

SYNTHESIS

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Mask Wearing in Children and COVID-19 – What We Know So Far

Introduction

Public Health Ontario (PHO) is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). “What We Know So Far” documents provide a rapid review of the evidence on a specific aspect or emerging issue related to COVID-19.

Updates in Latest Version

This updated version replaces the Evidence for Mask Use in Children section of the September 14, 2020 version of *Wearing Masks in Public and COVID-19 – What We Know So Far*.¹ The updated version provides additional evidence for mask use in children and examines mask wearing behaviours in children and the potential impacts of wearing masks.

Key Findings

- There were limited studies directly evaluating the isolated effectiveness of mask wearing in children. However, several studies found that mask mandates in schools have been associated with lower incidence of severe acute respiratory coronavirus 2 (SARS-CoV-2) infection. Wearing masks for outdoor sporting events is unlikely to be beneficial. Many of the studies examining COVID-19 incidence in schools had layered infection prevention and control measures in place, so it was challenging to measure the independent impact of mask wearing. In addition, most of the studies examined did not consider mask wearing in settings where variants of concern (VOCs) were circulating.
- Relatively little research has been published with respect to mask wearing behaviour and compliance in children. However, from the available studies of school and community settings, adherence to mask policies was typically high in children (53–97%) and uptake increased with age.
- There were variable findings with respect to negative health impacts in children who wore masks. Further research is needed to assess potential negative impacts of mask wearing in children, especially for longer-term use of masks.

Background

Wearing of masks in community settings has been shown to be an integral part of a layered approach of public health measures used to lower transmission of SARS-CoV-2 and the incidence of COVID-19.²⁻⁷ The effectiveness of mask wearing is likely a result of source control – protecting others from the mask wearer. Most of the evidence has been from adult populations. Currently, some jurisdictions (e.g.,

United Kingdom) are planning to lift mask mandates for indoor public spaces; however, officials in public health and medicine are urging caution when lifting masking policies.^{8,9}

In this *What We Know So Far* we examine: 1) associations between children wearing masks and COVID-19 incidence in schools and childcare settings, 2) mask wearing behaviours and attitudes in children, and 3) the potential negative impacts of mask wearing in children.

Methods

In considering feasibility, scope, and a need for responsiveness, we chose a rapid review as an appropriate approach to understanding SARS-CoV-2 infection incidence and mask wearing in children. A rapid review is a knowledge synthesis where certain steps of the systematic review process are omitted in order to be timely (e.g., duplicate reviewer screening of articles).¹⁰

We conducted literature searches on June 21, 2021, in MEDLINE, Embase and PsycINFO (search strategies available upon request). We searched PubMed and Google Scholar on July 12, 2021, for additional articles of interest.

English-language peer-reviewed and non-peer-reviewed records that described mask wearing in children were included. We restricted the search to articles published after January 1, 2020. This rapid review concentrated on evidence from systematic reviews and meta-analyses, supplemented by primary literature where appropriate. We reviewed citations from included articles to identify additional research.

Prior to publishing, PHO subject-matter experts review all *What We Know So Far* documents. As the scientific evidence expands, the information provided in this document is only current as of the date of respective literature searches.

Mask Wearing in Schools or Childcare and Association with COVID-19 Incidence

Main findings: There were limited studies directly evaluating the isolated effectiveness of mask wearing in children. However, several studies found that mask mandates in schools have been associated with lower incidence of SARS-CoV-2 infection. Wearing masks for outdoor sporting events was unlikely to be beneficial. Many of the studies examining COVID-19 incidence in schools had layered infection prevention and control measures in place, so it was challenging to measure the independent impact of mask wearing. In addition, most of the studies examined did not consider mask wearing in settings where VOCs were circulating.

Indoor settings

In six studies, authors reported few COVID-19 cases or reduced SARS-CoV-2 transmissions in school and childcare settings, in which mask wearing was a component of public health measures used.¹¹⁻¹⁷ Additionally, there was one article where the cause of outbreaks was attributed to the lack of mask wearing.¹⁸

- Using data from across the United States (US) (576,051 respondents), Lessler et al. (2021) reported there was a slight decrease in the risk of SARS-CoV-2 infection in household adults when children were required to wear a mask while attending in-person learning compared to virtual or homeschooling (self-reported): COVID-19-like illness (CLI) (adjusted odds ratio [aOR]:

0.89; 95% confidence interval [CI]: 0.79–1.01), positive test (aOR: 0.91; 95% CI: 0.83–1.00).¹⁹ CLI was defined as a fever of at least 100°F (37.8°C), along with cough, shortness of breath, or difficulty breathing.

- Using a survey and epidemiological data, Gettings et al. (2021) assessed the impact of school-level (kindergarten through grade 5) prevention strategies in Georgia, US, on the incidence of COVID-19 among students and staff prior to vaccine availability. On November 16, 2020, surveys were sent to all Georgia public K–5 school district superintendents (1,321 schools) and private school leaders (140 schools). The rate ratio (RR), by prevention strategy, adjusted for county-level 7-day incidence (cases per 100,000 population) on December 1, 2020 for: 1) face mask use for staff and teachers (required vs. optional), RR: 0.63 (95% CI: 0.47–0.85) and 2) face mask use by students (required vs. optional), RR: 0.79 (95% CI: 0.50–1.08).²⁰ In this study, only mandatory mask wearing (self-reported) by staff and teachers resulted in a statistically significant reduction in transmission. This study looked at multiple mitigations measures – barriers, physical separation of desks, flexible medical leave for teachers, class size, number of hand washing stations, ventilation enhancements, and masks – only mask mandates and ventilation enhancements were associated with significantly reduced COVID-19 incidence. PHO published a synopsis of this article, outlining additional findings and caveats.²¹ 11.6% (169/1,461) of schools responded to the survey; however, the authors note that the incidence of COVID-19 in participating schools was 3.08 per 500 and 2.90 per 500 in non-participating schools. Day-to-day compliance with proper mask-wearing or other preventative measures was not assessed.
- In a meta-analysis of 26 studies, Reynolds et al. (2021) (preprint) reported that mask wearing in school children was associated with a decreased risk of SARS-CoV-2 infection in schools (aOR: 0.52; 95% CI: 0.35–0.78).²²
- In a case control study of hospitalized children (<18 years; case-patients, n=154; control-patients, n=243) in Mississippi, US (September to November 2020), Hobbs et al. (2020) investigated risk factors for COVID-19 infection.²³ In children (≥2 years) who attended childcare or school during the 2 weeks before the SARS-CoV-2 test, the risk of a positive SARS-CoV-2 test was reduced when all children and staff self-reported wearing masks inside facilities (aOR: 0.4; 95% CI: 0.2–0.8).
- In a study of 2,149 children attending school and nurseries in Germany (June to November 2020), Hoch et al. (2021) reported that two children tested positive by nasopharyngeal swab.²⁴ The authors attributed the low transmission in these settings, in part, to the policy that all children attending primary schools had to wear masks on school premises, except when they were sitting in class. The median age of children was 7 years (range: 1–11).
- In Florida primary and secondary schools (schools, n= approximately 6,800; students, n=2,809,553), Doyle et al. (2021) reported that the rate of school-related cases in schools with mask mandates for children and staff indoors (1,171 per 100,000 population) was significantly lower than in schools without a mask mandate (1,667 per 100,000) (p<0.01).²⁵

Indoor and outdoor settings

Five studies included associations of outdoor mask wearing in children and COVID-19 incidence.

- In a survey of high school athletic directors (991 schools and 152,484 athletes) in the US, Watson et al. (2021) (preprint) reported that mask mandates were associated with a decreased COVID-19 incidence in girls' volleyball (incident rate ratio [IRR]: 0.53; 95% CI: 0.37–0.73; p<0.001), boys' basketball (IRR: 0.53; 95% CI: 0.33–0.83; p=0.008) and girls' basketball (IRR: 0.36; 95% CI: 0.19–

0.63; $p < 0.001$).²⁶ However, there were no statistically significant ($p > 0.05$) associations with mask use and playing football, cheer/dance, cross country running, soccer, golf, and softball (mostly outdoor sports).

- In a survey of 486 youth camps (ca. 90,000 campers) across the US (summer 2020), Suh et al. (2021) (preprint) reported on the mask wearing behaviour in campers and staff.²⁷ When all campers wore masks at all times, there was a reduced risk of infection in campers (RR: 0.36; 95% CI: 0.14–0.95) and staff (RR: 0.17; 95% CI: 0.08–0.40). When all staff wore masks, there was a reduced risk of infection in campers (RR: 0.39; 95% CI: 0.19–0.80) and staff (RR: 0.38; 95% CI: 0.24–0.60). When campers wore masks with or without other public health measures, there was always a reduction in infections.
- In a study of 207 schools (students, $n=30,074$) in Wisconsin, US (September 2020), Sasser et al. (2021) reported there were no significant associations between school COVID-19 incidence and mask use during cross country running (IRR: 0.71; 95% CI: 0.24–2.2; $p=0.52$), volleyball (IRR: 1.4; 95% CI: 0.3–6.6; $p=0.64$), football (IRR: 1.6; 95% CI: 0.57–5.1; $p=0.40$), and soccer (IRR: 2.3; 95% CI: 0.52–17).²⁸
- In a study of a COVID-19 outbreak at an overnight camp in Georgia, US (summer 2020), Szablewski et al. (2021) reported on 351 cases.²⁹ 8.7% (36/412) of attendees reported wearing a mask at all times, 60.0% (243/412) of campers reported wearing a mask “sometimes” and 32.3% (133/412) never wore a mask. The median age of attendees was 15 years (interquartile range [IQR]: 12–16). In a study of 224 index patients (7–19 years) from the Szablewski et al. (2021) report, Chu et al. (2021) reported in a univariable analysis that mask wearing in index cases reduced the risk of secondary household cases (OR: 0.2; 95% CI: 0.1–0.6); however, this was not significant in the multivariable analysis (aOR: 0.5; 95% CI: 0.2–1.3).³⁰

Mask Wearing Behaviours, Attitudes and Compliance

Main findings: There was relatively little research on mask wearing behaviour and compliance in children. However, from the available studies of school and community settings, adherence to mask policies was typically high in children (53–97%) and uptake increased with age.

School settings

We included six observational studies that investigated mask wearing behaviours and compliance (self-reported) in school settings. In general, compliance with mask mandates is high in the included studies (65–97%; includes direct observation and self-reporting by children and parents).

- Falk et al. (2021) investigated mask wearing behaviour in 17 rural K-12 schools (4,876 students and 654 staff) in Wisconsin, US.¹³ Among 191 cases reported during the study period (August 31 to November 29, 2020), 7 (3.7%) were attributed to in-school SARS-CoV-2 transmission. Using 37,575 observations by teachers on student mask wearing compliance, compliance was high and ranged from 92.1% to 97.4% during the study; however, non-compliance increased slightly from 2.6% to 7.9%.
- In a survey of 3,953 middle and high school students (13–21 years) in the US who attended in-person classes (October 2020), approximately 65% of students reported that fellow students wore a mask “all the time” in the classroom and in hallways or stairwells.³¹ Mask-wearing compliance was reported to be lower on school buses (42%), in restrooms (40%), in the cafeteria

(when not eating) (36%), during sports or extracurricular activities (28%) and outside on school property (25%).

- Chen et al. 2020 conducted a survey of 3,649 school-aged children 6–13 years of age about mask use in China.³² 51.6% reported good mask-wearing behaviour, with older children (grades 5–6 compared to grades 1–2; OR 1.21, 95% CI: 1.03–1.43). Better mask-wearing behaviour was reported when the child’s mother had a higher education level than primary school or below (e.g., junior college or undergraduate degree; OR: 1.87; 95% CI: 1.03–3.33; $p < 0.05$). In addition, when students lived outside of Wuhan, the likelihood of mask wearing in children was lower (e.g., in Hubei province but outside of Wuhan; OR: 0.70; 95% CI: 0.55–0.88; $p < 0.01$).
- In a study of mask-wearing behaviour in 1,152 high school students at graduation ceremonies, Mueller et al. (2021) reported that 70% properly wore masks; however, 18.7% had trouble with mask fit and 9.6% never wore a mask.³³
- In a prospective, multi-school staff survey of mask-wearing compliance among students in Atlanta, US (4-week period starting August 17, 2020), Mickells et al. (2021) reported that appropriate mask use by all class students was reported by teachers 76.9% of time.³⁴ The compliance increased by grade ($p < 0.001$), from 56.3% (pre-K) to 87.6% (grade 2). The results were based on 1,000 students and 1,048 classroom days.
- In a survey of parental attitudes towards the implementation of public health measures in schools reopening, Gilbert et al. (2020) reported that 68.3% (95% CI: 64.8–71.8) of parents ($n = 858$) agreed that masks should be mandated for all students and staff.³⁵ Agreement with mask mandates was highest among Hispanic and Latino parents (79.5%; 95% CI: 72.7–86.4), followed by Black parents (73.1%; 95% CI: 63.4–82.7), other non-Hispanic (66.9%; 95% CI: 54.2–79.5) and white parents (62.5%; 95% CI: 57.9–67.1).

Community settings

We included four observational studies that investigated the impact of mask wearing in children in community settings, noting that businesses have less sustained attention than schools to children’s adherence to mask mandates. In general, compliance with mask mandates is high in the included studies (53–89%; includes direct observation and self-reporting by children and parents), with decreasing compliance as age decreases. Some studies highlighted challenges for some populations in wearing masks (e.g., autism spectrum disorder).^{36,37}

- In a survey of 1,527 children and young adults (16–24 years) in Saudi Arabia, Al Naam et al. (2021) reported relatively good knowledge and attitudes on the importance of mask wearing.³⁸ The average knowledge score out of 25 for mask wearing was 23.0 (95% CI: 22.90–23.11; similar to other age groups) and the average attitude score out of 25 was 20.9 (95% CI: 20.73–21.09; lower than other age groups). For the 16–24 age group, the compliance score was 11.79 (95% CI: 11.67–11.91) out of 15. Compliance questions were related to work, public places, and at social gatherings.
- Beckage et al. (2021) assessed age, sex and mask use compliance among people ($n = 1,004$ observations) entering public businesses in Vermont, US (May 2020).³⁹ Mask use decreased with decreasing age: 91.4% (>60 years), 70.7% (26–60 years), 74.8% (15–25 years), and 53.3% (≤ 14 years). Compared to those <14 years old ($n = 30$), the odds of mask wearing increased for those 15–25 years old (OR: 2.72; 95% CI: 1.16–6.36). The <14 year age group likely contains individuals for which there was no mandated requirement to wear masks (age <2); this may mean it

includes parents with infants and infants not wearing masks. The authors “visually” assessed age.

- In a cross-sectional survey of children less than 18 years old (range: 3–17) in China (Wuhan and Shanghai; March 2020), Hou et al. (2021) reported that 82.2% (638/776) of children always wore masks outside of home during the pandemic, compared to before the pandemic (31.5%; 521/1,655).⁴⁰ Reasons for children not wearing masks were: no masks were available (42.4%; 61/144), children thinking masks were unattractive or uncomfortable (28.5%; 41/144), and parents thinking masks did not prevent infection (25.7%; 37/144). Girls were less likely to wear masks (OR: 0.61; 95% CI: 0.41–0.91). When a parent had some college education (compared to at least a bachelor’s degree) there was a decreased likelihood of mask wearing in children (OR: 0.42, 95% CI: 0.27–0.64; $p < 0.01$).
- In a survey of 719 youth (14–24 years) in the US (July 2020), DeJonckheere et al. (2021) reported that 89.2% (641/719) of respondents wore face coverings always or most of the time (includes school and community settings).⁴¹ Non-Hispanic Asian youth had the highest percentage of respondents that wore masks always or most of the time (96.1%), followed by Hispanic youth (93.6%), Black (86.7%) and white (86.5%). There were no differences by age, gender, education level, or location in US.
- In a study of 216 index patients (7–19 years) from the Szablewski et al. (2021) report, Chu et al. (2021) reported that as age increased, so did the mask wearing compliance (OR: 1.4; 95% CI: 1.2–1.6; age as a continuous variable).³⁰

Potential Negative Impacts of Mask Wearing

Main findings: There were variable findings with respect to negative respiratory and psychological health in children wearing masks. Further research is needed to assess potential negative impacts of mask wearing in children, especially for longer-term use.

Respiratory

We included four primary studies that investigated children. There was no evidence to indicate clinically significant physiological detriments to children that wear masks.

- In a survey of 2,954 parents of school-aged children in France, Assathiany et al. (2021) reported that 28.1% of respondents reported breathing discomfort in their children.⁴² In a survey of 663 pediatricians in the same study, 53.1% reported potential negative impacts of mask wearing on respiratory function in healthy breathing discomfort in their patients.
- In a survey of 1,527 children and young adults (16–24 years) in Saudi Arabia, Al Naam et al. (2021) reported relatively good knowledge on the importance of mask wearing.³⁸ The average knowledge score out of 25 for mask wearing was 23.0 (95% CI: 22.90–23.11; similar to other age groups). For the 16–24 age group, the barrier agreement score was 15.64 (95% CI: 15.45–15.43). Barriers identified were breathing ability, comfort, skin irritation, ear pain, and inconvenience with glasses. The score suggested that there was notable discomfort overall (e.g., breathing, irritation, ear pain) with use of masks recognized.
- In a cohort study of 47 (group A, age 24 months or less, $n=22$; group B, age >24 months to 144 months, $n=25$) healthy children wearing or not wearing surgical masks, Lubrano et al. (2021) reported there was no significant difference in median partial pressure of end-tidal CO_2 , O_2

saturation, pulse rate or respiratory rate during 30 minutes of usual play with or without a mask.⁴³

- In a study of 22 children wearing N95 masks with (n=11) or without (n=11) an exhalation valve, Lubrano et al. (2021) reported no significant differences in either group of O₂ saturation or pulse rate during normal play with or without an N95 mask or during a walking test wearing an N95 mask.⁴⁴ Respiratory rate and partial pressure of end-tidal CO₂ was significantly increased (p<0.05) in the group without an exhalation valve when comparing the first 15 minutes following wearing an N95 mask to no mask conditions; however, there was no statistically significant difference between 30 minutes following wearing an N95 mask or during the walking test compared to not wearing a mask. In the group with an exhalation valve, increases in respiratory rate and partial pressure of end-tidal CO₂ was significantly increased (p<0.05) only when comparing no mask to the walking test, but were not significantly different when comparing no mask to mask with exhalation valve during normal play. In Ontario and most jurisdictions, N95 masks are not recommended for use in children.

Psychological

We included three studies on the potential psychological impacts of wearing masks in children. One study shows a decrease in psychological impacts when children wear masks, while the other two studies did not compare mask wearing versus no mask wearing in children.

- In a cross-sectional study of school-aged children (n=1,199,320) in Guangdong province, China, Qin et al. (2021) reported that decreased frequency of mask use was associated with increased psychological distress (aOR: 1.39; 95% CI: 1.18–1.64; p=0.0; 126,355 students self-reported psychological stress).⁴⁵ Students that wore masks only on a few occasions, compared to students that wore masks at all times (includes school and community settings), had higher odds of self-reported psychological distress (OR: 2.19; 95% CI: 2.09–2.30). The classification of mental health issues was based on a 12-point scale (General Health Questionnaire) wherein authors indicated a score of 3 or more classified the individuals as having psychological distress.
- In a survey of parents (representing 25,930 children) in Germany, Schwarz et al. (2021) examined side effects of wearing masks in children (<1–17 years).⁴⁶ 68% of respondents said children reported at least one impairment while wearing masks (includes school, childcare and community settings). The most common complaint was irritability (60%), followed by headache (53%), difficulty concentrating (50%), less happiness (49%), reluctance to go to school (44%), malaise (42%), impaired learning (38%) and drowsiness/fatigue (37%). Masks were worn by children an average of 270 minutes per day. The authors noted a major limitation was there was no way to be sure that the reported impairments were related to mask use or not.
- In a survey of 2,954 parents of school-aged children in France, Assathiany et al. (2021) reported that 45.2% of respondents reported unspecified changes in mood for their children (80.9% of parents said their children felt embarrassed when wearing a mask in school).⁴²

Cognition and communication

We included two studies that reported on potential cognitive and communication impacts of wearing masks in children. The included studies did not suggest there were cognitive impacts associated with wearing masks in children. As for communication impacts, the two included studies did not agree with one another. More research is needed to understand the impact of mask wearing and cognition/communication problems, especially impacts of longer-term mask wearing in children.

- In a survey of 2,954 parents of school-aged children in France, Assathiany et al. (2021) reported that 45.1% of respondents reported speaking difficulties in their children when they wore masks⁴² This study did not demonstrate a relationship between mask wearing in children and speaking difficulties.
- In an experiment using 81 children (median age: 9.86 years; standard deviation: 1.84; range: 7–13) in Wisconsin, US, Ruba and Pollock (2020) assessed a child’s ability to make inferences from subjects not wearing any facial coverings, wearing sunglasses to cover the eyes, or wearing surgical masks to cover the mouth.⁴⁷ The authors found that children were able to infer the subject’s emotions (restricted to negative emotions such as sadness, fear and anger) even when parts of the face were covered, suggesting that wearing masks do not significantly impact a child’s social interactions. The authors did not describe how to discern happiness, or how they account for other contextual elements, which children may draw from to infer emotions.

Dermatological

Four studies reported on potential dermatological impacts of wearing masks in children. These studies lacked control groups and/or had small sample sizes limiting inference of any potential association with mask wearing and dermatoses in children.

- In a survey of parents (representing 25,930 children) in Germany, Schwarz et al. (2021) examined side effects of wearing masks in children (<1–17 years), where 269 reported deteriorated skin, especially increased pimples, rashes and allergic symptoms around the mouth area, as well as fungal infections in and around the mouth.⁴⁶ Masks were worn by children an average of 270 minutes per day (includes school, childcare and community settings). The authors noted a major limitation was there was no way to be sure that the reported impairments were related to mask use or not. The authors acknowledge that parents that do not have complaints about mask wearing in their children were less likely to take the survey.
- In a survey of 2,954 parents of school-aged children in France, Assathiany et al. (2021) reported that between 25% and 30% of respondents reported unspecified cutaneous disorders in their children.⁴² In a survey of 663 pediatricians, 42.4% reported cutaneous disorders in patients that wore masks. This study did not demonstrate a relationship between mask wearing in children and dermatoses.
- In a prospective, multi-center study of 873 patients with dermatoses that wore face masks in Italy, Damiani et al. (2021) reported that 24 children reported warts (caused by human papillomavirus; n=11), impetigo (caused by group A *Streptococcus* and *Staphylococcus aureus*; n=9) and molluscum contagiosum (caused by a poxvirus; n=4).⁴⁸ In children with warts, the mean (IQR) age was 14 years (8–21); nine children wore surgical masks and two wore cloth masks. Children with impetigo were 8 years old (2–14); four children wore N95 masks, three used community masks and two wore surgical masks. Children with molluscum contagiosum were 7 years old (3–12); all four children wore community masks. The authors hypothesized that infections were caused by itching of the skin under the mask and introducing pathogens; however, these dermatoses are common pediatric skin conditions.
- In a survey of 25 mask wearers, Cheok et al. (2021) reported that 48% (12/25) of respondents reported dermatological issues (e.g., unspecified rash, acne).⁴⁹ The exact age range in this group was not reported, nor was the types of masks reported (presumed to be surgical or cloth masks). The authors noted that dermatological issues were more common in those <25 years,

than other age groups (e.g., >65 years) ($p < 0.001$). This study did not demonstrate a relationship between mask wearing in youth and dermatoses.

Conclusions

Mask wearing in children was associated with reduced incidence of SARS-CoV-2 infections in schools and studies have shown low levels of transmission when masks (and other measures) have been implemented. Many of the studies that examined COVID-19 incidence and transmission in schools had layered infection prevention and control measures in place, so it was challenging to measure the independent impact of mask wearing. There was relatively high compliance in mask wearing behaviours in children and compliance increased with age; however, more research is needed to identify barriers to mask adherence. There were variable findings with respect to the negative health impacts of children that wear masks. Further research is needed to assess potential negative impacts of mask wearing in children, especially for longer-term use of masks.

PHO will continue to monitor the scientific evidence on mask use in children, updating this document as necessary.

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