COVID-19 Scientific Advisory Group Rapid Evidence Report

Topic: What role might children play in community SARS-CoV-2 transmission? What measures might mitigate potential additional risk of transmission of COVID-19 related to school and daycare reopening?

1. Are children more likely to have asymptomatic or mild COVID-19 infection compared with adults with COVID-19?

2. What are the transmission characteristics of COVID-19 in children?

a) **Are children as likely to transmit the infection as adults (addressing symptomatic or asymptomatic COVID-19)?**

b) **Are children more likely to become infected with COVID-19 at school or daycare, in the community, or within households? What is the risk to teachers and staff in the context of transmission at daycare and school?**

3. Are there differences in the patterns of detection of viral RNA, viable virus, and SARS-CoV-2 antibodies between adults and children throughout infection?

(a) **Is there a difference in SARS-CoV-2 RT-PCR or RNA load values and carriage of viable virus (assessed by viral culture or subgenomic mRNA) between children and adults?**

(b) **What is the current understanding of COVID-19 serologic responses in children and adults?**

4. Are public health interventions (e.g., masks, distancing, hand hygiene) appropriate and effective for these age groups?

5. What are potential harms of school closures during pandemics for children?

6. What are suggested strategies and considerations for safe school opening?

Context

- In order to form an informed plan for Alberta children returning to school, it is critical to understand the risks associated with COVID-19 infection and transmission in schools and daycare settings for children and staff, and the broader community.
- As well as potential risks due to COVID-19 exposure associated with school and daycare reopening, there are also potential risks associated with school closures during the COVID-19 pandemic.
- A variety of organizations, including the Canadian Pediatric Society and American Academy of Pediatrics, have urged that a safe return to school should be the starting goal, for the physical and mental health and wellbeing of students and families, due to concerns of harms such as:
  - Loss of education and socialization, mental health challenges secondary to isolation, food insecurity from missing school meals, and the potential for exposure to increased abuse with decreased avenues for reporting, among others
  - There are also significant societal and economic reasons to reopen schools and daycares, allowing parents to return to work. There is a real possibility of financial hardship affecting the health of families in the absence of predictable school reopening or provision of appropriate affordable childcare.
  - Low income families may be disproportionately compromised by remote schooling due to challenges of computer and internet resources, adequate space, and worsened food insecurity with the loss of school- based food programs.

Context (continued)

- Alberta Education has developed plans for September school reentry which encompass a range of possibilities: near-normal operations with in-school classes, partial in-school attendance with additional health measures, and continued at-home learning with cancellation of in-school classes[1]; at the time of publication of document, Scenario 1 (in school classes) is the operational plan in Alberta.
- Other groups such as the Hospital for Sick Children, Toronto, and Pediatric specialty associations have also provided guidance documents[2].
- This report is meant to collate current evidence around key public health questions that can inform the evolution of policy. Data examining evidence for differential infection rates by age, transmission patterns, and viral kinetics between adults and children are summarized, as are some models of school closure and community transmission dynamics. An initial review of potential harms of not opening schools, which is mostly based on expert consensus, is also presented. A literature review and analysis of data (derived from both literature and reputable media reports), focusing on countries with similar epidemiology and school system structures, was used to inform the recommendations.
- Evaluation of risk related to school-based transmission is complex because of varying epidemic and school lockdown patterns globally during the first 6 months of the pandemic. To mitigate this issue, pediatric and adult infection and transmission characteristics were compared across geographies. Limited epidemiologic data in the published literature was supplemented with information from government surveillance data and media reports.
- Further guidance from the World Health Organization and UNICEF is expected and this review will require updates with evolving information.
- This is a living review which will be updated to reflect best available science.

References used for Context[1,2]

Key Messages

- The degree of community transmission of COVID-19 appears to be a key determinant of risk in schools and daycares. In settings of low community transmission (for example in British Columbia), daycares have opened with no documented cases to date. In settings of high community transmission, multiple within-facility transmission cases are reported in schools and daycares (various US jurisdictions), reinforcing the importance of the community epidemic context in interpretation of school and daycare transmission reports, and also of overall population based transmission reduction methods to permit safe school opening
- Review of Alberta childhood SARS-CoV-2 epidemiology shows higher testing rates in children than in many jurisdictions, with very low rates of documented infection and hospitalization. There are no documented COVID-19 infections attributed to acquisition in school or daycare settings in Alberta: school closures occurred March 16, 2020, at which point there was 1 case in an <10 year old and 17 in 10-20 year olds, and transmission was largely travel related. As of July 27, 1,474 children (0 - 19 years) from Alberta have been documented to have confirmed or probable COVID-19, with no deaths, two intensive care admissions and 10 hospitalizations (0.8% hospitalization rate) reported. In kids under 10 specifically there are 561 cases with a 0.5% hospitalization rate, with no ICU admissions. By comparison, adults age 20-60 comprise 7228 cases, with a 3% hospitalization rate, 40 ICU admissions and 5 deaths.
- In Alberta, media reports indicate that 3 students attending a Catholic high school in person summer class in Calgary tested positive for COVID resulting in an outbreak investigation, although an outbreak was not declared.
- From population and cohort study analysis, there is a consistent finding that children appear more likely to have asymptomatic or mild disease. However, published data is limited in comparability by differing population testing strategies, disease definitions and public health interventions.

- Child to adult transmission appears to occur at a lower rate than adult to child or child to child transmission, based on epidemiologic observations from multiple countries.. This finding appears more robust in children <10 years old.
- Some studies show lower SARS-CoV-2 viral loads in children as compared to adults but others showed insignificant differences or, in one study, higher levels inferred by cycle threshold data. Therefore data are insufficient to support a conclusion on relative viral load in children. Children may have fewer cells with viral receptors in their upper airways, may have different droplet and cough dynamics and also may have some possible cross-protective immunity from endemic coronaviruses that commonly affect children.
- Fecal shedding of SARS-CoV-2 identified by RT-PCR may be prolonged in children. Viable virus has been isolated from stool and its survival in water has been demonstrated up to 25 days, so there is theoretic potential for transmission from feces although this has not been reported and the infectious dose is unknown.
- In current epidemiologic reports children are more likely to be exposed to and infected by SARS-CoV-2 at home, followed by travel. Transmission rates in schools and daycares are variable and overall, school outbreaks are described most commonly in areas with higher community transmission. Importantly, similar childhood infection rates have been found in otherwise similar countries with and without school closure. Older students (teens) may exhibit a higher likelihood of transmission than younger students.
- The risk of transmission to adults in school settings has been assessed with population based occupation relative risk data from Sweden, which did not close schools, finding that teachers risk of infection was similar to the overall population (RR 0.7 to 1.1) whereas taxi drivers had a 4.8 fold risk increase. However, middle and high school outbreaks have been documented with transmission to children and staff greater than the reported community rates, for example in a school in France prior to school closure and in a middle school in Israel, on reopening, both with specific context considerations[3] (consistent with superspreader events). Although concerning, reported large school based outbreaks are few in relation to the number of schools opening across countries.
- There is limited evidence to evaluate public health interventions (distancing, face coverings, hand hygiene) in children, and the feasibility and appropriateness of these measures varies considerably by age and developmental status with specific concerns about adherence challenges for masking in younger children.
- The effect of school closures on community transmission is mainly evaluated in modelling studies layered with multiple transmission reduction strategies, and these studies are constrained by input data quality/assumptions. The results of modelling studies to not allow conclusions to be drawn about the impact of school closures or opening on community transmission in settings similar to Alberta.
- There are considerable negative psychosocial impacts for children and their families resulting from prolonged school closures raised by various expert bodies.
- A summary of school opening strategies which were common across multiple sources is compiled and annotated with the Scientific Advisory Group current consensus below.

Committee Discussion

The committee supported the provision of pragmatic summary of considerations for safe school opening as a natural offshoot of the scientific evidence review. At initial discussion, the committee suggested increasing the focus on the different considerations for prevention measures across student age ranges/developmental considerations. One member highlighted WHO and UNICEF guidance is expected and the committee agreed that the document will require iterative review with release of new information, but also reflected that urgent planning needs suggest not delaying delivering this report to key stakeholders. Discussion of the use of masks highlighted differences of opinion predicated on the lack of data directly describing COVID-19 transmission reduction with cloth mask use in community settings, and a lack of data around the potential negative developmental, social and learning effects of non-medical masks in school settings, with specific concerns regarding adherence challenges and potential negative effects in younger children. There is therefore no stated recommendation for mask use in children and youth but acknowledgement of potential use of masks where feasible and appropriate, and in the context of outcome evaluation processes. It was noted that in general, the strength of evidence which can be generated around public health interventions can be limited compared to clinical treatment interventions. It was suggested that opportunities to inform local practice through a quality improvement approach to layered public health interventions should be explored.

Guiding Principle Recommendations

Recommendation 1: Cautious, monitored reopening of schools and daycares is feasible with support for risk reduction practices, in settings of low community COVID-19 transmission (as assessed by Public Health with consideration of case numbers, test positivity, hospitalization rates, Rt, and community transmission patterns). *Rationale: Children appear to have milder symptoms, low risk of severe illness, and epidemiologic data suggests a lower likelihood of transmitting COVID-19. Similarly, existing data from multiple jurisdictions suggests that schools are not likely to be the primary source of community outbreaks, and there are significant harms associated with extended school closure that may outweigh any benefits associated with the likely limited decrease in community spread. The potential harms related to school closure include social, emotional, and behavioral health, economic well-being of families, and academic achievement of children, with a disproportionate effect on low-income and minority children and those living with disabilities. Based on current data, COVID-19 non pharmaceutical interventions targeting contact patterns in the broader community should be prioritized over school closure as it is likely that such measures may offer reduction of community transmission of COVID-19 with fewer risks to children and families.*

Recommendation 2: Public health interventions should be supported with appropriate resources, and evaluated as part of safe school opening strategies. *Rationale: School transmission risk may be reduced through layered risk mitigation strategies. Broadly, these include symptom-based screening precautions for attendance, cohorting of classes, decreased group sizes where feasible, hand hygiene protocols, and enhanced cleaning for all age groups. In addition, age stratified application of measures such as physical distancing and potentially cloth masks where feasible and appropriate can be considered, and if implemented outcomes should be assessed. Secondary transmission should be minimized through mandatory and supported self-isolation with illness, and a robust and efficient testing, contact tracing and isolation system. Age and risk-based considerations should be applied for all students, staff and teachers in assessing personal protective equipment (PPE) needs. Further evidence that assesses the relative importance of droplet versus contact/fomites transmission in school settings, utility of cloth masks in this setting, and experience with school openings elsewhere will help in evolution of these measures.*

Practical Considerations

- Challenges to designing and implementing modified school programming include physical and financial resources that should be addressed with formal and transparent input from teachers, schoolboards, staff parents, and students. Workforce health is directly related to the wellbeing of children and families, and safe and stable school opening should be prioritized and resourced.

- Equitable support for schools should include ensuring availability of hand hygiene supplies, recommended PPE and environmental cleaning materials, and should consider methods to address structural deficiencies such as poor ventilation and crowded classrooms..

- Adults (teachers, care providers and support staff) are at higher risk of significant illness than the children they work with if they acquire COVID-19 during this pandemic; however, it is unclear that schools pose higher risks than other community settings. This is based on existing data suggesting that transmission risk from and between children is quite low compared with transmission from adults to others, and a population-based risk assessment by profession from Sweden. However, increasing age or other medical risks of individual adults in school settings should be considered when assessing in person versus virtual professional roles, and provision of personal protective equipment.

- A partial return to school (for example alternate day instruction) creates limitations on parents' ability to either be employed or participate meaningfully in their work. In addition, a hybrid model may create community transmission concerns related to the need for out of school care or supervision with exposures to caregivers, grandparents and other family, and mixing of children in different cohorts. For that reason, full-time supervision of cohorted children with part time direct instructional hours may be preferred to partial day instruction or partial week instruction. This is particularly important for younger children where effective virtual instruction is more challenging and the children are not as functionally independent as later junior high and high school students.

- Critical non-educational benefits associated with schools, such as meal programs, social interventions and community events, need to be incorporated into school opening plans and supported as possible.

- Many children and families have limited access to high-speed internet, computers and other resources needed to complete the home portion of the school curriculum, with the greatest impact on children who have the fewest opportunities. Planning and resources for appropriate support must be incorporated into virtual/distance learning options.

- Special needs students who are medically complex may face higher risks from SARS-CoV-2 with return as well as being most at risk of losing the supports they need due to modifications. Strategies to assist this group should be developed with trans-disciplinary involvement.

- Educational materials to assist teachers and parents in reinforcing hand and respiratory hygiene, and age appropriate physical distancing are required. Relevant factors include challenges with younger children due to their developmental stage, and the possibility of less adherence among older children, particularly those from homes that do not support school closure or public health interventions.

- Although the degree of anticipated risk reduction from cloth mask use is unclear (based on a paucity of data), to be consistent with other interim public health recommendations regarding cloth masking when unable to distance in group indoor settings, cloth masks may be supported in older children and teens (>10 years) who may be more likely to transmit COVID 19 than younger children, be better able to adhere to proper use, and have potentially fewer communication challenges from masking. Evolving evidence around the utility of mask use in community and school settings is expected and recommendations may change with further knowledge of potential benefits and harms.

- There is a lack of evidence to support development of best practices in classrooms, such that pragmatic cluster randomized trials or quality improvement projects with outcome evaluation should be considered in schools in partnership with school boards and teachers associations, with adherence to ethical principles. Measures with equipoise that could be assessed include but are not limited to: continuous masking for teachers, cloth versus medical masks for teachers (plus/minus face shields), varied cohort sizes for students, varied mask policies and acceptability and adherence to mask policies in children, and 1 versus 2 m physical distancing parameters.

Resource: Summary of recommended strategies to reduce COVID-19 risk in schools and daycares (derived from American Academy of Pediatrics, SickKids Hospital July 29, 2020 and US Centers for Disease Control reports)

Strategy	**Scientific Advisory Group Synthesis**
Screening and Sick Plans	- Clear school symptom screening policies and protocols for staff and students - At home symptom checks (consider integration of health screening with online attendance records) prior to school (entrance screening may be appropriate in some settings) - Strict sick exclusion policies for staff and students, with sick leave benefits for staff, clear sick leave policies, and back up rosters for teachers and staff - Sick plans for staff and students who develop symptoms on site (isolation areas/procedures, testing, return to school guidance) - Create communication systems for staff/students for self-reporting and exposure notification while testing results are pending - Develop protocols for preemptive isolation of cohorts or classes upon direction of public health for presumed COVID-19 contacts - Develop priority access to testing, and consider strategic asymptomatic testing of teachers/staff, and potentially older student as part of a public health-based school strategy and surveillance
Hygiene and Environmental Maintenance	- Handwashing is critical and hand hygiene supplies and resources to reinforce hand hygiene behaviours to staff and students should be available - Use soap and water when able, and hand sanitizer otherwise, with development of a sustainable supply chain for handwashing supplies - Structured handwashing opportunities (ie before and after eating, bathroom, entering school and classrooms, before and after outdoor time, and scheduled within room) at least 5 times daily - Strict no sharing policies for school supplies and food - Assess school setting for high touch surfaces and consider feasible interventions such as leaving doors open when feasible and installing motion sensor bathroom faucets and soap and towel dispensers. High touch surfaces should be cleaned regularly (once daily or more, although guidance may evolve with more data.) - Building maintenance should review HVAC systems, consulting if necessary, and optimize ventilation to reduce transmission risk as possible (refer to Scientific Advisory Group HVAC document). Individual classroom air conditioning units require specific review as maximizing the fraction of outside air and considering the pattern of air flow are potentially important considerations in reducing in middle and high school classroom transmission, based on evaluation of outbreak reports.
Physical Distancing and Cohorting	- The purpose of cohorting is to limit mixing of student and staff, so if a potential case is identified, their number of contacts (> 15 minutes face to face exposure) is confined to their cohort, which minimizes the risk of a transmissible infection and aids in rapid contact tracing. Cohorting of classes regardless of class size includes with limitation of mixing in

	common spaces is advised (in gyms, lunch breaks, halls). A homeroom system, or a study hall system where student may be working on different subjects with supervision in the same space are possible considerations. A planned assessment of different cohort sizes for the purposes of reducing risk of infection and need to quarantine is suggested – in some setting classes may be able to be subdivided into alternate spaces to reduce cohort size and allow optimal distancing. The benefit of cohorting may be affected by family exposures, busing/transport, and after school care mixing, as some children may be in several cohorts. Minimizing the number of cohorts each child is involved in and documenting cohorts is advised as possible. - Where possible, arrange classes to allow appropriate physical distancing (1-2m). – However, cohorting may preferred as more socially/developmentally acceptable in younger students than physical distancing. One metre distancing may approach the benefits of 2 m distancing in the setting of asymptomatic individuals. Distancing is more important in settings of prolonged exposure (e.g. the classroom) and is not an all-or-nothing proposition, as such optimizing distancing in as many indoor settings as is possible is likely valuable - Increasing access to alternate spaces (including outdoor spaces when possible) for either instructional time or alternating direct instructional and non-instructional time with non-teacher staff for supervision if required, or alternating in person instruction with virtual instruction for older students may support more consistent physical distancing. -Maintain extracurricular activities when public health interventions can be maintained, with the exception of singing, band with wind instruments, and team based higher contact sports pending further data as these activities may confer higher transmission risk - Outdoor play and learning is valuable and transmission of the virus is likely reduced in outdoor settings. Outdoor sports, particularly individual sports where distancing can be maintained, such as track and field, may be preferred forms of physical activity. Refer to Guidance for Sport, Physical Activity and Recreation - Assemblies, in-person inter-school and inter class sports or academic competitions should be avoided pending further data. Within cohort sporting activities can be considered. - School transportation requires consideration: where possible, parent drop-off and cohort based car-pooling should be supported. School and public bus policies around physical distancing (consideration of one child/family per seat), support for hand hygiene, masks if recommended by public health, and open windows if possible are advised. Bus transport, carpool/ridesharing should be considered when designing cohorts if possible. - Restrict non-essential visitors to schools, and limiting visit time, with pre-entry symptom screening, and required public health interventions in place. - Develop individual plans for students with health concerns to minimize risk and allow inclusion if feasible with particular attention to those with respiratory support needs (i.e. consider medical grade masks). Families that choose not to send their child/youth to school require remote learning opportunities and support.
Eating	- Cohort students in classrooms or outside if possible, or limit group mixing in cafeteria spaces by appropriate scheduling, - Physical distance in communal spaces for eating - If lunch provided, individually plate in kitchen

	- Maintain resources for lunch program delivery to students if schools close - Provide easy access to hand hygiene
Masks (Face coverings)	- Masks may be appropriate for children and youth based on age, communication considerations, and ability to adhere to mask hygiene recommendations. See Scientific Advisory Group Mask Use in Community Rapid Review. Although the degree of anticipated risk reduction from cloth mask use is unclear (based on a paucity of data), to be consistent with other interim public health recommendations regarding cloth masking when unable to distance in group indoor settings, based on current data, cloth masks may be supported in older children and teens (>10 years / grade 4) who may be more likely to transmit COVID 19 than younger children, be better able to adhere to proper use, and have potentially fewer communication challenges due masking. Evolving evidence around the utility of mask use in community and school settings is expected and would guide further recommendations. - In low transmission settings the masking considerations below would be optional to implement based on the current public health direction, and individuals who choose to wear masks, or not to wear masks when no mandate is in place should not be stigmatized[2]. - Where masks are recommended, teach and reinforce appropriate practices for staff and students including hand hygiene with doffing, and reinforce that the potential utility of masking is maximized with consistent use by the majority. - There may be contraindication for developmental, medical or mental health reasons: - School-aged children and youth who are not able to remove their mask without assistance should not wear a cloth mask due to safety concerns. - Children or youth who cannot tolerate a mask due to cognitive, sensory or mental health issues should also be exempt. - It should be noted and explained when and why different rules may exist in school settings and other public spaces (i.e schools have additional protection through screening, hand hygiene, cohorting). - All day mask wearing is difficult so safe removal for part of the day with enhanced distancing may be important. ***Considerations by age range:*** Based on current evidence, - In elementary school: in younger grades (under age 10/Grade 4), where transmission and illness from COVID-19 are lower, cohorting and hand hygiene may be favoured over strict distancing or masking for developmental reasons. - In middle school, cloth masks may be considered for all staff and students when physical distance cannot be maintained - In high schools, cloth masks may be encouraged for all staff and students when physical distance cannot be maintained

	- Schools should consider participation in selected outcomes evaluation of policies that may include cloth mask or no cloth mask use, with cohorting, distancing, hand hygiene) combinations as available and appropriate based on current recommendations - There is insufficient data to recommend use of cloth masks vs clear face shields as there are no trials of either in community or school settings. Outcome evaluations should be developed to assess the use of face shields if they are considered in specific school settings. - Consider school supplied masks, particularly for students in lower socioeconomic areas if masks are part of the school opening strategy. - Students with health conditions that place them at higher risk of severe disease who are part of a cohort that is recommended for mask use should use medical masks, and teachers with higher risk conditions should be supplied with medical masks, and consider the use of eye protection for personal risk reduction as well, consistent with World Health Organization Technical Guidance[4].
Health considerations, including children with complex needs	- If students with complex medical needs require aerosol generating procedures in school settings (eg. nebulizer therapy, suctioning of tracheostomy) additional precautions or alternative settings will need to be considered. - Ensure mental health programs are available for staff and students - Continue and optimize school immunization programs - Educate families and students about SARS CoV-2 and prevention practices - Minimize the number of transitions for supply teachers, and consider a 2 week interval between assignments - Most children with underlying medical conditions are safe to return to school after discussion with their health care providers. Health care providers will provide direction for those with immune suppression or complex needs. - Individual planning and consideration is required for children with medical, physical, developmental and behavioural complexities
School Closures	- School closures will be at the discretion of public health upon identification and epidemiologic evaluation of school based COVID-19 outbreaks. - Regional school closure may need to be considered in situations of elevated community transmission and large cluster events identified to be related to a school. - Consider a lower threshold for high schools to close than primary schools due to the larger geographical areas covered by high schools, potential for increased transmission in adolescents and increased ability for virtual teaching. Advice regarding out of school social interactions should be provided including consideration for social cohorting, outdoor activities, and preference for more virtual interactions in the event of school closures.

Strength of Evidence

With the rapid appearance and evolution of the COVID-19 pandemic, there has been an unprecedented volume and rate of data sharing, sometimes with limited peer review and quality assessment. The data in this topic area are largely derived from case reports, case series, truncated cohort analyses and expert opinion based on limited information. Publications and reports accrue daily. Even in the peer-reviewed literature, data and evidence are sparse; with many publications also being shared pre-review. The overall quality of the evidence is limited and there are many gaps, some of which are critical for informed decision-making.

To encompass useful information that has not yet been synthesized, this review made use of media articles, government websites and other sources of grey literature. Legitimate press publications have reporting standards, and appropriate media venues have been preferred however the limitations of these data must be understood.

Other limitations are related to the temporal constraints of emergence of a new disease over the past 6 months, for example there is limited data on long-term immunity. With respect to mitigating strategies, different strategies adopted by various countries has provided some information for limited predictive modeling, but considerable uncertainty remains regarding both the trajectory of the disease in different communities and the relative utility of various aspects of public health intervention, with data comparability limited by variation in amount of testing being performed. While other outbreaks and pandemics, including influenza, SARS and MERS can be used to inform modeling to some extent, they may not be predictive of the transmission kinetics of SARS-CoV-2.

In summary, quality limitations introduced by rapid information sharing, daily changes and updates with a fast-evolving pandemic and urgency in developing guidance introduce uncertainty in the data summary and interpretation.

Limitations of this review

- This review has several process limitations. The initial literature search became outdated quickly due to the rapidity of new publications, and new references were added during writing by iterative less formal searches.
- The rapid turnaround time may have affected the depth of literature analysis. Language limitations were mitigated by the reasonable utility of online translators
- There are general limitations to the COVID literature with numerous low-quality publications, and repetitions of case data as case reports evolve into cases series and cohort studies. Higher-quality studies with more detailed and higher quality evaluations are relatively rare and limited in scope.
- SARS-CoV-2 is a new disease, related to but unlike other severe coronaviruses, which appears to have some different characteristics than pandemic influenza so extrapolation from studies of pandemic influenza and other coronaviruses must be judicious.
- Data collection across jurisdictions is impacted by limitations on available health care and resources-as an example, many patients with suspected COVID-19 may not be tested due to lack of available testing materials and equipment, so data may not be comparable.
- The type of evidence available for some of the review questions is rapidly evolving and mainly presented in the form of small, opportunistic case reports and series, short-term cohort studies and population-level data analysis using limited data collected on partial samples in some impacted areas. Data are affected by variations in population demographics and therapies, rapidly evolving testing protocols and methodologies and limited capacity to do research on overwhelming epidemics.
- Many of the publications used in this review are pre-review or from non-peer-reviewed grey literature and media resources, and even peer-reviewed papers are pre-publications.

Summary of Evidence

1. Are children more likely to have asymptomatic or mild COVID-19 infection compared with adults with COVID-19?

Children are well described to constitute a low proportion of overall documented COVID-19 infections across many jurisdictions. The Government of Canada reports 7.1% of all documented positive cases to be in children 19 and under, compared to this age group forming 22.4% of the Canadian population[5](accessed 29 June 2020). In Alberta, the proportion of cases in children appears higher with 14.6% of all positive cases in children and youth 19 and under, with 25% of the total population in this age range[5] (accessed 27 July 2020), which may reflect different testing algorithms and higher test availability in Alberta, compared to jurisdictions where testing has focused on those with symptoms. Of the 1474 laboratory-confirmed pediatric cases in Alberta as of July 27, 2020, 12 have required hospitalization, most of whom were in the 10-19 age group (which also included the 2 ICU admissions.) Because schools closed March 16, 2020, at which point there were 18 cases in 0-19 year old, 17 of which were over 10, these numbers reflect community transmission and there have been no documented school COVID-19 transmission between children. In April, an in-depth review of available government website epidemiologic data from all countries reporting more than 1000 cases, demonstrated the pediatric COVID-19 incidence to be 1.9% of total COVID-19 cases worldwide[6]. This echoed early Chinese and Italian reports, with 2.1% and 1.2% pediatric incidence of total COVID infections respectively[7,8]. ***The proportion of pediatric cases detected in the total population is relatively low, but appears to be increasing over time[5,6,9–11], which may be related to broadened testing protocols as initially testing was focused on symptomatic people and hospital destined cases in many countries.***

Population studies show variation in prevalence of asymptomatic or mild cases in children, with literature in this area significantly challenged by inconsistent definitions and symptom history documentation (this is described in the Scientific Advisory Group report on asymptomatic transmission). Data from the Centers for Disease Control and Prevention in the United States reported that children comprised 1.7% of 149 760 positive COVID-19 cases occurring between February and April 2020 of which 27% of children had no reported symptoms, compared to 7% of adults[10]. However, a limitation of this study was uncertainty of completeness of data. Early data from China's Center for Disease Control reported 54.4% of 2135 confirmed or suspected COVID-19 children to be have asymptomatic or mild infection[12]. This is compared to Chinese nationwide data at the same time point, indicating 80.9% of the total population was "mild". However, different severity definitions were used for adults and children, making comparisons between groups difficult[7].

Cohort study results comparing asymptomatic and/or mild disease in children and adults appear to be more consistent. In a pediatric study from Zhejiang, China reporting data up to March 1, 2020, < 16 year olds were 5% of the documented cases, with 28% asymptomatic and 19% mild, compared to less than 5% of adults documented as asymptomatic[13]. Another study comparing asymptomatic disease in pediatric versus adult patients includes a household transmission study in Israel, which showed no symptoms in 28% of children compared to 12% of adults with COVID-19 PCR positive results[14]. Case series from China showed asymptomatic children to account for 15.8% to 48% of all COVID-19 positive patients[15–18]. These data may not be comparable because of the aforementioned definition and history documentation issues, including moderate classification for those with radiographic changes without clinical symptoms[12], which is discrepant from the WHO Classification of Disease Severity[19]. This may lead to the underreporting of clinically asymptomatic patients.

Other studies from China showed asymptomatic children to account for 15.8% to 48% of all COVID-19 positive patients[15–18]. These data may not be comparable because of the aforementioned definition and history documentation issues, including moderate classification for those with radiographic changes without clinical symptoms[12], which is discrepant from the WHO Classification of Disease Severity[19]. This may lead to the underreporting of clinically asymptomatic patients.

Population based serosurveys may help clarify the actual proportion of children infected compared to adults. A Spanish serosurvey of 61,075 people, contacted through representative household sampling used a point of care antibody test (sensitivity 82% specificity 100%) with a proportion confirmed by additional testing. There was considerable geographic variation with higher prevalence around Madrid (>10%) but overall seroprevalence was 5.0%. In 0-19 year olds, seroprevalence was 3.4% (1.1% in <1y (n=240), 2.1% age 1-4 (n=1681) and 3.1% age 5-9 (n=2846). Seroprevalence increased with age, peaking at 6.6% in age 70-74 using the POCT.
Overall seroprevalence in those who indicated they had no symptoms was 2.5%, compared to 18% in those who had compatible symptoms >14 days before testing (no pediatric asymptomatic data was presented). Similarly, a Swedish seroprevalence study has reported initial results[20], with the highest seroprevalence in Stockholm at 7.3%, and a seroprevalence of 4.7% in 0-19 year olds. ***Thus, emerging seroprevalence data suggests that children are underrepresented in PCR testing prevalence reporting, likely due to lower severity of illness, and in both of these studies, children overall are approximately 30% less likely to be seropositive than adults.***

A report from July 7, 2020 comparing COVID-19 in schoolchildren in Finland and Sweden suggested that the incidence of lab confirmed COVID in children age 1-19 did not differ between the two countries, although Finland implemented school closures and Sweden did not[21]. In Finland children 1-5 years had an incidence of 36/100,000 (.04%) and 6-15 years 42/100,000 (.04%) while older teens had infection rates of 98/100,000 (0.1%) and all ages 129/100,000 (0.13%)[21]. Neighboring Sweden, which did not lock down and had a higher population case rate of 508/100,000 (0.5%) also had low rates of documented infection in children (16/100,000 (0.02%) and 30/100,000 (0.03%) respectively for 1-5 and 6-15 year olds, with a higher rate of 150/100,000 (0.15%) in 16-19 year olds [21]. It should be noted that Sweden focused testing on symptomatic and hospitalized individuals so case counts are likely underrepresented. The period of school closure appeared to show slightly higher infection rates in Finland, raising the question of household transmission. Overall, however, in both countries the number of cases in primary school children was less than half of their percentage of the population. Admissions to ICU in this age group was rare in both countries at 1.25% in Sweden and 0.17% in Finland. It was noted that outbreak investigations in Finland have not suggested that children contribute significantly to transmission[21]

Hospitalization and mortality data also suggest that children have less severe disease than adults in acute SARS CoV-2 infection. State level pediatric data in the US (to June 18, 2020) showed children accounting for 0.6-3 % of all hospitalizations and 0.05% (n=53) of all US mortality from COVID-19[11]. Early Chinese data also supported a low mortality rate in children, at 0.1% of COVID-19 positive children, vs 2.3% of positive adults[7]. However, variability in assessing severity status in COVID-19 positive children is also confounded by the clinical testing protocol in place at the time of study. For example, a report from Madrid up to March 16, 2020, indicates that 60.9% of all COVID- positive children were hospitalized, with 10% requiring ICU admission[22]. However, this was during a time when testing protocols were assessing only patients at high risk of requiring admission, so these data do not have an appropriate denominator.

Significant complications of SARS CoV-2 infection have emerged in children, associated with a multisystem inflammatory syndrome (MIS-C)[23]. The hyperinflammatory syndrome is likely due to post infectious cytokine storm, and not all patients remain PCR positive at identification, leaving serology important for diagnosis. The US Center for Disease Control has reported 186 cases of MIS-C up to 20 May 2020 in a network of 53 hospitals. Median age has been 8.9 years and 62% were male. MIS-C has been associated with severe cardiac involvement, with 80% of the US cohort requiring ICU care, 20% requiring ventilation, 4% requiring ECMO, with 2% mortality[24]. 70% of children had four organ system involvement, with gastrointestinal, cardiovascular, hematologic, mucocutaneous and respiratory most involved. A population-based report from New York State described 99 confirmed or suspected MIS-C as of May 10. To estimate the incidence of this complication a population denominator of infected children would be required. As a rough estimate, as of May 10 there were 335,395 cases documented in New York State (public health data). Most “hotspot” seroprevalence studies yield overall estimates of approximately 5% of the population, and 3.5-5% of children infected. Using this more conservative estimate of 5% of children being infected, with a population data based estimate of 4.3 million children under age 18 in New York State, the estimated risk of this complication would be 99/216246 (0.05%) of infected children. Higher quality population-based data is needed to clarify the risk of this rare complication although existing information suggests that it is very rare.

Differences in incidence and severity with age and underlying illness also appear to be present, with infants and medically complex children at higher risk of severe disease or hospitalization. For example, Chinese infants were reported as having an increased proportion of severe and critical disease (10.7% of infants) compared to older children[25]. In addition, pre-existing medical conditions also appear to be a risk factor for severe disease in children. A report of PICU admissions in North America demonstrated 83% of patients had comorbidities[26]. A database study of patients with intellectual disability demonstrated an increased case fatality rate in those under 17 years old with disability of 1.6%, versus 0.1% in those without intellectual disability. Medical comorbidities were also higher in the former group[27]. However, screening of pediatric oncology patients in New York at risk of exposure demonstrated 20 of 178 patients positive, with only one patient requiring admission for COVID symptoms[28]. Further evaluation is required; however, these reports suggest that the overall severe infection rate is still low. ***In summary, multiple cohort studies show that children more frequently have asymptomatic and mild disease compared to adults with SARS CoV-2, and this is supported by mortality and hospitalization data. However, significant variability exists in the current data, as there have been rapid changes in disease definitions and testing protocols. Further population-based studies are needed to ascertain the range of disease severity and risk factors for severe COVID19 in children.***

2. What are the transmission characteristics of COVID-19 in children?

2a. Are children with symptomatic or asymptomatic COVID-19 as likely to transmit the infection as adults?

Symptomatic transmission

Most reported cases of COVID-19 transmission are from symptomatic individuals to close contacts, mainly describing adult index cases spreading the virus within household clusters[29–34], although asymptomatic testing and monitoring after exposure may vary between reports. One Irish cohort reported 3 symptomatic adults and 2 symptomatic children plus one asymptomatic child (age 10-15) who attended multiple venues with no symptoms reported by 1,155 contacts after 14 days (telephone follow-up). Two of the adult cases were linked by a recreational activity; the other adult travelled with the 3 children and was part of a household cluster[29]. In contrast, a centralized quarantine hospital in Guangzhou followed 4,950 close contacts of admitted patients. Children 0-17 years represented 15.8% of contacts, with incidence of infection 1.8%, which is lower than the observed overall infection rate in contacts of 2.6, and 4.2% in 60+ year old contacts. Increasing symptom severity increased transmission to contacts (asymptomatic 0.33%, mild 3.3%, moderate 5.6%, severe 6.2%). The likelihood of transmission was assessed by index patient symptoms, and expectoration as a symptom increased transmission to contacts to 13.6% (OR 5.09, $p<0.0001$) and fever non-significantly to 10.2% (OR 2.12, $p=.069$)[35]. A recent systematic review[36] demonstrated that symptomatic individuals were 2.55x more likely to infect contacts than asymptomatic and presymptomatic cases[36]. ***Overall, transmission is most frequently reported from symptomatic adults to other adults and children***.

Asymptomatic transmission

Many studies do not clearly differentiate between asymptomatic and presymptomatic cases, fail to exclude postsymptomatic positivity, and lack of symptoms in some clusters muddies the direction of transmission. Please see the Asymptomatic Transmission Rapid Review for additional discussion. Presymptomatic individuals are sometimes presumed to be the index case without supporting evidence [29,37–39]. In one cluster, an asymptomatic adult woman exposed via Wuhan was assumed to have transmitted COVID-19 to her children (8 year old F, 9 year old M), who developed symptoms and tested positive (RT-PCR) days before she had symptoms. She persistently tested negative until the convalescent stage[40]. Given the timeline, it cannot be assumed that the mother was the index case despite her travel history. In a different example, a 3-week-old infant in New York with no known exposures and unaffected (test negative) parents became symptomatic after grandparents visited; the grandparents developed symptoms 2 days after the baby[37]. In studies with meticulous isolation and testing of contacts for 14 days after a positive (RT-PCR) result, the proportion who remain asymptomatic is 15-20%, although symptomatic, presymptomatic and asymptomatic index cases[14,35,41–45] are reported with insufficient granularity for differentiation. A systematic review[36] found that about 41.8% of children were asymptomatic at the time of diagnosis, but only 8.4% remained asymptomatic throughout the infection.Due to the limited available data and lack of certainty around direction of transmission and presymptomatic vs asymptomatic status, ***it is not feasible to conclude any differences between pediatric and adult asymptomatic transmission***.

Differences of transmission between children and adults

Aggregated results from studies identifying index cases[29–35,37–40,42,44–49] show that of 120 children (<19 years old) with positive RT-PCR for COVID-19, 14 were identified as an index case (11.7%), in contrast to the 52.6% (257 of 489) COVID-19 positive adults described as a case cluster index. In these studies with identified cases with a clear direction of transmission, 91% of transmission was from adults, with one child to adult transmission, 8 transmissions between children, 63 adult to child transmissions and 24 transmissions between adults. This data accounts for only 96 of the 609 positive cases (15.8%) and represents trajectories within household studies, which may not be applicable to community or school settings.

Media reports provided an opportunity to capture more current data. Limited information prior to lockdown in Canada includes one Calgary child who attended daycare while symptomatic with no reported transmission to peers or staff[50]. In Canadian daycares limited to children of frontline service providers, 12 children and 13 adults tested positive[51–55]. Documented asymptomatic and/or test-negative contacts of the 25 infected individuals were available for 60 people at 3/6 sites after an undetermined follow-up period[51,52]. Direction of transmission was unclear. Schools in New South Wales, Australia identified several positive cases[56]. Viral PCR and antibody contact testing identified that 1/695 high school students most likely contracted COVID-19 at school (age of index case unspecified). At the primary school level, 1/168 students likely contracted COVID-19 from staff (adult to child transmission).

In the Netherlands the relative risk of transmission between age groups for 693 paired COVID-19 patients was examined, and data demonstrate that on a population bases people are more likely to be infected by those of a similar age[57], unlike the previously described household case cluster analyses. The highest numbers of cases were in the adult population (**Figure 2a**). They noted that 10 patients under 18 years of age did not transmit disease to 43 close contacts, while 55/566 close contacts of 221 adults (8.3%) were infected. It should be noted that schools in the Netherlands were closed in March and reopened in May with rotating classes and 15 child cohorts.

A very large contact tracing study from South Korea described 5,706 index patients and 59,073 contacts (January 20-March 27)[58]. The overall rate of infection in household contacts was 11.8% and non-household contacts 1.9%. Importantly direction of transmission was not able to be assessed. Household contacts of 10-19 year olds had a higher rate of infection (18.6%), but the lowest rate (5.4%) was seen in contacts of cases who were children 0-9 years old. It should be noted that 10-19 year olds represented only 2.2% of index patients, and 0-9 year olds 0.5% of index patients, and their contacts comprised 288/59,073 contacts (0.5%) of contacts traced in this study, with correspondingly wider confidence intervals around these data. There has been some suggestion of multiple exposures to the same index cases and out of school socialization as possible reasons for this observation which represents transmission dynamics during school closure. Other contact surveys showed that school closure and social distancing together decreased daily contacts and confined transmission to mostly household contacts in Wuhan, China[59] and in that setting, compared to those age 16-64, children age 0-15 had an OR of infection of 0.34, and those age >65 OR was 1.47. In another report, an increasing proportion of infected children was documented over time from 2% to 13 in Shenzen, China[60] increased potentially related to both increasing exposures with intrafamily transmission and increased testing in milder illness compared to earlier outbreak period.

Transmission between adults appears to be more likely than transmission between children, or from children to adults. Older teens' transmission patterns may be more like adults than younger children.

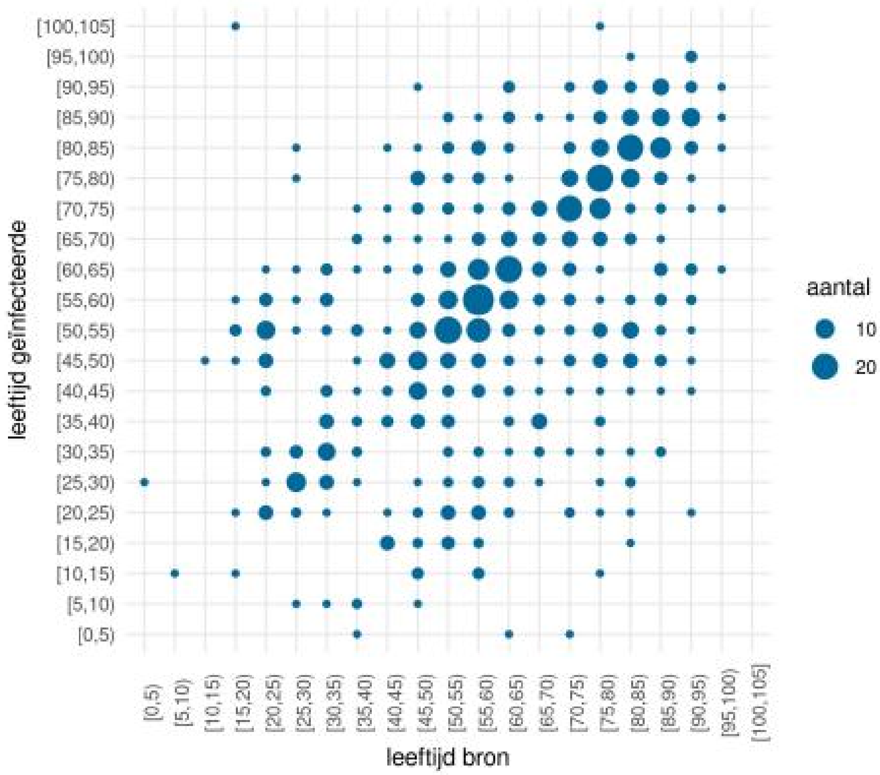

Figure 2a.

Translation: Y axis – Age infected, X axis – Age source, Legend – Number
Heat map demonstrating the relative COVID-19 transmission by age. From *Children and COVID 19: National Institute for public Health and the Environment: Ministry of Health, Welfare and Sport, Netherlands* https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19 .[57]

Table 2a. Literature and Media derived synthesis of cases by type of exposure and pediatric status

Location	Detection method	Total cases	Pediatric (%)	Adult (%)	Cases per exposed individual (%)*		
					Total	**Pediatric**	**Adult**
All exposures (total)	Mixed	12,411	29	81	2.92	1.33	5.79
Household	RT-PCR	1,068	32	68	22.86	19.32	20.49
All community	RT-PCR	815	12	88	2.59**	1.70	1.98
Daycare	RT-PCR	2,235	31	69	0.40	0.16	1.11
All school ages	Mixed	2,165	30	70	3.19	1.59	6.11
Elementary/Jr High (one study, France)	Serosurvey	140	42	58	10.37	9.44 (7.66 students)	11.17 (9.80 staff)
High school (one study, France)	Serosurvey	171	49	51	25.87	34.30 (33.47 student)	21.05 (10.57 staff)

*Results for the number of cases per exposure differ from total numbers as only some studies reported contacts and contact tracing results.

**Rate of total cases per exposure differ due to one study that did not provide adult:pediatric breakdown.

Table 2a references:[13,14,18,29–31,33–35,37–56,60–91] - quality of evidence: case reports, case series, cross-sectional and cohort studies, media reports. Publications on household exposures appeared in the literature around January 2020. Daycare data, published from about March, includes lockdown care provision to only children of essential workers. School data is mostly recent, reflecting reopening reported since mid-April. Differences in lockdown and community transmission status and mixed sources including intensive local studies, voluntary crowdsourced contributions and isolated case-cluster or single-location reports, potentially skew the data and impact generalizability.

Summary

Data worldwide to date consistently suggest that children appear to be less severely affected by COVID-19 than adults, with fewer documented infections and higher proportions of asymptomatic and mild infection. (Question 1, **Table 2a**). Teens may have a more "adult" pattern of transmission and infection risk than younger children. At a population level. However, even in setting of potentially lower infectiousness, the number and duration of contacts can lead to transmission. This combination of differences in exposure profiles, community reproductive rate (Question 4) and physiologic response to SARS-CoV-2 infection (Question 3) plausibly contribute to explaining the finding that ***transmission of SARS-CoV-2 is more likely from symptomatic people, and from adults, to close contacts (adult or child) than children to adults or each other, however the actual risk of transmission in a specific setting such as school is also influenced by reproductive rate.*** Evolving data will help to inform the complex interactions between these different factors, allowing a more accurate prediction of risk in specific settings.

2b. Are children more likely to become infected with COVID-19 at school or daycare, in the community, or within households? What are the risks to staff and students in the context of transmission at daycare and school?

Children may be exposed to COVID-19 at home, daycare, school, and (particularly with older children) organized or casual peer activities. The limited existing data on transmission in various settings is useful to guide potential strategies to reduce transmission.

Household

In household clusters reported from January to May 2020, children are more likely to be exposed to SARS-CoV-2 and infected at home by an adult family member or visitor[13,18,33–35,38–40,42–45,60,61,63,65–68,73,76,78,80,83,92–94] or by being in close proximity to a known relative adult with COVID-19[18,30,80,95–99]. When site of exposure was not indicated, there was often confirmed close contact between the child and an infected adult[35,64,67]. Overall, 87/96 (90.6%) of transmissions were from an adult index case to adults or children; child to child transmission accounted for 8.3% and child to adult transmission only 1.1% of household cases[30–34,37,39,40,44–47,49]. In another study[48], children similarly represented 3/32 index cases (9.4%).

Household consistently show the highest secondary attack rates (**Table 2a**), in agreement with a systematic review that demonstrated a household secondary attack rate of 15.4%, compared to 4.0% in non-household contacts[36]. Adults are more likely to be infected in household studies, with a relative risk of 1.40 for any adult and 3.23 for spouses compared to children[36].

The limited available evidence suggests that ***in households, it is more likely for an adult to transmit COVID-19 to another adult or a child than for a child to transmit virus to other children or adults***. This information should be interpreted cautiously given many reports were published during school closure and community lockdown, when children were less likely than adults to have community exposures.

Travel

In early case reports, children were infected via direct travel to Wuhan and other outbreak areas in China[13,63,64,67,76,83,100–102]. Other reports of children contracting SARS-CoV-2 from travel to an outbreak area include cases from Calgary, Canada (travel to USA) and Ireland[29,50]. Global travel restrictions since decreased travel-related cases, although they are once again on the rise, including many children infected in some recently reported overnight summer camp outbreaks[103–105]. More recently, multiple exposures have been reported during airline flights landing in Canada athough no resulting documented tranmsissions are recorded[106].

School and daycare exposure prior to closure

Early in the pandemic data for within-school transmission are limited as many jurisdictions closed schools. One case from Israel describes a 14.5 year old boy who was exposed at school (Yeshiva), but no information was provided about whether transmission was from an adult or another child[43]. School exposure was also identified in Ireland (no symptomatic infections resulting from the school exposures), Australia (two infections from school exposure), and France (661 individuals tested, 171 seropositive adults and children)[56,107]. The two cases in Australia included one child in elementary school, likely infected by an adult at the school, and one child in high school infected by another child[56]. One study from Ireland showed no evidence of transmission from pediatric cases despite exposure in multiple environments (school, recreational activities, household) with over 1,000 contacts[29]. In France, an asymptomatic COVID-19 positive child attended 3 different schools, in contact with 172 individuals (84 considered high/moderate risk) with no resulting secondary infections[70]. At least some daycare cases were linked to external contacts with COVID-19 including travel[50] or from family members exposed during essential work in high-risk occupations like health care[54], with no documented secondary transmission within the daycares. A random sample of 84 Belgian children age 6-30 months who attended daycare between February 29 and school closure March 18, recruited from a longstanding prospective nasopharyngeal swab study, detected zero cases of SARS-CoV-2 by RT-PCR while 51% of the same children tested positive for typical respiratory viruses[108], again suggesting that early in the pandemic children were minimally exposed at daycare.

A serologic investigation of high school students in a high incidence area in Northern France, which occurred prior to public health interventions, was described by Fontanet and colleagues, followed by a similar study in a primary schools after closure[71,85]. The elementary and high school seropositivity in these studies are shown in **Table 2a**. In the high school, 2 student index cases were known. Forty percent of tested students aged 15-17 demonstrated antibodies, while 43% of teachers and 59% of other school staff were antibody positive, with a prevalence of 25.9%m suggesting a possible superspreader event. In the retrospective serologic analysis of the primary school cohort (ages 6-11), the seropositivity in children of 8.8% was lower that the positivity rate of 11.8% in their parents and relatives, with 7.1% of teachers and 3.6% of non-teaching staff seropositive. In the elementary school study there were 3 potential index pupils in 3 separate schools with no secondary cases documented in schools and evidence of familial clustering. The results of these cross-sectional surveys, given the high seropositivity noted compared to the positive blood donor population of 3% in the area, may show referral bias with selection of those who thought they were infected; participation was less than 40% of those approached. Directionality and location of transmission cannot be ascertained through seroprevalence testing, and transmission may have occurred at the schools, in the community and in households.

The French regional comparison illustrated a ***potential increased risk of transmission in high school students, compared to primary grades***. This is also noted in a media report from Sweden reported an increased rate of COVID-19 spread in secondary school teachers compared to teachers at elementary schools or preschools[109]. Although one could assume closer interactions between younger students and staff, particularly at daycares, it is feasible that the higher infection rate for secondary school teachers may be secondary to a higher number of students contracting COVID-19 during out of school activities[86,110,111], via student athletics[112,113] or higher transmissibility from older children. It is difficult to interpret the school-based transmission of COVID-19 from early reports or apply the information in the context of public health measures that have since been placed.

School and daycare exposures after reopening

Since school reopening, the number of reported cases in school children has varied considerably between jurisdictions. Where community rates of transmission are high and climbing, described school outbreaks cannot be entirely attributed to transmission at school. For instance, child care facilities in Texas, where requirements for daycare entry and pre-screening place in May but repealed on June 12[114], reported 141 staff and 69 child infections on June 15; these numbers increased to 894 staff and 441 children by July 6 and 1207 staff, 592 children on July 9[88]. During that period, daily new cases in Texas increased from 1,964 to 6,991 then 8,201 and cumulative cases climbed from 90,211 June 15 to 236,541 July 9, demonstrating rapid increases in community infections mirrored by the cases detected in daycare children[115]. There are emerging reports that show similar findings of cases identified in childcare or schools in areas of rapid community spread[114,116,117]. In early July, a Missouri summer camp for teens 13-18 reported 82 infected individuals[104]. Although all campers had to provide negative test results within 12 days of attending and some public health precautions, including cloth masks for staff were in place, campers aggregated in large groups for singing and physical activity and did not stay in cohorted cabin groups, and there were 15 campers per cabin in presumably smaller spaces with limited ventilation. Follow-up was available only for Georgia-based attendees, and demonstrated that the attack rate was 44% (260/597) children 6-10, 44% in 11-17 year olds and 33% for 18-21 year olds. Staff members, who attended for the longest time period, had an attack rate of 56% and infection rate increased with time spent at camp [105].

As well as increases in community infection rates, transmission in schools may be impacted by the stringency of public health measures; while daycares in many parts of the USA report screening, cohorting and other measures[118], precautions were recently lifted in Texas, where daycare cases are soaring, and at least two affected summer camps used minimal precautions[104]. In South Africa, several school outbreaks were not specifically linked with index cases in the student body or faculty and background community rates of transmission were climbing[114,116,117]. Two weeks after school opening with public health precautions, the United Kingdom, whose total COVID-19 cases have been decreasing but are still higher than many European countries[119], reported that 24/199 new outbreaks were identified in schools (the age, including student/staff status, were not reported)[120]. The article noted concerns of insufficient space and supplies to allow compliance with recommendations for distancing and precautions like hand washing. Twelve of the school-linked outbreaks had only one confirmed case, while the other 12 demonstrated possible secondary spread[121]. Some schools assign student-teacher “bubbles” which are immediately quarantined after a positive test, potentially arresting COVID-19 spread at these sites[55,122–125].

In Israel, schools opened for all students age 7 and up on May 18th with no health precautions other than masks[126]. A highly cited Jerusalem school outbreak described an attack rate (based on positive PCR regardless of symptoms) of 13.2 percent for students and 16.6% for staff [127]. Described conditions included crowding (>30 students per class) with a May 19 heat wave allowing exemption from masks, and use of single room air-conditioning units. Students mixed in classes, schoolyard and public spaces, extra-curricular activities and school buses. The report did not clarify whether students used masks within air-conditioned classes as exemptions were noted for heat. In the highest affected age group (13-15 year olds) 44.1- 49.2% were symptomatic at assessment, with 76% of staff symptomatic. The high rate of asymptomatic test positive individuals is noted and prior symptomatic infection (during school break) was not excluded, which may inflate the degree of posited in school transmission versus possible earlier undocumented mild infection and continued RT-PCR positive carriage. “Recovery from infection”, presumably reflecting RT-PCR testing - was faster in the asymptomatic group, supporting either current asymptomatic infection or post symptomatic shedding. To establish an in-school attack rate range with a lower boundary, the symptomatic RT-PCR positive infection attack rate was 5.6% in students and 12.5% in adults which is similar to household transmission rate ranges. Overall, this outbreak seems to be attributable to teenage students returning to class in the context of minimal to no mitigating interventions. Follow-up demonstrated spread from students to family and community members, and milder disease in students than in adults.

Provinces and countries with a lower reported background rate and strong public health precautions in place during school return have not reported significant school-related outbreaks during the first few weeks of opening. Schools in 22 countries across Europe have used modified opening approaches with public health precautions since early May, mainly allowing graduating students to complete their examinations and opening kindergartens and elementary classes. After 2 weeks, there was no significant increase in child cases in those countries[128]. Longer-term evaluation demonstrated that in European countries with a relatively low background rate of transmission, opening schools with public health measures did not increase the overall infection rate in children but in countries with higher background transmission rates, in this case Germany, transmission in schools was documented after opening even with public health measures in place[129]. After reopening schools in Australia 2 secondary cases were reported: one elementary child with an adult index case at the school, and one high school student infected by a peer[56]. In Quebec, a June 3 report noted that 44 students and 34 teachers had positive viral tests for COVID-19 after elementary school resumed, with no comment on community vs school transmission[130].

Some jurisdictions with low background community rates have been successful in opening daycares. No COVID-19 cases have been reported in British Columbia daycares since reopening in mid-May[131], in the context of public health measures including screening, distancing and cleaning protocols[132]. As well, no transmission was noted in single daycare cases in New Brunswick[54,131]. Taiwan avoided widespread planned school closures, instead initially mandating local temporary class or school closure, based on low thresholds for infected cases with apparent success[133]. Korea has used a similar approach, and is so far successful although several high schools near Seoul were recently closed after single cases appeared, all in teens[134]. At least one of those cases was linked to the recent reopening of a local nightclub district. Several European countries prioritized opening class for younger children in May, with reduced class sizes (often 12-15 people), physical distancing, temperature checks and handwashing with no significant increases in cases[126]. Germany is an outlier, opening schools first to high school students with public health precautions in place; with the older students there was a rise in school-related cases[126].

Sweden allowed businesses and activities to remain open with only recommended precautions around social distancing. The result was a relatively high background rate of COVID-19 infection compared to other European countries. School for >16 year olds was conducted remotely with in person classes with attention to hand hygiene, outdoor instruction and reduction of large gatherings for schools for <16 year olds. Sweden had a higher number of cases (52,424 total) than Finland (7,110), with cases identified mainly in people > 19 years old. As previously described, a comprehensive comparison of school cases between Sweden and Finland, which undertook school closures, showed that children in both countries had low overall case numbers, minimal ICU admissions (1/584 cases in Finland, 14/1124 in Sweden) and no pediatric deaths[135].

Schools and daycares are part of community life. Reopening schools in regions with low community transmission, with public health measures in place, does not appear to significantly increase the growth rate of COVID-19 infections, while reopening with a higher community transmission rate appears to increase transmission between students even with measures to prevent transmission in place[136] although this occurred in Germany, where older rather than younger children were the first to return to school[70]. ***Where community transmissions are high or climbing, school outbreaks may reflect transmission within schools or transmission in households and other community locations. Student age and public health measures in the school setting may impact transmission rates***.

Bus and Public Transportation in School Planning
There is little data on transmission in public transport. A quarantine centre cohort in Guanzhou where close contacts were observed and had serial testing found that only 1 of 818 close contacts from public transport settings acquired infection: this rate of 0.1% was markedly lower than healthcare (1%) and household contact infection rates (10.2%)[137]. In contrast, an outbreak description with superspreader event in Zhejiang province described 126 passengers who took two buses (59 from Bus #1 and 67 from #2) on a 100-minute round trip to attend a 150-minute worship event. The source patient, who became symptomatic right after the event, was a passenger on Bus #2. The buses were air conditioned with recirculating air. Passengers in Bus #2 had a 41.5 (95% confidence interval [CI]: 2.6–669.5) times higher risk of getting COVID-19 compared to those in Bus #1, and 11.4 (95% CI: 5.1–25.4) times higher risk compared to all other individuals attending the outdoor worship event[138]. Finally, in a report of the relative risk of COVID-19 infection among various professions, in Sweden, bus drivers had a RR of 4.3 (3.6-5.1).

Taken together, it is possible that longer exposure time on a bus (100 minutes in the outbreak report, and presumably for an entire shift in the case of bus drivers) particularly with air conditioning/recirculating air, may pose increased risk for COVID-19 infection. Measures taken elsewhere to reduce public transit risk include masking, temperature checks for transit workers, enhanced cleaning, running transit at 50% capacity, having all passengers enter at the back door, and using windows to increase the fraction of external air instead of air conditioning[139].

Transmission to teachers and staff
School and daycare educators and staff may have concerns about occupational risk of COVID-19 transmission. A Swedish occupation-based relative risk analysis showed the relative risk of infection in teachers was not significantly different than that of the general population (0.7 in primary school to 1.1 in day care) compared to other professions[21], with the highest risk occupations including taxi and bus drivers, and restaurant workers (Table 2 below). However, even assuming that the risk of contracting COVID-19 from students may be equivalent to or lower than the risk from the same number of community based contacts, it is important to highlight the possible risk of adult to adult transmission in school and daycares, as evidenced by a North Carolina school outbreak affecting 5 school administrators, custodians, counselors and athletic staff who remained at work after school closure. However, ***there is no evidence to suggest that transmission to teachers and staff is higher than community-based transmission.***

Table 2. Relative risk per occupational group within the school. Number of cases and number of active persons in population per occupation. Median age at diagnosis. Relative risk (95% confidence interval)

profession	Number of cases / number i population	median Age at diagnosis	RR (95% CI)
SENIOR HIGH SCHOOL TEACHER	29 / 30.357	47	0.7 (0.5 - 1)
Compulsory school	160 / 105.418	50	1.1 (0.9 - 1.3)
recreation	18 / 16,753	49	0.8 (0.5 - 1.3)
Preschool teacher	68 / 68.605	44	0.7 (0.6 - 0.9)
Other educators with theoretical specialist	27 / 19,033	53	1 (0.7 - 1.5)
Nanny	124 / 88.658	45	1 (0.8 - 1.2)
Student assistants and others	53 / 36.116	49	1.1 (0.8 - 1.4)

Figure 2b: Table extracted from a Swedish study evaluating occupational transmission[17]

Summary
Attack rates are higher in households than in community settings. Transmission in the daycare setting appears to be low for children and staff (**Table 2a**). Cautious reopening in European countries suggests that transmission may be higher in teens than younger children but limited if public health precautions are in place. A large serologic study in a small community with early emergence (February) of COVID-19 suggests that many staff, students and families were infected, but did not provide context with respect to direction or location of transmission [71,85]. ***Overall, exposed children appear to be less likely to become infected than exposed adults in most settings. Daycare and school staff do not appear to be at increased risk of contracting COVID-19 in the workplace.***

3. Are there differences between detectable and viable viral RNA and COVID-19 serology between adults and children throughout infection?

3a. Is there a difference in SARS-CoV-2 RT-PCR or RNA load values in children vs adults with infection? Is there a difference in carriage of viable virus (assessed by viral culture or subgenomic mRNA) between children and adults?

Is there a difference in SARS-CoV-2 RT-PCR or RNA load values in children vs adults with infection?
Presence of SARS-CoV-2 RNA has been demonstrated by RT-PCR in serum, saliva, bronchoalveolar lavage, stool and from nasopharyngeal, pharyngeal and anal swabs in both adults and children[140]. Differences in detection exists between sites. In one analysis of 205 COVID-19 patients from China ages 5 - 67 years, SARS-CoV-2 viral RNA was detected in 93% of bronchoalveolar lavage samples, 72% of sputum, 32% of pharyngeal swabs, 29% of stool samples, 1% in blood and 0% in urine[140]. Detection and quantification of viral RNA, infectious viral particles and immune response are important in understanding transmission, infection, disease course and immunity.

Upper respiratory tract (nasopharyngeal and oropharyngeal) viral load
In this discussion viral load is inferred from cycle threshold values for real time RT-PCR tests, which has limitations with variations among same/different assays performed by various laboratories and does not provide quantified viral copy number; in cases where unless the test has been set up and validated as such; this was not the case with most of the studies summarized here and will be indicated when reported.

Viral load in respiratory samples varies by specimen type; there is conflicting data on the estimated viral load associated with disease stage and severity. For example, one study of 323 samples taken from 76 patients with confirmed COVID-19 showed higher viral loads, inferred by cycle threshold (Ct) at multiple sites during early and progressive stages of infection compared with the convalescent stage[141]. While 90% of 21 moderate patients in another study no longer had detectable nasopharyngeal virus by 10 days of infection, 10 severe patients shed detectable virus for longer, with peak mean viral loads estimated by Ct approximately 60x greater than those of mild to moderate patients[142]. Another Ct-based study of 85 SARS-CoV-2 positive patients from Shenzen, China also demonstrated lower levels and shorter periods of viral RNA detection in the 23 asymptomatic children and adults[143]. In direct contrast, a cross-sectional retrospective study from New York estimated viral load in nasopharyngeal swabs of 205 patients with confirmed COVID-19, using a Ct method. The initial viral load was lower in patients who were hospitalized than those who were discharged from the Emergency Department, and higher viral load was associated with shorter duration of symptoms[144]; this retrospective study did not follow discharged patients to capture the timeline of viral shedding and patients with a worsening trajectory resulting in hospital admission later in the course of illness may not have been identified.

The severity of disease may affect the duration of infectious virus shedding, and antibody testing may be useful to guide infection control measures as assessment of likely infectivity. A preprint study of critically ill patients suggests that a higher viral load (> 7 log/ml) in respiratory tract specimens was associated with isolation of infectious SARS-CoV-2, and the presence of neutralizing antibody was associated with absence of infectious virus[145]. In these patients infectious virus could be isolated for up to 20 days (median 8 days, < 5% probability after 15.2 days of symptoms), which is longer than the 8 day duration of viable virus shedding in less ill patients described in an earlier publication[146].

The observed timeline of viral load inferred by Ct appears to be highest early during infection and decline during convalescence, but differences in observed maximum viral detection exist between studies and between sample sites. In one study 94 serially tested by oropharyngeal swab for up to a month after illness onset viral loads were initially high, but decreased to nearly undetectable by 21 days, with no differences between sex, age or disease severity[147]. However, another Ct study evaluating nasopharyngeal samples taken from 18 contacts of COVID-19 patients noted that viral load was initially low and peaked at day 10 of symptoms[148]. A recent retrospective cross sectional study attempted Vero cell culture from RT-PCR positive samples, with 26/89 (29%) demonstrating growth. No viral growth was observed from specimens with a Ct of >24, or symptom onset to test time of > 8 days[149]. Similarly, an earlier paper suggested that no replicating virus (assessed by subgenomic RNA) was detectable after day 8 in a detailed virological assessment of nine patients with early symptoms[146]. A variety of additional publications have confirmed prolonged PCR positivity, with one description of 56 hospitalized patients in which severe illness was associated with higher viral loads (by 60 fold) and a longer time to RT-PCR clearance[150]. Viral RNA shedding was prolonged with a median of 24 days to become SARSCoV-2 RT-PCR negative (and 32.1% still positive at 1 month post onset)[150]. A preprint study of 1343 probable and confirmed outpatient COVID-19 cases in New York were assessed with serologic and nasopharyngeal RT-PCR testing[151]; 249/584 participants with antibody and PCR testing were RT-PCR positive at 20 days (11-42 days) from symptom onset and 12 days (5-28 days) from symptom resolution. In this cohort, 19% of survey participants with previous self-reported symptoms were PCR positive at testing[151].

It has been proposed that lower viral titers in children explain their lower case rate and decreased symptoms[152]. A Korean study compared quantitative viral loads in 12 mildly symptomatic and asymptomatic children (<18 years) from combined naso- and oropharyngeal swabs[153], with 55% still positive at week 3. Fecal RT-PCR positivity and viral load remained high (>80%) through 3 weeks. Eighty percent were positive by PCR of saliva in the first week with a sharp decline thereafter. Symptomatic children had a higher initial viral RNA load (9.01 vs 6.32 log, p=0.048) with considerable variability and overlap. Other studies also suggest that the pediatric population (18 years and under) have lower viral load than adults[148,152,153]. However, not all studies demonstrate these differences. A large review of community tests in Germany compared 77,996 serial nasopharyngeal swabs taken from 3,303 COVID-19 positive patients[154]. Using a Roche Lightcycler platform there were no differences in viral loads by age estimated from raw data and a Bayesian model, but screening after mid-March adopted different PCR equipment (Roche Cobas) during a period of lesser contact testing (with lockdown measures in place contact testing was reduced). During this period, viral load differed between ages, with 29% of children 0-6 and

37% of those age 0-19 bearing >250,000 copies (the minimum associated with viable virus on cell culture), compared to 51.4% in those age 20+[154]. The authors commented that although this difference was statistically significant it was unlikely to be clinically significant and this study has been interpreted as showing no difference in viral load of children and adults. However, reanalysis of these data using different statistical methods was published by another group in a public response, with the conclusion that children (grouped as 0-6 and 1-10) have lower viral loads than adults[155]. There was no clear evidence of clinically significant variations in viral load (by RT-PCR) by age in other studies[148,156]although the pediatric arm in one was underpowered[156]. More recently, the Children's Hospital of Chicago evaluated 145 symptomatic patients with mild to moderate COVID-19 illness age 1 month to 65 years using RT-PCR cycle threshold values as a proxy for viral load, which is not a validated quantitative methodology. They excluded those with severe or asymptomatic illness or illness beyond 1 week to minimize differences other than patient age[157]. Children under 5 years were reported to have higher nasopharyngeal SARS-CoV-2 viral RNA (lower Ct values, p=0.02) compared with children age 5-17 years, who were similar to adults age 18+ (p=0.34), Concerns raised around this report include: cultivatable virus or qualitative viral load were was not evaluated, the very low Ct values reported are felt to represent possible technical concerns, and "outliers" with higher Ct values were excluded in the calculation of the median in the 0-5 y age group only. However, this study suggests a potentially wider range of Ct values in younger children including the possibility of higher inferred viral loads than previously described. [157].

Another factor that may impact transmission, independently of the measurable viral load in airway samples, is cough dynamics. One research group suggests that differences between pediatric and adult bronchoalveolar structure, respiratory dynamics and cough mechanics will produce lower amounts of exhaled droplets, making children poor transmitters of SARS-CoV-2; this concept remains theoretical and needs to be evaluated further[158]. Given that there is less data for children than adults, that viral load varies during the course of COVID-19 infection and by sample site, as well as the potential for variation between aerosol formation dynamics and different detection methods, ***there is a significant knowledge gap with respect to the impact of SARS-CoV-2 viral load on the transmission of COVID-19 as well as differences between viral load in children and adults.***

SARS-CoV-2 in fecal samples

Compared to RT-PCR detection of SARS-CoV-2 from nasal swabs, some studies suggest that fecal shedding occurs in the latter period of infection, including and beyond symptomatic convalescence[15,47,93,159–162]. Currently transmission between individuals is largely suspected to be oral-oral. However, similarly to SARS-CoV and MERS coronavirus, fecal-oral transmission may be another route for SAR-CoV-2 infection[162,163] that may persist after respiratory symptoms resolve. A retrospective cohort in Beijing, China also detected SARS-CoV-2 RNA in fecal samples from COVID-19 positive patients for days to weeks after respiratory samples (sputum) no longer tested positive[159]. Further case studies from Shandong, China and Qingdao, China confirm that SARS-CoV-2 can be present in stool up to four weeks after abatement of symptoms[93,164]; another found a mean difference of 8.6 days between positive respiratory and fecal testing[152]. In addition to prolonged shedding, estimates of SARS-CoV-2 RNA quantity in feces remain relatively consistent over time, whereas nasopharyngeal swab and saliva specimens initially rise during the development and active phases of infection, then decline during the convalescent phase in symptomatic children, with a similar pattern of expression in asymptomatic children[153].

Fecal detection is prolonged in pediatric patients compared to adults[160]. In one study, the majority of pediatric COVID-19 patients had RT-PCR positive stool samples until 10 days after hospital discharge[161] and children were more likely than adults to have RT-PCR positive fecal samples compared to respiratory swabs 14 days post onset of symptoms[152] with prolonged fecal positivity by RT PCR compared to adults[93,153,160,164]. The difference between child and adult fecal shedding may be due in part to differences in age-related gastrointestinal trace ACE2 receptor expression[160].

As well as detecting viral RNA in fecal samples, infectious SARS-CoV-2 has been isolated from fecal samples of infected patients[165] and can survive in water for up to 25 days[166]. ***Although there is no strong evidence for fecal-oral transmission of SARS-CoV-2, such transmission is feasible, and should be considered when considering safety and hygiene precautions for school and daycare operation.***

SARS-CoV-2 in blood and other body fluids
SARS-CoV-2 is rarely detected in COVID-19 patient serum or urine[140]. It is highly unlikely that these forms of transmission are of concern for school[154]. Similarly, although viral RNA has been detected in the expressed breast milk of an infected mother[167], oral transmission is not supported by current data. Since transmission depends on aerosolization of live virus in fluid there is no evidence that expressed breast milk is a source of viral transmission, a reassuring consideration for some daycare centres where expressed breast milk is provided for children.

SARS-CoV-2 binding sites in the nasopharyngeal tract
SARS-CoV-2 enters cells mainly via angiotensin-2-converting enzyme 2 (ACE2) and transmembrane serine protease 2 (TMPRSS2) proteins. Existing transcriptome datasets show that ACE2 and TRPRSS2 expression are significantly lower in pediatric (age not specified) than adult nasal and bronchial epithelial tissue brush samples, which may have implications for viral transmission. Lower and similar values were seen in peripheral mononuclear blood cells (children and adults) and adult saliva[168]. Comorbidities that increased receptor expression in the airways included essential hypertension and ACE2 blood levels were higher in adults with asthma[168]. Adult patients with confirmed COVID-19 infection have higher estimated (Ct) viral loads in nasal and oropharyngeal samples (sputum, throat and nasal swabs) than other sites[141], based on RT-PCR and ddPCR, in keeping with patterns of ACE2 and TRPRSS2 expression[141]. In addition, the viral load (evaluated by ddPCR) was significantly higher in sputum than throat or nasal swab (17,429 copies/test vs 2,552 and 651, respectively). Although SARS-CoV-2 has been demonstrated in multiple organ systems, these receptor studies support that the majority of transmission likely occurs through respiratory secretions, and some data suggest that ACE2 expression may provide a biological rationale for the possible reduced viral load and lower infection rates seen in children.

Is there a difference in carriage of viable virus (assessed by viral culture or subgenomic mRNA) between children and adults?
Detection of SARS-CoV-2 RNA does not necessarily mean that infectious virus is present[153]. In a small cohort study of children from Switzerland (16 years and under), SARS-CoV-2 virus isolate from nasopharyngeal swab only infected 52% of VeroE6 cells, confirming that shedding patterns of the culture competent virus in symptomatic children resemble that of adults[81]. As well, at least one study shows infectious viral particles in stool samples from an infected patient[169]; this study also demonstrated viral replication in bat and human intestinal epitheloid cells, an *in vitro* system for studying viral activity[169]. Although not a direct representation of infectivity, a minimum of 250,000 copies/ml were required for isolation of infectious viral particles from fecal material[154]. These results seem to indicate that SARS-CoV-2 carried by children has a similar infectious profile to the virus from adult samples. ***Virus detected in children using RT-RNA and other techniques should be considered to have similar viability, measured in its ability to infect cells in vitro, to virus detected in adults based on current limited data.***

3b. What is the current understanding of the antibody response in COVID-19 during and after infection?

There is emerging literature describing SARS-CoV-2 antibody response dynamics. For SARS-CoV-2, specific epitopes of the nucleocapsid[56] and spike[170] proteins[143,171,172] are specific targets for IgM and IgG antibodies. One detailed evaluation of the course of seroconversion in asymptomatic, presymptomatic and moderately symptomatic COVID-19 positive patients[143] demonstrated seroconversion is >90% of asymptomatic and presymptomatic cases. Of 22 children < 14 years, 10 (45%) were asymptomatic; only 13/63 adults (21%) were asymptomatic. Fewer asymptomatic patients seroconverted with detectable IgM (45.5%) than presymptomatic and symptomatic (62.5% and 63.2%) patients; 10-30% seroconverted in the first week of illness, a peak at 15-30 days, and decline to 50% 1-2 months after hospital admission. In contrast, IgA and IgG seroconversion rates were >90% in all patients, and similar (91-93%) regardless of symptomatology. Peak IgG and IgA levels were achieved in 15-30 days. Other studies also describe gradual seroconversion with a plateau in antibody levels by about week 2 in non-ICU patients but increasing levels in sicker patients until about week 3[171], and higher seroconversion to IgM (>80%)[172], however these studies focused on severe patients and took few time points and did not include children. Multiple other studies showed that IgG specific to SARS-CoV-2 develops within two weeks of symptom onset of symptoms in both children and adults and that the seroprevalence of anti-SARS-CoV-2 IgG is highest in the middle age bracket (ages 18-50 years)[173–184]. Serial analysis of patient serum and prevalence of anti-SARS-CoV-2 IgG show high titers during the acute phase (about day 10 of symptoms) that start to decrease after 15 days[177]. Children were more likely to be asymptomatic and less likely to demonstrate a significant IgM response, but did develop a similar IgG response to adults[143]. While the degree of symptoms impacted seroconversion, most patients with documented SARS-CoV-2 infection did mount an IgG response and maintain detectable antibody levels for at least 2 months, regardless of symptoms[143,171,172,176,177,179,181–183]. ***There is a significant evidence gap regarding the ability of detectable antibody to provide immunity.***

Antibody activity can be evaluated using *in vitro* assays. In one study, SARS-CoV-2-specific neutralizing antibodies (NAbs) were measured in a pseudotypical-lentiviral-vector-based neutralization assay from 175 adult COVID-19 patients who had common or mild symptoms. Patient plasma samples had high titres of SARS-CoV-2-specific NAbs from day 10 to 15 after infection, with higher levels in elderly and middle-aged patients in comparison to the youngest age group (**Figure 2c1**)[177]. Young children (age 5-9 years) developed lower levels of NAb than older children and adults in at least one evaluation[179], in agreement with antibody quantification studies[143,176,177,179–183]. Overall, most patients developed stable IgG titres during convalescence. NAbs have previously been considered for therapy or prevention of a number of viral infections and SARS-CoV-2-specific NAbs are under investigation as a therapeutic intervention[180]

A recent preprint from the UK that assessed stored (pre-COVID-19) sera for evidence of preexisting humoral immunity to SARS-CoV-2 showed the presence of IgG to S2 subunit reactive antibodies in children and adults (12/95, 12.6% of samples of SARSCoV-2 uninfected individuals)[185]. Five of 50 (10%) stored samples from pregnant women, and 21/48 (44%) of stored samples from children and youth (the latter sampled in late spring when typical seasonal coronavirus HCoV infection is common) revealed antibodies could neutralize SARS-CoV-2. This finding is potentially attributable to recent or remote infection with other circulating coronaviruses. From an immunologic perspective it seems that the S2 subunit epitopes may be functionally relevant in providing cross immunity between HCoVs and SARS-CoV-2. A possible reduction of illness severity and lessened susceptibility to infection might account for the age distribution of COVID-19 rates and symptoms, given that these seasonal infections are common in children. However, public health measures that prevent COVID-19 will also tend to reduce other HCoVs so maintenance of immunity to these other coronaviruses will likely be affected by non-pharmaceutical interventions. Practically speaking, it will also be important to distinguish between cross-reactive and SARS-CoV-2 antibody responses in assessing serologic data.

Given the pandemic timeline, it is not possible to ascertain whether children or adults develop lasting immunity to SARS-CoV-2, or whether immunity developed after a single infection is sufficient to protect against reinfection in the future at this stage of the pandemic. At least one recent publication demonstrated a weaker antibody response in a small number of asymptomatic patients[186], with lower IgG levels in the acute phase and reduced levels during the convalescent phase; 40% became seronegative during convalescence, compared to 12% of symptomatic patients. This is in keeping with information from the Spanish seroprevalence survey. Whether a specific antibody level correlates with protective immunity and protection from reinfection is thus far unknown. Reinfections are seen in less severe seasonal coronavirus infections. In one study using healthy volunteers, 10/15 were successfully infected with strains of seasonal coronavirus; the other 5/15 showed a mucosal IgA response suggesting that they were able to prevent symptomatic infection[187]. Serum-specific IgA and IgG peaked at week 12. In this study, all 5 volunteers who were not infected and 6/9 previously infected volunteers were infected one year later when re-challenged with live virus, however symptom duration and severity and mean time for viral shedding were lower after the second challenge, suggesting an element of protection[187]. Long-lived T cell immunity has been described after epidemic SARS-2003 (infections with SARS-CoV), and T cell immunity played an important role in recovery from that disease with T cell responses durable for many years (>10 years) compared to rapidly waning antibody responses[188]. It is anticipated that cellular immunity as well as neutralizing antibodies will be needed for long-lasting protection from SARS-CoV-2. A study published July 13 from Scripps Institute has identified a specific antibody gene, IGHV3-53, that promotes a strong antibody response and may be helpful in vaccine development[189]. Understanding effective vaccine components and the importance of the T cell response is critical given some early speculation over the potential barriers to acquisition of long-term immunity[190].

There is a significant knowledge gap with respect to lasting antibody mediated immunity to SARS-CoV-2, especially in children.

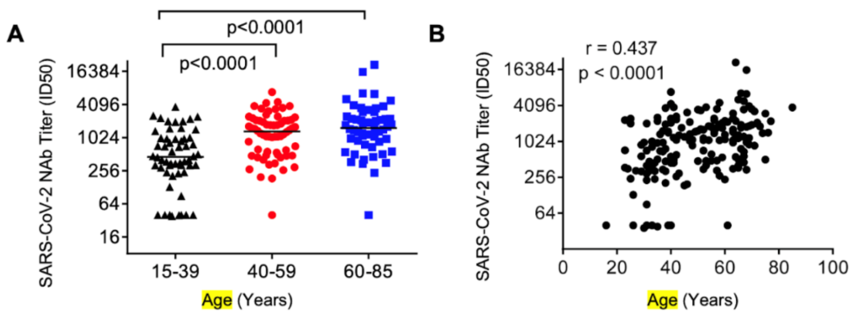

Figure 3b. Adapted from "Neutralizing antibody responses to SARS-CoV-2 in a COVID-19 recovered patient cohort and their implications by Wu et al., 2020" Elderly and middle-age recovered COVID-19 patients developed higher levels of SARS-CoV-2-specific NAbs than young recovered patients[180]. NAbs titers of young (15-39 years), middle-age (40-59 years), and elderly (60-85 years) patients were compared. P values were calculated using *t* test.

Cross-sectional and population-level studies are being done to estimate the actual population infection rate and possible implications for immunity to SARS-CoV-2. As previously summarized, a Spanish population based serosurvey showed an overall seroprevalence was 5.0% with geographic variation[191]. Seropositivity was It was 18% in participants who reported symptoms > 2 weeks before the assay. Overall seroprevalence in those who did not report symptoms was 2.5% and 90% of participants with a self-reported positive RT-PCR to SARS-CoV-2 had a positive IgG test. Children 0-19 years were less likely to have specific IgG; seroprevalence was 2.4% (1.1% in infants <1 year), increasing to 4.4% in people age 20-34, 5.3% in age 35-49 and 5.8% in age 50+. Sweden is also monitoring seroconversion at a population level[20]. In 1,104 samples (excess samples from outpatient care for other indications 7.3% were positive in Stockholm, with lower levels in other cities less impacted by the pandemic (Skane 4.2%, Vastra Gotaland 3.7%). They were most common in age 20-64 (6.7%); children 0-19 were 4.7% and age 65+ 2.7%. This however is not a convenience not representative population sample. A Swiss population based study of 2,776 participants recruited from an existing general population cohort study and their immediate family members (age 5 and up) showed that seroprevalence was 3.5% at the onset of the study and 10.6% 5 weeks later, with lower rates noted in children age 5-9 (0.8%)[179].

There is minimal data available with respect to seropositivity across age ranges to SARS-CoV-2 in Canada, however early results from a national study of donor blood demonstrated <1% seropositivity in 10,000 samples taken from Canadian blood donors during the last 2 weeks in May[192]. Another cross-sectional study analyzed residual sera collected from outpatient laboratories in Vancouver (British Columbia), demonstrating neutralizing antibodies to SARS-CoV-2 at 0.28% (2/869) seroprevalence in March and 0.55% (4/885) in May, which suggests that community infections are 8-fold greater than reported cases[193] in British Columbia.

The finding that population based seroprevalence is lower in children than adults supports data of documented infection that children have lower infections rates than adults in epidemics thus far. *With <10% seroprevalence in countries that have reported a significant level of infections and high burden of mortality and morbidity,* ***population based immunity after natural infection is unlikely to affect transmissions dynamics (ie, herd immunity is not likely) after the first wave of the pandemic.***

4. Are public health interventions (e.g., masks, distancing, hand hygiene) appropriate and effective for children and youth?

To date, there is minimal evidence available (small number of studies; lower quality evidence) on the effectiveness of public health interventions (PHIs) for COVID-19 focusing on pediatric populations. This section contains a summary of the appropriateness and effectiveness of public health interventions, including masks, distancing, hand hygiene, in pediatric populations. It is important to understand the current status of the evidence in this area as jurisdictions around the world have begun to lift public health restrictions including the reopening of schools. Early in the pandemic, school closures were seen as a way to reduce the spread of the virus[194–199]. As restrictions begin to lift globally, including daycare and school re-openings, considerations must be made to recommend the safest way to increase social contacts while maintaining key PHIs and mitigating the spread of SARS-CoV-2. Given the shift in the understanding of pediatric transmission, it is too early to see quality evidence on the effectiveness of PHIs in pediatric populations to reduce the spread of SARS-CoV-2.

Hand Hygiene, Masks and Physical Distancing

A cross-sectional study by Chen et al[200] surveyed children in Wuhan between the ages of 1-13 years (median=9) about mask wearing and hand hygiene in schools[200]. Excellent hand hygiene understanding and behavior was seen in 42.1% of children whereas 51.2% of children showed good mask-wearing behaviour. The authors also found that 42.2% reported that it is difficult to find child-sized masks, with only 32.5% of primary school children wearing properly fitted masks. Concerns around the risks of mask wearing in children under 2 to 3 years of age have been raised due to increased risk for suffocation, instead advocating for distancing measures and hand hygiene in this age group[67,201]. Further, it is suggested that for school aged children, both schools and parents should educate their children on the importance of measures such as mask wearing and hand hygiene in order to increase children's compliance[201]. In certain settings, plexiglass shields with cleaning protocols might be considered to minimize droplet exposure and improve separation if physical distancing measures are constrained although these measures have not been studies for efficacy of transmission reduction.

There is longitudinal information transmission in the context of school reopening and implementation of masking which suggested initial successful school opening in the absence of community or school mask use. In Switzerland, schools closed in mid-March during an increasing epidemic with cases peaking in late March then dropped steadily into mid-May, with school reopening May 11. Masks were not required in schools, and mask use in the community was "rare" during April and May as the epidemic declined. A paper assessing the effectiveness of interventions in controlling Rt in Switzerland suggested that transmission reduction started slightly before measured mobility changes, suggesting that messaging about basic hygiene may have initiated proactive behaviour change with positive effects prior to school closure[202]. Subsequently, community cases started in increase late in June, and masks were made mandatory on public transit July 6, and have since been recommended for students age 15+ in Lucerne (for distances < 1.5 m). However, mask availability remained poor until mid-July. As of July 24 reported case numbers had continued to increase, with 2 teachers testing positive in schools and a separate nightclub-related cluster[203]. In this circumstance schools reopened when the epidemic first wave was controlled, and without widespread mask use in the community or in schools, and cases remained stable for 6 weeks. However, with subsequent increasing community transmission, masking is being promoted in public transit and in some high schools. This experience and similar international experiences will merit followup.

Physical distancing measures have also been evaluated for SARS CoV-2, along with other severe betacoronviruses and MERS. Chu et al (2020), conducted a metanalysis to investigate the optimal distance to avoid person to person transmission, along with evaluation of masks and eye protection[204]. Transmission of viruses was lower with distancing of more than 1 meter versus less (aOR 0.18, risk difference -10.2%, moderate certainty), and further decreased by a relative risk of 2.02 per metre (Figure 4a). Mask use resulted in a risk difference of -14.3% (low certainty), and eye protection of -10.6% (low certainty).

Given the limited literature specific to PHIs in pediatric populations in relation to COVID-19, it is important to consider evidence from previous epidemics pertaining to reduction of virus transmission in these groups. A case control study from Spain during the H1N1 pandemic demonstrated that in children, handwashing more than 5 times daily significantly reduced infections compared to less frequent handwashing (aOR 0.62 (.39-.99)) with a stronger effect in school age than preschool children. Mask use did not have enough uptake within the population to comment on its effectiveness[205]. A randomized trial of hand washing and mask wearing in Thailand during the

2009 H1N1 pandemic did not show decreased transmission within the household, however community transmission was not assessed[206]. A small study prior to the H1N1 pandemic showed hand sanitizer gel was minimally disruptive and highly acceptable, with 94-100% of grade kindergarten to grad 6 teachers reporting they would use in a pandemic. A trial of mask use was moderate to severely disruptive for the majority, although 94-100% teachers would also use in a pandemic[207].

Importantly, there are no studies examining the efficacy of cloth masks in decreasing transmission of respiratory viruses in the community, in children or in adults. For more details on the effectiveness of wearing masks in the general population, please refer to the Effectiveness of Wearing Masks to Reduce Spread of COVID-19 in the Community Rapid Review.

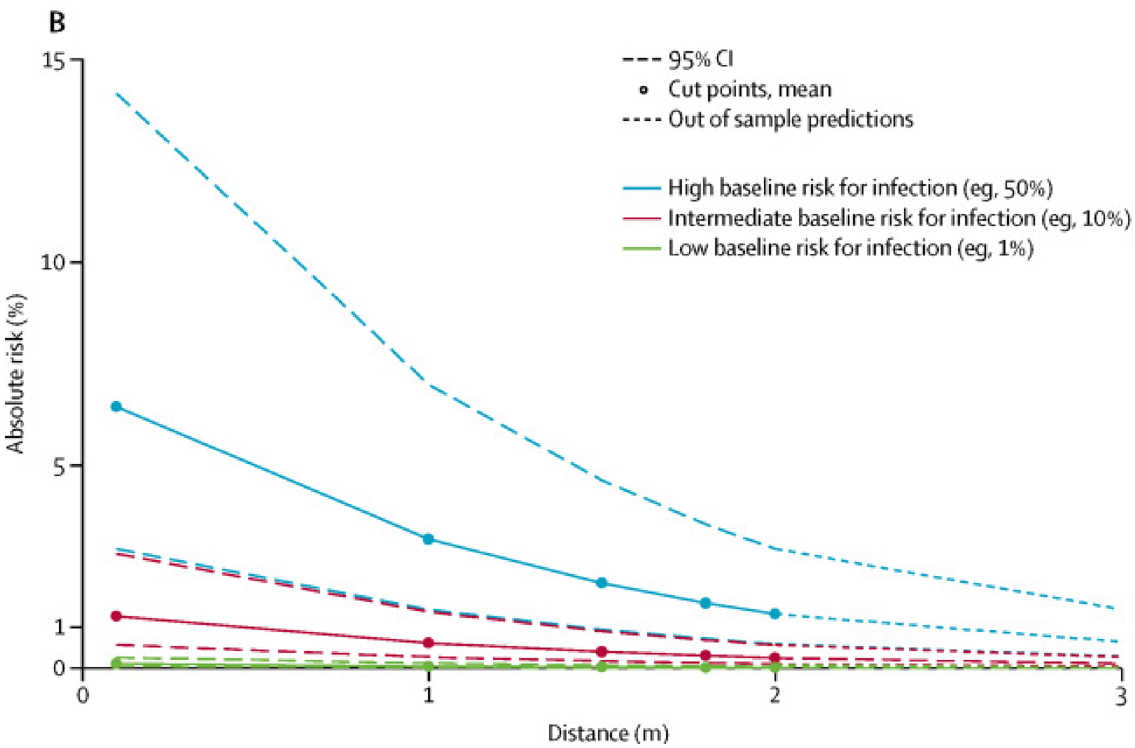

Figure 4a. Change in absolute risk with increasing distance (modified from Chu et al, 2020)[208]. Absolute risk of transmission from an individual infected with SARS-CoV-2, SARS-CoV, or MERS-CoV with varying baseline risk and increasing distance (B).

Schools Closures and Modelling Studies
As jurisdictions around the world relax or lift restrictions, early experiences and evidence has begun to emerge on the impact of reopening schools on COVID-19 transmission. As described previously, there are many media reports available on school outbreaks which presented case counts for students and/ or staff. These reports highlight the potential challenges to implementing the suggested PHIs in certain situations such as those with limited resources and vague PHI protocols[209,210].

Looking outside of COVID-19, an earlier systematic review[211] on the impact of school closures during the H1N1 influenza pandemic found that school closures mitigate community transmission, which illustrates the possibility that school closure can affect community transmission of some viruses. Analysis showed that the longer the school closures delayed an epidemic peak, the less the attack rate (r=0.479, p<0.05). Furthermore, there was a positive correlation between the duration of infectiveness and delaying the epidemic peak through school closure (r=0.54, p<0.05). However, the degree to which influenza epidemic parameters can be used to infer COVID-19 epidemic is unclear given different transmission dynamics including the possibility of higher likelihood of presymptomatic transmission of COVID-19.

Contact patterns during school closures are of relevance in COVID-19 transmission, with a diary-based study comparing regular school/ work days and those during school-closure performed by Litvinova et al[212] during influenza season. A significant reduction in the number of contacts students have during school closure was seen, with a 75% reduction in contact in individuals age 0-18. This is attributable to the drop in students' contacts with classmates (6.3/day down to 0.5/day and schoolmates (1.5/day down to 0.3/day). A 20% reduction in student contacts with those 19-59 years old was also found, whereas a 52% increase was seen in student contacts with ≥60 years of age (52%). The latter observation suggests a role of grandparents in care or socialization during closures and raises concerns for enhanced risk to this group of COVID-19 transmission with school closure. With respect to changes in contacts for teachers during school closures, there was a 26% decrease in contact with individuals between 19-59 years of age[212]. In another paper from the same investigators, modeling the impact of school closures in Shanghai (where children age 5-19 represent 9.5% of the population school based closure policies were not sufficient to entirely prevent a COVID-19 outbreak, but they could affect disease dynamics and hence hospital surge capacity.[59]

Table 4b provides a summary of modelling studies that project the impact of school closures or re-openings on the transmission of SARS-CoV-2. The literature consistently indicates that school closures are potential supportive measures to reducing the spread of SARS-CoV-2[194,195,197,198,213,214]. However, much of the projection modelling for SARS-CoV-2 spread primarily focuses on transmission in the general population and includes PHIs such as school closures and school holidays. Further, it is important to note that the accuracy of projection models, which are always a simplification of the problem, are constrained by our limited and evolving knowledge of SARS-CoV-2 transmission dynamics. There are also many sources of uncertainty and no standardized approach for calculating and reporting uncertainty in these models. As such, interpretation of the results of modelling studies should always be considered within the context of these limitations. For more details on COVID-19 modelling studies, please refer to the COVID-19 Models, Scenarios & Thresholds Rapid Review.

With respect to the reopening of schools and their potential impact on the spread of SARS-CoV-2, a preprint from Panovska-Griffiths et al. [194] modelled the impact of various school reopening strategies (reopen in June vs phased reopening) in the United Kingdom, combined with relaxing of social distancing measures society-wide, using a stochastic agent-based model of SARS-CoV-2 transmission. The model suggests that avoidance of a secondary pandemic wave is possible across reopening scenarios using an enhanced strategy of testing 25-72% of symptomatic infections, tracing 40-80% of their contacts and isolating those cases that are symptomatic with/without a positive diagnosis. Alternatively, reopening schools on June 1, 2020 without testing, tracing and isolation strategies in place was projected to result in R increasing above 1, with a secondary wave projected at 2.5 times the size of the first wave. Limitations to the study include the level of uncertainty in the mode and use of a variety of sources across different settings.

Davies et al.[214] constructed a series of models to simulate age-stratified infection rate and impacts of 3 months of school closures using 3 cities in different countries with varying child demographics: Milan, Italy (high median age), Birmingham, UK (intermediate median age), Bulawayo, Zimbabwe (low median age) and compared influenza-like infection (ILI) to COVID-19. In ILIs, school closure decreased peak incidence 17-35%, whereas for COVID-19, school closure did not have as great an effect with a smaller delay and decrease in peak (1-6 day delay in peak and 9-18% decrease in peak). Modelling scenarios with assumption of high subclinical infectiousness resulted in higher impact of school closure on reducing transmission. Specifically, assumption of 100% subclinical infectiousness resulted in a 37-53% transmission reduction compared to 0% subclinical infectiousness[214]. The authors suggest that asymptomatic and presymptomatic infection transmission play a sizable role in peak modeling (assuming viability of viral load), and school closure is likely to be more effective if transmission before symptoms occurs.

Targeted school closures may be a consideration for regions with increased transmission. In a non-peer reviewed model, Munday and colleagues simulated a network model of school and household transmission based on familial connections between schools in the Netherlands. With an R_0 of 1.6, 5 to 28 percent of schools could seed an outbreak outside of their own province, demonstrating substantial variation in the impact of regional school closures. Closure of secondary schools appeared to reduce connectivity to other regions.

Negative modelled effects of school closures

It is important to note that not all studies have found that school closures are likely to positively impact the pandemic[133,215]. Potential exposure patterns in pediatric populations from daycare to high school have been explored in a systematic review and meta-analysis on the exposures of children outside of the home[216]. The authors report that child exposure to outside contacts may negate transmission reduction from school closures. Sports events, public transit, and visiting friends occurred in these age groups during school closures, with the outside contacts higher in children whose parents disagreed with the closures, and teenagers (12 years to 17 years) who were most often involved in activities outdoors. This suggests that school closures may shift the contact patterns of children and youth but may not eliminate transmission risk.

The effect of nonpharmaceutical interventions (including school closure) on SARS-CoV-2 transmission in Switzerland was assessed using the change in the basic reproduction number at a national and cantonal level based on hospitalization and death numbers (avoiding dependence on test availability)[202]. Reductions in R_0 started one week before school closure, synchronous with activity changes related to smartphone activity mobility patterns, and started before official implementation of nonpharmaceutical interventions, which sequentially included a ban on gatherings of >1000, school closures, closures of nonessential activities, and voluntary home isolation/ban on gatherings of more than 5 people. Overall nonresidential mobility decreased by 50-75%. Transmission reduction started slightly before measured mobility changes suggesting that messaging about basic hygiene may have initiated proactive behaviour change with positive effects prior to school closure[202].

Alteration in childcare patterns may also reduce impact in transmission and mortality rates intended by school closures. Bayham and Fenichel[215] modelled the impact of child-care obligations for US healthcare workers during school closures and the impact of healthcare worker absenteeism on mortality. The authors report that the healthcare sector in the US has very high child-care obligations (28.5%, 95%CI: 28.5, 29.1; for those with children aged 3-12), with 15% (95%CI: 14.8, 15.2) of health-care workforce not having additional support from household contacts. Further, the model showed that if the infection mortality rate rose to 2.35% from 2% following a 15% decline in available health-care workers based on child-care needs, then school closure could result in a higher number of deaths than those prevented[215].

Davies et al.[198] used a stochastic, age-structured transmission model to explore a range of intervention scenarios, including introduction of school closures, social distancing, shielding of elderly groups, self-isolation of symptomatic cases, and extreme lockdown-type restrictions in the UK. The authors suggest that when considering the potential impact of children being cared for by grandparents, over a period of school closure from March 17 (i.e. after intensive interventions implemented) to July 20, 2020, one additional contact per weekday between children younger than 15 years and an older individual could, in the worst case, almost eliminate the benefit of closing schools in terms of the number of deaths and peak ICU bed occupancy. The authors found that no single intervention (including school closures, social distancing, elderly shielding or self-isolation) would effectively impact R_0 enough to lead to the required decline in total case numbers. The most comprehensive scenario of interventions (i.e., deploying all four interventions simultaneously) resulted in the largest impact on decreasing R_0; however, it was only sufficient to halt the epidemic altogether in a small proportion of simulations.

In summary, the literature suggests that community-based PHIs can reduce transmission of SARS-CoV-2 although there is less data around these measures in pediatric age ranges. Implementing PHIs will vary across various situations depending on availability of resources and community prevalence of COVID-19. The current paucity of evidence on the appropriateness and effectiveness of PHIs in pediatric populations for COVID-19, especially in the school setting, precludes evidence-based recommendations at this time. The degree to which school closures may reduce COVID-19 transmission remains unclear; models are very subject to assumptions used and the reduced infection rate in, and possibly reduced transmission from children reduced the ability to infer from or compare to previous observations around school closures in influenza pandemics. The negative impacts of school closure, as described below, must be taken into consideration.

Until more evidence becomes available, risk-based assessments using prevalence data, analyzing pattern of outbreaks as related to schools, involving frontline staff to discuss feasibility of measures by age, and protocolized management of positive cases and contacts in the school/daycare can be suggested as practical guidance until more evidence becomes available. Further study to build high quality evidence is needed to expand the understanding of the age-stratified impact of PHIs to reduce SARS-CoV-2 transmission in pediatric populations as well as comparing the effectiveness of PHIs in pediatric populations compared to adult populations.

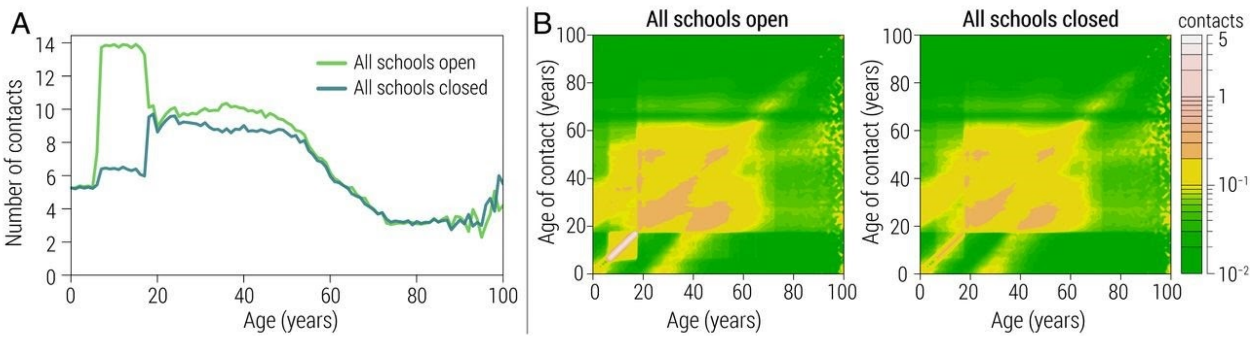

Figure 4b: ***Estimated number of contacts at the population level.*** Adapted from Litinova et al.[212] (*A*) Estimated mean daily number of contacts by age by assuming that all schools are either regularly open or closed at the same time as a consequence of the school-closure policy. (*B*) Estimated mean daily number of contacts by age of contact and contacted individuals, by assuming that all schools are regularly open (*Left*) and that all schools are closed at the same time as a consequence of the school-closure policy (*Right*).

5. What are the potential harms of school closures during pandemics for children?

COVID-19 infection so far has exhibited different age dynamics than other respiratory viruses such as influenza, and based on available evidence, schools are unlikely to be a primary driver of community transmission ink, the context of many school closure early in the COVID-19 pandemic. However, if there is ongoing community transmission, there is likely at least a corresponding risk of transmission in schools. The burden of morbidity and mortality in children is relatively small but transmission to adult school staff, and older family members remains a concern, and the effectiveness of public health measures in schools have not been well assessed.

There are clear potential harms to children, families and communities associated with prolonged school closures, primarily associated with social disparities that education systems attempt to level. These have been extrapolated from experience in previous pandemics, with multiple editorials, governmental and non-governmental agencies highlighting concerns, which are now becoming substantiated in media reports. In March, UNESCO estimated that 89% of the global student population was out of school due to COVID-19 school closures. In contexts of extreme poverty, gender disparities are compounded by lack of access to education by increasing girls and young women's roles in domestic responsibilities, susceptibility to abuse, early marriage and pregnancy[217,218]. Concerns of increase in undetected/unreported child abuse have also been raised in the US[219,220]. Early COVID-19 pandemic reports describe potential food insecurity in 6.6% of European children and up to 14% of American children, with school programs in the US feeding 35 million children in need daily[221,222]. Educational inequalities are also amplified during school closures, and while many schools offer digital classes, access to internet services is decreased in low income communities[222,223].

Lack of access to public health services provided by schools is also of concern. Several reports have highlighted the importance of schools in delivering vaccinations and concerns of lower immunization rates have been raised globally, with the WHO reporting a significant decrease in diphtheria, tetanus, pertussis vaccine in the first four months of 2020[224]. Early childhood services, such as speech and physical therapies, no longer have mechanisms to reach students in need[225,226]. Children with disabilities have also lost access to behavioural aides and support workers[227]. In areas of socioeconomic disadvantage, these services may not be attainable by other means.

Mental health has also been a concern for children during pandemics and school isolation. Decreased access to physical education, increased screen time and sleep disruption may affect their physical and mental health[228]. In addition, psychological impacts of quarantine and school closures have been noted. After the 2009 H1N1 pandemic, post-traumatic stress disorder symptoms were noted in up to 30% of quarantined children studied in the US[229]. A survey of grade 2-6 student from Wuhan in March 2020, showed increased rates of depressive and anxiety symptoms in students from Wuhan at 22.4% and 18.9% respectively, compared to 17.2% with depressive symptoms in previous studies[224]. Schools can be a mechanism for identifying and addressing mental health concerns in youth, including substance use and suicidal ideation[226]. A large UK survey in March of adolescents requiring mental health services reported a decline in mental health in over 80% of respondents, with 26% reporting inability to access further support[230]. Overall, children may be at increased risk of mental health concerns during school closures, with decreased accessibility to services.

Further challenges are introduced with respect to identifying appropriate interventions for schools to implement to mitigate COVID spread on reopening. Several agencies, including the American Academy of Pediatrics and Hospital for Sick Children have provided guidance, although effective means to implement ideal strategies is a concern[226,231,232]. While numerous agencies advocate for return to school, guidance on key public health interventions, such as physical distancing, class sizes and masks, differ. However, there appears to be consensus that school-based policies used to mitigate the spread of COVID-19 to prevent school closure must be balanced against harms to children, families and society with keeping children home. It may be important to prioritize education amongst other opportunities to expand social interaction and economic activities.

6. What are suggested strategies and considerations for safe school opening?

A number of international stakeholders in education, child health care and infection control have developed guidance of safe school reopening during the COVID-19 pandemic. The vast majority of these guidelines are based on expert opinion, as limited literature exists for the implementation of public health interventions in children. Difficulties arise to operationalize guidance when many levels of government, health care and education are involved in development, with varying resources and infrastructure available in different regions. Guidance documents also occasionally differ in opinion, potentially resulting in lack of clarity for the end user. In table 6, we summarize three major documents for school reopening, highlighting clarifications and suggestions from the Scientific Advisory Group. In addition, we provide further suggestions based on research summarized in this document and others from the Scientific Advisory Group.

School reopening strategies may be altered depending on level of community spread and phase of reopening in a particular region[233]. As there is continuous evolution of knowledge of the impact of SAR COV-2, guidance has to remain flexible to allow for incorporation of new evidence and response to outbreaks. However, the general principles of the guidance documents encourage maintaining the ability for students to be physically present within schools[234], due to significant psychosocial harms described previously.

Guidance on school reopening strategies are generally based around key public health interventions of screening, physical distancing, hygiene and face coverings (masks or shields). Recommendations on facial covering in children are the most variable, likely due to the lack of evidence in their utility in children[234,235]. Physical distancing guidelines also vary, which may due to the lack of physical space in many areas and an effort to balance the ability to return to school with physical distancing guidelines[233,234]. Discrepancies also exist in suggested screening protocols, especially whether screening should occur within homes or schools[233–235]. Significant interpretation of these guidelines will be required to develop practical implementation processes based on available resources.

The National Academy of Science, Engineering and Medicine guidance document was not included in the table of potential recommendations but merits some discussion for its equity lens and multistakeholder review process[236].

Highlighted issues include a discussion of the financial costs of potential mitigation strategies, and additional challenges in poorer quality buildings. Recommendations include a focus on local data use in shared decision making with public health officials, and development of decision making coalitions (such as a local task force) with representative of school staff, families, local health officials, and other community interests. A recommendation for federal and state level resource support to school districts is made with additional support suggested for aging facilities in under resourced areas. High priority mitigation strategies in this report include hand hygiene, physical distancing, mask wearing, and limiting large gatherings. Cleaning, ventilation and air filtration, and cohorting students are also endorsed. This report is not summarized in Table 6. A useful extract from it is provided in Figure 6 below, describing practices in different countries.[236].

Of note, The Hospital for Sick Children had released a comprehensive document outlining guidance for school reopening on June 17, 2020[232]. This was revised on July 29, based on evolving transmission data, public health guidance and input from broader medical, educational and geographical areas[2]. The more recent guidelines are highlighted below, with the main differences in the update concerning guidance are surrounding mask use, transitioning from 'not requiring or recommending' mask use, to recommending in older students when physical distancing cannot be maintained, and consideration in younger age groups[2]. There was considerable debate within the group and consensus was not reached on guidance. Subsequently, a level of agreement was stated. There is also more definitive guidance on physical distancing, with 1 metre acceptable for elementary and middle school students, and 2 metres preferred for high school.

Table 6. Suggested strategies for school reopening (AAP, Sick Kids, CDC)

Strategy	Guideline Suggestions	Considerations from Guidelines	Scientific Advisory Group Suggestions
Screening and Sick Plans	- School screening policies[1,233–235,237] - Home temperature checks[219] - Conduct daily health checks of staff and students[233] - Strict sick exclusion policies[1,233–235,237] - Plan for when staff/students become sick[233,234] - Routine virologic or serologic testing not recommended[234] - Implement flexible sick leave policies[233] - Have back up roster of trained staff[233] - Create communication system for staff and	School temperature checks are discouraged as they create lines and decrease educational time in large groups[234,235] Identify area to isolate and protocol for pickup/transport for anyone with COVID-like symptoms[233] Advise to not return until meet public health guidance to discontinue home isolation[233]	- Clear school symptom screening policies and protocols for staff and students - At home symptom checks (consider integration of health screening with online attendance records) prior to school (entrance screening may be appropriate in some settings), with emphasis on truthful reporting - Strict sick exclusion policies for staff and students, with sick leave benefits for staff, and clear sick leave policies, and back up rosters for teachers and staff - Sick plans for staff and students who develop symptoms on site (isolation areas/procedures, testing, return to school guidance) - Create communication systems for staff/students for self-reporting and exposure notification while testing results are pending - Develop protocols for preemptive isolation of cohorts or classes upon direction of public health for presumed COVID-19 contacts

	family to self-report and notify of exposures[233]		- Develop priority access to testing, and consider strategic asymptomatic testing of teachers/staff, and potentially older student as part of a public health-based school strategy and surveillance
Hygiene and Environ-mental mainten-ance	- Handwashing critical[1,233–235,237] - No sharing policies[1,233–235,237] - Decrease number of high touch surfaces - Clean high touch surfaces as often as possible (at least daily)[1,233–235,237] - May use soap and water, use hand sanitizer when not available[235] - Clean all indoor school equipment[1,233–235,237] - Outdoor play equipment with high touch surfaces should be cleaned regularly[234] -Optimize ventilation and increase outdoor air[233] - Ensure water systems are safe after prolonged closure[233]	Handwashing may be limited by access to soap and water Have adequate supplies to support healthy hygiene behaviours Post signs on how to stop the spread of COVID-19, properly handwash, everyday protective measures.	- Handwashing is critical and resources to teach handwashing and hygiene behaviours to staff and students should be available - Use soap and water when able, and hand sanitizer otherwise, with development of a sustainable supply chain for handwashing supplies - Structured handwashing opportunities (ie before and after eating, bathroom, entering school and classrooms, before and after outdoor time, and scheduled within room) at least 5 times daily - Strict no sharing policies for school supplies and food - Assess school setting for high touch surfaces and consider feasible interventions such as limiting closed doors, and installing motion sensor bathroom equipment if feasible. High touch surfaces should be cleaned regularly (once daily or more, although guidance may evolve with more data.) - Building maintenance should review HVAC systems, consulting if necessary, and optimize ventilation to reduce transmission risk as possible (refer to HVAC document). Individual classroom air conditioning units require specific review as maximizing the fraction of outside air and considering the pattern of air flow are potentially important considerations in reducing in middle and high school classroom transmission, based on evaluation of outbreak reports.
Physical Distancing and Cohorting	- Cohort classes[1,233–235,237] - Smaller class sizes if feasible[234,235]	Encourage cohorts for younger students and those with comorbidities. Cohort secondary students if possible, limit	- The purpose of cohorting is to limit mixing of student and staff exposure numbers are reduced in the event of a transmissible infection at school. Cohorting of classes as much as possible, with limited mixing in common spaces is advised (in gyms, lunch

	- Use outdoor spaces[234,235] - Desks 3-6 ft apart[2,234], 6 feet apart[233] - Cancel large gatherings, field trips, inter-group event[1,233–235,237] - Avoid singing and exercising in close proximity[234,235] - Cancel extracurricular activities in Step 1 and 2 opening[233] - Limit buses when possible[234,235] - Distance on school buses with one child/seat or alternate seats when possible[233] - Stagger drop off times[233] - Limit non-essential visitors[1,233–235,237] - Consider ways to accommodate children/families at risk of serious illness[233] -Students with medical conditions may attend school as usual, with health care guidance[235]	crossover of students and teachers. Consider intensive course blocks. Weigh benefits of physical distancing with benefits of maintaining in-school instruction. Maintain extracurricular activities if possible[234,235] Avoid parents in schools when possible and use plexiglass shields as needed	breaks, halls). A planned assessment of different cohort sizes for the purposes of reducing risk of infection and need to quarantine is suggested – in some setting classes may be able to be subdivided into alternate spaces to reduce crowding and contact numbers. The benefit of cohorting may be affected by busing/transport and after school care mixing as some children may be in several cohorts. - Where possible arrange classes to allow appropriate physical distancing (1-2m). One metre distancing may approach the benefits of 2 m distancing in the setting of asymptomatic individuals. For high school students, 2 metre distancing is preferred given potential higher transmission risk. Cohorts may be more feasible and socially acceptable in younger students than physical distancing - If physical distancing cannot be maintained, consider increasing access to alternate spaces for non-instructional time, with non-teacher staff for supervision if required, or alternating in person instruction with virtual instruction for older students -Maintain extracurricular activities when public health interventions can be maintained, with the exception of singing, band with wind instruments, and team based higher contact sports pending further data as these activities may confer higher transmission risk - Outdoor play and learning is valuable and transmission of the virus is likely reduced in outdoor settings. Outdoor sports, particularly individual sports where distancing can be maintained, such as track and field, may be preferred forms of physical activity. Refer to Guidance for Sport, Physical Activity and Recreation - In-person inter-school and class sports or academic competitions should be avoided pending further data. Within cohort sporting activities can be considered. - Consider layered public health interventions for school transport, such as

			parent drop-off, cohort car-pooling, school and public bus, such as physical distancing (one child/family per seat), support for hand hygiene, masks if currently recommended, and open windows if buses are used. Consider bus, carpool/ridesharing when designing cohorts if possible. - Restrict non-essential visitors to schools, and visitors attend time should be limited with pre-visit symptom screening, and public health interventions in place. - Develop individual plans for students with health concerns to minimize risk and allow inclusion if feasible with particular attention to those with respiratory support needs (i.e. consider medical grade masks). Families that choose not to send their child/youth to school require remote learning opportunities and support.
Eating	- Cohort in classroom or outside[1,233–235,237] - Close communal spaces if possible[1,233–235,237] Separate lunch breaks[234,235] - Eat outside if possible[234,235]	Maintain school lunch programs during school closures for food security issues Bring own lunches if possible If meals provided, individually plate to limit shared utensils	- Cohort students in classrooms or outside if possible - Physical distance in communal spaces for eating - If lunch provided, individually plate in kitchen - Maintain resources for lunch program delivery to students if schools close - Provide easy access to hand hygiene
Masks/ Face Coverings	- Universal face coverings in high school when not distanced[2,233,234] - Use when feasible in elementary[234] -When community transmission is low, mask use should not be mandatory for any age group (SK, 78% agreement) -Mask not currently recommended for elementary school (SK 61% agreement), 33%	Mask use is not recommended for children under 2 years and may be difficult to implement for preschool ages. Teach staff and students proper use, removal and washing of face coverings. Ensure efforts are made for physical distancing to allow for breaks from mask wearing Consider medical, developmental or mental	Although the degree of anticipated risk reduction from cloth mask use is unclear (based on a paucity of data), to be consistent with other interim public health recommendations regarding cloth masking when unable to distance in group indoor settings, based on current data, cloth masks may be supported in older children and teens (>10 years / grade 4) who may be more likely to transmit COVID 19 than younger children, be better able to adhere to proper use, and have potentially fewer communication challenges due masking. Evolving evidence around the utility of mask use in community and school settings is expected and would guide further recommendations. - In low transmission settings the masking considerations below would be OPTIONAL to implement based on the current public health

	recommended when distancing not maintained. -Masks recommended for middle school when physical distancing not maintained (SK 64% agreement) -Masks recommended for high school when distancing not maintained (SK 61% agreement, 22% recommend at all times). - Masks not required for staff, unless physical distancing not maintained[235] - Teach and reinforce face covering in all staff[233]	health reasons for inability to mask wear. Facial expressions are an important part of communication and should be taken into consideration when developing PPE strategies for teachers. Mask use should not be discouraged if a personal choice is made to wear.	direction, and individuals who either choose to wear masks, or not to wear masks when no mandate is in place should not be stigmatized[2]. - Where masks are recommended, teach and reinforce appropriate practices for staff and students including hand hygiene with doffing, and reinforce that the potential utility of masking is maximized with consistent use by the majority. - There may be contraindication for developmental, medical or mental health reasons: - School-aged children and youth who are not able to remove their mask without assistance should not wear a cloth mask due to safety concerns. - Children or youth who cannot tolerate a mask due to cognitive, sensory or mental health issues should also be exempt. - It should be noted and explained when and why different rules may exist in school settings and other public spaces (ie schools have additional protection through screening, hand hygiene, cohorting). - All day mask wearing is difficult so safe removal for part of the day with enhanced distancing may be important. ***Considerations by age range:*** Based on current evidence, - In elementary school: in younger grades (under age 10/Grade 4), where transmission and illness from COVID-19 are lower, cohorting and hand hygiene may be favoured over strict distancing or masking for developmental reasons. - In middle school, masks may be considered for all staff and students when physical distance cannot be maintained - In high schools, masks may be encouraged for all staff and students when physical distance cannot be maintained - Schools should consider participation in selected outcomes evaluation of policies that may include mask or no mask use, with cohorting, distancing, hand hygiene) combinations - There is insufficient data to recommend use of cloth masks vs clear face shields as there are no trials of either in community or school settings. Outcome evaluations should be developed to assess the use of face shields if

			they are considered in specific school settings. - Consider school supplied masks, particularly for students in lower socioeconomic areas if masks are part of the school opening strategy. - Students with health conditions that place them at higher risk of severe disease who are part of a cohort that is recommended for mask use should use medical masks, and teachers with higher risk conditions should be supplied with medical masks, and consider the use of eye protection for personal risk reduction as well, consistent with World Health Organization Technical Guidance[4].
Health considerations, including children with complex needs	- Use inhalers and spacers over nebulizers when possible[234] - Have N95 equipment available for aerosol generating procedures[234] -The majority of children with underlying medical conditions are safe to attend school. Discussion with health care providers is recommended. Particular attention should be given for those with new or augmented immunosuppression (SK) Consideration is required for children with medical, physical, developmental and behavioural complexities[2] - Continue school immunizations[234] - Mental health outreach[234,235]		- If students with complex medical needs require aerosol generating procedures in school settings (eg. nebulizer therapy, suctioning of tracheostomy) additional precautions will need to be considered. - Ensure mental health programs available for staff and students - Continue school immunizations - Educate families and students about SARS-CoV-2 and prevention practices -Minimizing the number of transitions for supply teachers, and consider a 2 week interval between assignments -Most children with underlying medical conditions are safe to return to school after discussion with their health care providers. Health care providers will provide direction for those with immune suppression or complex needs. -Consideration is required for children with medical, physical, developmental and behavioural complexities

	Educate families and communities on risks of SARS CoV-2[233,235]		
School Closures	In the event a person diagnosed with COVID-19 has been in the building and poses a risk, consider closing for 1-2 days for disinfection[233] Consider extended school dismissals when community transmission is substantial[233]	Maintain distance learning, meal programs and other essential services Continue to coordinate with health officials	- School closures will be at the discretion of public health - Regional school closure may need to be considered in situations of elevated community transmission and large cluster events identified to be related to a school. - Consider a lower threshold for high schools to close than primary schools due to the larger geographical areas covered by high schools, potential for increased transmission in adolescents and increased ability for virtual teaching. Advice regarding out of school social interactions should be provided including consideration for social cohorting, outdoor activities, and preference for more virtual interactions.

Figure 6: Table summarizing health guidelines from international sources. Adapted from Melnick et al[236]

Summary of Health and Safety Practices

	China	Denmark	Norway	Singapore	Taiwan
Context	Gradual reopening since March	Opened April 15 for children up to age 12	Opened April 27 for Grades 1–4	Opened until April 8, then closed due to non-school-related outbreak	Never fully closed; local, temporary closures as needed
Health screening	Temperature checks at least twice daily	Temperature checks on arrival	Temperature checks on arrival	Temperature checks twice daily	Temperature checks on arrival
Quarantine and school closure policy	Quarantine if sick until symptoms resolve	Stay home 48 hours if sick	Stay home if sick until symptom-free 1 day	Quarantine required and legally enforced if one has had close contact with a confirmed case; school closes for deep cleaning if case confirmed	Class is suspended 14 days if one case confirmed, school suspended 14 days if 2+ cases
Group size and staffing	Class size reduced from 50 to 30 in some areas of the country	Class sizes reduced to accommodate 2-meter (6 feet) separation in classrooms; non-teaching staff provide support	Maximum class size 15 for Grades 1–4, 20 for Grades 5–7	No maximum class size; classrooms are large enough to ensure 1–2 meter (3–6 feet) separation	No maximum class size; students in stable homerooms; subject-matter teachers move between classes
Classroom space/ physical distancing	Group desks broken up; some use dividers	Physical distancing (2 meters) within classrooms; use of outdoor space, gyms, and secondary school classrooms	Physical distancing within classrooms; use of outdoor space encouraged	Group desks broken up in Grade 3 and up; 1–2 meter (3–6 feet) distance maintained	Group desks broken up; some use dividers
Arrival procedures	Designated routes to classes; multiple entrances	No family members past entry; staggered arrival/ dismissal	No family members past entry; staggered arrival/ dismissal	No family members past entry; parents report travel; staggered arrival/ dismissal	No family members past entry
Mealtimes	Eat at desks or, if cafeteria used, seating is assigned in homeroom groups	Sit well apart while eating; no shared food	Eat at desks or, if cafeteria used, homeroom groups enter in shifts	Assigned seating in cafeteria with 1–2 meter (3–6 feet) spacing	Eat at desks; some use dividers
Recreation	Some schools have suspended physical education	Students play outside as much as possible; play limited to small groups within homeroom	Students sent outside as much as possible; play limited to small groups; outdoor space divided and use is staggered	Inter-school sports suspended; small-group play time staggered	Sports and physical education suspended
Transport	Using "customized school buses" with seats farther apart to limit proximity	School buses allowed; only one student per row	Private transportation encouraged; one student per row on buses	Still running buses and public transit	Still running buses and public transit, cleaning at least every 8 hours
Hygiene	Masks required, provided by the government; frequent handwashing	Frequent handwashing; posters and videos provided	Staff training on hygiene standards; frequent handwashing; posters and videos provided	Frequent handwashing; posters and videos provided	Masks required, provided by the government; windows and air vents left open
Cleaning	Guidance for cleaning, disinfecting, and waste disposal	Guidance for cleaning and disinfecting; government provides cleaner, thermometers	Guidance for frequent and thorough cleaning; disinfecting not required; students help clean	Common areas cleaned frequently (e.g., every 2 hours); students help clean	Detailed guidance for cleaning and disinfecting common areas

SOURCE: *Reopening Schools in the Context of COVID-19: Health and Safety Guidelines From Other Countries* by Hanna Melnick and Linda Darling-Hammond, with the assistance of Melanie Leung, Cathy Yun, Abby Schachner, Sara Plasencia, and Naomi Ondrasek

Evolving Evidence

The evidence for these research questions is rapidly evolving. Many jurisdictions are currently developing guidance and protocols for reopening schools based on the evidence to date, which is mainly observational, during early periods of the COVID-19 pandemic, when mass societal isolation and school closures were in place in most areas. As there is increased social, economic and education reopening, along with changes in testing protocols, identified transmission dynamics in children will likely evolve. This review will be updated as new data from quality trials and studies are available.

Date question received by advisory group: June 4, 2020
Date report submitted to committee: July 9, 2020
Internal recirculation of updated draft to key stakeholders: August 7, 2020
Date of first assessment: August 7, 2020
(If applicable) Date of re-assessment:

Authorship and Committee Members

This review was written by Allison Carroll, Anne Hicks, and Lynora Saxinger (co-chair), with assistance from Seija Kromm and Jamie Boyd, with further research assistance from Shelby Henry, Aaron Vander Leek, Alexander Hicks, Caseng Zhang, and external scientific review by Alexander Doroshenko, Bonita Lee, Catherine Burton, Joseph Vayalumkal, Michelle Bailey and Susanne Benseler. The Scientific Advisory Group was involved in discussion and revision of the document: Braden Manns (co-chair), Lynora Saxinger (co-chair), John Conly, Alexander Doroshenko, Shelley Duggan, Nelson Lee, Elizabeth Mackay, Andrew McRae, Jeremy Slobodan, James Talbot, Brandie Walker, and Nathan Zelyas. Additional acknowledgements for research and report generation assistance: Prachi Shah, Yuba Raj Paudel, Amanda Davis, Bronwen Hicks and Zoha Khawaja.

Appendix

List of Abbreviations

ACE2: angiotensin-2-converting enzyme 2 protein

AHS: Alberta Health Services

CI: confidence interval

COVID-19: Coronavirus Disease-2019

ddPCR: droplet digital polymerase chain reaction

H1N1: influenza A

ICU: intensive care unit

IgA: Immunoglobulin A

IgG: Immunoglobulin G

IgM: Immunoglobulin G

ILI: influenza-like illness

KRS: Knowledge Resource Services

MERS: Middle East Respiratory Syndrome

Nabs: neutralizing antibodies

NPI: non-pharmaceutical intervention

PCR: polymerase chain reaction

PHI: public health intervention

R_0: basic reproductive number

R_{eff}: effective reproductive number

RCT: randomized controlled trial

RNA: Ribonucleic acid

RT-PCR: Reverse transcription polymerase chain reaction

SAG: Scientific Advisory Group

SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2

TMPRSS2: transmembrane serine protease 2 protein

Methods

Literature Search

A literature search was conducted by Nicole Loroff, a Knowledge Resources Services (KRS) librarian within the Knowledge Management Department of Alberta Health Services. Search was conducted in OVID MEDLINE, PubMed, TRIP Pro, Google, Google, LitCovid, WHO Global Research Database on COVID-19, CADTH, National Institute for Health and Care Excellence (NICE), Centre for Evidence-Based Medicine (CEBM), medRxiv & BIORxiv. The media search included Twitter, Reddit, Google, Facebook & Apple News. The flow of study inclusion is depicted in a PRIMSA Diagram (Figure 1). A total of *222* studies were included within this review document based on the inclusion/ exclusion criteria (Tables 2 & 3).

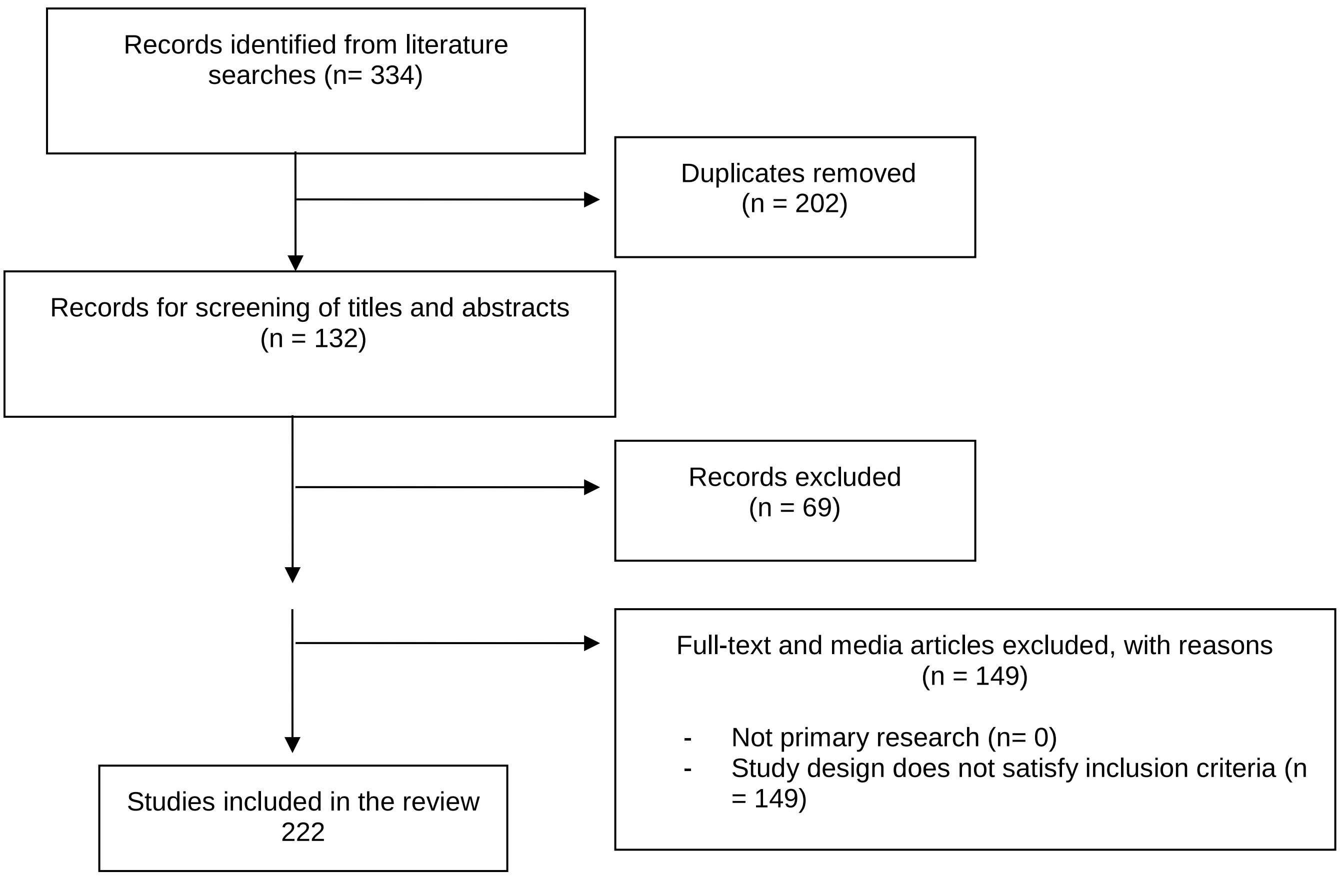

Figure 1: Modified PRISMA diagram of the literature screening process

Table 1: Inclusion and exclusion criteria for the literature search

Inclusion Criteria	Exclusion Criteria
• Must mention COVID-19 (SARS-CoV-2) - Specifically mentions child within article • No parameters with respect to infection or death rate but they will be documented • No country limits • Published in 2020 • English language or viable in Google translate • Peer-reviewed research • Pre-print research • Reputable grey literature (eg. government reports) • Media articles • Blog posts • Academic institutions (eg. case count websites) • No restriction on research methods	1. Article is not from a credible source 2. Article does not have a clear research question or issue 3. Presented data/evidence is not sufficient to address the research questions 4. Does not mention COVID-19 (SARS-CoV-2) 5. Does not specifically mention child of any age 6. Only discusses all ages results 7. Languages other than English (peer-reviewed literature) or that could not be translated using Google Translate (grey literature)

Table 2. Inclusion and exclusion criteria for sources to be considered in the rapid review

Inclusion Criteria	Exclusion Criteria
• Must mention COVID-19 (SARS-CoV-2) - Specifically mentions child within article • No parameters with respect to infection or death rate but they will be documented • No country limits • Published in 2020 • English language or viable in Google translate • Reputable source (can be correlated) • Reputable grey literature (eg. government reports) • Media articles • Blog posts • Academic institutions (eg. case count websites) • No restriction on research methods	1. Article is not from a credible source 2. Presented data/evidence is not sufficient to address the research questions 3. Does not mention COVID-19 (SARS-CoV-2) 4. Does not mention child of any age (only total people or unspecified numbers or no numbers) e.g. daycare outbreak with no details 5. Languages other than English (peer-reviewed literature) or that could not be translated using Google Translate (grey literature)

Exclusion criteria for study quality were adapted from the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018). Potential articles were evaluated on three criteria: 1) Peer reviewed or from a reputable source; 2) Clear research question or issue; 3) Whether the presented data/evidence is appropriate to address the research question. Preprints and non peer-reviewed literature (such as commentaries and letters from credible journals) are not excluded out of hand due to the novelty of COVID-19 and the speed with which new evidence is available.

Table 2 below is a narrative summary of the body of evidence included in this review. The categories, format, and suggested information for inclusion were adapted from the Oxford Centre for Evidence-Based Medicine, the Cochrane Library, and the AGREE Trust (Urwin, Gavinder & Graziadio, 2020; Viswanathan et al, 2012; Wynants et al., 2020; Brouwers et al., 2010).

Table 2. Narrative overview of the literature included in this review.

	Description
Volume	332 publications and 98 media articles were included
Quality	For studies, consider issues such as: • Most studies were case reports and series, with some population-level data analyses and modeling studies. • Sample sizes ranged from population-level studies with thousands of participants, although these were few in number, to single case reports and case series with as few as 1-3 participants (most frequent). • Risk of bias: The risk of bias in this review was considerable. Emerging data is published daily, and in most countries, limitations on test type and availability existed, particularly during times when the outbreak evolved rapidly. Death rates are felt to be significantly underrepresented, particularly during disease peak times when many died without testing. Asymptomatic individuals may never have been tested in many scenarios, particularly in hard-hit countries; the exception is in China, where contacts of confirmed cases were sometimes hospitalized and observed, although for a variable period of time, whether or not they tested positive. The significant selection bias presented by these scenarios suggests that the number of symptomatic and asymptomatic cases and severity of cases cannot be estimated. Sponsor/source bias is introduced by willingness of different countries and reporting agencies and their ability to report cases; Reporting bias and adequacy: testing was not adequate in many situations, and given the rapidity and limited testing available, and difficulty determining whether cases were reported only once or included in larger analyses contributes to reporting bias. Attrition bias is less likely; with most of these studies being cross-sectional with limited if any follow-up attrition was not an issue. Performance bias was considerable; depending on test availability and local protocol different criteria to get tested and different types of test varied not only between locations but also over time in the same locations; in some cases even the sample site (nasopharyngeal vs oropharyngeal) changed over time. Detection bias was also an issue since tools and measures varied; as well the type of test and interpretation of testing varied. Individual studies may provide low quality evidence for one outcome but high quality evidence for another. This study was based almost entirely on individual studies; the rapidly evolving nature of the situation has not allowed for production of significant high quality studies or systematic reviews of the literature. • Time frames varied and depending on the state of the epidemic in specific locations outcomes and detection varied. This was addressed in the document as feasible. • Controls were not always the same as intervention groups, and intervention varied considerably (for instance, distancing in some schools was 2 m and in other schools 1.5 or 1 m; mask wearing varied between 'all the time' and 'only between classes'

	and the use of air conditioning and adherence to safety measures also varied). As well, different countries had varying rates of background community spread and public health interventions in place when schools opened, different ages of children came to school, and cohorting practices varied. For guidelines, consider (Brouwers et al. 2010): • Guideline sources for public health interventions and school opening varied by jurisdiction. • Author conflict of interest varied. Due to the rapid evolution of data, media was included; where feasible media sources were backed up with government or institutional data, however this was not always possible, and even crowdsourced data was used for daycare cases (indicated in review). When it was not possible to connect media stories with at least institutional data, cross-referencing between media stories and local demographic information was used as much as possible, and legitimate (mainstream) media were a focus. • Most data gathering for journal articles was opportunistic, using public health collections, existing population cohorts and reported cases with contact tracing rather than any formal recruitment strategies with clear inclusion and exclusion criteria. • Few studies, mainly those that adapted existing cohorts for evaluation for COVID-19 antibodies, described any form of stakeholder or participant engagement methods. Most studies and reports reflected samples of convenience. • The values and goals of impacted populations were not described in most of the published literature; a few of the news articles quoted individual people or surveys regarding their opinions on topics such as wearing a mask in public, but only one[203] reported results of an actual survey and even in that case considerable bias, given that the survey was voluntary, was likely. • Potential identified and unintended harms associated with interventions were discussed in this survey. • Health equity was considered and found to have a considerable effect on people in the study. The most vulnerable populations are most at risk of infection, and also most at risk of having their children kept home from school. This report identified that considerable effort will be required to protect vulnerable populations from additional inequity due to the impact of both COVID-19 and the health measures implemented to help control transmission.
Applicability	The literature search returned studies from around the world and so inclusion was prioritized to those most applicable to an Alberta context. The amount of available evidence directly relevant to answering the questions varied by but all of which had limited evidence, particularly high quality evidence across questions.
Consistency	Data and solutions varied considerably by source type and jurisdiction; even timeline impacted both data and solutions due to rapid evolution of knowledge about SARS-Co-V-2 and the constantly changing demographic of its spread as well as variations in management and reporting.

Search Strategy

PICO

- **P**opulation of interest:
    -Younger children ages 0-9 and older children aged 10-19
- **I**nterventions/Exposure:
    -School or daycare setting

-Use of isolation precautions
- **C**omparator:
-Adults
- **O**utcome:
-Asymptomatic or mild infection with COVID-19 (SARS-CoV-2)
-Transmission of COVID-19 (asymptomatic and symptomatic), especially to -teachers and daycare staff
-PCR and RNA viral loads and viable virus
-Location of infection
-Utility of public health interventions

KRS SEARCH STRATEGY

Database(s): **Ovid MEDLINE(R) and In-Process & Other Non-Indexed Citations and Daily** 1946 to June 10, 2020

Search Strategy: #	**Searches**	**Results**
1	exp Coronavirus/ or Coronavirus Infections/ or coronaviru*.mp. or corona viru*.mp. or ncov*.mp. or n-cov*.mp. or novel cov*.mp. or COVID-19.mp. or COVID19.mp. or COVID-2019.mp. or COVID2019.mp. or SARS-CoV-2.mp. or SARSCoV-2.mp. or SARSCoV2.mp. or SARSCoV19.mp. or SARS-Cov-19.mp. or SARSCov-19.mp. or SARSCoV2019.mp. or SARS-Cov-2019.mp. or SARSCov-2019.mp. or severe acute respiratory syndrome coronaviru*.mp. or severe acute respiratory syndrome cov 2.mp. or 2019 ncov.mp. or 2019ncov.mp.	25868
2	exp Child/ or Adolescent/ or Young Adult/ or (child* or kid or kids or toddler* or infant* or baby or babies or newborn* or teen* or youth* or youngster* or adolescent* or adolescence or juvenile* or minors or pediatric*).ab,ti.	4255735
3	1 and 2	2240
4	limit 3 to english language	2003
5	limit 4 to yr="2020 -Current"	665
6	Schools/ or School Teachers/ or Child Day Care Centers/ or (school* or highschool* or pre-school* or preschool* or daycare* or day care* or day-care* or childcare or child care or teacher*).ab,ti.	336820
7	5 and 6	32
8	1 and 6	160
9	limit 8 to english language	145
10	limit 9 to yr="2020 -Current"	101
11	exp Disease Transmission, Infectious/ or (transmit* or transmiss* or infectivity or infectiousness or spread*).ab,ti.	738522
12	5 and 11	222

13	exp Family/ or (house or household* or home* or family or familial or families or parent* or caregiver*).ab,ti.	1988329
14	(child-to-adult or "child to adult" or child-to-parent or "child to parent").ab,ti.	5124
15	13 or 14	1989831
16	12 and 15	62
17	RNA, Viral/ or (RTPCR or RT-PCR or RNA or viral load* or mRNA).ab,ti.	971785
18	5 and 17	64
19	exp Asymptomatic Diseases/ or (asymptomatic or presymptomatic or pre-symptomatic or "not showing symptom*" or "not displaying symptom*" or subclinical or mild or milder or severity).ab,ti.	910155
20	(no adj2 symptom*).ab,ti.	22364
21	19 or 20	927490
22	5 and 21	156
23	exp Infection Control/ or exp Hand Hygiene/ or Masks/ or Social Distance/ or (mask* or facemask* or face-mask* or distancing or hand wash* or contact*).ab,ti.	525782
24	5 and 23	170
25	Coronavirus Infections/pc [Prevention & Control]	1777
26	2 and 25	125
27	limit 26 to english language	115
28	limit 27 to yr="2020 -Current"	78

PubMed

Search Strategy: #	**Searches**	**Results**
1	"coronavirus"[MeSH Terms] OR "coronavirus infections"[MeSH Terms] OR "coronaviru*"[Title/Abstract] OR "corona virus"[Title/Abstract] OR "ncov*"[Title/Abstract] OR "n cov*"[Title/Abstract] OR "novel cov"[Title/Abstract] OR "COVID-19"[Title/Abstract] OR "COVID19"[Title/Abstract] OR "COVID-2019"[Title/Abstract] OR "COVID2019"[Title/Abstract] OR "SARS-CoV-2"[Title/Abstract] OR "SARSCoV-2"[Title/Abstract] OR "sarscov2"[Title/Abstract] OR "SARSCoV19"[Title/Abstract] OR "sars cov 19"[Title/Abstract] OR "severe acute respiratory syndrome cov 2"[Title/Abstract] OR "2019 ncov"[Title/Abstract] OR "2019ncov"[Title/Abstract] OR "severe acute respiratory disease"[Title/Abstract]	40804
2	"child"[MeSH Terms] OR "adolescent"[MeSH Terms] OR "young adult"[MeSH Terms] OR "child*"[Title/Abstract] OR "kid"[Title/Abstract] OR	4302885

	"kids"[Title/Abstract] OR "toddler*"[Title/Abstract] OR "infant*"[Title/Abstract] OR "baby"[Title/Abstract] OR "babies"[Title/Abstract] OR "newborn*"[Title/Abstract] OR "teen*"[Title/Abstract] OR "youth*"[Title/Abstract] OR "youngster*"[Title/Abstract] OR "adolescent*"[Title/Abstract] OR "adolescence"[Title/Abstract] OR "juvenile*"[Title/Abstract] OR "minors"[Title/Abstract] OR "pediatric*"[Title/Abstract]	
3	1 and 2	3351
4	limit 3 to english language	3003
5	limit 4 to yr="2020 -Current"	1372
6	"schools"[MeSH Terms] OR "school teachers"[MeSH Terms] OR "child day care centers"[MeSH Terms] OR "school*"[Title/Abstract] OR "highschool*"[Title/Abstract] OR "pre school*"[Title/Abstract] OR "preschool*"[Title/Abstract] OR "daycare*"[Title/Abstract] OR "day care*"[Title/Abstract] OR "day care*"[Title/Abstract] OR "child care"[Title/Abstract] OR "childcare"[Title/Abstract] "teacher*"[Title/Abstract]	348952
7	5 and 6	74
8	1 and 6	324
9	"disease transmission, infectious"[MeSH Terms] OR "transmit*"[Title/Abstract] OR "transmiss*"[Title/Abstract] OR "infectivity"[Title/Abstract] OR "infectiousness"[Title/Abstract] OR "spread*"[Title/Abstract]	754384
10	5 and 9	389
11	(Family[MeSH Terms]) OR (house[Title/Abstract] OR household*[Title/Abstract] OR home*[Title/Abstract] OR family[Title/Abstract] OR familial[Title/Abstract] OR families[Title/Abstract] OR parent*[Title/Abstract] OR caregiver*[Title/Abstract] OR child-to-adult[Title/Abstract] OR "child to adult"[Title/Abstract] OR child-to-parent[Title/Abstract] OR "child to parent"[Title/Abstract])	2046697
12	10 and 12	107
13	(RNA, Viral[MeSH Terms]) OR (RTPCR[Title/Abstract] OR RT-PCR[Title/Abstract] OR RNA[Title/Abstract] OR viral load*[Title/Abstract] OR mRNA[Title/Abstract])	992527
14	5 and 13	107
15	"asymptomatic diseases"[MeSH Terms] OR "asymptomatic"[Title/Abstract] OR "presymptomatic"[Title/Abstract] OR "pre-symptomatic"[Title/Abstract] OR "subclinical"[Title/Abstract] OR "mild"[Title/Abstract] OR "milder"[Title/Abstract] OR "severity"[Title/Abstract]	930339
16	5 and 15	299
17	"infection control"[MeSH Terms] OR "hand hygiene"[MeSH Terms] OR "masks"[MeSH Terms] OR "social distance"[MeSH Terms] OR "mask*"[Title/Abstract] OR "facemask*"[Title/Abstract] OR "face	537101

	mask*"[Title/Abstract] OR "distancing"[Title/Abstract] OR "hand wash*"[Title/Abstract] OR " contact*"[Title/Abstract]	
18	5 and 17	239

TRIP Pro/Google/Google Scholar (first 10 pages screened)

(coronaviru* OR "corona virus" OR ncov* OR n-cov* OR COVID-19 OR COVID19 OR COVID-2019 OR COVID2019 OR SARS-COV-2 OR SARSCOV-2 OR SARSCOV2 OR SARSCOV19 OR SARS-COV-19 OR SARSCOV-19 OR SARSCOV2019 OR SARS-COV-2019 OR SARSCOV-2019 OR "severe acute respiratory syndrome cov 2" OR "severe acute respiratory syndrome coronavirus*" OR "2019 ncov" OR 2019ncov) AND (child* or kid or kids or toddler* or infant* or baby or babies or newborn* or teen* or youth* or youngster* or adolescent* or adolescence or juvenile* or minors or pediatric) from:2020

coronaviru* OR "corona virus" OR ncov* OR n-cov* OR COVID-19 OR COVID19 OR COVID-2019 OR COVID2019 OR SARS-COV-2 OR SARSCOV-2 OR SARSCOV2 OR SARSCOV19 OR SARS-COV-19 OR SARSCOV-19 OR SARSCOV2019 OR SARS-COV-2019 OR SARSCOV-2019 OR "severe acute respiratory syndrome cov 2" OR "severe acute respiratory syndrome coronavirus*" OR "2019 ncov" OR 2019ncov) AND (child* or kid or kids or toddler* or infant* or baby or babies or newborn* or teen* or youth* or youngster* or adolescent* or adolescence or juvenile* or minors or pediatric) AND (school* or highschool* or pre-school* or preschool* or daycare* or day care* or day-care* or child care or childcare or teacher*) from:2020

LitCovid/WHO Global Research Database on COVID-19/CADTH/National Institute for Health and Care Excellence (NICE)/Centre for Evidence-Based Medicine (CEBM)/medRxiv &BIORxiv (date limited where possible; keywords searched in conjunction with covid-19 terms where necessary)

child or children or children transmission or school or daycare or childcare of children mask or children distancing or children hand hygiene or children hand washing or children asymptomatic or children symptomatic or children viral load or children RTPCR

MEDIA SEARCH STRATEGY

Grey Literature sources/strategies included:

- Twitter:
    - covid and school and case - 0 screened
    - covid and daycare - 0 screened
    - daycare and covid and outbreak - 1 screened; 1 accepted
    - school and covid and outbreak - 3 screened; 2 accepted
    - covid and transmission and school - 1 screened; 1 accepted
    - coronavirus and case and school - 6 screened; 5 accepted
    - coronavirus and daycare and outbreak - 0 screened
    - coronavirus and teacher and cases - 2 screened; 2 accepted
    - children and COVID-19 and transmission - 1 screened; 1 accepted
    - coronavirus and child and transmission - 0 screened

- community and coronavirus and child - 0 screened
- coronavirus and teacher and cases - 1 screened; 1 accepted
- daily twitter update following the source "CBC" - 1 screened; 1 accepted

- Reddit:
  - covid and school and case - 22 screened; 16 accepted
  - coronavirus and school and transmission - 1 screened; 1 accepted
  - COVID-19 and school - 2 screened; 1 accepted
  - covid and daycare - 0 screened
  - covid and child and transmission - 0 screened
  - coronavirus and child and case - 0 screened
- Google:
  - COVID-19 and daycare and outbreak - 12 screened; 5 accepted
  - coronavirus or COVID-19 and school or daycare - 6 screened; 5 accepted
  - coronavirus or covid-19 and teacher and cases - 6 screened; 2 accepted
- Facebook:
  - coronavirus and school - 3 screened; 3 accepted
  - coronavirus and daycare - 8 screened; 6 accepted
  - COVID-19 and school - 5 screened; 2 accepted
  - COVID-19 and daycare - 3 screened; 1 accepted
- Apple News:
  - Apple News Feed - 1 screened; 1 accepted

Critical Evaluation of the Evidence

There were considerable variations in the quality of evidence presented in this review, which are summarized in Table 2 of the Appendix. In brief, COVID-19 emerged near the end of 2019 and has rapidly progressed in the form of a global pandemic, impacting various countries differently based on the timeline of appearance and ability to suppress transmission through public health measures and other means. Each country has faced limitations in identifying, tracing and caring for patients that has made it impossible to identify the number of people infected (denominator) or attribute mild, moderate and severe symptoms and even death to COVID-19 accurately. Schools were closed in many countries for a number of months and return to school has been implemented differently across local, provincial and national jurisdictions, with variable background community rates and public health precautions at the time of reopening, further limiting the interpretation of data. Even detection of the virus in human samples varies by location of sampling and assay type, and it is not entirely clear when detection of viral particles by RNA analysis is equivalent to carriage of infectious virus. Seropositivity studies are limited by availability, participation and the potential for cross-reactivity between seasonal coronavirus and SARS-CoV-2 S2 proteins.

On the whole, most of the published literature consists of limited case reports, series, small, short cohort studies and cross-sectional studies from single jurisdictions, all impacted by the current status of COVID-19 in their area at the time the study was completed, and the literature is not able to keep pace with the rapid nature of disease progression in many countries. Selection, reporting and other biases must be taken into account in the data interpretation and only cautious conclusions can be made.

Reference List

1. Province of Alberta AE. *K to 12 School Re-Entry*.; 2020. https://www.alberta.ca/k-to-12-school-re-entry-2020-21-school-year.aspx.

2. Sick Kids. *COVID-19: Guidance for School Reopening July 29, 2020 (Updated)*. Toronto; 2020. https://mail-attachment.googleusercontent.com/attachment/u/0/?ui=2&ik=fa86eabe2a&attid=0.2&permmsgid=msg-f:1673586043354436426&th=1739c5a3af31534a&view=att&disp=inline&realattid=7393685b68728a6f_0.1.1&saddbat=ANGjdJ9vK2Wnhwr6ru7KjOdNqRtVvDCe0XBDaqu5_-hdo1.

3. Godin M. What the U.S. Can Learn From Other Countries About Reopening Schools in a Coronavirus Pandemic. *TIME*. https://time.com/5868098/schools-reopening-coronavirus-denmark-south-korea-israel/.

4. World Health Organization. Advice on the use of masks in the context of COVID-19. https://www.who.int/publications/i/item/advice-on-the-use-of-masks-in-the-community-during-home-care-and-in-healthcare-settings-in-the-context-of-the-novel-coronavirus-(2019-ncov)-outbreak. Published 2020. Accessed July 28, 2020.

5. Government of Canada. Epidemiological Sumary Covid-19 Cases : National Overview. Coronavirus disease 2019 (COVID019): Epidemiology update. https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html#a3. Published 2020. Accessed July 23, 2020.

6. Barton M, Mehta K, Kumar K, et al. COVID- 19 Infection in Children: Estimating Pediatric Morbidity and Mortality. *medRxiv Prepr*. 2020:1-26. doi:10.1101/2020.05.05.20091751

7. Wu Z, McGoogan JM. Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases from the Chinese Center for Disease Control and Prevention. *JAMA - J Am Med Assoc*. 2020;323(13):1239-1242. doi:10.1001/jama.2020.2648

8. Livingston, E; Bucher K. Coronavirus Disease 2019 (COVID-19) in Italy. *JAMA*. 2020;323(14):1335. https://jamanetwork.com/journals/jama/fullarticle/2763401.

9. Butcher K. Member of coaching staff at Douglass High School tests positive for COVID-19. *Kfor*. https://kfor.com/news/local/member-of-coaching-staff-at-douglass-high-school-tests-positive-for-covid-19/?utm_medium=referral&utm_source=facebook.com&utm_campaign=socialflow&fbclid=IwAR1PbaNPwJ-q8eop6ylTaF0yz1dvWq0Rel8xURsWy90w982nYOj5_Vu_AYg.

10. Bialek S, Gierke R, Hughes M, McNamara LA, Pilishvili T, Skoff T. Coronavirus disease 2019 in children — United States, February 12–April 2, 2020. *Morb Mortal Wkly Rep*. 2020;69(14):422-426. doi:10.15585/MMWR.MM6914E4

11. Voted SD. Children and COVID-19: State-Level Data Report as of 6/11/20. 2020. https://downloads.aap.org/AAP/PDF/AAP_COVID-19_State-Level_Data_Report_6.11.20.pdf.

12. Dong Y, Dong Y, Mo X, et al. Epidemiology of COVID-19 among children in China. *Pediatrics*. 2020;145(6). doi:10.1542/peds.2020-0702

13. Qiu H, Wu J, Hong L, Luo Y, Song Q, Chen D. Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study. *Lancet Infect Dis*. 2020;20(6):689-696. doi:10.1016/S1473-3099(20)30198-5

14. Dattner I, Goldberg Y, Katriel G, et al. The role of children in the spread of COVID-19: Using household data from Bnei Brak, Israel, to estimate the relative susceptibility and infectivity of children. *medRxiv*. 2020:2020.06.03.20121145. doi:10.1101/2020.06.03.20121145

15. Xu Y, Li X, Zhu B, et al. Characteristics of pediatric SARS-CoV-2 infection and potential evidence for persistent fecal viral shedding. *Nat Med*. 2020;26(4):502-505. doi:10.1038/s41591-020-0817-4

16. Prehypertension T. c or r e sp ondence Treating Prehypertension. *Arch Intern Med*. 2006:416-418. https://www-nejm-org.ahs.idm.oclc.org/doi/pdf/10.1056/NEJMc2005073?articleTools=true.

17. Zhang B, Liu S, Zhang J, et al. Children hospitalized for coronavirus disease 2019 (COVID-19): A multicenter retrospective descriptive study. *J Infect*. 2020;(xxxx):11-12. doi:10.1016/j.jinf.2020.04.045

18. Chen C, Cao M, Peng L, et al. Coronavirus Disease-19 Among Children Outside Wuhan, China. *SSRN Electron J*. 2020. doi:10.2139/ssrn.3546071

19. World Health Organization. Clinical management of COVID-19. https://www.who.int/publications/i/item/clinical-management-of-covid-19. Published 2020. Accessed July 20, 2020.

20. Folkhalsomyndigheten. First results from ongoing study or antibodies to covid-19 virus. Initial results from ongoing investigation of antibodies to covid-19 virus. https://www.folkhalsomyndigheten.se/nyheter-och-press/nyhetsarkiv/2020/maj/forsta-resultaten-fran-pagaende-undersokning-av-antikroppar-for-covid-19-virus/. Published 2020.

21. Public T, Agency H. Covid-19 in schoolchildren. https://www.folkhalsomyndigheten.se/contentassets/c1b78bffbfde4a7899eb0d8ffdb57b09/covid-19-school-aged-children.pdf.

22. Liu W, Zhang Q, Chen J, et al. Detection of Covid-19 in children in early january 2020 in Wuhan, China. *N Engl J Med*. 2020;382(14):1370-1372. doi:10.1056/NEJMc2003717

23. Riollano-Criz. Mariawy; Akkoyun, Esra; Briceno-Brito E et al. Multisystem Inflammatory Syndrome in Children (MIS-C) Related to COVID-19 : A New York City Experiance. *Alberto Paniz Mondolfi*. https://onlinelibrary-wiley-com.login.ezproxy.library.ualberta.ca/doi/epdf/10.1002/jmv.26224.

24. Feldstein, LR; Rose, EB; Horwitz S et al. Multisystem Inflammatory Syndrome in U.S. Children and Adolescents. *N Engl J Med*. 2020;383:334-346. https://www.nejm.org/doi/full/10.1056/NEJMoa2021680.

25. Du W, Yu J, Wang H, et al. Clinical characteristics of COVID-19 in children compared with adults in Shandong Province, China. *Infection*. 2020;48(3):445-452. doi:10.1007/s15010-020-01427-2

26. Shekerdemian LS, Mahmood NR, Wolfe KK, et al. Characteristics and Outcomes of Children with Coronavirus Disease 2019 (COVID-19) Infection Admitted to US and Canadian Pediatric Intensive Care Units. *JAMA Pediatr*. 2020;2019:1-6. doi:10.1001/jamapediatrics.2020.1948

27. Turk MA, Landes SD, Formica MK, Goss KD. Intellectual and developmental disability and COVID-19 case-fatality trends: TriNetX analysis. *Disabil Health J*. 2020;(xxxx):100942. doi:10.1016/j.dhjo.2020.100942

28. Lu X, Zhang L, Du H, et al. SARS-CoV-2 infection in children. *N Engl J Med*. 2020;382(17):1663-1665. doi:10.1056/NEJMc2005073

29. Heavey L, Casey G, Kelly C, Kelly D, McDarby G. No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020. *Eurosurveillance*. 2020;25(21):1-4. doi:10.2807/1560-7917.ES.2020.25.21.2000903

30. Le HT, Nguyen L V., Tran DM, et al. The first infant case of COVID-19 acquired from a secondary transmission in Vietnam. *Lancet Child Adolesc Heal*. 2020;4(5):405-406. doi:10.1016/S2352-4642(20)30091-2

31. Li Y, Zhao R, Zheng S, et al. Lack of Vertical Transmission of Severe Acute Respiratory Syndrome

Coronavirus 2, China. *Emerg Infect Dis*. 2020;26(6):1335-1336. doi:10.3201/eid2606.200287

32. Lin J, Duan J, Tan T, Fu Z, Dai J. The isolation period should be longer: Lesson from a child infected with SARS-CoV-2 in Chongqing, China. *Pediatr Pulmonol*. 2020;55(6):E6-E9. doi:10.1002/ppul.24763

33. Pan X, Chen D, Xia Y, et al. Asymptomatic cases in a family cluster with SARS-CoV-2 infection. *Lancet Infect Dis*. 2020;20(4):410-411. doi:10.1016/S1473-3099(20)30114-6

34. Park JY, Han MS, Park KU, Kim JY, Choi EH. First pediatric case of coronavirus disease 2019 in Korea. *J Korean Med Sci*. 2020;35(11):1-7. doi:10.3346/jkms.2020.35.e124

35. Luo, L; Liu, D; Liao X-L et al. Author Affiliations. *medRxiv Prepr Serv Heal Sci*. 2020. doi:10.7551/mitpress/10890.003.0026

36. Koh, Wee; Naing, Lin; Rosledzana M et al. What do we know about SARS-CoV-2 transmission? A systematic review and meta-analysis of the secondary attack rate, serial interval and asymptomatic infection. *medRxiv*. 2020. https://www.medrxiv.org/content/10.1101/2020.05.21.20108746v1.

37. Dumpa V, Kamity R, Vinci AN, Noyola E, Noor A. Neonatal Coronavirus 2019 (COVID-19) Infection: A Case Report and Review of Literature. *Cureus*. 2020;2019(5). doi:10.7759/cureus.8165

38. Huang L, Zhang X, Zhang X, et al. Rapid asymptomatic transmission of COVID-19 during the incubation period demonstrating strong infectivity in a cluster of youngsters aged 16-23 years outside Wuhan and characteristics of young patients with COVID-19: A prospective contact-tracing study. *J Infect*. 2020;80(6):e1-e13. doi:10.1016/j.jinf.2020.03.006

39. Mao LJ, Xu J, Xu ZH, et al. A child with household transmitted COVID-19. *BMC Infect Dis*. 2020;20(1):4-8. doi:10.1186/s12879-020-05056-w

40. Chen M, Fan P, Liu Z, et al. A SARS-CoV-2 familial cluster infection reveals asymptomatic transmission to children. *J Infect Public Health*. 2020;13(6):883-886. doi:10.1016/j.jiph.2020.05.018

41. Bi Q, Wu Y, Mei S, et al. Epidemiology and transmission of COVID-19 in 391 cases and 1286 of their close contacts in Shenzhen, China: a retrospective cohort study. *Lancet Infect Dis*. 2020;3099(20):1-9. doi:10.1016/S1473-3099(20)30287-5

42. Secondary H, Rate A, Determinants A.); L.-Q. Fang, Beijing Institute of Microbiology and Epidemiology, 20 Dong-Da Street, Fengtai District, Beijing, China 100071. 2020;32611. https://www.medrxiv.org/content/medrxiv/early/2020/04/15/2020.04.11.20056010.full.pdf.

43. Somekh E, Gleyzer A, Heller E, et al. The Role of Children in the Dynamics of Intra Family Coronavirus 2019 Spread in Densely Populated Area. *Pediatr Infect Dis J*. 2020;Publish Ah(Xx):2019-2020. doi:10.1097/inf.0000000000002783

44. Su L, Ma X, Yu H, et al. The different clinical characteristics of corona virus disease cases between children and their families in China–the character of children with COVID-19. *Emerg Microbes Infect*. 2020;9(1):707-713. doi:10.1080/22221751.2020.1744483

45. Cai J, Xu J, Lin D, et al. A Case Series of children with 2019 novel coronavirus infection: clinical and epidemiological features. *Clin Infect Dis*. 2020;(Xx Xxxx):1-5. doi:10.1093/cid/ciaa198

46. Posfay-Barbe KM, Wagner N, Gauthey M, et al. COVID-19 in Children and the Dynamics of Infection in Families. *Pediatrics*. 2020:e20201576. doi:10.1542/peds.2020-1576

47. Kam KQ, Yung CF, Cui L, et al. A Well Infant with Coronavirus Disease 2019 (COVID-19) with High Viral Load. *Clin Infect Dis*. 2020;(February):2019-2021. doi:10.1093/cid/ciaa201

48. Zhu Y, Bloxham CJ, Hulme KD, et al. infections. 2020.

https://www.medrxiv.org/content/10.1101/2020.03.26.20044826v1.full.pdf.

49. Zeng, L; Tao, X; Yuan W et al. First Case of Neonate Infected With Novel Coronavirus Pneumonia in China. *Chinese J Pediatr*. 2020;58. http://rs.yiigle.com/yufabiao/1182000.htm.

50. Jones, J; Tait, C; Woo A. Child at Calgary Daycare tests positive for COVID-19, as outbreak hits young people for the first time. *The Globe and Mail*. https://www.theglobeandmail.com/canada/article-child-at-calgary-daycare-tests-positive-for-covid-19-canadas-first/. Published 2020.

51. National Post Wire Service. Twelve Children Infected with COVID-19 in Quebec's First Daycare Outbreak. *National Post*. https://nationalpost.com/news/canada/twelve-children-infected-with-covid-19-in-quebecs-first-daycare-outbreak. Published 2020.

52. Durham Radio News. Two Toronto daycares now have COVID-19 outbreaks. *Durham Radio News, Toronto*. https://www.durhamradionews.com/archives/126526. Published May 8, 2020.

53. Henriques B. Outbreak of COVID-19 reported at Quebec daycares for essential workers : Ministry of Education. *Global News*. https://globalnews.ca/news/6936803/outbreak-coronavirus-daycares-montreal/.

54. MacKinnon B-J. Two Daycares Affected by Active Cases of COVID-19 in Campbellton Region. *CBC News*. https://www.cbc.ca/news/canada/new-brunswick/covid-19-campbellton-child-daycare-balmoral-1.5583146.

55. McPolin S. Covid-19 case confirmed at Sutton-at-Hone Church of England Primary in Dartford. *Kent Online*. https://www.kentonline.co.uk/dartford/news/school-pupil-contracts-coronavirus-228945/. Published 2020.

56. (NCIRS) NC for IR and S. COVID-19 in schools – the experience in NSW. 2020;9(April):1-5. http://ncirs.org.au/sites/default/files/2020-04/NCIRS NSW Schools COVID_Summary_FINAL public_26 April 2020.pdf.

57. RIVM National Institute for Public Health and the Environment. Children and COVID-19. RIVM Children and COVID-19. https://www.rivm.nl/en/novel-coronavirus-covid-19/children-and-covid-19. Published 2020.

58. Park, YJ; Choe, YJ; Park O et al. Contact Tracing during Coronavirus disease outbreak, South Korea 2020. *Emerg Infect Dis CDD*. 2020;26(10). https://wwwnc.cdc.gov/eid/article/26/10/20-1315_article.

59. Zhang J, Litvinova M, Liang Y, et al. Changes in contact patterns shape the dynamics of the COVID-19 outbreak in China. *Science (80-)*. 2020;368(6498):1481-1486. doi:10.1126/science.abb8001

60. Liu J, Liao X, Qian S, et al. Community Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, Shenzhen, China. 2020;26(6). https://wwwnc.cdc.gov/eid/article/26/6/20-0239_article.

61. An P, Zhang M. Novel coronavirus SARS-CoV-2: familial spread resulting in COVID-19 pneumonia in a pediatric patient. *Diagn Interv Radiol*. 2020;26(3):262-263. doi:10.5152/dir.2020.20157

62. Liu P, Cai J, Jia R, et al. Dynamic surveillance of SARS-CoV-2 shedding and neutralizing antibody in children with COVID-19. *Emerg Microbes Infect*. 2020;9(1):1254-1258. doi:10.1080/22221751.2020.1772677

63. Shen Q, Guo W, Guo T, et al. Novel coronavirus infection in children outside of Wuhan, China. *Pediatr Pulmonol*. 2020;55(6):1424-1429. doi:10.1002/ppul.24762

64. Shi Y, Wang X, Liu G, et al. A quickly, effectively screening process of novel corona virus disease 2019 (COVID-19) in children in Shanghai, China. *Ann Transl Med*. 2020;8(5):241-241. doi:10.21037/atm.2020.03.22

65. Song W, Li J, Zou N, Guan W, Pan J, Xu W. Clinical features of pediatric patients with coronavirus disease

(COVID-19). *J Clin Virol*. 2020;127(April):104377. doi:10.1016/j.jcv.2020.104377

66. Wang H, Li Y, Wang F, Du H, Lu X. Rehospitalization of a Recovered Coronavirus Disease 19 (COVID-19) Child with Positive Nucleic Acid Detection. *Pediatr Infect Dis J*. 2020;39(6):E69-E70. doi:10.1097/INF.0000000000002690

67. Zhu L, Wang J, Huang R, et al. Clinical characteristics of a case series of children with coronavirus disease 2019. *Pediatr Pulmonol*. 2020;55(6):1430-1432. doi:10.1002/ppul.24767

68. Zhou Z, Zhou H, Lin X, Su Z, Zhao L, Chen X. Outbreak of COVID-19 in a family , Wenzhou ,. 2020:1-5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7267103/pdf/S0950268820001089a.pdf.

69. Mayer ME, Kong G, Barrington-trimis JL, Mcconnell R, Leventhal AM, Krishnan-sarin S. ce pt e d us cr ip t Ac ce pt cr t. 2001;2019:1-14.

70. Mao KEA. M e mo. *Heal (San Fr*. 2020;2:9637-9637. https://www.fhi.no/globalassets/dokumenterfiler/rapporter/2020/children-in-the-transmission-of-sars-cov-2-covid-19-report-2020.pdf.

71. Fontanet A, Tondeur L, Madec Y, et al. Cluster of COVID-19 in Northern France: A Retrospective Closed Cohort Study. *SSRN Electron J*. 2020:1-22. doi:10.2139/ssrn.3582749

72. Cheng HY, Jian SW, Liu DP, Ng TC, Huang WT, Lin HH. Contact Tracing Assessment of COVID-19 Transmission Dynamics in Taiwan and Risk at Different Exposure Periods before and after Symptom Onset. *JAMA Intern Med*. 2020:1-8. doi:10.1001/jamainternmed.2020.2020

73. Wang Z, Ma W, Zheng X, Wu G, Zhang R. Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID- 19 . The COVID-19 resource centre is hosted on Elsevier Connect , the company ' s public news and information. 2020;(January). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7151261/pdf/main.pdf.

74. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med*. 2020;382(13):1199-1207. doi:10.1056/NEJMoa2001316

75. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med*. 2020;382(13):1199-1207. doi:10.1056/NEJMoa2001316

76. Feng, K; Yun, X; Wang X et al. Analysis of CT Features of 15 Children with 2019 Novel Coronavirus Infection. *Chinese J Pediatr*. 2020;58. http://rs.yiigle.com/yufabiao/1181979.htm.

77. Garazzino S, Montagnani C, Donà D, et al. Multicentre Italian study of SARS-CoV-2 infection in children and adolescents, preliminary data as at 10 April 2020. *Eurosurveillance*. 2020;25(18):1-4. doi:10.2807/1560-7917.ES.2020.25.18.2000600

78. Zhang GX, Zhang AM, Huang L, et al. Twin girls infected with SARS-CoV-2. *Chinese J Contemp Pediatr*. 2020;22(3):221-225. doi:10.7499/j.issn.1008-8830.2020.03.008

79. Emergency C-N, Team CM. Osong Public Health and Research Perspectives. *Osong Public Heal Res Perspect*. 2012;3(1):62. doi:10.1016/j.phrp.2012.03.003

80. Tang, A; Xu, W; Shen M et al. A retrospective study of the clinical characteristics of COVID-19 infection in 26 children. *medRxiv Prepr Serv Heal Sci*. 2020;21(1):1-9. https://www.medrxiv.org/content/10.1101/2020.03.08.20029710v1.full.pdf.

81. L'Hullier, Arnaud G; Torriani, Giulia; Pigny F et al. Culture-Competent SARS-CoV-2 in Nasopharynx of Symptomatic neonates, Chlidren, and Adolescents. *Emerg Infect Dis CDD*. 2020;26(10). https://wwwnc.cdc.gov/eid/article/26/10/20-2403_article?deliveryName=USCDC_333-DM32083.

82. Zhang, C; Gu, J; Chen Q et al. Clinical Characteristics of 34 Children with Coronavirus Disease-2019 in the West of China: a Multiple-center Case Series. *medRxiv Prepr Serv Heal Sci*. 2020;21(1):1-9. https://www.medrxiv.org/content/10.1101/2020.03.12.20034686v1.full.pdf.

83. Liao J, Fan S, Chen J, et al. Epidemiological and Clinical Characteristics of COVID-19 in Adolescents and Young Adults. *Innov*. 2020;1(1):100001. doi:10.1016/j.xinn.2020.04.001

84. Cai J, Xu J, Lin D, et al. A Case Series of children with 2019 novel coronavirus infection: clinical and epidemiological features. *Clin Infect Dis*. 2020;145(6):6-10. doi:10.1093/cid/ciaa198

85. Fontanet, A; Grant, R; Tondeur L et al. *Seroprevalence_Ecoles*.; 2020. https://www.pasteur.fr/fr/file/35404/download.

86. Catlett M. *It Has Come to Our Attention, 5 JM Graduates Test Positive after Being at Graduation Together*. Fredericksburg, Virginia; 2020. http://www.cityschools.com/blog/2020/06/19/it-has-come-to-our-attention-5-jm-graduates-test-positive-after-being-at-graduation-together-https-bit-ly-jmcovidgrad/.

87. Oster E. *Child Care Open in Pandemic: Data*.; 2020. https://docs.google.com/spreadsheets/d/1L45r63t8hpYfGLpT6gWKjYMscu8Wut6jtlxO-1FAW9c/edit#gid=204576280.

88. Streicher, Brad; Reding S. COVID-19 surges past 1,700 cases in Texas child care facilities. *KVUE News (ABC) Texas*. https://www.kvue.com/article/news/health/coronavirus/coronavirus-austin-texas-child-care-day-care-cases-update/269-49ec5dcf-d3d2-4c36-811a-59b1c1c2837b. Published 2020.

89. Bessler K. As COVID-19 cases spike in Texas daycare centers, Illinois numbers remain low. *The Center Square, Illinois*. https://www.thecentersquare.com/illinois/as-covid-19-cases-spike-in-texas-daycare-centers-illinois-numbers-remain-low/article_de3405ea-c08c-11ea-9b0c-5f9db164535e.html. Published 2020.

90. Williams CA. More teachers infected as Covid-19 spreads across Cape Town schools. *IOL South Africa*. https://www.iol.co.za/news/south-africa/western-cape/more-teachers-infected-as-covid-19-spreads-across-cape-town-schools-50168608. Published 2020.

91. Estrin D. After Reopening Schools, Israel Orders Them To Shut If COVID-19 Cases Are Discovered. *NNational Public Radio*. https://www.npr.org/sections/coronavirus-live-updates/2020/06/03/868507524/israel-orders-schools-to-close-when-covid-19-cases-are-discovered. Published June 3, 2020.

92. Zhu H, Wang L, Fang C, et al. Clinical analysis of 10 neonates born to mothers with 2019-nCoV pneumonia. *Transl Pediatr*. 2020;9(1):51-60. doi:10.21037/tp.2020.02.06

93. Xing YH, Ni W, Wu Q, et al. Prolonged viral shedding in feces of pediatric patients with coronavirus disease 2019. *J Microbiol Immunol Infect*. 2020;53(3):473-480. doi:10.1016/j.jmii.2020.03.021

94. Chang TH, Wu JL, Chang LY. Clinical characteristics and diagnostic challenges of pediatric COVID-19: A systematic review and meta-analysis. *J Formos Med Assoc*. 2020;119(5):982-989. doi:10.1016/j.jfma.2020.04.007

95. Wang S, Guo L, Chen L, et al. A case report of neonatal COVID-19 infection in China. *Clin Infect Dis*. 2020. doi:10.1093/cid/ciaa225

96. Alonso Díaz C, López Maestro M, Moral Pumarega MT, Flores Antón B, Pallás Alonso CR. First case of neonatal infection due to SARS-CoV-2 in Spain. *An Pediatr*. 2020;92(4):237-238. doi:10.1016/j.anpedi.2020.03.002

97. Zhang ZJ, Yu XJ, Fu T, et al. Novel coronavirus infection in newborn babies aged <28 days in China. *Eur Respir J*. 2020;55(6):2-5. doi:10.1183/13993003.00697-2020

98. Yu N, Li W, Kang Q, et al. Clinical features and obstetric and neonatal outcomes of pregnant patients with COVID-19 in Wuhan, China: a retrospective, single-centre, descriptive study. *Lancet Infect Dis*. 2020;20(5):559-564. doi:10.1016/S1473-3099(20)30176-6

99. Buonsenso D, Costa S, Sanguinetti M, et al. Neonatal Late Onset Infection with Severe Acute Respiratory Syndrome Coronavirus 2. *Am J Perinatol*. 2020;37(08):869-872. doi:10.1055/s-0040-1710541

100. Chan JFW, Yuan S, Kok KH, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. 2020;395(10223):514-523. doi:10.1016/S0140-6736(20)30154-9

101. See KC, Liew SM, Ng DCE, et al. COVID-19: Four Paediatric Cases in Malaysia. *Int J Infect Dis*. 2020;94:125-127. doi:10.1016/j.ijid.2020.03.049

102. Ji, L-N; Chao, S; Wang Y-J et al. Clinical features of pediatric patients with COVID-19 : a report of two family cluster cases. *World J Pediatr*. 2020;16(3):267-270. https://pubmed.ncbi.nlm.nih.gov/32180140/.

103. Kane P. Camp Ozark sends campers home due to coronavirus outbreak. *KATV News*. https://katv.com/news/local/camp-ozark-sends-campers-home-due-to-coronavirus-outbreak. Published 2020.

104. Lee A. Summer camps close after Covid-19 outbreaks among campers and staff. *CNN*. https://www.cnn.com/2020/07/08/us/missouri-arkansas-summer-camp-covid-19-trnd/index.html. Published 2020.

105. Szablewski, CM; Chang, KT; Brown M et al. *SARS-CoV-2 Transmission and Infection Among Attendees of an Overnight Camp — Georgia, June 2020*.; 2020. https://www.cdc.gov/mmwr/volumes/69/wr/mm6931e1.htm.

106. Dangerfield K. Passengers on 31 flights in Canada may have been exposed to COVID-19 in July. *Global News2*. 2020.

107. England C-, Keeling MJ, Tildesley MJ, et al. The impact of school reopening on the spread of. 2020:1-20. https://www.medrxiv.org/content/10.1101/2020.06.04.20121434v1.full.pdf.

108. Desmet, S; Ekinci, E; Wouters I et al. No SARS-CoV-2 carriage observed in children attending daycare centers during the first weeks of the epidemic in Belgium. *medRxiv Prepr Serv Heal Sci*. 2020.

109. Jallhage L. *Nu Öppnar Kågeskolan Igen Efter Coronadödsfallet*. https://www.lararen.se/nyheter/coronaviruset/efter-larardoden--nu-oppnar-kageskolan-igen.

110. O'Kane C. Students bring COVID-19 back from Myrtle Beach trips. *CBS News*. https://www.cbsnews.com/news/coronavirus-students-travel-bring-back-covid-19-ohio-west-virginia/?ftag=CNM-00-10aab7e&linkId=91608307. Published June 13, 2020.

111. Turner S. Pongfest' party in Lakeway leaves large number of high school students exposed to COVID-19. *Kvue (ABC News)*. https://www.kvue.com/article/news/health/coronavirus/lakeway-party-coronavirus-pongfest/269-9a3d62c4-b910-4823-9b95-e1dc986939a5?fbclid=IwAR2Bh-td5HLzEYRA-tGSBN8ybRW-mmS-QhoZs7tZlN4u8fNMrgJmcJkjXKI. Published 2020.

112. Barber H. Kansas high school confirms positive COVID-19 test after resuming athletic activities. *Kansas City Star*. https://www.kansascity.com/sports/high-school/article243711857.html. Published 2020.

113. WCNC Staff. Fort Mill High School cancels football practices after person tests positive for COVID-19. *WCNC News Charlotte NC*. https://www.wcnc.com/article/news/health/coronavirus/fort-mill-high-coronavirus-athletics/275-10af3ccc-1590-4e23-9278-d3a5a3dc0ea3. Published 2020.

114. Hoyt J. Texas child care centers see sharp increase in coronavirus cases after months of relative calm.

The Dallas Morning News. https://www.dallasnews.com/news/public-health/2020/06/19/texas-childcare-centers-see-sharp-increase-in-coronavirus-cases-after-months-of-relative-calm/. Published 2020.

115. Johns Hopkins University Medicine. Daily State-by-State Testing Trends. Johns Hopkins University & Medicine : Coronavirus Resource Center. https://coronavirus.jhu.edu/testing/individual-states/texas. Published 2020. Accessed July 24, 2020.

116. Richard S. 'Stop classes now': Fears grow as 185 COVID-19 cases found in one school. *Muhabarishaji*. https://www.muhabarishaji.com/2020/06/stop-classes-now-fears-grow-as-185-covid-19-cases-found-in-one-school/. Published 2020.

117. Mfeka W. 63 schools in KZN have positive Covid-19 cases. *IOL South Africa, Durban*. https://www.iol.co.za/dailynews/news/kwazulu-natal/63-schools-in-kzn-have-positive-covid-19-cases-49903989. Published 2020.

118. Fox EG. The YMCA provided childcare to 40,000 kids during lockdown and said it didn't see any coronavirus outbreaks. Here are 11 precautions it took that worked. *Insider*. https://www.insider.com/how-the-ymca-childcare-centers-prevented-coronavirus-outbreaks-2020-7. Published July 2, 2020.

119. Our World in Data. Coronavirus Pandemic (COVID-19). *Our World in Data*. https://ourworldindata.org/coronavirus.

120. Sharma R. UK coronavirus cases : 1 in 4 Covid-19 outbreaks outside care homes linked to schools. *In News*. https://inews.co.uk/news/health/uk-coronavirus-cases-covid-19-outbreaks-care-homes-schools-450595.

121. Sharma R. UK coronavirus cases: 1 in 4 COvid-19 outbreaks outside care homes linked to schools. *I News*. https://inews.co.uk/news/health/uk-coronavirus-cases-covid-19-outbreaks-care-homes-schools-450595. Published June 19, 2020.

122. Cunningham, Melissa; Towell N. Third primary school, childcare centre close after positive COVID-19 tests. *The Sydney Morning Herald*. https://www.smh.com.au/national/third-primary-school-forced-to-close-after-child-tests-positive-to-covid-19-20200616-p552yo.html. Published 2020.

123. Litton S. Child tests positive for COVID-19, daycare closes. *Wow KTV*. https://www.wowktv.com/news/local/child-tests-positive-for-covid-19-daycare-closes/. Published 2020.

124. Kealy C. Daycare in Forest temporarily closes after COVID-19 case. *ABC 13 News Virginia*. https://wset.com/news/coronavirus/lynchburg-kindercare-temporarily-closes-after-covid-19-case. Published 2020.

125. South Yorkshire Live. Sheffield's Norfolk Community Primary School confirms positive case of Covid-19. *Examiner Live*. https://www.examinerlive.co.uk/news/local-news/sheffields-norfolk-community-primary-school-18468341.

126. Guthrie, BL; Tordoff, DM; Meisner J et al. *Summary of School Re-Opening Models and Implementation*.; 2020. https://globalhealth.washington.edu/sites/default/files/COVID-19 Schools Summary %282%29.pdf?mkt_tok=eyJpIjoiTkRreE5XWXlORFF3TXpNeCIsInQiOiJIbVNQTTVySEo0Vzk1cHVBZVVqWnFGVmR1UEJxRGdpd01mTXg4OGw3Mk5nTnpmaUoyMGt2UXIwWVZBOE5GVjIybHA5aStrbzJ3MUxsanoxamZibmlocm.

127. Stein-Zamir, Chen; Abramson, Nitza; Shoob H et al. A large COVID-19 outbreak in a high school 10 days after schools' reopening, Israel, May 2020. *Eurosurveillance*. 2020;25(29). https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.29.2001352#html_fulltext.

128. Boffey, Daniel; Willsher K. Schools reopening has not triggered rise in Covid-19 cases, EU ministers told. *The Guardian*. https://amp.theguardian.com/world/2020/may/18/french-minister-tells-of-risks-of-missing-

school-as-more-pupils-return-covid-19. Published 2020.

129. Stage, HB; Shingleton, J; Ghosh S et al. Shut and re-open: the role of schools in the spread of COVID-19 in Europe. *medRxiv Prepr Serv Heal Sci*. 2020.

130. Forest-Briand VE. 44 students in Quebec have confirmed cases of COVID-19. *CBC Kids News*. https://www.cbc.ca/kidsnews/post/44-students-in-quebec-have-confirmed-cases-of-covid-since-schools-reopened. Published 2020.

131. Gawley K. Zero Daycare Cases Reported in BC by June 5. *City News (News 1130)*. https://www.citynews1130.com/2020/06/11/has-covid-19-spread-at-b-c-daycares/. Published June 11, 2020.

132. Provincial Health Services Authority BC for DC. *Public Health Principles*.; 2020. http://www.bccdc.ca/Health-Info-Site/Documents/School-Public-health-principles-childcare-operators-staff.pdf.

133. Viner RM, Russell SJ, Croker H, et al. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. *Lancet Child Adolesc Heal*. 2020;4(5):397-404. doi:10.1016/S2352-4642(20)30095-X

134. Hollingsworth, Julia; Kwon J. In Asia, children are going back to school. But education in the time of coronavirus is not without difficulties. *CNN*. https://www.cnn.com/2020/05/21/asia/schools-reopening-asia-coronavirus-intl-hnk/index.html. Published 2020.

135. Kissler SM, Tedijanto C, Goldstein E, Grad YH, Lipsitch M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science*. 2020;368(6493):860-868. doi:10.1126/science.abb5793

136. University of Washington Department of Global Health. HOW TO REOPEN SCHOOLS: WHAT SCIENCE AND OTHER COUNTRIES TEACH US (QUOTES BRANDON GUTHRIE/COVID LIT. REP.). https://globalhealth.washington.edu/news/2020/07/13/how-reopen-schools-what-science-and-other-countries-teach-us-new-york-times-includes. Published 2020.

137. Liu, LLD; Wu, X-B; Jing Q-L et al. Modes of contact and risk of transmission in COVID-19 among close contacts. *medRxiv*. 2020. https://www.medrxiv.org/content/10.1101/2020.03.24.20042606v1.

138. Shen, Y; Martinez, L; Li, C; Chen Z. Airborne transmission of COVID-19: epidemiologic evidence from two outbreak investigations. *SSRN Electron J*. 2020. https://www.researchgate.net/profile/Changwei_Li2/publication/340418430_Airborne_transmission_of_COVID-19_epidemiologic_evidence_from_two_outbreak_investigations/links/5e87b59ba6fdcca789f10d66/Airborne-transmission-of-COVID-19-epidemiologic-evidence-from-.

139. Wong Y. To limit coronavirus risks on public transport, here’s what we can learn from efforts overseas. *Conversat*. 2020. https://theconversation.com/amp/to-limit-coronavirus-risks-on-public-transport-heres-what-we-can-learn-from-efforts-overseas-133764.

140. Wang D, Hu B, Hu C, et al. Clinical Characteristics of 138 Hospitalized Patients with 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. *JAMA - J Am Med Assoc*. 2020;323(11):1061-1069. doi:10.1001/jama.2020.1585

141. Yu F, Yan L, Wang N, et al. Quantitative Detection and Viral Load Analysis of SARS-CoV-2 in Infected Patients. *Clin Infect Dis*. 2020;(Xx Xxxx):2-7. doi:10.1093/cid/ciaa345

142. Pan, Y; Zhang, D; Wan L. Viral dynamics in mild and severe cases of COVID-19. *Lancet Infect Dis*. 2020;20(6):656-657. https://www.thelancet.com/journals/laninf/article/PIIS1473-3099(20)30232-2/fulltext#sec1.

143. Zhang Z, Xiao T, Wang Y, et al. *Early Viral Clearance and Antibody Kinetics of COVID-19 among Asymptomatic Carriers*.; 2020. https://www.medrxiv.org/content/10.1101/2020.04.28.20083139v1.full.pdf.

144. Argyropoulos, KV; Serrano, A; Hu J et al. Association of initial viral load in SARS-CoV-2 patients with outcome and symptoms. *Am J Pathol*. 2020. https://ajp.amjpathol.org/article/S0002-9440(20)30328-X/pdf.

145. van Kampen, Jeroen; van de Vijver, DAMC; Fraaij P et al. Shedding of infectious virus in hospitalized patients with coronavirus disease-2019 (COVID19): duration and key determinants. *medRxiv*. 2020. https://www.medrxiv.org/content/10.1101/2020.06.08.20125310v1.full.pdf.

146. Woelfel, R; Corman, VM; Guggemos W et al. Clinical presentation and virological assessment of hospitalized cases of coronavirus disease 2019 in a travel-associated transmission cluster. *medRxiv Prepr Serv Heal Sci*. 2020. https://www.medrxiv.org/content/10.1101/2020.03.05.20030502v1.

147. He, X; Lau, EHY; Wi P et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. *medRxiv Prepr Serv Heal Sci*. 2020. https://doi.org/10.1101/2020.03.15.20036707.

148. Bhat TA, Kalathil SG, Bogner PN, Blount BC, Goniewicz ML, Thanavala YM. An animal model of inhaled Vitamin E acetate and Evali-like lung injury. *N Engl J Med*. 2020;382(12):1175-1177. doi:10.1056/NEJMc2000231

149. Bullard, J; Dust, K; Funk D et al. Predicting infectious SARS-CoV-2 from diagnostic samples. *Clin Infect Dis*. 2020. https://academic.oup.com/cid/article/doi/10.1093/cid/ciaa638/5842165.

150. XXiao, Ai; Tong, Yi; Gao C et al. Dynamic profile of RT-PCR findings from 301 COVID-19 patients in Wuhan, China: A descriptive study. *J Clin Virol*. 2020;127. https://www.sciencedirect.com/science/article/pii/S1386653220300883?via%3Dihub.

151. Wajnberg, A; Mansour, M; Leven E et al. Humoral immune response and prolonged PCR positivity in a cohort of 1343 SARS-CoV 2 patients in the New York City region. *medRxiv Prepr Serv Heal Sci*. 2020. https://www.medrxiv.org/content/10.1101/2020.04.30.20085613v1.

152. Santos VS, Gurgel RQ, Cuevas LE, Martins-Filho PR. Prolonged fecal shedding of SARS-CoV-2 in pediatric patients. A quantitative evidence synthesis. *J Pediatr Gastroenterol Nutr*. 2020;Publish Ah. doi:10.1097/mpg.0000000000002798

153. Han MS, Seong M-W, Kim N, et al. Viral RNA Load in Mildly Symptomatic and Asymptomatic Children with COVID-19, Seoul. *Emerg Infect Dis*. 2020;26(10):202449. doi:10.3201/eid2610.202449

154. Jones TC, Mühlemann B, Veith T, et al. An analysis of SARS-CoV-2 viral load by patient age. *medRxiv*. 2020:2020.06.08.20125484. doi:10.1101/2020.06.08.20125484

155. McConway, Kevin; Spiegelhalter D. Is SARS-CoV-2 viral load lower in young children than adults? Jones et al provide evidence that it is (in spite of their claims to the contrary). Medium. https://medium.com/@d_spiegel/is-sars-cov-2-viral-load-lower-in-young-children-than-adults-8b4116d28353. Published 2020.

156. Shi F, Wu T, Zhu X, et al. Association of viral load with serum biomakers among COVID-19 cases. *Virology*. 2020;546(April):122-126. doi:10.1016/j.virol.2020.04.011

157. Heald-Sargent, T; Muller, WJ; Zheng X et al. Age-Related Differences in Nasopharyngeal Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Levels in Patients With Mild to Moderate Coronavirus Disease 2019 (COVID-19). *JAMA Pediatr*. 2020. doi:doi:10.1001/jamapediatrics.2020.3651

158. Riediker M, Morawska L. Low Exhaled Breath Droplet Formation May Explain Why Children are Poor SARS-CoV-2 Transmitters. *Aerosol Air Qual Res*. 2020;20(Iii):1513-1515. doi:10.4209/aaqr.2020.06.0304

159. Rubin JE, Crowe SE. Annals of internal medicine®. *Ann Intern Med*. 2020;172(1):ITC1-ITC14.

doi:10.7326/AWED202001070

160. Ma X, Su L, Zhang Y, Zhang X, Gai Z, Zhang Z. Do children need a longer time to shed SARS-CoV-2 in stool than adults? *J Microbiol Immunol Infect*. 2020;53(3):373-376. doi:10.1016/j.jmii.2020.03.010

161. Zhang T, Cui X, Zhao X, et al. Detectable SARS-CoV-2 viral RNA in feces of three children during recovery period of COVID-19 pneumonia. *J Med Virol*. 2020;92(7):909-914. doi:10.1002/jmv.25795

162. Yuan C, Zhu H, Yang Y, et al. Viral loads in throat and anal swabs in children infected with SARS-CoV-2. *Emerg Microbes Infect*. 2020;9(1):1233-1237. doi:10.1080/22221751.2020.1771219

163. Yu ITS, Li Y, Wong TW, et al. Evidence of Airborne Transmission of the Severe Acute Respiratory Syndrome Virus. *N Engl J Med*. 2004;350(17):1731-1739. doi:10.1056/NEJMoa032867

164. Xing Y, Ni W, Wu Q, et al. Prolonged presence of SARS-CoV-2 in feces of pediatric patients during the convalescent phase. *medRxiv*. 2020;(6):2020.03.11.20033159. doi:10.1101/2020.03.11.20033159

165. Wolfel, R; Corman, VM; Guggemos W et al. Virological assessment of hospitalized patients with COVID-19. *Nature*. 2020;581:465-469. https://www.nature.com/articles/s41586-020-2196-x.

166. Shutler J, Zaraska K, Holding TM, et al. Risk of SARS-CoV-2 infection from contaminated water systems. *medRxiv*. 2020:2020.06.17.20133504. doi:10.1101/2020.06.17.20133504

167. Tam PCK, Ly KM, Kernich ML, et al. Detectable severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in human breast milk of a mildly symptomatic patient with coronavirus disease 2019 (COVID-19). *Clin Infect Dis*. 2020;2(Xx Xxxx):1-3. doi:10.1093/cid/ciaa673

168. Sharif-Askari, N; Sharif-Askari, F; Alabed M et al. Airways expression of SARS-CoV-2 receptor, ACE2, and TMPRSS2 is lower in children than adults and increases with smoking and COPD. *Mol Ther Methods Clin Dev*. 2020;18:1-6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7242205/.

169. Zhou, J; Li, C; Liu X et al. Infection of bat and human intestinal organoids by SARS-CoV-2. *Nat Med*. 2020;26:1077. https://www.nature.com/articles/s41591-020-0912-6.

170. Xia W, Shao J, Guo Y, Peng X, Li Z, Hu D. Clinical and CT features in pediatric patients with COVID-19 infection: Different points from adults. *Pediatr Pulmonol*. 2020;55(5):1169-1174. doi:10.1002/ppul.24718

171. Sun B, Feng Y, Mo X, et al. Kinetics of SARS-CoV-2 specific IgM and IgG responses in COVID-19 patients. *Emerg Microbes Infect*. 2020;9(1):940-948. doi:10.1080/22221751.2020.1762515

172. Qu J, Wu C, Li X, et al. Profile of IgG and IgM antibodies against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). *Clin Infect Dis*. 2020;(Xx Xxxx):10-13. doi:10.1093/cid/ciaa489

173. Kohler PF, Farr RS. Elevation of Cord over maternal IgG immunoglobulin: Evidence for an active placental IgG transport [39]. *Nature*. 1966;210(5040):1070-1071. doi:10.1038/2101070a0

174. Schopper D, Ravinetto R, Schwartz L, et al. Research ethics governance in times of Ebola. *Public Health Ethics*. 2017;10(1):49-61. doi:10.1093/phe/phw039

175. Higgins-Dunn, N; Breuninger, K; Kim J. New York antibody study estiamtes 13.9% of residents have had the coronavirus, Gov. Cuomo says. CNBC Health and Science. https://www.cnbc.com/2020/04/23/new-york-antibody-study-estimates-13point9percent-of-residents-have-had-the-coronavirus-cuomo-says.html. Published 2020.

176. Sikora K, Officer CSM, Barwick I, Officer CSM, Hamilton C. Serological prevalence of antibodies to SARS CoV-2 amongst cancer centre staff. *Medrxiv*. 2020;(May):15-17. doi:10.1101/2020.05.16.20099408

177. Guo L, Ren L, Yang S, et al. Profiling Early Humoral Response to Diagnose Novel Coronavirus Disease (COVID-19). *Clin Infect Dis*. 2020;(Xx Xxxx):1-8. doi:10.1093/cid/ciaa310

178. Zhang W, Du RH, Li B, et al. Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. *Emerg Microbes Infect*. 2020;9(1):386-389. doi:10.1080/22221751.2020.1729071

179. Stringhini S, Wisniak A, Piumatti G, et al. Seroprevalence of anti-SARS-CoV-2 IgG antibodies in Geneva, Switzerland (SEROCoV-POP): a population-based study. *Lancet*. 2020;6736(20):1-7. doi:10.1016/S0140-6736(20)31304-0

180. Xun J, Lu L, Jiang S, Lu H, Wen Y, Huang J. Patient Cohort and Their Implications. *medRxiv*. 2020. https://www.medrxiv.org/content/10.1101/2020.03.30.20047365v2.full.pdf.

181. Shakiba M, Hashemi Nazari SS, Mehrabian F, Rezvani SM, Ghasempour Z, Heidarzadeh A. Seroprevalence of COVID-19 virus infection in Guilan province, Iran. *medRxiv*. 2020:2020.04.26.20079244. doi:10.1101/2020.04.26.20079244

182. Stringhini S, Wisniak A, Piumatti G, et al. Repeated seroprevalence of anti-SARS-CoV-2 IgG antibodies in a population-based sample from Geneva, Switzerland. *medRxiv*. 2020:2020.05.02.20088898. doi:10.1101/2020.05.02.20088898

183. Bendavid E, Mulaney B, Sood N, et al. COVID-19 Antibody Seroprevalence in Santa Clara County, California. *medRxiv*. 2020:2020.04.14.20062463. doi:10.1101/2020.04.14.20062463

184. Zorzoli M. EXCLUSIVE The new data of Robbio, the only Italian country to take the immunity test for all citizens. 70% asymptomatic. Business Insider Italia. https://it.businessinsider.com/esclusiva-cosa-rivelano-i-primi-test-di-robbio-primo-paese-italiano-a-fare-i-test-sullimmunita-a-tutti-i-cittadini/. Published 2020. Accessed June 20, 2020.

185. Ng, Kevin W; Faulkner, Nikhil; Cornish GH et al. Pre-existing and de novo humoral immunity to SARS-CoV-2 in humans. *bioRxiv2*. 2020. https://www.biorxiv.org/content/10.1101/2020.05.14.095414v2.full.pdf.

186. Long, Q-X; Tang, X-J; Shi Q-L et al. Clinical and immunological assessment of asymptomatic SARS-CoV-2 infections. *Nat Med*. 2020. https://www.nature.com/articles/s41591-020-0965-6.

187. Callow, KA; Parry, HF; Sergeant, M; Tyrrell D. The time course of the immune response to experimental coronavirus infection of man. *Epidemiol Infect*. 1990;105(2):435-446.

188. Liu, WJ; Zhao,, M; Liu K et al. T-cell immunity of SARS-CoV: Implications for vaccine development against MERS-CoV. *Antivir Res*. 2017;137:82-92. https://pubmed.ncbi.nlm.nih.gov/27840203/.

189. The Scripps Research Institute. Scientists discover key element of strong antibody response to COVID-19. *Medical Press*. https://medicalxpress.com/news/2020-07-scientists-key-element-strong-antibody.html. Published 2020.

190. Lovelace B. Coronavirus antibodies may last only two to three months after infection, study suggests. *CNBC*. https://www.cnbc.com/2020/06/18/coronavirus-antibodies-may-last-only-2-to-3-months-after-infection-study-suggests.html. Published June 18, 2020.

191. Pollán M, Pérez-Gómez B, Pastor-Barriuso R, et al. Prevalence of SARS-CoV-2 in Spain (ENE-COVID): a nationwide, population-based seroepidemiological study. *Lancet (London, England)*. 2020;6736(20):1-11. doi:10.1016/S0140-6736(20)31483-5

192. Canadian Blood Services. How common is COVID-19? Early results from Canadian Blood Services' seroprevalence study provide some insights. Canadian Blood Services. https://www.blood.ca/en/stories/how-common-covid-19-early-results-canadian-blood-services-seroprevalence-study-provide-some. Published July 22, 2020. Accessed July 22, 2020.

193. Skowronski, Danuta M; Sekirov, Inna; Sabaiduc S et al. Low SARS-CoV-2 sero-prevalence based on anonymized residual sero-survey before and after first wave measures in British Columbia, Canada,

March-May 2020. *medRxiv*. 2020. https://www.medrxiv.org/content/10.1101/2020.07.13.20153148v1.full.pdf.

194. Panovska-Griffiths, J; Kerr, CC; Stuart R et al. Determining the optimal strategy for reopening schools, work and society in the UK: balancing earlier opening and the impact of test and trace strategies with the risk of occurrence of a secondary COVID-19 pandemic wave. *medRxiv Prepr Serv Heal Sci*. 2020. https://www.medrxiv.org/content/medrxiv/early/2020/06/01/2020.06.01.20100461.full.pdf.

195. Prem K, Liu Y, Russell TW, et al. The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modelling study. *Lancet Public Heal*. 2020;5(5):e261-e270. doi:10.1016/S2468-2667(20)30073-6

196. Iksal M. Age profile of susceptibility, mixing, and social distancing shape the dynamics of the novel coronavirus disease 2019 outbreak in China. *medRxiv Prepr Serv Heal Sci*. 2020;21(1):1-9. https://www.medrxiv.org/content/medrxiv/early/2020/03/20/2020.03.19.20039107.full.pdf.

197. Ferguson NM, Laydon D, Nedjati-Gilani G, et al. Report 13: Estimating the number of infections and the impact of non-pharmaceutical interventions on COVID-19 in 11 European countries. *Imp Coll*. 2020;(March). doi:10.25561/77482

198. Davies NG, Kucharski AJ, Eggo RM, et al. Effects of non-pharmaceutical interventions on COVID-19 cases, deaths, and demand for hospital services in the UK: a modelling study. *Lancet Public Heal*. 2020:11-15. doi:10.1016/S2468-2667(20)30133-X

199. Cauchemez S, Ferguson NM, Wachtel C, et al. Closure of schools during an influenza pandemic. *Lancet Infect Dis*. 2009;9(8):473-481. doi:10.1016/S1473-3099(09)70176-8

200. Chen X, Ran L, Liu Q, Hu Q, Du X, Tan X. Hand hygiene, mask-wearing behaviors and its associated factors during the COVID-19 epidemic: A cross-sectional study among primary school students in Wuhan, China. *Int J Environ Res Public Health*. 2020;17(8). doi:10.3390/ijerph17082893

201. Esposito S, Principi N. To mask or not to mask children to overcome COVID-19. *Eur J Pediatr*. 2020;27:9-12. doi:10.1007/s00431-020-03674-9

202. Lemaitre, JC; Perez-Saez, J; Azman, AS; Rinaldo, A; Fellay J. Swiss Medical Weekly. Swiss Medical Weekly. https://smw.ch/article/doi/smw.2020.20295. Published 2020. Accessed July 25, 2020.

203. Meier P. Why the Swiss are reluctant to wear face masks. *Swiss Info*. https://www.swissinfo.ch/eng/easing-the-lockdown_why-the-swiss-are-reluctant-to-wear-face-masks/45751636. Published May 11, 2020.

204. Chu, DK; Akl, EA; Duda S et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *Lancet*. 2020;3395(10242):1973-1987. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31142-9/fulltext.

205. Torner N, Soldevila N, Garcia JJ, et al. Effectiveness of non-pharmaceutical measures in preventing pediatric influenza: A case-control study. *BMC Public Health*. 2015;15(1):1-8. doi:10.1186/s12889-015-1890-3

206. Simmerman, JM; Suntarattiwong, P; Levy J et al. Findings from a household randomized controlled trial of hand washing and face masks to reduce influenza transmission in Bangkok, Thailand. *Influenza Other Respi Viruses*. 2011;5(4):256-267.

207. Allison, MA; Guest-Warnick, G; Nelson D et al. Feasibility of elementary school children's use of hand gel and facemasks during influenza season. *Influenza Other Respi Viruses*. 2010;4(4):223-229. https://onlinelibrary.wiley.com/doi/full/10.1111/j.1750-2659.2010.00142.x.

208. Liu Y, Gu Z, Xia S, et al. What are the underlying transmission patterns of COVID-19 outbreak? An age-specific social contact characterization. *EClinicalMedicine*. 2020;22:100354. doi:10.1016/j.eclinm.2020.100354

209. Ludidi V. VIDEO: Coronavirus cases affect two schools. *IOL Daily Voice South Africa*. https://www.dailyvoice.co.za/news/video-coronavirus-cases-affect-two-schools-49546049. Published 2020.

210. Goldner B. Gaston County daycare shuts down after COVID-19 case. *WCNC News Charlotte*. https://www.wcnc.com/article/news/local/second-baptist-daycare-gaston-county-daycare-shuts-down-covid-19-case/275-3ee85f89-f033-4f68-88f2-4a7669a3b0f2?fbclid=IwAR0RN4jTo4IkRk4IMTEPqkveeL2UQqrO6oGoYxLjhcxTiKqXR0bcU7a_4dc.

211. Bin Nafisah S, Alamery AH, Al Nafesa A, Aleid B, Brazanji NA. School closure during novel influenza: A systematic review. *J Infect Public Health*. 2018;11(5):657-661. doi:10.1016/j.jiph.2018.01.003

212. Litvinova M, Liu QH, Kulikov ES, Ajelli M. Reactive school closure weakens the network of social interactions and reduces the spread of influenza. *Proc Natl Acad Sci U S A*. 2019;116(27):13174-13181. doi:10.1073/pnas.1821298116

213. Domenico L Di. Expected impact of reopening schools after lockdown on COVID-19 epidemic in Ile-de-France. *Medrxiv*. 2020:2020.05.08.20095521. doi:10.1101/2020.05.08.20095521

214. Davies NG, Klepac P, Liu Y, Prem K, Jit M, Eggo RM. Age-dependent effects in the transmission and control of COVID-19 epidemics. *Nat Med*. 2020. doi:10.1038/s41591-020-0962-9

215. Bayham, J; Fenichel E. Impact of School Closures for COVID-19 on the US Health-Care Workforce and Net Mortality : A Modelling Study. *Lancet Public Heal*. 2020;5(5):e271-e278. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7270508/.

216. Brooks SK, Smith LE, Webster RK, et al. The impact of unplanned school closure on children's social contact: Rapid evidence review. *Eurosurveillance*. 2020;25(13). doi:10.2807/1560-7917.ES.2020.25.13.2000188

217. UNESCO. Covid-19 school closures around the world will hit girls hardest.https://en.unesco.org/news/covid-19-school-closures-around-world-will-hit-girls-hardest. Published 2020.

218. Oduor M. Close to 4,000 school girls impregnated in Kenya during COVID-19 lockdown. *Africa News*. 2020.

219. Schmidt S. With kids stuck at home, ER doctors see more severe cases of child abuse. *Washington Post*. 2020. https://www.washingtonpost.com/education/2020/04/30/child-abuse-reports-coronavirus/.

220. Abramson A. How COVID-19 may increase domestic violence and child abuse. https://www.apa.org/topics/covid-19/domestic-violence-child-abuse.

221. Dunn C. Feeding Low-Income Children during the Covid-19 Pandemic. *NEJM Perspectives*. https://www.nejm.org/doi/full/10.1056/NEJMp2005638?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub++0pubmed. Published 2020.

222. Lancker W PZ. COVID-19, school closures, and child poverty: a social crisis in the making. *Lancet Public Heal*. 2020;5(5):e243-e244. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7141480/.

223. Weale S. Organise catch-up summer schools to help disadvantaged pupils, UK told. *The Guardian*. https://www.theguardian.com/education/2020/jun/03/organise-catch-up-summer-schools-to-help-disadvantaged-pupils-uk-told. Published 2000.

224. Organization WH. WHO and UNICEF warn of a decline in vaccinations during COVID-19. WHO

Newsroom.

225. Royal College of Paediatrics and Child Health UK. Open letter from UK paediatricians about the return of children to schools.https://www.rcpch.ac.uk/sites/default/files/2020-06/open_letter_re_schools_reopening_2020-06-17.pdf. Published 2020.

226. American Academy of Pediatrics. COVID-19 Planning Considerations: Guidance for School Re-entry. https://services.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/clinical-guidance/covid-19-planning-considerations-return-to-in-person-education-in-schools/. Published 2020. Accessed July 20, 2020.

227. Lucie E. Funding flexibility offered for Alberta children with special needs during COVID-19. *CBC NEws*. https://www.cbc.ca/news/canada/calgary/fscd-angela-bladon-trish-bowman-rajan-sawhney-covid-1.5513215. Published 2020.

228. Wang G, Zhang Y, Zhao J, Zhang J JF. Mitigate the effects of home confinement on children during the COVID-19 outbreak. *Lancet*. 2020;395(10228):945-947. https://pubmed.ncbi.nlm.nih.gov/32145186/.

229. Sprang G. Posttraumatic Stress Disorder in Parents and Youth After Health-Related Disasters. *Disaster Med Public Health Prep*. 2013;7(1):105-110.

230. Minds Y. Coronavirus: Impact on young people with mental health needs. Young Minds.

231. Couto M. SickKids guidance for return to school only a starting point, critics say. *CBC News*. https://www.cbc.ca/news/health/covid-school-guidance-reaction-1.5619753. Published 2020.

232. Sick Kids. COVID-19: Recommendations for School Reopening. https://www.sickkids.ca/PDFs/About-SickKids/81407-COVID19-Recommendations-for-School-Reopening-SickKids.pdf. Published 2020.

233. Centers for Disease Control and Prevention. Interim Guidance for Administrators of US K-12 Schools and Child Care Programs. https://www.cdc.gov/coronavirus/2019-ncov/community/schools-childcare/guidance-for-schools.html.

234. Korioth T, Writer S. AAP interim guidance on school re-entry focuses on mitigating COVID- 19 risks. 2020. https://www.aappublications.org/news/aapnewsmag/2020/06/26/schoolreopening062620.full.pdf.

235. Hospital for Sick Kids. Recommendations for School Reopening. 2020. https://www.sickkids.ca/PDFs/About-SickKids/81407-COVID19-Recommendations-for-School-Reopening-SickKids.pdf.

236. Learning Policy Institute. Reopening Schools in the Context of COVID-19: Health and Safety Guidelines From Other Countries. https://learningpolicyinstitute.org/product/reopening-schools-covid-19-brief.

237. Brunswick N. Supporting a Safe Return to School for Canada ' s Children and Youth. 2020:2-3. https://www.cps.ca/uploads/advocacy/Supporting_a_Safe_Return_to_School.pdf.