

SARS-CoV-2 transmission in K-12 schools in the Vancouver Coastal Health Region: a descriptive epidemiologic study

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Abstract

Background: There is an urgent need to assess the role of schools in the spread of SARS-CoV-2 in Canada to inform school-related public health measures. We describe the epidemiology of SARS-CoV-2 infection in students and staff in the Vancouver Coastal Health (VCH) region in the first three months of the 2020/2021 academic year, and examine the extent of transmission in the school setting.

Methods: This descriptive epidemiologic study using contact tracing data included all SARS-CoV-2 cases reported to VCH between September 10 and December 18, 2020 who worked in or attended schools in-person. Case and cluster characteristics were described.

Results: There were 699 school staff and student cases during the study period, including 25 non-VCH residents. Among VCH resident cases, 71% of those linked to a confirmed case/cluster were linked to a household contact, <1.5% were hospitalized and there were no deaths. Out of 699 cases present at school, 26 clusters with school-based transmission resulted 55 secondary cases. Staff members composed 54% of index cases (14/26) while making up 0.08% of the school population. Among clusters, 88% had fewer than 4 secondary cases.

Interpretation: The incidence of COVID-19 in the school population was lower than that of the general population in VCH during the study period. There were no deaths and severe disease was rare. School-based transmissions of SARS-CoV-2 were uncommon, and clusters were small. Our results support the growing body of evidence that children in schools do not play a major role in the spread of SARS-CoV-2.

Introduction

At the outset of the pandemic, schools were closed across Canada in a dual effort to reduce the circulation of SARS-CoV-2 in the community and decrease risks associated with infection among staff and students(1). In the intervening months, evidence has suggested that school closures and decreased in-person learning have had negative impacts on the mental health, wellbeing, educational attainment, social connection, health care access, and health behaviors of students, families, and staff(1-12). Combined with high social and economic tolls(13-15), these unintended consequences have compelled consideration of

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the efficacy of school closures in limiting morbidity and mortality associated with the COVID-19 pandemic.

Evidence now indicates that age is a significant risk factor for severe disease, and children typically have a mild course of illness(16-22). There is also a growing body of literature suggesting that children's in-person school attendance may not be a significant driver of SARS-CoV-2 transmission; both contact-tracing and test-based studies from other jurisdictions have identified little or no transmission in the school setting(23-34). Internationally, studies illustrate that school re-opening has not impacted numbers of paediatric cases in the community(23,35,36) and that the risk of SARS-CoV-2 infection has not increased for educational staff working with children(30,36,37). However, there is limited data in Canada regarding risk of SARS-COV-2 transmission in schools. Given that risk of transmission is influenced by community-level epidemiology, public health measures, health system infrastructure, and other jurisdictional factors, this study contributes needed evidence within the Canadian context. We aimed to describe incident cases who attended kindergarten to grade 12 (K-12) schools in-person, assess the extent of SARS-CoV-2 transmission in schools, and characterize clusters where school-based transmission was observed.

Methods

Setting

Vancouver Coastal Health (VCH) serves over 1.1 million people(38) across urban, rural, and remote geographies. In the 2020/2021 school year, there were 358 total schools, including 104 independent and 254 public schools in the VCH region offering in-person instruction. 17,742 staff and 105,905 students worked in or attended school in-person. Schools in BC reopened following the summer holidays on September 10, 2020 and closed for winter break after December 18, 2020. Prior to reopening, schools implemented COVID-19 safety plans including public health measures (e.g. protocols for testing and contact tracing), environmental measures (e.g. physical barriers and enhanced cleaning and disinfection),

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administrative measures (e.g. changes in scheduling and work practices, health and wellness policies, and cohorting), personal measures (e.g. staying home when sick, physical distancing, hand hygiene and respiratory etiquette), and personal protective equipment. Non-medical mask use was supported, but not required(39). Plans were developed with support from Public Health.

Public Health Investigation and Response

SARS-CoV-2 testing was available for anyone with symptoms, and advised for students or staff with fever or new symptoms which persisted for over 24 hours. Tests were generally processed within 24 hours, and positive tests were automatically reported to VCH's Office of the Chief Medical Health Officer, which investigated cases within 24 hours, and identified contacts(40). Individual risk assessments were performed for all contacts, integrating cases' symptoms, ages of cases and contacts, nature and duration of contact, setting (e.g. indoor/outdoor), and presence/absence of known SARS-CoV-2 transmission. Individuals with high risk exposures were advised to self-isolate for 14 days; those with lower risk exposures were advised to self-monitor for symptoms. Asymptomatic testing could be recommended in the course of investigation but was not routine. Mass testing and school closures due to SARS-CoV-2 transmission were not required during the study period.

Data sources

We obtained data from VCH's electronic interface specifically developed for COVID-19 case and contact management, capturing contact tracing interview data including demographics, school name, grade, case's role (e.g. staff, student), dates of attendance, associated comorbidities, symptoms, and epidemiologic linkage to other cases both within and outside of the school. Hospitalizations and ICU admissions to VCH hospitals were determined using individual data linkages to acute care data. Provincial Health Services Authority provided hospitalization data for BC Children's Hospital. Districts confirmed denominators of staff and students attending in-person during the study period. Duplicate case

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entries were discarded based on unique identifiers. Cases with a missing or incorrect location were reclassified based on city of residence or postal code.

Study design

We extracted all lab-confirmed and probable cases aged 5 and older at time of case report between September 10 and December 18, 2020, who, during their contact tracing interview reported working in or attending a K-12 school during their incubation or infectious periods. Student and staff cases were limited to those working or attending school in the VCH region. We excluded cases who exclusively worked in or attended a daycare or post-secondary institution, attended school online, and were homeschooled. School staff and student cases were categorized as either school aged (aged 5-17) or aged 18 and over. We described case characteristics including age, sex, location, linkage to known cases/clusters, comorbidities, symptoms at time of initial interview, status (recovered/removed from isolation or deceased), and hospitalization/ICU admission.

To identify potential school transmission events, we analyzed all clusters where 2 or more cases were reported within a 14-day period in a school. Cases who did not interact with staff or students in the learning setting (e.g. building maintenance staff not present during school hours) were excluded. A chart review of the cluster cases and their epidemiologically linked cases was conducted between December 21, 2020 and January 18, 2021 to verify the likely source of acquisition of SARS-CoV-2 infection. A case was determined to be a contact's likely source of acquisition if they had prolonged contact during the case's infectious period and the contact's incubation period. Sources were categorized as household, social, school, or other. Index and secondary cases were determined by symptom onset date. If there was no contact with a positive case, this was recorded. For school clusters, index and secondary cases were determined by symptom onset date. All cases with multiple potential exposures were reviewed by DB and AC. The source of acquisition was attributed to the school if the non-school source had an unclear

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3 symptom onset date and no clear source of acquisition themselves. The primary outcome was the number
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5 of school-based transmissions.
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10 All analyses were conducted using the statistical computing software R Studio(41). P-values were based
11 on Pearson's chi-squared test for categorical variables and independent t-tests for continuous variables.
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16 *Ethical considerations*

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18 In consultation with the UBC Office of Research Ethics, this study did not require institutional research
19 ethics review as the analysis was completed as part of routine public health surveillance and operations.
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24 **Results**

25 *Description of cases in schools*

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27 In the four weeks prior to school reopening, weekly incidence ranged from 0.8 to 3.2 per 10,000
28 population in VCH, based on 2019 population estimates(38); in the four weeks following reopening,
29 weekly incidence ranged from 2.4 to 2.8 per 10,000 population. Weekly incidence among VCH residents
30 peaked from November 15-21 at 9.4 per 10,000 population; weekly incidence among school staff and
31 students similarly peaked from November 15-21 at 6.6 per 10,000 population. Between September 10 and
32 December 18, 8,755 cases of SARS-CoV-2 infection among VCH residents were reported (73 per 10,000
33 population), of which 674 (8%) were staff members or students. With an additional 25 staff and student
34 cases who resided outside the VCH region, there were 699 cases among 123,646 staff and students
35 working in or attending school in-person (55 per 10,000 population) in 270 unique VCH region K-12
36 schools during the same period. Characteristics of the 674 VCH resident staff and student cases are
37 described in Table 1.
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Figures 1A and B. 7-day average of new SARS-CoV-2 cases among VCH residents, reported between August 1 and December 18, 2020. Please note the different axis used in Figure 1b to compare trends between school and community cases

Figure 1A

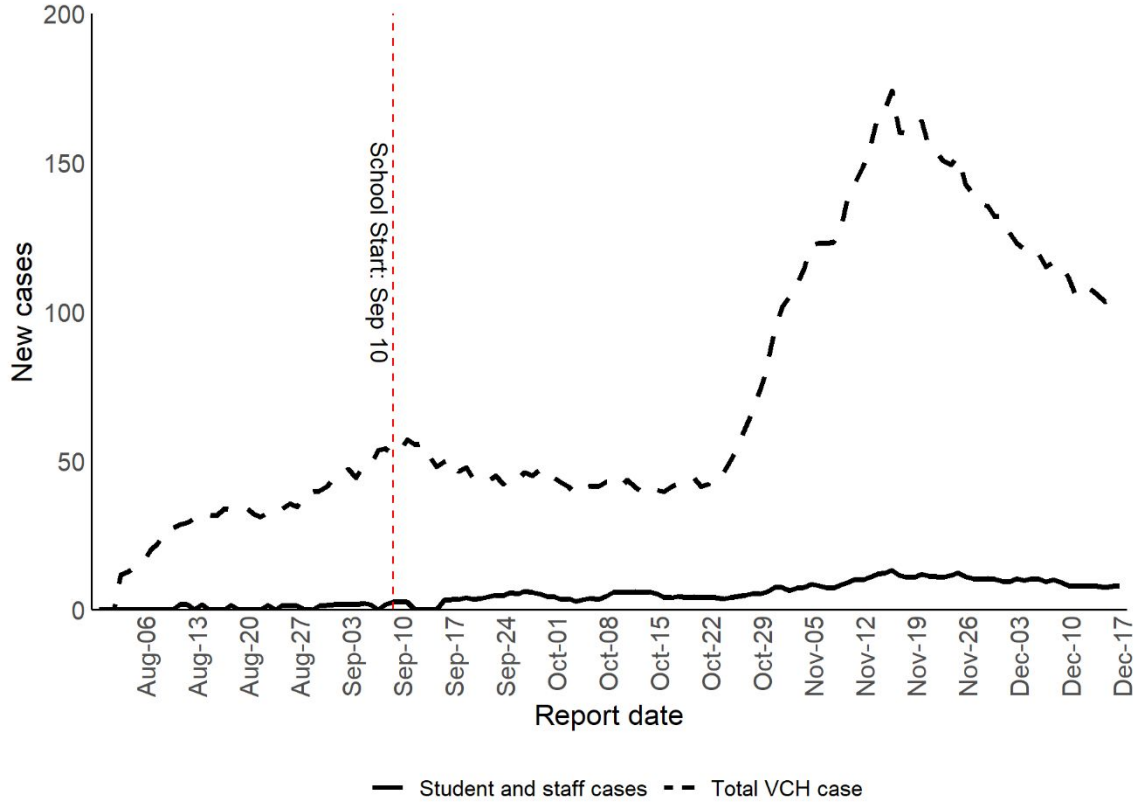


Figure 1B

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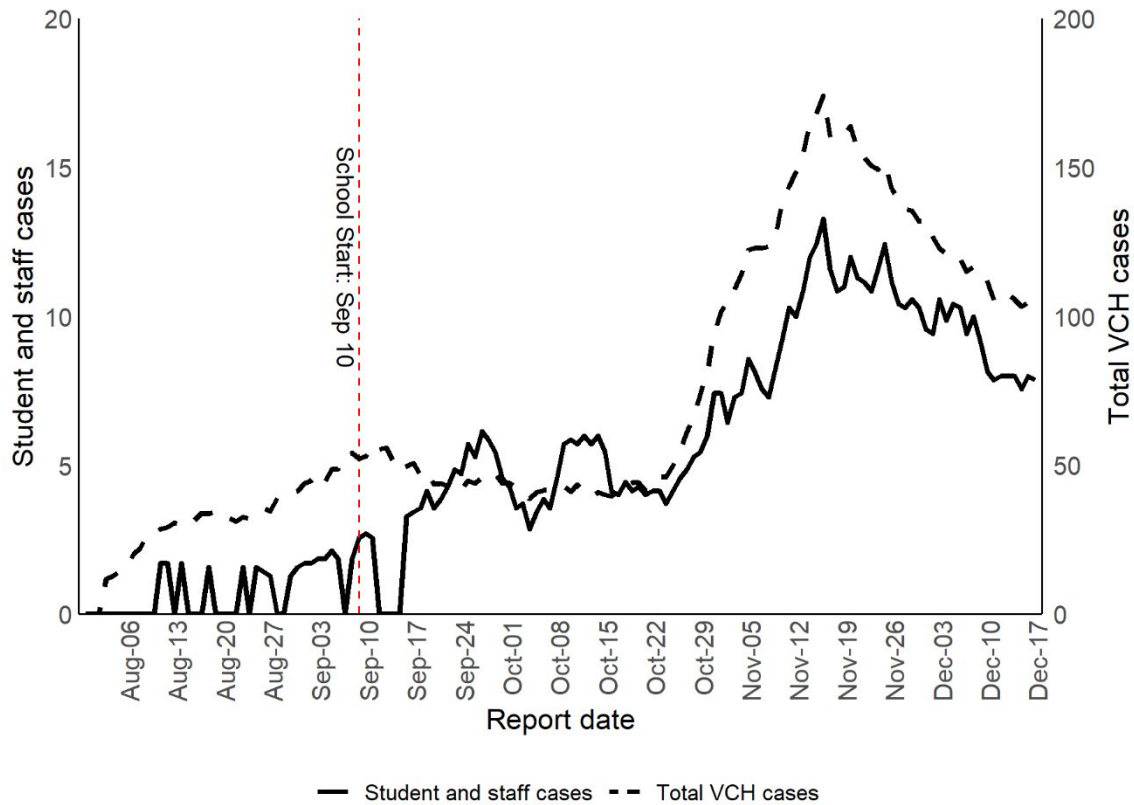


Table 1. Characteristics of 674 student and staff SARS-CoV-2 cases residing in the VCH region reported between September 10 and December 18, 2020^a

Variable	18+ years, <i>N</i> =157 <i>n</i> (%)	5-17 years, <i>N</i> =517 <i>n</i> (%)	Total, <i>N</i> =674 <i>n</i> (%)	P value
Age at time of report				<0.01
Median [Range]	39 [18-73]	12 [5-17]	14 [5-73]	
Aged ≥65 years at time of report	2 (0.4)	NA	2 (0.3)	0.01
Sex				<0.01
Female	104 (66)	224 (43)	328 (49)	
Male	53 (33)	292 (57)	345 (51)	

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Health Service Delivery Area				0.5
Coastal Rural	6 (3.8)	33 (6.4)	39 (5.8)	
Coastal Urban	29 (19)	107 (21)	136 (20)	
Richmond	29 (19)	99 (19)	128 (19)	
Vancouver	93 (59)	278 (54)	371 (55)	
Linked to confirmed case or cluster				<0.01
No	62 (40)	114 (22)	176 (26)	
Yes, non-household contact	50 (32)	94 (18)	144 (21)	
Yes, household contact	45 (29)	309 (60)	354 (53)	
Case status				0.6
Recovered/Removed from isolation	157 (100)	517 (100)	674 (100)	
Deceased	0	0	0	
Ever Hospitalized	-	-	<10 (1.5)	0.2
Ever Admitted to ICU	-	-	<10 (<1.5)	0.07
One or more comorbidities	36 (23)	37 (7.2)	73 (11)	<0.01
Comorbidity types ^b				<0.01
Cancer	2 (1.3)	0 (0)	2 (0.3)	
Cardiac	5 (3.2)	1 (0.2)	6 (0.9)	
Diabetes	7 (4.5)	3 (0.6)	10 (1.5)	
Immunocompromised	3 (1.9)	8 (1.5)	11 (1.6)	
Pregnant	3 (1.9)	0 (0)	3 (0.4)	
Respiratory	2 (1.3)	6 (1.2)	0 (0)	
Smoking/vaping	27 (17)	22 (4.3)	49 (7.3)	
One or more COVID symptoms	155 (99)	501 (97)	656(97)	0.2

^aData accurate as of January 12, 2021. Excludes 25 cases who resided outside of VCH region but worked in/attended school in-person in the VCH region. ^bComorbidity types were not mutually exclusive.

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Clusters of SARS-CoV-2 infection in schools

There were 71 school clusters totaling 251 cases reported between September 10 and December 18, 2020. No school-based transmission was suspected in 45 clusters (63%), with all 142 cases within these clusters likely acquiring SARS-CoV-2 outside of the school setting. Within the 26 clusters containing at least one school-acquired case, a further 28 cases likely acquired infection outside of the school setting. Of the 170 cases (19 staff and 151 students) temporally clustered within 14 days of other school cases but without evidence of school-based transmission, 107 (63%) were attributable to household contacts, 17 (10%) to social networks, 4 (2.4%) to sports teams, and 2 (1.2%) to work outside of school. 40 students and staff (24%) had no known contact with another case inside or outside of school.

Cases with evidence of school-based transmission

Out of 699 cases present at school, we observed transmission stemming from 26 index cases resulting in 55 secondary cases in the school. Among cases linked to school-based transmissions, 49 (60%) were female. Index cases were older with a median age of 24 (range 5-61) compared to secondary cases with a median age of 11 (range 5-64). Staff accounted for 54% of index cases (14/26) and 25% of secondary cases (14/55). Staff cases (n=28) included 19 teachers, 6 support workers, and 3 principals/office staff members. Of the 81 index and secondary cases, 47 (58%) worked in or attended a K-7 school, 25 (31%) a grade 8-12 school, and 9 (11%) a K-12 school.

The characteristics of clusters with school transmission are presented in Table 2. Among 26 total clusters, 13 (50%) had only 1 secondary case, 10 (38%) had 2-3 secondary cases, and 3 (12%) had 4 or more secondary cases. All clusters with 4 or more secondary cases had an index staff case and occurred in grades K-7. Clusters whose index case was a staff member had a median size of 3 (range 2-8); clusters whose index case was a student had a median size of 2 (range 2-3). There were 8 (31%) clusters involving

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students only, all among Grades 4-12, and 4 clusters (15%) involving staff members only. Of the 14 clusters including both staff and students, 9 (64%) occurred in grades K-7 and 5 (36%) in grades 8-12.

School-based activities where transmission may have occurred are presented in Table 3. Evidence of transmission was most commonly found in a shared classroom, but no specific class type was more frequently identified. For some cases, there were multiple exposures settings within the school, notably through socializing with a classmate. An assessment of which within-school exposure setting was most likely responsible for transmission was not conducted.

Table 2. Characteristics of 26 clusters with evidence of school-based transmission

Variable	Grades K-7 <i>N=13 clusters</i>	Grades 8-12 <i>N=9 clusters</i>	Staff only <i>N=4 clusters</i>	All grades <i>N=26 clusters</i>
Number of cases per cluster				
Median [Range]	2 [2-8]	3 [2-4]	2.5 [2-4]	2.5 [2-8]
Role of index cases <i>N=26 cases</i> n (%)				
Staff	7 (54)	3 (33)	4 (100)	14 (54)
Student	6 (46)	6 (67)	0 (0)	12 (46)
Role of secondary cases <i>N=55 cases</i> n (%)				
Staff	4 (12)	3 (20)	7 (100)	14 (25)
Student	29 (88)	12 (80)	0 (0)	41 (75)

Table 3. School settings where transmission may have occurred for 55 school-acquired SARS-CoV-2 cases^a

Exposure setting	Grades K-7 <i>N=35 exposure settings</i>	Grades 8-12 <i>N=17 exposure settings</i>	Staff only <i>N=7 exposure settings</i>	All grades n (%) <i>N=59 exposure settings</i>
Class	28 (26 students,	11 (10 students,	2 (2 staff)	41 (70)

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	2 staff)	1 staff)		
Office/Meeting/Staff room	2 (2 staff)	1 (1 staff)	3 (3 staff)	6 (10)
Socializing at school	3 (3 students)	2 (2 students)	0	5 (8)
Unspecified interaction	0	1 (1 student)	2 (2 staff)	3 (5)
Field trip	0	2 (1 student, 1 staff)	0	2 (3)
Cohort	2 (2 students)	0	0	2 (3)

^aThere were multiple potential exposure settings for some cases.

Interpretation

During the study period 8,755 cases of SARS-CoV-2 infection were reported among VCH residents (73 per 10,000 population) compared to 674 student and staff cases among VCH residents (55 per 10,000 population). While 251 cases were temporally clustered with another case in the same school within a 14-day period, 170 (68%) of these cases had no evidence of school-based transmissions. We identified 26 clusters with evidence of school-based transmission resulting in 55 school-acquired cases (0.04% of 123,646 individuals working in or attending school) in 25/358 (7.0%) schools in the VCH region. Cluster sizes were small, with 50% leading to 1 secondary case and 88% having fewer than 5 cases total. The index case was a staff member in just over half of the clusters (54%), and the largest clusters were observed in elementary schools. A shared classroom accounted for the majority of transmissions; no particular class/activity (e.g. physical education) was noticeably higher risk for transmission.

Our findings support the growing body of evidence that schools are likely not a significant driver of SARS-CoV-2 transmission(23,36). In concordance with other studies, we found that a household case was the predominant source of SARS-CoV-2 infection for school-aged children(30,32), and that school-based acquisitions were uncommon(29,30,32,33). Individuals with COVID-19 seldom infected others at

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3 school; out of the 699 student and staff cases (including 25 non-VCH residents working in or attending a
4 VCH school), we identified school-based transmissions stemming from 26 index cases (3.9%). The ratio
5 of secondary cases to total primary cases in the school setting was 0.09 in the school setting, compared to
6 0.27 observed in Luxembourg(30), 0.08 in Germany(32) and 0.02 in South Korea(23). While we did not
7 systematically track the number of contacts in the school setting per index case, the secondary attack rate
8 is likely to be very low given the low number of identified secondary cases, in concordance with prior
9 studies across several countries(24,25,28,30). As observed elsewhere, where school-based transmission
10 occurred, the number of secondary cases was limited(23,31,42), although there has been one large high
11 school outbreak described in Israel(43) in the context of crowding and a concurrent heat wave.
12 Interestingly, we observed a larger number of secondary cases when the index case was an adult, similar
13 to the experience in England(31) and Singapore(26). Finally, our findings reinforced the observation that
14 numerous cases in a school can reflect multiple introductions from the community rather than school-
15 based transmissions(2).

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33 Our study was population-based and avoided bias due to cluster selection. However, our analysis was
34 limited by the reliance on data collected as part of routine public health operations. While Medical Health
35 Officers could request asymptomatic testing for the purposes of public health investigation, universal
36 testing was not required. However, although transmissions between undetected (e.g. asymptomatic and
37 not tested) cases could not be examined, studies where all classroom contacts have been tested have
38 reported low levels of transmission(24,28,33). Our study was also limited by potential recall bias due to
39 reliance on case report for the epidemiologic investigations, supplemented with information from school
40 administrators and staff. The potential for misclassification of the likely source of acquisition for cases
41 with multiple exposures was minimized via independent review of these cases by two members of the
42 research team. No distinction was made between secondary and tertiary cases. Furthermore, this study
43 was limited to descriptive statistics and causal inferences cannot be drawn.

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Of note, our study was conducted in the context of limited circulation of SARS-CoV-2 variants of concern in British Columbia, a strong collaboration between the public health and education sectors, good school-based infection prevention and control measures, and rapid access to testing and contact tracing, which may have limited transmission. During the study period, test results were typically available within 24 hours, and contact tracing was completed within 24 hours of receipt of a positive test. Further studies will be required to evaluate the impact of individual infection prevention and control measures.

In conclusion, from September 10 to December 18, 2020 we detected minimal clusters and low rates of secondary transmission within the school setting. In-person school attendance may not expose students and staff to higher risks than those experienced in the community when infection prevention and control measures are in place, and adequate case and contact management capacity is available. Caution should be taken in generalizing these findings due to differences in underlying epidemiology, public health measures, health system infrastructure, and culture, among other factors that may differ by jurisdictions. However, our findings suggest that schools may be able to safely remain open in settings with moderate community transmission. Acknowledging harms associated with decreased school attendance, school closures and widespread quarantine of students and staff should be considered with caution.

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VCH SCHOOL STAFF AND STUDENT CASES AND CLUSTERS
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Appendix

The study protocol and BC Centre for Disease Control COVID-19 Public Health Guidance for K-12

School Settings document are available upon request by emailing the corresponding author.

Table A1. Data dictionary

Term	Definition
Lab confirmed case	A person with laboratory confirmation of infection with the virus that causes COVID-19 performed at a community, hospital or reference laboratory (NML or a provincial public health laboratory) running a validated assay. This consists of detection of at least one specific gene target by a NAAT assay (e.g. real-time PCR or nucleic acid sequencing).(44)
Probable-lab case	A person (who has had a laboratory test) with fever (over 38 degrees Celsius) or new onset of (or exacerbation of chronic) cough AND who meets the COVID-19 exposure criteria and in whom a laboratory diagnosis of COVID-19 is inconclusive. Inconclusive is defined as an indeterminate test on a single or multiple real-time PCR target(s) without sequencing confirmation or a positive test with an assay that has limited performance data available.(44)
Probable epi-linked case	A person (who has not had a laboratory test) with fever (over 38 degrees Celsius) or new onset of (or exacerbation of chronic) cough AND either close contact with a confirmed case of COVID-19 or lived in or worked in a closed facility known to be experiencing an outbreak of COVID-19 (e.g., long-term care facility, prison).(44)
COVID-19 Symptoms	Any one of: abdominal pain, arthralgia, chills, coma, confusion, conjunctivitis, cough, diarrhea, discoloration of toes or fingers, dizziness, fatigue, fever, headache, loss of appetite loss of sense of smell/taste, myalgia, nasal congestion, nausea, pharyngitis, rash, rhinorrhea, shortness of breath/breathing difficulty, or vomiting.(44)
Recovered / Removed from isolation	Self-isolation for a person diagnosed with COVID-19 has been discontinued based on criteria outlined by Interim Guidance(40,44).
Deceased	Death from any cause occurring in a person diagnosed with COVID-19 with no period of complete recovery between illness and death.(44)
Ever Hospitalized	Any person admitted to a hospital for at least an overnight stay, or with a prolongation of hospitalization, for reasons directly or indirectly related to their COVID-19 infection, and with no period of complete recovery between illness and admission.(44)
Ever Admitted to ICU	Any person admitted to an intensive care unit (ICU) for at least an overnight stay, or with a prolongation of ICU stay, for reasons directly or indirectly related to their COVID-19 infection, and with no period of complete recovery between illness and admission.(44)

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Cancer	Malignancy or cancer diagnosed in the last 5 years.
Cardiac	Chronic cardiac disease, excluding hypertension.
Diabetes	Client self-report at time of case interview.
Immunocompromised	Client self-report at time of case interview.
Pregnant	Client self-report at time of case interview.
Respiratory	Other chronic respiratory / pulmonary condition, excluding asthma.
Smoking/vaping	Client self-report at time of case interview.
Linked to confirmed case: Yes, non-household contact	Client report close contact with a probable or confirmed case of COVID-19 in a non-household setting within 14 days prior to illness onset.
Linked to confirmed case: Yes, household contact	Client reported close contact with a probable or confirmed case of COVID-19 in a household setting within 14 days prior to illness onset.
Linked to confirmed case: No	Client did not report close contact with a probable or confirmed case of COVID-19 within 14 days prior to illness onset.
Staff	Case reporting working in a K-12 school within the learning setting in-person, or directly interacting with those within the learning setting, including teachers, support workers, principals/vice principals and office staff members.
Student	Case (or proxy) reporting attending a K-12 school in-person.

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Figure A1. Study population selection flow diagram (including non-VCH resident staff and student cases)

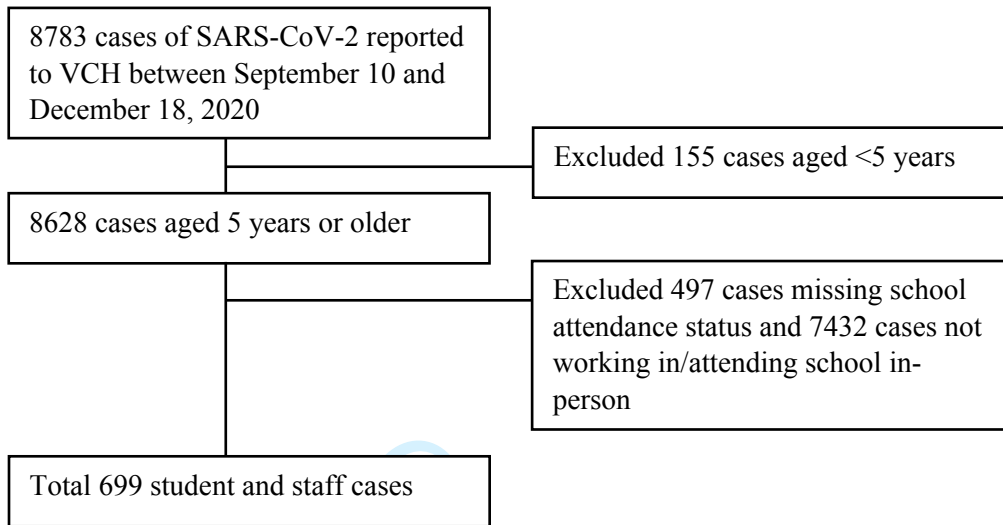


Figure A2. School clusters identification flow diagram

