Clinical Infectious Diseases

BRIEF REPORT

Novel Coronavirus 2019 Transmission Risk in Educational Settings

Chee Fu Yung,[1,2,3] Kai-qian Kam,[1,2] Karen Donceras Nadua,[1,2] Chia Yin Chong,[1,2,3] Natalie Woon Hui Tan,[1,2,3] Jiahui Li,[1,2] Khai Pin Lee,[4] Yoke Hwee Chan,[2,5] Koh Cheng Thoon,[1,2,3,a] and Kee Chong Ng[2,5,a]

[1]Infectious Disease Service, Department of Paediatrics, KK Women's and Children's Hospital, Singapore, [2]Duke–National University of Singapore Medical School, Singapore, [3]Lee Kong Chian School of Medicine, Imperial College London, Nanyang Technological University, Singapore, [4]Children's Emergency, Department of Paediatrics, KK Women's and Children's Hospital, Singapore, and [5]Division of Medicine, KK Women's and Children's Hospital, Singapore

Transmission risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in schools is unknown. Our investigations, especially in preschools, could not detect SARS-CoV-2 transmission despite screening of symptomatic and asymptomatic children. The data suggest that children are not the primary drivers of SARS-CoV-2 transmission in schools and could help inform exit strategies for lifting of lockdowns.

Keywords. transmission; COVID-19; SARS-CoV-2; pediatric; school.

The clinical manifestation of novel coronavirus disease 2019 (COVID-19) in children has been reported to range from asymptomatic to moderate rather than severe, but the burden of disease and their role in community transmission remains unknown [1, 2]. Many countries have implemented school closures nationwide as part of lockdown measures in an effort to slow community transmission of COVID-19. However, a recent systematic review using available evidence from the severe acute respiratory syndrome (SARS) outbreak found that school closures were not effective in controlling the epidemic [3]. In addition, modeling studies of COVID-19 estimate that school closures on their own would only reduce overall mortality by 2%–4% [3]. Understanding the risk of acquiring COVID-19 in specific settings such as schools would allow us to identify drivers of the epidemic and thus inform public health control strategies. This report describes the risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission among children in educational settings (preschool and secondary school).

Received 27 April 2020; editorial decision 11 June 2020; accepted 23 June 2020; published online June 25, 2020.

[a]K. C. T. and K. C. N. contributed equally to this work.

Correspondence: C. F. Yung, KK Women's and Children's Hospital, 100 Bukit Timah, Singapore 229899 (yung.chee.fu@singhealth.com.sg).

Clinical Infectious Diseases® 2021;72(6):1055–8

DOI: 10.1093/cid/ciaa794

METHODS

Study Population

In February and March 2020, comprehensive nationwide surveillance and contact tracing as part of Singapore's public health strategy identified 3 potential SARS-CoV-2 seeding incidents in 3 separate educational settings [4, 5]. There were 2 preschools and 1 secondary school. Clinical and epidemiological data of the confirmed cases and their contacts from school were extracted for analysis.

Interventions and Investigations

All close contacts (eg, students from the same class) were placed under quarantine (14 days from last exposure). Quarantined individuals who developed fever or any respiratory symptom were immediately sent for medical evaluation of COVID-19 and admitted for isolation. Other schoolmates who were not deemed to be close contacts were not quarantined and continued with classes. All students/parents of the school were advised to monitor for symptoms and were similarly admitted for COVID-19 evaluation if they were unwell within the 14-day incubation period. All admitted cases required at least 2 negative nasopharyngeal (NP) swabs to be taken on 2 separate calendar days before being discharged from the hospital. Schools were not routinely closed, but targeted public health measures were implemented. These included terminal cleaning of the schools and measures to reduce student mixing, such as suspension of extracurricular or sport activities and staggered recess breaks. For the third incident (preschool 2), in addition to the above measures, the preschool was closed for 14 days following quick detection of an increasing number of staff members with COVID-19. Furthermore, a single NP swab screening for SARS-CoV-2 among asymptomatic children attending the preschool was also initiated to identify potential asymptomatic cases.

The study was approved by the Singhealth Centralised Institutional Review Board. Written informed consent was waived in light of the need to inform public health outbreak control policies.

RESULTS

Symptomatic Screening of Secondary School and Preschool 1

A 12-year-old student who attended secondary school and a 5-year-old who attended preschool were both found to be SARS-CoV-2 positive from contact tracing following their exposures to adult family household members who were part of a community cluster. Both students attended their respective educational settings on the first day of their symptoms before subsequently being diagnosed with COVID-19 and isolated in the hospital.

In the secondary school setting, a total of 8 students from the school developed symptoms and were screened for SARS-CoV-2 during the incubation period. The mean age was 12.8 years and there was on average an 11-day interval between last exposure and the first NP swab from the contacts. (Table 1) The most common presenting symptom was cough (87.5%), followed by rhinorrhea (37.5%). All 8 symptomatic student contacts tested negative from that school.

In the preschool setting (preschool 1), a total of 34 preschool student contacts developed symptoms during the incubation period postexposure and hence were swabbed for SARS-CoV-2. The mean age was 4.9 years and there was on average a 5-day interval between last exposure and the first NP swab from the contacts. Similar to the secondary school setting, the common presenting symptoms were cough (94.1%) and rhinorrhea (41.2%). Only 14·7% of them presented with fever. All 34 symptomatic contacts at the preschool were found to be negative for SARS-CoV-2.

Asymptomatic and Symptomatic Screening of Preschool 2

The third incident involved a preschool cluster where the index case was an adult staff member. This preschool setting (preschool 2) developed into a significant cluster where up to a total of 16 adult staff members of the preschool with an additional 11 cases from their own households were infected [4, 5]. A total of 77 children from the preschool (about 73% of the total preschool student population) were evaluated. Of these, 8 were symptomatic and 69 were asymptomatic. The mean interval between last exposure to NP swab sampling was about 6 days and 10 days for symptomatic and asymptomatic children, respectively. SARS-CoV-2 infection was not detectable from screening of all 77 children. There was no significant difference in age or sex between those who provided an NP swab vs those who did not. The remaining 27% who chose not to provide an NP screening swab did not develop any symptoms while under close monitoring and quarantine.

Table 1. Clinical Epidemiology and Nasopharyngeal Swab Results of School/Preschool Contacts (N = 119)

Characteristic	Secondary School (n = 8)	Preschool 1 (n = 34)	Preschool 2 (n = 77)	
Presence of symptoms in contacts	Yes	Yes	Yes (n = 8)	No (n = 69)
Age, mean, y (range)	12.8 (12.0–15.0)	4.9 (2.8–6.2)	4.1 (3–6)	3.6 (1–6)
Sex				
Male	8 (100)	20 (58.8)	4 (50)	36 (52.2)
Female	0 (0)	14 (41.2)	4 (50)	33 (47.8)
Admitted				
Yes	5 (62.5)	11 (32.3)	0	0
No	3 (37.5)	23 (67.6)	8 (100)	69 (100)
NP sample SARS-CoV-2 PCR positive	0	0	0	0
Interval between last exposure to index case and date of first NP sample from contact, d, mean (range)	11 (7–15)	5 (4–7)	5.5 (2–16)	9.5 (9–16)
Close contact under quarantine				
Yes	5 (62.5)	9 (26.5)	8 (100)	69 (100)
No	3 (37.5)	25 (73.5)	0	0
Contact				
Same class	5 (62.5)	9 (26.4)	Unknown	Unknown
Same year	1 (12.5)	7 (20.6)	Unknown	Unknown
Same school	2 (25.0)	18 (52.9)	8 (100)	69 (100)
No. of NP specimens taken				
1	3 (37.5)	23 (67.6)	8 (100)	69 (100)
≥2	5 (62.5)	11 (32.4)	0	0
Symptoms				
Fever	2 (25.0)	5 (14.7)	3 (37.5)	NA
Cough	7 (87.5)	32 (94.1)	5 (62.5)	NA
Sore throat	1 (12.5)	1 (2.9)	1 (12.5)	NA
Rhinorrhea	3 (37.5)	14 (41.2)	6 (75.0)	NA
Shortness of breath	1 (12.5)	0	0	NA
Diarrhea	1 (12.5)	0	0	NA
Chest radiograph findings				
Normal	1 (12.5)	0 (0)	NA	NA
Abnormal	0 (0)	4 (11.8)	NA	NA
Not done	8 (87.5)	30 (88.2)	8 (100)	NA

Data are presented as no. (%) unless otherwise indicated.

Abbreviations: NA, not applicable; NP, nasopharyngeal; PCR, polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome 2.

DISCUSSION

Comprehensive surveillance and screening of symptomatic student contacts following exposure to an index COVID-19 student case up to the first day of symptom onset in a secondary school and a preschool setting found no evidence of disease transmission. In addition, screening of both symptomatic and asymptomatic children who were exposed to a major COVID-19 cluster of adult staff members in a separate preschool setting also did not detect any SARS-CoV-2 infection.

Prior studies showed that the viral load of SARS-CoV-2 infection peaked soon after symptom onset and that it was possible for transmission to occur independent of symptoms [1, 6]. Environmental viral contamination from a generally well pediatric COVID-19 case had also been demonstrated [7]. However, during our investigations, evidence of COVID-19 disease was undetectable among symptomatic contacts in both secondary and preschool settings. In the third transmission study (preschool 2), the attack rates among staff members in the preschool and their households were unsurprisingly high in view of the high R_0 and attack rates reported in the community [8, 9]. Despite screening both symptomatic and asymptomatic children in preschool 2, SARS-CoV-2 infection was also undetectable. Taken together, these findings suggest that the risk of SARS-CoV-2 transmission among children in schools, especially preschools, is likely to be low. The only other published school transmission risk study involved a symptomatic 9-year-old child with COVID-19 who attended 3 different schools [10]. Subsequent follow-up and testing of symptomatic children from the preschools also did not detect virus transmission. The reason for this low attack rate among children is unclear. A recent study using single-nucleus multiomic profiling of alveolar epithelial cells found that lung samples from young children expressed fewer genes (*ACE2* and *TMPRSS2*) known to be utilized by SARS-CoV-2 for cell entry [11]. Therefore, children may be more resistant to SARS-CoV-2 infection at a cellular level.

Our data from SARS-CoV-2 screen testing performed at educational settings show that ensuring children with acute respiratory symptoms stay away from school, immediately from the first day of symptom onset, could be effective in preventing transmission of SARS-CoV-2. Blanket school closures may not be necessary to mitigate the risk of COVID-19 outbreaks in educational settings. School closures are associated with community-wide socioeconomic impact beyond the educational needs of children (eg, parents need to take leave from work to care for their house-bound children) [12]. They could even propagate the transmission of SARS-CoV-2, as unsupervised children can increase social activities in the community instead of practicing social distancing. These findings could help inform exit strategies for current lockdowns. Allowing schools to reopen while maintaining other social distancing measures would have major advantages in terms of supporting essential workers, especially healthcare workers with children.

In the study, the mean interval between last exposure and NP swab sample date of contacts ranged from 5 to 11 days. However, it was unlikely that timing of sample collection would have missed infected cases, since available viral load studies have shown both early viral load peaks and long duration of polymerase chain reaction (PCR) detection, especially in children [1, 6]. No serology was performed to assess the true burden of infection. High levels of herd immunity from asymptomatic transmission in children could have affected the findings, but this was unlikely in view of the very low number of pediatric cases detected in Singapore following a coordinated major containment effort in place since January 2020. Approximately 40% of symptomatic contacts were additionally tested via multiplex PCR and, of these, about half were positive for other viral respiratory pathogens (rhinovirus, adenovirus, and metapneumovirus).

In conclusion, our data suggest that children are not the primary drivers of SARS-CoV-2 transmission in schools, especially preschools. We found that SARS-CoV-2 transmission among children in schools appears to be significantly lower than that observed for other respiratory viruses, such as influenza. This could help inform strategies for lifting of current lockdowns. Based on these findings, more targeted control measures for preschool settings such as keeping symptomatic children away from schools, instead of blanket closures, could be considered.

Notes

Author contributions. C. F. Y. designed the study. C. F. Y., K.-q. K., K. C. T., and K. C. N. collected and analyzed the data. C. F. Y. drafted the first draft. All authors provided input to the final manuscript.

Acknowledgments. The authors thank the staff of KK Women's and Children's Hospital for their unwavering dedication in ensuring that patients continue to be cared for under the challenging conditions of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic.

Potential conflicts of interest. The authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest.

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