases which could be linked back to outbreaks that started within ECEC or schools, as well as “upstream” cases linked to the first case in each event (for example the SARS-CoV-2 positive parents of children who were the first case at their school). Among these cases there were 78 individuals (4.6%)

School type	ECEC and schools in Victoria ^{18,19}	SARS-CoV-2 events	Outbreaks (% of events)	Total Cases*	Total Contacts
ECEC	4,118	104	28 (26.9)	391	4,015
Primary	1,566	93	25 (26.9)	321	2,773
Mixed level	245	28	15 (53.6)	358	3,731
Secondary	344	106	45 (42.5)	623	7,640
Specialist	108	8	2 (25.0)	40	280
All settings	6,381	339	115 (33.9)	1,691	18,423

Table 1: Number of ECECs and schools and number of all SARS-CoV-2 events (n=339) in Victorian ECEC and schools over three school terms, 25 January 2020 – 18 September 2020.

* Some individuals were linked to multiple outbreaks.

	Cases, N (%)	Contacts, N (%)
Total	1,691	18,423
Children	806 (47.7)	13,159 (71.4)
0-5 years	163 (9.6)	3,212 (17.4)
6-12 years	275 (16.3)	3,554 (19.3)
13-15 years	125 (7.4)	1,548 (8.4)
16-18 years	243 (14.4)	4,845 (26.3)
Adults	885 (52.3)	3,397 (18.4)
Age not recorded	0 (0.0)	1,867 (10.1)
Female	922 (54.5)	5,998 (32.6)
Male	768 (45.4)	4,813 (26.1)
Other or sex not stated	1 (0.1)	7,612 (41.3)
Relationship to event*		
Student	604	13,661
Staff	265	2,887
Household	780	1,206
Other	87	549

Table 2: Characteristics of cases and contacts associated with SARS-CoV-2 events in Victorian ECECs and schools.

* Note that the same individual may be associated with multiple outbreaks in different ways, so subtotals exceed grand totals.

hospitalised: 10 staff, 10 students, 50 household members, and 8 people linked to ECEC or school events in other ways.

Table 2 shows the characteristics of cases and contacts linked to events in ECEC and schools. Children accounted for 71.4% of contacts linked to events in ECEC and schools, but only 47.7% of confirmed cases. Conversely, adults accounted for 52.3% of cases despite comprising only 18.4% of contacts. There were fewer cases and fewer contacts aged 0-5 compared to older children (aged 6-12) and adolescents (aged 13-18), despite ECEC remaining open to all children for all but six weeks of the study period.

A lower proportion of events in which a young child (aged 0-5) was the first identified case resulted in an outbreak compared to events where the first case was an adult (Risk ratio 0.35, 95% CI 0.19-0.68, see Table 3). There was evidence of a dose-response relationship

between the age of the first case and the occurrence of an outbreak. Adults made up the greatest number of first cases (n=115), followed by adolescents aged 16-18 years, consistent with the fact that senior high school students were on-site for face-to-face learning for more time than other age groups in 2020.

When the first case was an adolescent aged 16-18, an approximately equal proportion of events became outbreaks as when the first case was an adult. A large proportion of events with a first case in this age group occurred during the period when senior high school students were learning face-to-face while other students learned remotely, and when transmission in the community was approaching its highest level. Figure 2 shows the number of events by the stage of restrictions and the age of the first case, and the number of outbreaks among those events.

Geographic and temporal patterns

Ninety-seven percent of cases (n = 1,651) linked to ECEC and schools occurred from June to August, when community transmission in Victoria was highest (Figure 1). Total notifications in Victoria peaked at 725 new cases reported in the state on 4 August, a rate of 11 cases per 100,000 population on that day. Cases linked to ECECs and schools increased and decreased following the trend in cases the broader community. Victoria's "second wave" began after relaxation of restrictions in the community, which included the staged return to schools for onsite learning in term 2 from late May to early June. Cases continued to rise during the school holiday period, when stage 3 'stay-at-home' restrictions were re-enacted in the community. Similarly, the geographic distribution of cases linked to ECEC and schools was highly consistent with the broader epidemic in the community (Figure 3).

Just over half (58%, n=198) of all events in ECEC and schools occurred in the three-week period when senior high-school students and students of essential workers attended onsite. The resumption of remote learning for almost all students was one component of the most

Age of first case	Number of events	Outbreaks* (% of events)	Risk ratio for outbreak occurrence (95% CI)	P-value (chi-squared test)	Median number of cases per outbreak (IQR)
Child 0-5	64	9 (14.1)	0.35 (0.19, 0.68)	0.0005	5 (3, 6)
Child 6-12	59	18 (30.5)	0.77 (0.49, 1.20)	0.2626	6 (4, 9)
Adolescent 13-15	21	7 (33.3)	0.84 (0.44, 1.60)	0.6152	8 (4, 10)
Adolescent 16-18	77	33 (42.9)	1.08 (0.77, 1.52)	0.6063	8 (5, 12)
Adult 19+	115	45 (39.1)	Reference group		6 (3, 13)
Multiple first cases*	3	3 (100)	-	-	-
All events	339	115 (33.9)	-	-	6 (4, 11)

Table 3: Occurrence of outbreaks based on the age of the first case

* Statistics for outbreaks with multiple first cases were not calculated due to the small number (n=3).

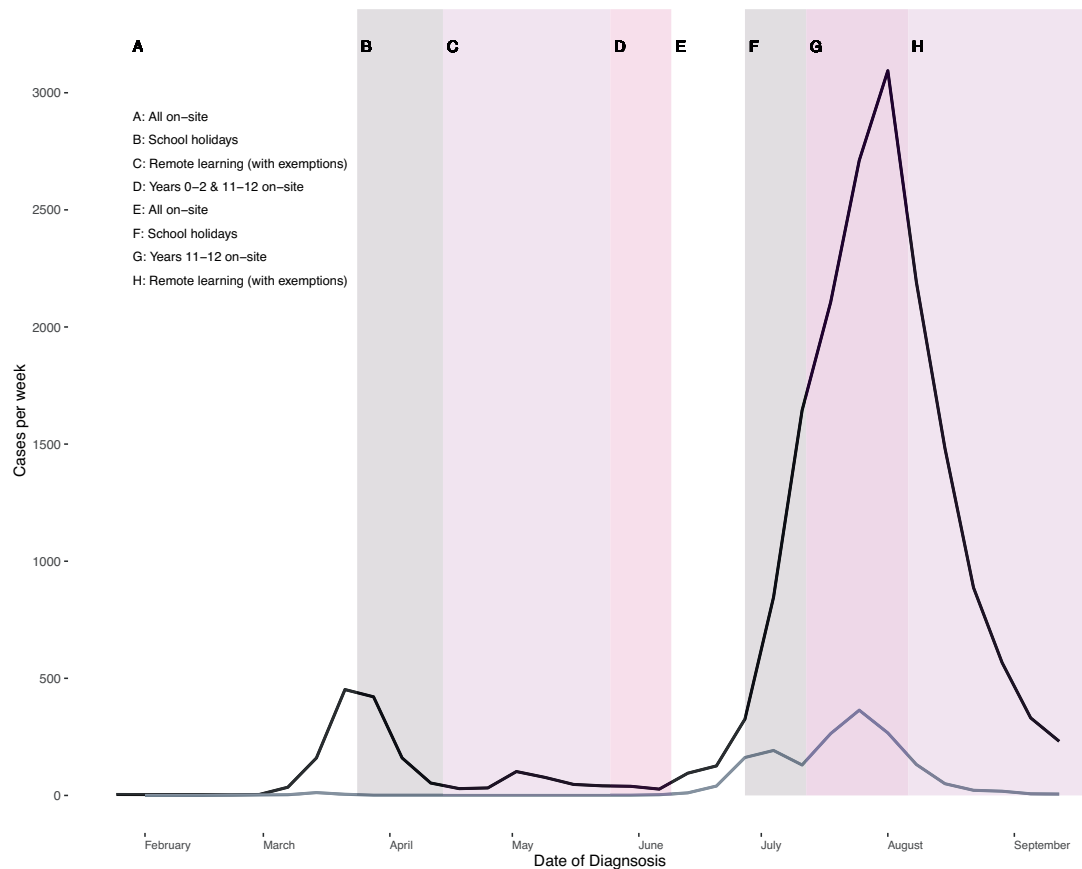


Figure 1. Epidemiological curve of SARS-CoV-2 diagnoses in children and adults associated with ECEC or schools (grey line), and all other confirmed cases in Victoria (black line).

stringent restrictions in Greater Melbourne, however cases linked to ECEC and school events had already declined prior to introduction of the additional measures, while senior high school students were still on site (Figure 1).

Public health actions

Table 4 shows more detailed characteristics of outbreaks, according to the total number of cases ultimately identified. Data on facility closures were available for 278 of 339 (82%) events. Facilities were closed in a median of one day (IQR: 0–2 days) from the date DHHS was notified of the first case. The median time between notification and closure was one day for events with one case, and two days in events with 10 or more cases in staff and students. ECEC and schools were closed for a median of eight days (IQR: 6–12). In line with public health requirements to complete contact tracing prior to facility reopening, the number of days that ECEC and schools were closed was higher in events involving 10 or more cases compared to those where single

cases occurred, with medians of 23 days (IQR: 19–27) and 7 days (IQR: 5–9) respectively (Table 4).

Discussion

We found that over the first three school terms and during the height of transmission in Victoria in 2020, ECEC and school outbreaks were relatively uncommon and that most outbreaks that did occur were small (<10 cases). During a period of higher transmission in the community when senior secondary students continued learning onsite, numerous individual SARS-CoV-2 cases occurred in school students and staff, but outbreaks within schools and especially in ECEC only occurred in a minority of events. Rapid closure of sites and the testing, tracing, and quarantine processes likely contributed to limiting the size of the outbreaks. Our findings are consistent with other settings which had strong public health responses to SARS-CoV-2 infections and outbreaks in schools in 2020 including New South Wales, Australia, and some other settings that kept their preschools and primary schools open

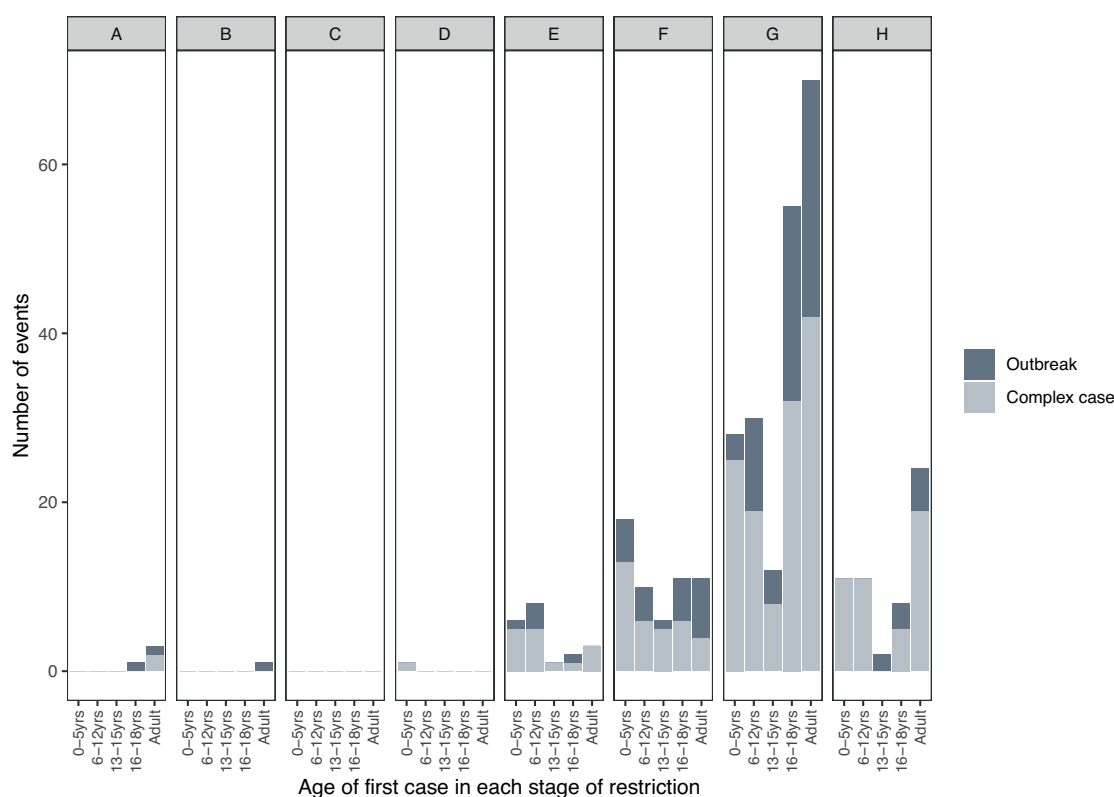


Figure 2. Total events and proportion which became outbreaks, stratified by the age of the first case and the contemporaneous restrictions on ECEC and schools

throughout parts of 2020, albeit with varying background incidence rates.^{20–24}

The role of children in SARS-CoV-2 transmission is a topic of critical importance, given the impact of ECEC and school closures on children's well-being and development. Transmission dynamics involving children are likely to change with the emergence of more infectious variants, and the roll-out of vaccines to adolescents and adults. Consistent with previous evidence²² we found that events with the first case in a child aged 0–5 years were far less likely to progress to an outbreak and involved fewer contacts, when compared to events when the first case was in an adolescent or adult. However, it should be noted that the number of events by age group would have been affected by the restrictions to onsite learning which varied by facility level; there was a period of several weeks where young children and senior secondary school students (16–18 years) had on-site learning, while an overwhelming majority of primary school and junior secondary school students (6–15 years) were learning remotely. Despite this, however, outbreaks in ECEC remained rare. Outbreaks linked to senior secondary students would likely have been influenced by the fact that class sizes for this age group would have been largely normal during this period, while the

younger children of essential workers would likely have been learning in smaller groups.

There have been reports of SARS-CoV-2 outbreaks in preschools, primary and secondary schools in numerous settings. Nevertheless, a number of countries in the European Union, as well as Taiwan, Hong Kong and South Korea, and New South Wales found that reopening schools in the context of low transmission and school mitigation measures was not associated with increases in community transmission in 2020.^{20–22,24} In Victoria, swift public health action curtailed potential outbreaks, and Victoria achieved elimination of local transmission in late 2020,¹⁰ although this was temporary, and schools and ECEC reopened to all students. Taken together, these observations suggest that ECEC and schools were unlikely to play a predominant role in broader community transmission when community and school mitigation measures were in place and community transmission was kept low. However, as more infectious variants have since emerged, and as adolescents and adults achieve high rates of vaccination coverage, the significance of ECEC and school settings for SARS-CoV-2 transmission may change.

We found that first cases in adults and older adolescents more often resulted in outbreaks, and further

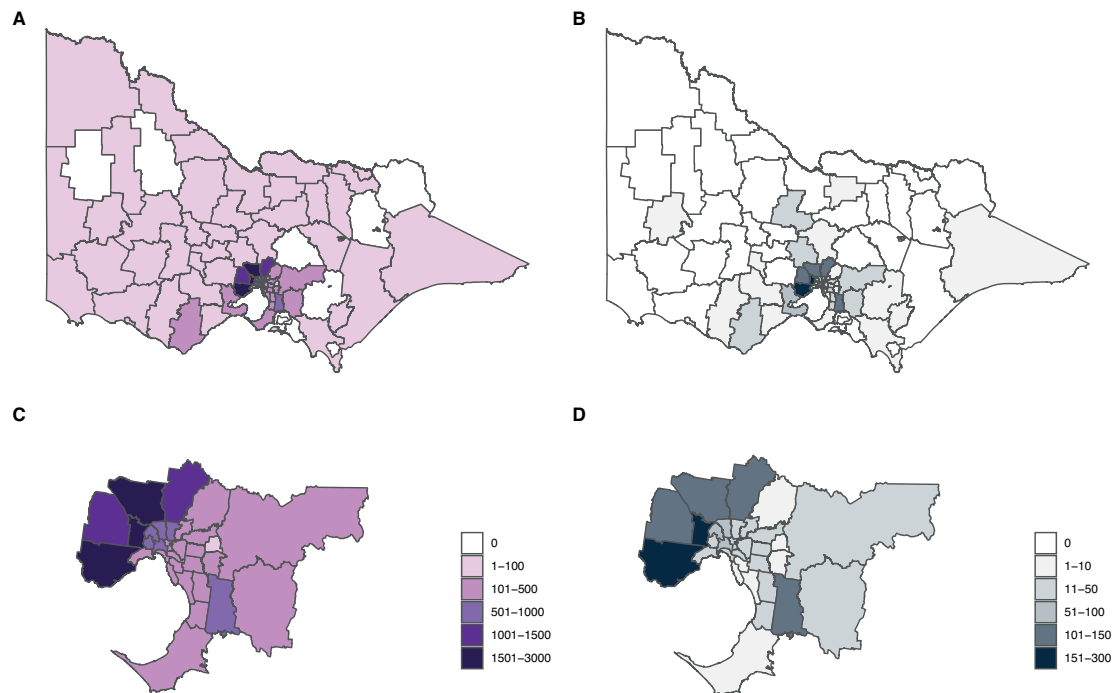


Figure 3. Comparison of SARS-CoV-2 case numbers across Victorian (A, B) and Melbourne (C, D) local government areas, comparing cases linked to ECEC and schools (B, D) to all other cases (A, C).

mitigation measures were recommended in these age groups, including masks.²⁵ Additionally, household transmission was common and it is important that measures are taken to prevent transmission in the household as much as possible, noting the considerable

challenges when parents must still provide care to children when one or the other is SARS-CoV-2 positive. Consistent with this, a large study in the UK found that there was a small but significant increased risk of SARS-COV-2 infection among adults living with

	Total	Complex case	2-4 cases	5-9 cases	10+ cases
Number of outbreaks	339	224	86	17	12
School type, n (col %)					
ECEC	104 (30.7)	76 (33.9)	22 (25.6)	3 (17.7)	3 (25.0)
Primary	93 (27.4)	68 (30.4)	21 (24.4)	2 (11.8)	2 (16.7)
Mixed	28 (8.3)	13 (5.8)	11 (12.8)	2 (11.8)	2 (16.7)
Secondary	106 (31.3)	61 (27.2)	31 (36.1)	10 (58.8)	4 (33.3)
Special	8 (2.4)	6 (2.7)	1 (1.2)	0 (0.0)	1 (8.3)
Number of contacts, median (IQR)	29 (6-70)	20 (3-47)	50 (16-84)	114 (54-177)	111 (78-250)
Number of days to closure, median (IQR)*	1 (0-2)	1 (0-2)	1 (0-2)	2 (0-3)	2 (0-3)
Days closed, median (IQR)*	9 (6-12)	7 (5-9)	11 (7-14)	12 (9-17)	23 (19-27)

Table 4: Outbreak management by the number of staff and student cases associated with an Early Childhood Education and Care (ECEC) or school event.

* These data available for 278 of 339 events (82%).

children, and that the risk of infection increased with child's age (0-11 years HR: 1.06, 12-28 years HR: 1.22).²⁶

There were several limitations to our analysis. We used routinely collected surveillance data, therefore, we did not have complete oversight of data collection and cleaning practices. We were unable to conduct analyses by class or year level as these data were not available. Additionally, because these data are observational, they do not provide a robust basis for causal inference. The data in this paper are based on diagnosed and reported cases only. Communicable diseases surveillance systems rarely achieve perfect case ascertainment. Some cases may be missed, for example when asymptomatic individuals do not receive testing. As such, the data reported in this article may not accurately reflect the true disease burden and transmission dynamics that occurred in the community during the study period. Some asymptomatic cases linked to outbreaks may have been tested late, which could have led to incorrect identification of the 'first case' and this may bias our results towards adults appearing to be the first case (as they are more likely to experience symptoms). Negative test results were not available for every individual linked to ECEC or school events, which precluded calculation of secondary attack rates.

In conclusion, we found that in the context of low-to-moderate community transmission, mitigation measures and rapid public health responses mitigated ECEC and school outbreaks in 2020 while the original variant of SARS-CoV-2 was circulating. However, the frequent introductions of SARS-CoV-2 into ECEC and schools during periods of higher community transmission highlights the importance of controlling community transmission, especially with the emergence of more infectious variants. When vaccination begins to bring SARS-CoV-2 incidence down, ECEC and schools should be prioritised for reopening and remaining open whenever possible, with mitigation strategies tailored to the age of the students and degree of local community transmission.²⁵

Large-scale research programmes are critical to understand the natural history of SARS-CoV-2 infection and transmission in children and adolescents, including the impact of new variants, and to monitor the impact of ECEC and school reopening on SARS-CoV-2 transmission. High quality prospective cohort studies with universal testing, viral genomics, and serology will help to clarify the transmission dynamics and natural history of new variants of SARS-CoV-2 in children and adolescents. This is particularly important as high vaccination coverage among adolescents and adults is achieved in many settings, which will result in younger children experiencing an increasing proportion of SARS-CoV-2 infections. Moreover, further research is needed to understand the psychosocial and educational harms of prolonged school closures over the longer term, and to identify the best ways to address these as children and

adolescents return to school. These impacts may be substantial, and will likely disproportionately affect disadvantaged families, exacerbating health and other inequities.²⁷

Declaration of interests

KS is employed by the Department of Health (previously the Department of Health and Human Services), Victorian Government. KR was also employed by the Department of Health and Human Services, Victorian Government at the time the research project was undertaken. All authors declare funding received by the Department of Health and Human Services for the conduct of the study.

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Authors' Contributions

FR and SG conceived the study. KR and KS analysed the data and produced the tables and figures. FR undertook the literature review. All authors contributed to study design, analysis planning, interpretation of the results, and writing the manuscript.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.lanwpc.2021.100369](https://doi.org/10.1016/j.lanwpc.2021.100369).

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