BMJ Paediatrics Open

SARS CoV-2 seroprevalence in a US school district during COVID-19

Sean S M Bullis,[1] Benjamin Grebber,[2] Sally Cook,[3] Nancy R Graham,[4] Marya Carmolli,[4] Dorothy Dickson,[4] Sean A Diehl,[4] Beth D Kirkpatrick,[1,4] Benjamin Lee [5]

To cite: Bullis SSM, Grebber B, Cook S, *et al*. SARS CoV-2 seroprevalence in a US school district during COVID-19. *BMJ Paediatrics Open* 2021;**5**:e001259. doi:10.1136/bmjpo-2021-001259

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjpo-2021-001259).

SSMB and BG contributed equally.

BG and BL are joint first authors.
SSMB and BG are joint first authors.

Received 11 August 2021
Accepted 18 September 2021

[1]Department of Medicine, University of Vermont College of Medicine, Burlington, Vermont, USA
[2]University of Vermont College of Medicine, Burlington, VT, USA
[3]Vermont Department of Health, Burlington, Vermont, USA
[4]Department of Microbiology and Molecular Genetics, University of Vermont College of Medicine, Burlington, Vermont, USA
[5]Department of Pediatrics, University of Vermont College of Medicine, Burlington, VT, USA

Correspondence to
Dr Benjamin Lee; blee7@uvm.edu

ABSTRACT

Reduced symptomatology and access to testing in children have led to underestimates of paediatric COVID-19 prevalence and raised concerns about school safety. To explore COVID-19 prevalence and risk factors in school settings, we conducted a SARS-CoV-2 serosurvey in a Vermont, USA school district in December 2020. Among 336 students (63%) and 196 teachers/staff (37%), adjusted seroprevalence was 4.7% (95% CI 2.9 to 7.2) and was lowest in preK-5 students (4–10 Years). Seroprevalence was 10-fold higher than corresponding state PCR data but was low overall with no evidence of onward transmissions. These results further support feasibility of in-person learning during COVID-19 with appropriate mitigation measures.

At the beginning of the COVID-19 pandemic, near-universal school closures were enacted to mitigate spread of SARS-CoV-2. Early studies suggested that children were less susceptible to SARS-COV-2 and less likely to transmit.[1] However, their high frequency of asymptomatic infections[2] called into question the accuracy of incidence estimates using symptom-based testing and the true role of paediatric transmission, concerns that heavily influenced school reopening debates.

Therefore, we conducted a cross-sectional serosurvey to estimate COVID-19 prevalence and risk factors among students and staff attending ≥2 days/week of in-person learning in Colchester School District (Vermont, USA). Patients or the public were not involved in study design, conduct, reporting or dissemination. The University of Vermont Institutional Review Board approved the study. All participants/parent provided written informed consent and all children ≥grade 6 provided written assent. Exclusion criteria including bleeding or clotting disorder or other condition that would preclude safe blood collection. Capillary blood collection via fingerprick was performed 2–19 December 2020 for detection of serum anti-SARS-CoV-2 IgG using the Mount Sinai two-step ELISA, which requires detection of antibodies to both receptor binding domain and full-length spike protein.[3 4] Participants completed a self-administered REDCap questionnaire to assess risk factors (online supplemental materials). At the time of the study, state guidelines mandated universal masking for all students and staff and physical distancing of three feet for pre-Kindergarten (pre-K)–6th-grade students and six feet for 7th–12th-grade students. Seroprevalence with 95% CIs was calculated using Blaker's method and adjusted for estimated assay sensitivity (95%) and specificity (99%) according to the formula $\text{prevalence}_{\text{adjusted}} = (\text{prevalence}_{\text{observed}} + \text{specificity} - 1)/(\text{sensitivity} + \text{specificity} - 1)$.[4 5]

A total of 532 enrolled participants completed antibody measurement: 336 students (63%) and 196 teachers/staff (37%). The participation rate was 18% among students, equally distributed across age groups and 44% among teachers/staff. Overall adjusted seroprevalence was 4.7% (95% CI 2.9 to 7.2) and was similar among students and teachers/staff (table 1). Adjusted seroprevalence was lowest (1.8%, 95% CI 0.0 to 5.8) in pre-K-5 students. 527 participants (99%) completed the questionnaire, including all seropositive individuals. 95% identified as white race alone, similar to Vermont overall (94%). Two teachers/staff reported prior COVID-19, both were seronegative. Eighteen participants reported prior household COVID-19 contact between March and December 2020; none was seropositive. Thirty participants reported close non-household COVID-19 contact, only one student was seropositive. No associations were detected between seropositivity and out-of-state travel, sports participation, group activities or symptomatic illness without confirmatory testing. Nearly, all (99%) reported that family members wore masks ≥75% of the time in public.

In a low-incidence US region, we detected low SARS-CoV-2 seroprevalence among

Table 1 SARS-CoV-2 IgG seroprevalence

	Total N	Age, years median (IQR)	Seropositive N	Unadjusted seroprevalence % (95% CI)	Adjusted seroprevalence % (95% CI)
Teachers/staff	196	45.1 (36.3–53.4)	11	5.6 (2.9 to 9.8)	4.9 (2.0 to 9.3)
Students	336	12.2 (8.5–14.9)	18	5.4 (3.3 to 8.2)	4.6 (2.5 to 7.7)
PreK-5	149	8.3 (6.7–9.8)	4	2.7 (0.9 to 6.5)	1.8 (0.0 to 5.8)
Grades 6–8	82	13.1 (12.3–13.8)	6	7.3 (3.2 to 14.9)	6.7 (2.4 to 14.8)
Grades 9–12	105	16.1 (15.1–17.1)	8	7.6 (3.4 to 14.4)	7.0 (2.5 to 14.3)
Grades 6–12	187	14.6 (13.3–16.3)	14	7.5 (4.4 to 12.1)	6.9 (3.6 to 11.8)
Total	532	–	29	5.5 (3.7 to 7.7)	4.7 (2.9 to 7.2)

N, number; preK, pre-Kindergarten.

students and staff attending in-person learning midway through the 2020–2021 academic year. Seroprevalence increased with age, consistent with patterns of COVID-19 incidence in US children.[6] As observed elsewhere, our findings suggest significant (10-fold) under-detection of SARS-CoV-2 infections in US children.[7] Cumulative incidence in Vermont as calculated from census and Vermont Department of Health PCR as of December 2020 was 0.46% in children ≤19.[8 9] Our cohort reported few known contacts with SARS-CoV-2-infected individuals, suggesting that missed asymptomatic infections may have occurred, even in a low-risk population in a low-incidence region. Importantly, however, our data indicate that such infections were not associated with known cases of onward transmission. Of note, our study occurred prior to vaccine rollout and significant emergence of the more infections Alpha and Delta variants. Our study had several limitations. Participation was limited to a single school district and response rate was low, limiting precision and introducing potential selection bias, meaning results may not be readily generalisable. We were unable to perform antibody measurement before the school year, preventing estimation of the timing of infections and successful vaccine rollout in 2021 precluded planned follow-up assessment. Individuals with waning antibody responses may have been missed. Finally, questionnaire data are subjected to recall bias. Our results further support the global experience demonstrating feasibility, with proper mitigation, of in-person education during COVID-19. Until younger children are eligible for vaccination and where community transmission remains high or vaccine coverage remains limited, mitigation measures remain important to ensure safe in-person learning, particularly as more infectious variants circulate.

Acknowledgements The authors would like to thank Annie Penfield-Cyr for her assistance with the REDCap database. The authors would like to thank Meghan Baule, Amy Minor and Lindsey Campion of the Colchester School District, the Vermont Department of Health and multiple volunteers from the Vermont Medical Reserve Corps and the University of Vermont Medical Centre and University of Vermont Larner College of Medicine for their assistance with the study. Dr. Benjamin Grebber's current affiliation is Department of Pediatrics, Tufts Children's Hospital, Boston, MA, USA.

Contributors BL conceptualised and designed the study, managed recruitment, enrolment, specimen collection, processing and ELISA, performed data management and analyses and reviewed and revised the manuscript. SSMB performed specimen collection and ELISA, data entry, drafted the initial manuscript and reviewed and revised the manuscript. BG and SC assisted with study instrument design, managed and performed specimen collection and reviewed and revised the manuscript. SAD, NRG and MC established and/or performed ELISA, and reviewed and revised the manuscript. DD assisted with study design, performed instrument design and data management, performed analyses and reviewed and revised the manuscript. BDK reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Funding This work was supported by Children's Miracle Network Hospitals Fund (award number not applicable) and NIH/NIGMS [P20 GM125498-01].

Disclaimer The funders had no role in the design, conduct, analysis, or interpretation of this study.

Competing interests None declared.

Patient and public involvement statement Patients or the public were not involved in the design, reporting, or dissemination of this project. The superintendent, principals, and school board of Colchester School District granted prior approval of the project and assisted with initial communication to district families for project referral.

Patient consent for publication Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

ORCID iD

Benjamin Lee http://orcid.org/0000-0001-7213-5631

REFERENCES

1 Lee B, Raszka WV. COVID-19 transmission and children: the child is not to blame. *Pediatrics* 2020;146:e2020004879.
2 He J, Guo Y, Mao R, *et al*. Proportion of asymptomatic coronavirus disease 2019: a systematic review and meta-analysis. *J Med Virol* 2021;93:820–30.
3 Stadlbauer D, Amanat F, Chromikova V, *et al*. SARS-CoV-2 seroconversion in humans: a detailed protocol for a serological assay, antigen production, and test setup. *Curr Protoc Microbiol* 2020;57:e100.
4 Mount Sinai hospital laboratory COVID-19 ELISA IgG antibody test EUA summary. Available: https://www.fda.gov/media/137029/download [Accessed 11 Mar 2021].
5 Reiczigel J, Földi J, Ozsvári L. Exact confidence limits for prevalence of a disease with an imperfect diagnostic test. *Epidemiol Infect* 2010;138:1674–8.
6 Leeb RT, Price S, Sliwa S, *et al*. COVID-19 trends among school-aged children - United States, March 1-September 19, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1410–5.
7 Hobbs CV, Drobeniuc J, Kittle T, *et al*. Estimated SARS-CoV-2 seroprevalence among persons aged <18 years - Mississippi, May-September 2020. *MMWR Morb Mortal Wkly Rep* 2021;70:312–5.
8 Current activity in Vermont: Vermont department of health. Available: https://www.healthvermont.gov/response/coronavirus-covid-19/current-activity-vermont [Accessed 15 Mar 2021].
9 QuickFacts: Chittenden County, Vermont: United States census bureau. Available: https://www.census.gov/quickfacts/fact/table/chittendencountyvermont,VT/PST045219 [Accessed 3 Mar 2021].