Public Health Ontario | Santé publique Ontario

ENVIRONMENTAL SCAN

(ARCHIVED) Evidence and Experiences Relevant to Secondary School Settings during the COVID-19 Pandemic

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Key Findings

- In Ontario, the number of cases and percent positivity in children aged 14-17 years has increased since August 30, 2020. The cumulative incidence per 100,000 is higher than other pediatric age groups but lower than adults. The proportion of cases in this age group has remained stable after schools closed (3.8% of all cases reported August 30 to December 18, 2020 vs. 3.7% of all cases reported December 19, 2020 to January 11, 2021).
- Of all cases reported in those aged 14-17 years between August 30 and December 18, 2020, 4.4% were reported to have likely been acquired as part of a public health unit reported school outbreak.
- There was no evidence identified examining the impact of secondary school closures compared with closures of all grades or ages. However, data from the first wave found that regional school closures for in-person learning were associated with reduced COVID-19 cases[1-3] and school closures can potentially reduce transmission (e.g., reproductive number,[2,3] infection growth rate[1] and total cases[4]) during the COVID-19 pandemic. Assessing the impact of any public health measure in isolation (e.g., school closures) is challenging given that multiple measures tend to be implemented concurrently.
- During COVID-19 resurgence, some jurisdictions closed schools completely (i.e., no virtual or in-person attendance),[5-7] while others implemented mixed approaches, offering both in-person and virtual learning, [8,9] or full-time virtual learning.[10,11] Others have re-opened to in-person attendance after a sustained period of low COVID-19 incidence.[12]

- While national or regional data on COVID-19 incidence and transmission specific to secondary schools is limited, data from England shows that maintaining full-time in-person learning during resurgence of COVID-19 may have contributed to higher COVID-19 incidence among secondary school-aged populations. Short (e.g., two-week) school closures have been associated with only a brief reduction in case incidence among school-age populations (i.e. Wales, Northern Ireland, Belgium).[13-17]

- There are important negative impacts of public health measures to this age group. Adolescents have experienced negative health outcomes during the pandemic that include worsening mental health, decrease in education, and are at increased risk of disordered eating behaviours.[18] When making decisions about regional school closures it is important to consider public health aims (including short and long term goals of decreasing community transmission) and known harms of closures as well as strategies to mitigate harms.

Purpose and Scope

This document summarizes evidence and contextual information (January 2021) about secondary school closures during the Coronavirus Disease 2019 (COVID-19) pandemic. Specifically, this focused scan addresses the following five questions:

- What is known about the **Ontario context** in terms of COVID-19 epidemiology in secondary school-aged children?

- What does recent evidence tell us about COVID-19 **transmission** amongst adolescents and secondary/high school students in school settings?

- What does recent evidence tell us about the **effectiveness of school closures** on COVID-19 transmission?

- What does recent evidence tell us about the **impacts of school closures on adolescents' health**?

- What actions around secondary school closures have occurred in **other jurisdictions**?

We acknowledge the need to monitor rapidly emerging evidence, including with respect to variants, which were out of scope for this scan.

This document can be used by public health decision-makers to inform understanding of school closure in the context of the COVID-19 pandemic as well as understand the approaches to school closure implemented in select jurisdictions.

Background

In recent months, restrictive community-based public health measures have been implemented in various jurisdictions (national and regional) to manage COVID-19 resurgence and related health system capacity impacts. Restrictions have been implemented in a variety of settings including social gatherings, schools, businesses, and places of worship.[19] While some evidence suggests that schools are not the main drivers of community transmission,[20] regional school closures have been a component of community-based public health measures for COVID-19 at various times since early 2020.[21] Cases in schools can reflect case numbers in the broader community;[19,22-24] however, outbreaks in schools occur[25] and have also been estimated to increase as community incidence increases. However, studies evaluating transmission in schools settings are often limited by the lack of systematic testing of contacts to assess asymptomatic infection. [26,27]

Decision-makers around the world face the ongoing challenge of balancing measures to reduce transmission of COVID-19 and actions that may potentially amplify spread in the community. This is of critical importance related to schools, given the established harms from public health measures during COVID-19.[18] In terms of reopening schools for in-person instruction, recent reviews recommend the best approach to support school reopening is the suppression of COVID-19 to near zero case incidence in the broader community.[20]

At this time, Ontario is experiencing high community prevalence across the province requiring stringent public health measures to manage related health system capacity compromise, different from when schools re-opened in September 2020.[28] Both elementary and secondary schools remain closed in higher prevalence jurisdictions.[29] In Europe, some countries have also closed schools during resurgence.[19,30] Further, emerging variants of concern have impacted public health measures in some countries such as the United Kingdom (UK) with schools in England currently closed to most pupils until at least the end of February 2021.[31,32]

In some jurisdictions, recommended strategies to reduce COVID-19 risk, and potentially harms of school closure, include school closure considerations by age group. For example, in Alberta, an expert consensus panel suggest a lower threshold for high schools to close than primary schools due to the larger geography covered by high schools and increased ability for online learning in adolescents.[27] A recent report by the United States (US) Centers for Disease Prevention and Control (CDC) noted that there is a lower incidence of COVID-19 among younger children, suggesting that the risk of transmission among children associated with reopening child care centers and elementary schools may be lower than that for reopening high schools and institutions of higher education.[33]

To inform actions in the COVID-19 pandemic, this focused scan examines relevant evidence and contextual information on secondary school-aged children, school closures and the impact of school closures.

Methods

The methods for this document involved three components: describing Ontario data; an evidence review; and a targeted scan of select countries and jurisdictions to identify documentation on restrictive measures in secondary schools, relevant to Ontario (conducted December 17-18, 2020; updated January 20, 2021).

The Ontario context section includes Ontario epidemiological data (e.g. ICES, Public Health Ontario (PHO)) and selected survey data reported by a sample of Ontario secondary school students from the Cannabis, Obesity, Mental health, Physical activity, Alcohol, Smoking, and Sedentary behaviour (COMPASS) report.[34] The COMPASS system is a research platform for evaluating natural experiments and generating practice-based evidence in school-based prevention. See Appendix A for technical notes regarding Ontario epidemiological data.

The evidence review included primary literature (searched December 17, 2020) as well as evidence summarised from existing syntheses that were provided by experts and also a targeted grey literature search (e.g., PHO's umbrella review of evidence on COVID-19 and children,[24] a European Centre for Disease Prevention and Control (ECDC) report[26] and an Ontario Science Table report.[35]). Specifically, the section on 'COVID-19 transmission and the role of secondary school settings' was informed by three living reviews produced by the National Collaborating Centre for Methods and Tools (NCCMT)[25,36,37] and two additional papers (Australia and Israel contexts).[20,38] The section on 'relative effectiveness of secondary school closure' section was informed by seven studies (see Appendix B for details).

The jurisdictions included from the scan are: England, Wales, Northern Ireland, Belgium, France, Spain, Italy, Israel and Australia. These jurisdictions were selected for previous PHO scans due to relevance to Ontario in terms of health system context and having experienced relative control over COVID-19 infections after the first wave, followed by COVID-19 resurgence requiring re-escalation of community-based public health measures. England, Wales and Northern Ireland are considered separately as their pandemic response governance has operated at the individual country level; thus, relevant to the Ontario context. Records were obtained through online searches conducted using Google and government websites to identify recent policies, media articles, government websites, and reports.

This scan did not include a detailed consideration for the emerging COVID-19 variants of concern; however, it is acknowledged that this is a rapidly evolving situation in Ontario which has implications for public health measures including school settings.

Ontario Context

Ontario Epidemiology in Secondary School-aged Children

CONFIRMED CASES IN 14 TO 17 YEAR OLDS IN ONTARIO

- Cumulatively, there have been a total of 7,767 cases in children aged 14-17 years between January 2020 and January 14, 2021 (using data extracted January 14, 2021). The number of cases in children aged 14-17 years is increasing over time.[39] Between August 30 and December 18, 2020 (last day of school prior to winter holiday for the majority of schools), there have been 4,256 confirmed cases of COVID-19 in this age group. Between December 19, 2020 and January 14, 2021 (i.e. the period of time since the last day of school prior to the start of holidays for most jurisdictions), there have been 2,794 cases reported amongst children aged 14-17 years.
    - Between August 30 and December 18, 2020, children aged 14-17 years accounted for 3.8% of all COVID-19 cases reported in this period. This age group accounted for 3.7% of all cases reported between December 19, 2020 and January 14, 2021.
    - Cases reported from approximately early January on would reflect those acquired after schools closed and without possible school exposure. Monitoring of cases in school aged children will be important as some public health units (PHUs) have begun to reopen for in-person learning.
- The cumulative rate of COVID-19 cases aged 14-17 rate is 1,221.5 cases per 100,000 population. This cumulative rate (as of January 14) is higher than for other pediatric age groups (i.e., <14 years) but lower than in those aged ≥18 years. For comparison, the cumulative rate is 530.2 per 100,000 in those aged 0-3, 697.0 per 100,00 in those aged 4-8, 943.0 per 100,000 in those aged 9-13 and 1,718.4 per 100,000 in those aged ≥18 years.
- Data from ICES show the percent positivity for children tested for COVID-19 aged 14-17 has increased over time, since August 30 (Figure 1); the most recent data show a decline in percent positivity for the first time since September.[40] The percent positivity in this age group for the most recent week available (January 10 to 16, 2021) was 12.2%. This compares to 5.5% for all age groups (excluding those residing in long-term care) across the province for the same time period. Percent positivity by age group is likely to vary by PHU; factors that influence per cent positivity can include incidence, testing volumes and screening guidance.

Figure 1. Percent positivity for Ontario and select age groups, August 30, 2020 – January 16, 2021, as produced by ICES[40]

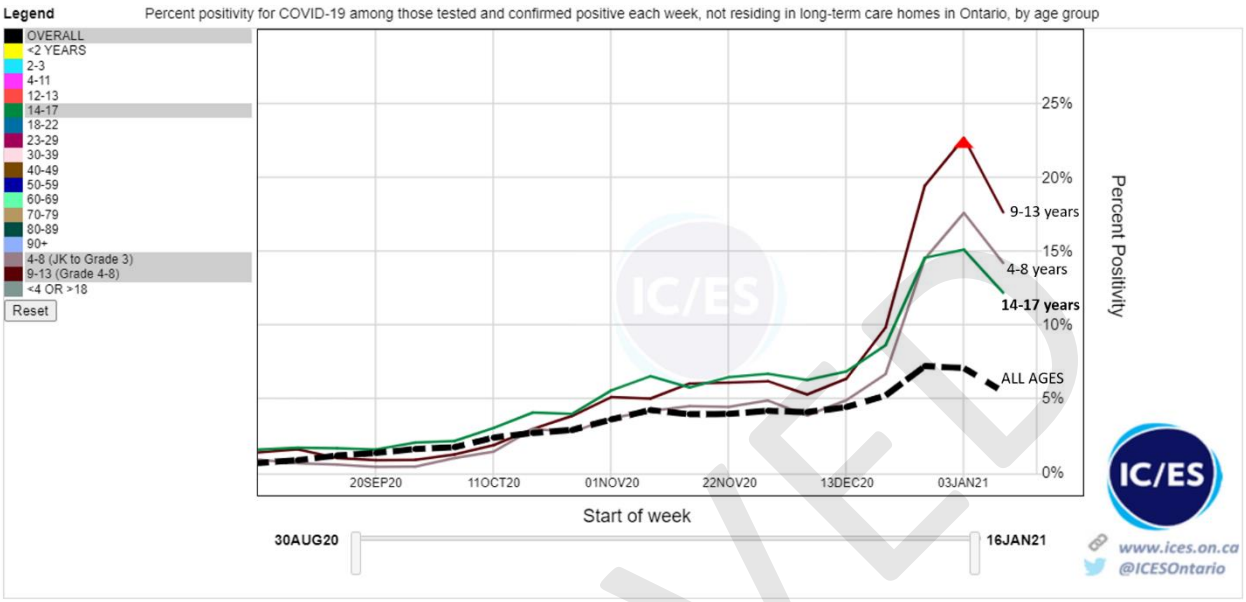

Image source: ICES COVID-19 dashboard [Internet]. Toronto, ON: ICES; 2021 [updated 2021 Jan 21; cited 2021 Jan 25]. Available from: https://www.ices.on.ca/DAS/AHRQ/COVID-19-Dashboard

- Among cases reported between August 30 and December 18, 2020, the most frequent likely source of acquisition in individuals aged 14-17 years was close contact (69.9%); no known epidemiological link (11.6%); information missing or unknown (10.1%); outbreak-associated (8.0%); and travel (0.5%) (Table 1).
    - Over this time period, there were 290 cases in the 14 to 17 year age group that were identified by the local PHU as associated with any school outbreak (242 cases associated with secondary school outbreaks, 41 cases associated with elementary/secondary school outbreaks, 7 cases associated with elementary school outbreaks). The likely source of acquisition for these 290 cases was most frequently reported as outbreak-associated (n=188, 64.8%), followed by close contact (35.2%).
    - This indicates that even among cases documented as associated with a school outbreak, over one-third likely acquired COVID-19 from a known close contact (e.g., a sibling in the household of an outbreak-associated case or the index case of a school outbreak, where identifiable).

Table 1. Confirmed cases of COVID-19 by likely source of acquisition* for cases aged 14-17 years by time periods of interest: Ontario

Likely source of acquisition	Cumulative reported cases (January 15, 2020 to January 14, 2021)	Percentage	Cumulative reported cases (August 30 to December 18, 2020)	Percentage	Cumulative reported cases (December 19, 2020 to January 14, 2021)	Percentage
Close contact of a confirmed case	5,371	69.2%	2,973	69.9%	1,881	67.3%
Information missing or unknown	944	12.2%	430	10.1%	499	17.9%
No known epidemiological link	897	11.6%	492	11.6%	312	11.2%
Outbreak-associated (any outbreak setting)	499	6.4%	341	8.0%	91	3.3%
School outbreak-associated	217	(43.5% of outbreak-associated; 2.8% of all cases)	188	(55.1% of outbreak-associated; 4.4% of all cases)	26**	(28.6% of outbreak-associated; 0.9% of all cases)
Travel	50	0.6%	19	0.5%	11	0.4%
Epidemiological link – type unspecified	6	0.1%	1	0.0%	0	0.0%
Total	**7,767**	**100.0%**	**4,256**	**100.0%**	**2,794**	**100.0%**

Note: *An individual may be linked to an outbreak but have a different likely source of acquisition. As such, the values provided in this table do not align with the number of cases associated with an outbreak.
**Cases may be linked to a school outbreak following school closure (because it takes time for the case to arise, be identified and data entered).

OUTBREAKS IN SCHOOL SETTINGS IN ONTARIO

Another way to examine the relevant data is to describe outbreaks in schools and cases linked to these outbreaks (versus cases by age group and likely source of acquisition including outbreaks, as presented above). An enhanced summary of school outbreaks and associated cases was recently published by PHO.[41]

- Overall, a total of 513 outbreaks have been reported in schools between August 30, 2020 and January 2, 2021 (nb: this end date allows for outbreaks related to the fall semester to be identified and entered into the data). Of these, 115 (466 associated cases [all ages] have been in secondary schools, 27 (182 associated cases [all ages]) in elementary/secondary schools and, and 371 outbreaks in elementary school settings (and 1,413 associated cases [all ages]).
    - Among the 115 outbreaks (and 466 outbreak associated cases) in secondary school settings, 132 cases were aged ≥18, 268 cases aged 14-17 and 63 aged <14 years, and 3 were missing age.

- There have also been 27 outbreaks (and 182 associated cases [all ages]) in elementary/secondary school settings (i.e., schools educating children in a combination of elementary and secondary grades). Among the 182 cases, 88 cases were aged ≥18, 41 cases aged 14-17 and 53 aged <14 years.

- To note, cases can be associated with an outbreak but may not have the outbreak listed as their likely source of acquisition. As such, 317 cases aged 14-17 were associated with a school outbreak reported between August 30, 2020 and January 2, 2021 (268 of which were associated with a secondary school outbreak); however, only 210 of these cases (66.2%; 210/317) were reported to have likely acquired their infection as a result of a school outbreak.

- This differs from above due to differences in time periods (i.e., 290 cases associated with school outbreaks in those aged 14-17 years reported between August 30 and December 18, 2020, and an additional 27 outbreak-associated cases in this age group were reported between December 19, 2020 and January 2, 2021).

- The median number of cases associated with secondary school outbreaks is 2 and appears to be relatively consistent since schools reopened. The maximum number of cases associated with a single secondary school outbreak is 40 (see technical notes in the Appendix A).

Health Behaviours of Ontario Secondary School students – Selected Survey Findings

An online survey of 3,100 Ontario secondary school students was conducted by COMPASS during April and May, 2020.[34] Students responded to questions about their knowledge of COVID-19, degree of adoption of preventative measures, feelings and concerns, consequences of COVID-19 on their well-being, substance use, and mental health, and ways that they coped and adapted to school closures.

Most students (74%) reported that they got along well with their families, but they also did not like having to stay home (62%). Students also reported feeling calm and relaxed, but more than half (56%) also reported concern for the future. There was an increase in boredom, loneliness, stress, and anxiety compared to before the pandemic. Most students reported an increase in their time spent watching television/movies, playing video games, and/or surfing/posting on social media and communicating with their friends online. Close to half of students (46%) reported an increase in their time spent sleeping and about one third (32%) reported an increase in their time spent being physically active. Only a few students (2-10%) reported an increase in their use of substances during the COVID-19 pandemic. The 2-10% represents the increase in the different types of substances; 2% for cigarette smoking, 5% increased vaping, 6% cannabis use, 10% alcohol consumption. The two most frequently reported coping mechanisms included staying connected with friends online (79%) and playing video games, watching TV or movies, and/or surfing the internet/social media (76%).[34]

Evidence Review – Secondary School-aged Children

COVID-19 in Secondary School-aged Children

Earlier in the pandemic, a small proportion of cases were in children.[24,35] Both the PHO umbrella review and the Ontario Science table report this may be indicative of testing patterns, reduced exposure (e.g., school closure), or under-detection (e.g., due to asymptomatic infections) of paediatric cases.[24,35] Over time, the proportion of cases in children has increased and it is recognized that children of all ages are susceptible.[24,35] Syntheses of published and grey literature have examined susceptibility to COVID-19 and age.[24,35,38,42-44] Some systematic reviews that have extracted information in the adolescent age group show that adolescents age 14 years and older appear to have similar susceptibility as adults.[25] Seroprevalence studies have also shown comparable rates between adolescents (no specific age defined) and adults.[45]

While some serology studies show younger adults (< 35 years old) often have the highest rates of seropositivity in comparison to other age groups, there are limitations and biases to these types of studies.[42] Data from Finland and Sweden also show higher reported cases amongst older children (6-15 years and 16-19 years), compared to younger children (1-5 years).[46] One explanation for the elevated rates in these older age groups is the close and prolonged interactions and mixing amongst this group.[42] An Ontario report ('The Role of Children in SARS-CoV 2 transmission' August 31, 2020) specifies that "early suggestions that children are considerably less important for SARS-CoV-2 transmission than adults are not confirmed by recent research".[35]

COVID-19 Transmission – Role of Secondary School Settings

Earlier analyses of COVID-19 infection amongst students attending school (following school re-opening in Australian and Italian contexts) describe similarities with community trends, but also report primary and secondary school-aged differences. For example, evidence identified by the NCCMT report show higher cases among adolescents than younger children.[20,44,47] Confirmed cases of COVID-19 in primary schools in Victoria, Australia were less likely to result in an outbreak, compared to cases identified in the secondary schools.[20] Contact tracing studies (Australian and Italian contexts) of young children in primary schools also yield fewer contacts and secondary cases than those in secondary schools.[20,33,42,47]

As noted earlier, a recent CDC report suggests that the risk for COVID-19 introduction and transmission among children associated with reopening child care centers and elementary schools might be lower than that for reopening high schools and institutions of higher education.[33] A recent (January 21, 2021) update of the NCCMT review concluded that while the risk of transmission from children to children and children to adults in primary school and daycare settings is low (when infection prevention and control (IPAC) measures are in place and adhered to), the risk of transmission within secondary schools is less clear.[36] This may be due the levels of adherence of IPAC measures in secondary school settings and activities outside of the school settings.[36]

An ECDC report (December 23, 2020) updates evidence on COVID-19 in children and the role of school settings. While outbreaks in schools have been reported across various European Union (EU) countries, ECDC reports that the prevalence of COVID-19 in the school reflects the prevalence in the community.[26]

The ECDC report concludes that transmission in schools is relatively uncommon and that school settings play a limited role in transmission. “Factors related to the level of community transmission and nature of contact with others appear to have a higher impact on one’s risk of exposure” (e.g., social activities and gatherings with people outside of the household) than presence in a school. This aligns with some key messages from the ECDC such as school closures alone are insufficient to prevent community transmission and other public health measures need to occur at the same time (e.g., restrictions on mass gathering).[26] The ECDC acknowledges initial reports about increased transmissibility of the new ‘UK variant’ are not taken into account at the time they completed their report. Any new evidence may have implications on the re-opening and closure of schools.

The literature on transmission in school-aged children and youth is evolving and the potential for school-aged children and youth to transmit is recognised.[24] While there are varying contexts among the summarised literature, the need to exercise caution when considering re-opening secondary schools is highlighted. Additional factors to consider for re-opening secondary schools include rates of community spread and enhanced in-school measures.[20,42] However, guidance generally indicates that school operation for in-person instruction should continue to be coupled with other mitigation measures in schools (e.g., symptom and exposure screening, physical distancing, masking, hand hygiene, reduced cohort/class sizes).[25]

Adolescent Health Impacts from Public Health Measures

A rapid review was conducted by PHO on the negative impacts of community-based public health measures implemented in response to COVID-19 on the health and well-being of young children and families. The literature searches were completed to May 2020.[48] The rapid review was updated (January 2021), based on literature searches in September 2020 reflecting data collected during the first wave of the pandemic March-June 2020.[18] One study was qualitative so adolescents could provide their experiences more specifically related to school closure. The most recent (January 2021) rapid review findings describe a range of health impacts on adolescents due to public health measures during the COVID-19 pandemic: anxiety and depressive symptoms, post-traumatic stress symptoms, self-harm and suicidal ideation, disordered eating behaviours and substance use. One-third of Canadian children and adolescents reported worrying more during the pandemic,[49] and 32% of children and adolescents in the UK reported worsening overall mental health.[50]

Chinese adolescents reported significantly increased levels of depressive symptoms (24.9%), non-suicidal self-injury (42.0%), and suicidal ideation (29.7%),[51] as well as anxiety and post-traumatic stress symptoms.[52] One review and one primary study identified increased risk of disordered eating behaviours.[53,54]

The proportion of adolescents who used substances did not change significantly during the public health measures, compared to before the pandemic lockdown/ public health measures. However, of those adolescents who reported any substance use, the frequency of alcohol and cannabis use increased; 23.6% used while physically with friends (face-to-face), 31.6% used virtually with friends, and 42.0% used substances, mainly alcohol, with their parents.[55]

Of particular concern may be adolescents with pre-existing mental health issues or in priority populations. Adolescents reporting previous early life stress had higher depressive symptoms[56] and those reporting previous mental health issues reported higher anxiety.[57] Adolescents identifying as Lesbian, Gay, Bisexual, Transgender, and Queer or Questioning (LGBTQ)[58] reported feeling anxious and uncertain about school closure, as well as feelings of grief due to losing a “safe space”, particularly those who only disclose their LGBTQ identity at school.[59]

A caveat; all of the studies included in this review used data collected in the first wave of the pandemic. Therefore school closure and other public health measures were happening simultaneously. As the initial search was conducted in September 2020 when students had not yet returned to school, the impact of a hybrid model (i.e. some in-person learning) could not be explored. Additionally, the independent impact of school closures is challenging to assess.

Relative Effectiveness of Secondary School Closure

A rapid review by PHO ('COVID-19 Pandemic School Closure and Reopening Impacts' July 27, 2020) was based on published and grey literature about COVID-19 and school closures, primarily focused on transmission and pathogens.[60] The literature search was completed on July 11, 2020 and the rapid evidence review included 10 studies regarding the effectiveness of school closure. Both primary and secondary schools were included in the rapid review. No secondary school specific data was available. The findings are consistent with the present evidence review; COVID-19 outbreaks in school settings were not commonly reported. The PHO rapid review also described evidence from modelling studies that predicted a resurgence of COVID-19 upon reopening of schools; however, they assert that impacts can be mitigated by implementing additional measures in schools and the community (e.g., reduced class sizes, testing symptomatic people, contact tracing).[60]

For this scan, an updated search in the MEDLINE database was conducted on December 17, 2020 for primary literature published from June 1 to December 15 2020. English-language peer-reviewed and non-peer-reviewed records that describe impacts of school closure on COVID-19 were included. Modelling studies that describe a projection for potential impacts were excluded.

From the updated primary literature search, a total of seven studies were identified that report about the impact of school closure during COVID-19.[1-4,61-63] The seven studies together span numerous countries and describe both school and university settings within a January to July 2020 timeframe, therefore reporting effectiveness from wave 1 of the pandemic, when there may have been limitations related to unstructured reporting, limited or targeted testing and minimal or no enhanced health and safety measures in schools. Some studies also include non-pharmaceutical interventions.[1] **No secondary school specific data was identified.**

Overall, closures of educational settings appeared to be effective at contributing to a reduction in the spread of COVID-19 in wave 1, and re-opening was associated with an increase in transmission. All seven studies reported a relationship between school closure and reduction in COVID-19 indicators such as reproduction number,[2,3] mortality,[4,61,62] infection growth rate,[1] and total cases.[4] The timing of school closures may also have been a factor in effectiveness;[61-63] however, this data should be interpreted with caution. Overall, from the included evidence, delaying school closures was reported to be associated with increased COVID-19 indicators (e.g., incidence rate, hospitalisations, mortality).[1,61-63]

For more details on the seven included studies, see Appendix B.

Secondary School Jurisdictional Scan: School Closures for Select Jurisdictions since Fall 2020

The findings below, based on a grey literature scan (initially conducted on December 17 and 18, 2020, updated on January 20 2021), describe the use and approaches to secondary school closure in select jurisdictions since the school year commenced in the fall 2020 (during a period of COVID-19 resurgence). The jurisdictions included are: England, Wales, Northern Ireland, Belgium, France, Spain, Italy, Israel and Australia (Victoria, Melbourne).

Where available, trends for COVID cases in specific age groups and in secondary settings are provided; however, it was beyond the scope of this report to add broader epidemiological trends.

UNITED KINGDOM (ENGLAND)

SECONDARY SCHOOL CLOSURES

- The four-tiered *COVID-19 Contain Framework* (implemented July 18, 2020) granted local authorities in England powers to respond to and prevent COVID-19 transmission in their local area.[64] The tiers in the framework defined by higher COVID-19 transmission (tier one is lowest transmission, tier four is highest) involved moving secondary schools online:
    - In tier one all schools were open; in tier two secondary schools moved to a model that combine in-person and online education, with full-time in-person attendance permitted only for vulnerable students; in tiers three and four in-person attendance at secondary schools was only permitted for vulnerable students.
- During the national lockdown from November 5, 2020 to December 2, 2020, all schools remained open to in-person attendance.[65] On December 3, 2020, England implemented a new tiered framework which still permitted students (regardless of the "tier" they reside in) to attend school as normal, unless they are self-isolating.[66]
- The national holiday guidance in England recommended that all students continue to attend school until the end of the term, and that schools should not change the term end date.[67]
- As of January 4, 2021, related to evolving response to COVID-19 UK Variant of Concern, in-person attendance in all secondary schools in England is restricted to vulnerable students (e.g., those who have a social worker, have an 'education, health and care plan', have difficulty engaging with remote education,[68] or are deemed vulnerable for another reason) and students whose parents/guardians are critical workers.[68,69] The remaining students must attend school virtually. It is important to note that nationwide, the UK government has not required face coverings in education settings.[70]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- During the period in which there were no school closures in England, secondary school-aged students had high COVID-19 infection rates.[68] From November 13 to December 11, 2020, the UK Infection Surveys reported that the estimated percentage of the population testing positive for COVID-19 infection continues to be the highest among secondary school-aged students in school Year 7 (first year of secondary school) to Year 11 (final year of secondary school), which captures students aged 12 to 16.[71-75]
- The most recent UK Infection Survey published on January 8 2021, reported that infection rates are no longer increasing among England's school-age population.[76]
- **Caveats:** UK COVID-19 Infection Survey reports an estimate of the percentage of the entire secondary school aged population that has tested positive for COVID-19 (percent positive), based on confirmed cases and population estimates for this age group. The age range represented in Year 7 to Year 11 data is 12 to 16 years of age, which does not align exactly with Ontario's secondary school population.

UNITED KINGDOM (WALES)

SECONDARY SCHOOL CLOSURES

- Leading up to the lockdown period beginning on October 23, 2020, all staff and pupils in Wales had returned to school in-person since September, 2020.[77]

- The lockdown period covering October 23, 2020 to November 9, 2020 was timed during a mid-term break for all Welsh schools. Secondary schools re-opened after the half-term break, for years seven and eight.[7]

- The Welsh county with the highest COVID-19 infection rates closed its schools on December 9, 2020 ahead of the planned holiday closure; however, the Welsh Government, committed to keeping schools open until the term ends on December 18, 2020.[78] For the last week of the school term (December 14 to December 18, 2020) secondary schools across Wales had the discretion to move to remote/online learning.[79]

- As of January 8, 2021, related to the response to the UK Variant of Concern, all secondary students in Wales are attending school remotely, with the exception of vulnerable children and children of critical workers, who have the option to attend school in-person along with students taking essential exams and assessments. This is set to be re-assessed on January 29, 2021.[79]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- As of January 14, 2021, the COVID-19 case rate among Welsh residents aged 15 to 19 is 6,511 per 100,000 (among females) and 5,220 per 100,000 (among males). This is an increase from a month prior, when on December 17, 2020, the COVID-19 case rate among Welsh residents aged 15 to 19 is 5174 per 100,000 (among females) and 3976 per 100,000 (among males).[17]

- **Caveats:** All COVID-19 case incidence data reported by the UK Government for Wales is stratified by both age and sex, therefore age groups cannot be observed without stratifying by sex. The data for Wales reported by the UK Government only reports the data by age and sex for the most recent reporting week, therefore trends over time cannot be observed.

UNITED KINGDOM (NORTHERN IRELAND)

SECONDARY SCHOOL CLOSURES

- In September 2020, all schools in Northern Ireland re-opened for the first time since March, 2020. Safety measures in school included staggered start times, and one-way movement systems requiring face coverings for post-primary students.[80]

- Schools in Northern Ireland closed for two weeks (including the half-term holiday) starting on October 19, 2020.[6]

- Regulations for the holiday period covered December 23 to December 27, 2020.[81] This guidance noted that schools should not change or extend their Christmas holidays or close early this term, and that students should continue to attend school until the last day of term unless they have been told to self-isolate. Remote learning was only encouraged if children have been told to self-isolate.

- As of January 20, 2021, related to response to the UK Variant of Concern, all secondary schools must provide remote learning to students until the mid-term break in mid-February 2021.[81] Vulnerable children and children of key workers will have access to schools for supervised learning.

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- For the week leading up to the two week school closure on October 19, 2020 (week of October 12 to October 18, 2020) 1,100 residents aged 0 to 19 tested positive for COVID-19, which accounted for 15% of all positive tests over a seven day period.[16]

- After the second week of Northern Ireland's school closure, only 640 residents aged 0 to 19 tested positive for COVID-19, accounting for 12.9% of all positive tests over a seven day period.[15]

- Prior to the holiday period (reporting week of December 10 to 16, 2020), 14.6% of Northern Ireland's positive lab confirmed COVID-19 tests were among those aged 0 to 19 (n=516 total cases in this age group over the seven day period).[82]

- Most recently, as of January 19 2021 (reporting week of January 13 to 19, 2021), 10.8% of Northern Ireland's positive lab confirmed COVID-19 tests were among those aged 0 to 19 (n=635 total cases in this age group over a seven day period).[14]

- **Caveats:** Northern Ireland Department of Health reports on ages 0 to 19 years combined into one cohort, and does not have further disaggregated data by school-age cohorts. Ages 0 to 19 does not align with Ontario's secondary-school age population. The data is presented as total weekly case incidence, and is not population adjusted.

BELGIUM

SECONDARY SCHOOL CLOSURES

- All schools in Belgium reopened on September 1, 2020 when the academic year started, with all students over the age of 12 and teachers required to wear mask.[83]

- The planned autumn break from November 2 to 11, 2020 was extended until November 15, 2020 to keep schools closed.[5] On November 16, 2020, secondary school students returned to school after the prolonged school holiday, with alternating weeks of in-person and online education.[5]

- Belgium's education ministers ruled against extending the planned holiday school closure over the holidays. The ministers decided to re-open schools as planned on January 4, 2021 and ruled against extending the holiday school closure.[84]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- Over the seven day period leading up to the school closure on November 2, 2020, there were 8,445 COVID-19 cases identified among the 10 to 19 age group (7.4% of total cases identified during this period for all age groups).[13]

- During the first week of school closures in Belgium (November 2 to 9, 2020), only 3458 cases were identified among the 10 to 19 age group (5.5% of total cases identified during this period for all age groups).[13] One week is soon after closures, and the median incubation period is 5-7 days and added delay of identifying positive lab tests should be considered. During the second week of school closures (November 9 to 16, 2020), 2,482 new COVID-19 cases identified among the 10 to 19 age group (6.2% of total cases identified during this period for all age groups).[13]

- Prior to the holiday period (during the week of December 9 to 16, 2020), there were 1,644 new COVID-19 cases identified among the 10 to 19 age group in Belgium (10% of total cases identified during this period for all age groups).[13]

- During the most recent 14-day period of reporting (January 6 to 19, 2021), there were 2,402 new COVID-19 cases identified among the 10 to 19 age group in Belgium (10% of total cases identified during this period for all age groups).[13]

- **Caveats:** Sciensano aggregates age groups into set categories, and ages 10 to 19 are reported as one aggregated age cohort, which does not align with Ontario's secondary-school age population. The data is presented as total weekly case incidence, and is not population adjusted.

FRANCE

SECONDARY SCHOOL CLOSURES

- France's national wave two lockdown began on October 30, 2020, however, lycées (the second/final stage of high school in the French education system for students aged 15 to 18) remained opened to in-person attendance.[85] On November 2, 2020, all lycées across France were given permission to move up to half of their classes online as the country's lockdown continues.[9,85]

- Full compliance with the reinforced high school protocols (from November 2 onward) has required high schools in France to adapt their educational approach. Some high schools have had to implement a pedagogical continuity plan with alternating pupils attending in-person organized by half-class, by grade or by week.[9]

- Before the planned holiday closures (as of December 18, 2020), about 30% of high schools in France have maintained 100% face-to-face; and 69% of high schools applied a continuity plan, 60% of which are organized by half-class and 30% of which are organized by grade-level.[9] Since December 4, 2020, there have been no reported closures of high schools in France.[9]

- After the planned period of holiday school closures, all high schools remain open in France.[86,87]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- France's Ministry of Education published case summaries of COVID-19 infection in education settings (rather than school-aged children), since reopening schools in September 2020. Among France's students, COVID-19 infections have been declining since November 20, 2020 (at which point they were 13,870 over seven days) to 4,548 over seven days on December 11, 2020.[9] This is the most recent case summary reporting (Dec 11, 2020) in education settings.

- **Caveats**: All students (primary and high school) are reported in a single aggregate group for confirmed cases over the past seven days. The data is presented as total weekly case incidence, and is not population adjusted.

ITALY

SECONDARY SCHOOL CLOSURES

- All schools re-opened nationally at the start of the school year in September, 2020, after being closed to in-person attendance for six months.[88,89] On October 22, 2020, the Lombardy, Lazio (where Rome is located), and Campania (where Naples is located) regions all prohibited in-person attendance at all secondary schools.[90]

- On November 5, 2020, under the new national restrictions, school attendance was moved to online for all secondary school students across Italy.[91]

- Italy implemented additional measures around the holiday break from December 21, 2020 to January 6, 2021 during which schools were already set to close. On January 7, 2021, all secondary schools must guarantee in-person teaching activities for 75% of the student population.[92]

- Secondary school students in Italy were delayed in their return to school until January 11, 2021 rather than the originally planned January 7, 2021.[8] As of January 11, 2021 secondary students returned to in-person learning for only 50% of their classes.

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- Ahead of Italy's planned re-opening of schools in September, they ordered the testing of nearly half of all Italian school staff, through which they identified 13,000 cases (2.6% of all staff tested).[93] The staff who tested positive where prohibited from returning to school.

- A recent population-based study on secondary transmission of COVID-19 in school settings in northern Italy after they re-opened in September, found notable increases in transmission within schools, particularly in secondary schools.[47] The study also found that the attack rate was higher in secondary schools, than it was in primary schools.[47]

- Prior to the holiday period (as of December 16, 2020), 11% of new COVID-19 cases in Italy over the past 30 days were among those in the 0 to 18 age group (n=63,285 total cases over the past 30 days).[94]

- As of January 19, 2021, 12.2% of new COVID-19 cases in Italy over the past 30 days were among those in the 0 to 18 age group (n=47,082 total cases over the past 30 days).[94]

- **Caveats:** The data from Larosa et al., 2020 are specific to northern Italy (specifically Reggio Emilia, Italy).[47] The NCCMT rated the strength of the Larosa et al., 2020 study as moderate in a recent evidence review.[25] Incidence and transmission trends over time could not be retrieved from Istituto Superiore di Sanità, 2020 data for the 0 to 18 age group.[94] Ages 0 to 18 are reported as one aggregated age cohort, which does not align with Ontario's secondary-school age population. The data from Istituto Superiore di Sanità, 2020 is reported as total weekly case incidence, and is not population adjusted.[94]

SPAIN

SECONDARY SCHOOL CLOSURES

- Between September 7 and 14, all schools in Spain reopened for the new school year, with all children over the age of six required to wear a mask while in school.[95,96]

- During the state of emergency declared on October 25, 2020, all schools remained open.[97] As of December 2020, less than 1% of schools in Spain had been closed.[98] In January 2021, several regions in Spain introduced stricter measures; however, school closures have not been included in these measures at the regional or national level.[99,100]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- Regional data from Spain on the 14-day cumulative incidence of COVID-19 among school-aged populations was included in a larger study called *Analysis and prediction of Covid-19 for EU-EFTA-UK and other countries*.[96]

- Spain's regional data shows that the re-opening of schools in September 2020 was followed by a slight increase in COVID-19 incidence among the school-age population in Catalonia (among ages 10 to 19) and Andalucía (among ages 15 to 29), and a significant increase in COVID-19 Castilla y León among those ages 10 to 19.[96] However, the report notes that the increase in incidence may be due, in part, to the increased COVID-19 screening at schools in high-incidence areas.

- **Caveats:** The report includes slightly different age group for each of Spain's regions. The report also notes that the particular case of Castilla y León remains open for future research.[96]

ISRAEL

SECONDARY SCHOOL CLOSURES

- On September 7, 2020, 30 cities that were classified in the 'red' zone were placed into lockdown which involved prohibiting in-person school attendance for all schools (except preschools).[101]

- On September 11, 2020 (the start of the Jewish High Holiday season), nationwide restrictions were implemented which included the closure of all schools.[102]

- During the subsequent nationwide lockdown from September 25, 2020 to October 11, 2020, schools remained closed.[103]

- Ministers in Israel approved a two-week lockdown, which included the closures of all schools, beginning on January 7, 2021 and subsequently extended until at least January 31, 2021.[10,11]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- In May, 2020, a large outbreak occurred in a high school in Jerusalem ten days after schools re-opened. There were 1,164 students (aged 12–18 years, grades 7–12) tested and 153 cases confirmed among the students (attack rate of 13%).[104,105] It was reported that classes were crowded in the school, and that public health measures were not adequate to prevent transmission.[104] On May 19-21, 2020 (days leading up to the outbreak), there was an extreme heat-wave leading to the Ministry of Health exempting schoolchildren from wearing facemasks for these three days.[105]

- **Caveats:** The data is a singular experience of one school in Jerusalem, Israel in May 2020 which is not considered a period of COVID-19 resurgence for this review. However, we have included because this study is widely reported. A recent NCCMT evidence review of transmission in schools rated the strength of the Stein-Zamir et al., 2020 study[105] on the outbreak as low.[25]

AUSTRALIA (REGIONAL VICTORIA AND METROPOLITAN MELBOURNE)

SECONDARY SCHOOL CLOSURES

- In July 2020, under the initial lockdown measures in metropolitan Melbourne and the surrounding suburbs (which were hotspots of COVID-19), in-person school attendance was permitted; however, on August 2, 2020 schools moved to online only in metropolitan Melbourne.[106]

- On September 16, 2020 schools reopened in metropolitan Melbourne with social distancing measures in place.[107] As of December 6, 2020 schools were open to onsite learning in Regional Victoria.[12]

COVID-19 CASES AMONG SECONDARY SCHOOL-AGED POPULATION

- Data from July and August, 2020 on school transmission in Regional Victoria indicated that infections associated with schools peaked when community transmission was highest in July and then declined in August, suggesting that cases in schools reflect transmission in the broader community.[20]

- There were fewer COVID-19 clusters and outbreaks in primary school compared to secondary schools in Regional Victoria, and secondary schools required more extensive contact tracing than events in primary schools due to higher median number of contacts (53 vs. 16 median contacts per event).[20]

- Since September 2020, the 7-day moving average of cases per day in Australia has been less than 31 cases (average over seven days).[108] As of January 19 2021, there were only 186 active COVID-19 cases across the country, with a reported 7-day average case growth of 14 cases. While not specific to the secondary school aged population, this underscores the low levels of COVID-19 infection in Australia.[109]

- **Caveats:** The data from Australia in the Murdoch Children's Research Institute report only covers up to August 2020, which does not cover the entire period of the secondary school measures/closures outlined in the preceding section.

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Appendix A: Technical Notes for Ontario Epidemiological Data

- The data for the 'Ontario epidemiology in secondary school aged children' section of report were based on:
    - Information extracted from the Ontario Ministry of Health (Ministry) integrated Public Health Information System (iPHIS) database for Toronto Public Health as of **January 14, 2021 at 1 p.m.**
    - Information successfully uploaded to the Ministry from local systems: Toronto Public Health (Coronavirus Rapid Entry System) CORES and The Ottawa Public Health COVID-19 Ottawa Database (The COD) as of **January 14, 2021 at 2 p.m.**
    - Information successfully extracted from the Public Health Case and Contact Management Solution (CCM) for all other PHUS by PHO as of **January 14, 2021 at 1 p.m.**
    - Percent positivity data obtained from the ICES COVID-19 Dashboard. Details and limitations of these data can be found at the COVID-19 ICES Dashboard.[40]
- CCM plus (which includes CCM, iPHIS, CORES and The COD) are dynamic disease reporting systems, which allow ongoing updates to data previously entered. As a result, data extracted from CCM and the local systems represent a snapshot at the time of extraction and may differ from previous or subsequent reports.
- Ontario population projection data for 2020 were sourced from Ministry, IntelliHEALTH Ontario. Data were extracted on November 26, 2019.
- The data only represent cases reported to public health units and recorded in CCM plus. As a result, all counts are subject to varying degrees of underreporting due to a variety of factors, such as disease awareness and medical care seeking behaviours, which may depend on severity of illness, clinical practice, changes in laboratory testing, and reporting behaviours.
- Only cases meeting the confirmed case classification as listed in the MOH COVID-19 case definition are included except where noted (e.g., analyses that describe the relationship between COVID-19 and marginalization). This includes persons with a positive detection of serum/plasma immunoglobulin G (IgG) antibodies to SARS-CoV-2, which was added to the confirmed case definition on August 6, 2020.
- Cases of confirmed reinfection, i.e. where genome sequencing indicates the two episodes are caused by different viral lineages, added to the confirmed case definition on November 20, 2020, are counted as unique investigations.
- COVID-19 cases from CCM plus for which the Classification and/or Disposition was reported as ENTERED IN ERROR, DOES NOT MEET DEFINITION, IGNORE, DUPLICATE, or any variation on these values have been excluded. The provincial case count for COVID-19 includes cases that are counted once across all systems from which the case data are obtained. Duplicate records may exist if these records were not identified and resolved prior to data upload to the Ministry.

- Likely source of acquisition is determined by examining the epidemiologic link and epidemiologic link status fields in CCM and local systems. If no epidemiologic link is identified in those fields the risk factor fields are examined to determine whether a case travelled, was associated with a confirmed outbreak, was a contact of a case, had an Epidemiological link with type unspecified, had no known epidemiological link (sporadic community transmission) or was reported to have an unknown source/no information was reported. Some cases may have no information reported if the case is untraceable, was lost to follow-up or referred to FNIHB. Cases with multiple risk factors were assigned to a single likely acquisition source group which was determined hierarchically in the following order:
    - For cases with an episode date on or after April 1, 2020: Outbreak-associated > close contact of a confirmed case > travel > no known epidemiological link > information missing or unknown
    - For cases with an episode date before April 1, 2020: Travel > outbreak-associated > close contact of a confirmed case > no known epidemiological link > information missing or unknown
- 'Cases associated with school outbreaks' includes cases that are linked to an outbreak, by school classification type (Elementary, Elementary/Secondary, Secondary, Post-Secondary), that met the definition of a school outbreak.
- School classification types are defined by the Ministry of Education.
    - Elementary/Secondary schools include public or private schools educating children in a combination of elementary and secondary grades (e.g., Kindergarten to Grade 8, Grades 9 to 12, and Kindergarten to Grade 12).
- Outbreaks are declared by the local medical officer of health or their designate in accordance to the Health Protection and Promotion Act and criteria outlined in Ministry guidance documents.
- School outbreaks include outbreaks declared on or after week 36 (August 30 to September 5, 2020).
    - The last day of school prior to closure for the winter holidays in Ontario was December 18th, 2020. Due to potential lags in data entry, school outbreaks reported two weeks past the last day of school were included (outbreaks reported up to January 2nd, 2021).
    - As of January 14th, the majority of school in Ontario have not re-opened for in-person learning. However, a number of schools re-opened in Northern Ontario starting the week of January 11th, 2021.

Appendix B: Details of Effectiveness Studies

Brauner et al., analyzed the effect of non-pharmaceutical interventions (NPIs) between January 22 and May 30, 2020 across 41 countries.[2] The NPIs were implemented nationally or regionally affecting at least 75% of the populations. The effectiveness is expressed as a percentage reduction in R_t. and this study found that **closing both schools and universities had 38% reduction** (95% prediction interval: 16 to 54%). They were not able to determine the individual effects of closing schools or universities as those were implemented either on the same day or in close sequence in most countries.

Li et al., evaluated the association between NPI status and transmission of SARS-CoV-2 between Jan 1 and July 20, 2020 across 131 countries.[3] The association is determined by the ratio of reproduction number (R) between daily R of each stage and the R from the last day of the previous stage (e.g., NPI status change). The change in R over time after introducing school closure showed a reduction in reproduction number in all three time points: Day 7 (R ratio 0.89, 95% CI 0.82–0.97), Day 14 (0.86, 95% CI 0.72–1.02), and Day 28 (0.85, 95% CI: 0.66–1.10). Furthermore, this study also found that relaxation of school closure was associated with an increase in R in the same time points: Day 7 (R ratio 1.05, 95% CI: 0.96–1·14) Day 14 (1.18, 95% CI 1.02–1.36), and Day 28 (1.24, 95% CI 1.00–1.52).

Auger et al., conducted a population-based interrupted time series analyses in all 50 states in the United States between March 9, and May 7, 2020, which allowed at least 6 weeks of data collection after school closures in each state.[61] The adjusted analyses of relative change per week showed school closure was significantly associated with declines in incidence of COVID-19 (−62%, 95% CI −71% to −49%) and mortality (−58%, 95% CI −68% to −46%). In comparison to the highest quartile, closing school when the cumulative incidence of COVID-19 was in the lowest quartile was associated with 128.7 fewer cases per 100 000 population and with 1.5 fewer deaths per 100 000 population over 16 days. School closure was temporally associated with decline in COVID-19 incidence and mortality. There was also a temporal association between school closure and timing of implementation. States that closed schools earlier while cumulative incidence of COVID-19 was low had the largest relative reduction; however, other concurrent NPIs may have also contributed to these reductions.

Hsiang et al., evaluated the impact of NPIs on growth rate of COVID-19 infections across China, South Korea, Italy, Iran, France and the United States from the earliest available dates to April 6, 2020.[1] When estimating the effect of individual policy, only three countries had data on school closure-specific data. The change in growth rate of infections as percent growth per day were: -10.33% in Italy (estimated effect size –0.11, 95% CI –0.25-0.03), -0.9% in France (-0.01, 95% CI -0.09-0.07) and 2.63% in USA (0.03, 95% CI –0.03-0.09). There is greater overall uncertainty in evaluating individual interventions than combined. However, 22 out of 29 point estimates of individual policy are likely to have contributed to reduction of infection growth rate and combined effect of policies within each country reduces the growth rate of infections substantially and statistically significantly.

As most European countries closed schools from March 11 to 20, 2020, Klimek-Tulwin et al., assessed the impact of this government intervention on the incidence rate of COVID-19 on the day of closure and in the following days post implementation across 15 countries (Belgium, Finland, France, Germany, Italy, Norway, Spain, UK, Poland, Romania, Hungary, Latvia, Lithuania, Argentina, Brazil).[62] The study found a strong linear correlation between the day of school closure and the incidence rate in the following days (16^{th}, 30^{th}, and 60^{th} days since the 100^{th} confirmed case in each country). The authors suggest that early closure was found to be statistically significantly correlated with lower incidence rates.

Matzinger et al., in a preprint study, examined the effect of school closure in the United States between March 6 and May 1, 2020. They found three states that separated interventions by at least a week so individual impact can be assessed.[4] In Georgia, total cases declined 8 days after school closure and death rates dropped 14 days later. Seven days post school closure, the initial doubling rate of 2.2 days for total positive cases dropped to 3.5 days. Similarly, there was a twofold drop in total cases 8 days later in Tennessee and 2 days after official closing (or 10 to 12 days after the start of spring break) in Mississippi. They concluded that closing schools appeared to reduce the rate of infections by half, starting 8 to 14 days post closure, and also similarly reduced hospitalizations but with lag times 2 to 4 days longer than for positive infections.

Piovani et al., assessed the impact of early social distancing interventions on cumulative mortality of COVID-19 in 37 countries between January 1 and June 30, 2020.[63] The length of the ascending phase is expressed as number of days from t_0 to peak daily mortality with t_0 as the first COVID-19 death. The unadjusted analyses showed that countries with a high cumulative mortality during the first wave started to close the schools significantly slower (median: 7.5 days, p=0.001) later than countries with a lower cumulative mortality. Similarly, countries with a long ascending phase closed the first school significantly slower median of (median: 6.5 days, p=0.007) than those with a short ascending phase. The adjusted analyses showed that each one day delay in school closure was, on average, associated with an increase of cumulative mortality by 4.37% (95% CI 1.58-7.17) over the study period.

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