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SYNTHESIS

Mask-wearing in Children and COVID-19… What We Know So Far

2nd Edition, 1st Revision: August 2022

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 to Latest Version

This document is an update to *Mask Wearing in Children and COVID-19 – What We Know So Far* (February 17, 2022).[1] This revision provides additional evidence, current to August, 2022, concerning mask use in children in the context of COVID-19. This update identified 21 additional eligible publications with evidence relevant to one or more of the topics examined in this synthesis; however, the key findings have not changed substantively.

Key Findings

- Studies have shown that schools with masking policies have been associated with lower incidence of severe acute respiratory coronavirus 2 (SARS-CoV-2) infection compared to schools without mask mandates for children. Most studies included schools that implemented mask policies combined with other layers of infection prevention controls, overall emphasizing that masking along with layered infection prevention measures may reduce SARS-CoV-2 transmission in schools.

- Studies of children playing sports demonstrated inconsistent results related to the impact of mask-wearing during indoor or outdoor sports. There were relatively consistent results to indicate that outdoor sports were associated with decreased COVID-19 incidence compared to indoor sports, regardless of mask-wearing.

- Overall, masks were associated with reduced infections in summer camp settings. The impact of children masking in summer camp settings was challenging to isolate however, because the camps also used other prevention measures. For example, there were instances at overnight camps where, following negative COVID-19 tests combined with other prevention measures, mask requirements were lifted and SARS-CoV-2 incidence remained low.

- Studies evaluating child adherence to masking policies have shown similar results in school (range from individual studies: 43%–97%) and community settings (34%–96%), with increased adherence as age increased.

- There was no objective evidence for reduced respiratory function in children who wore masks, with commonly reported complaints being subjective. There was no evidence of negative cognitive impacts and there were mixed results for studies on the psychological, communicative and dermatologic impacts of child mask-wearing.

Background

Wearing masks in community settings has been an important part of a layered approach of public health measures used to lower transmission of SARS-CoV-2 and the incidence of COVID-19; [2-8] however, the majority of research has been conducted in the adult population.[9-14] The effectiveness of mask-wearing is likely primarily a result of source control – protecting others from the mask-wearer.

This update was conducted in the summer months of 2022, leading up to the 2022–23 school year. At the time of writing, several key things have changed with regards to the COVID-19 pandemic response in Ontario since the previous version of this rapid review (published in February 2022). Public health measures in community settings such as masking, physical distancing and capacity limits have largely been lifted, including in schools at the end of the 2021–22 year. COVID-19 vaccination has been available to children over age 5 since Fall of 2021, and as of July 28, 2022, COVID-19 vaccination is available to children over the age of 6 months.[15,16] Ontario is experiencing its seventh wave of the COVID-19 pandemic, dominated by the variant of concern (VOC) Omicron. Omicron remains the dominant strain in Ontario and the risk implications for its multiple sub-lineages (e.g., BA.4 and BA.5) are under ongoing investigation, however the latest risk assessments report increased risk of transmissibility and reinfection, and increased risk of lowered vaccine effectiveness or breakthrough infection.[17,18]

In this rapid review, we examine:

- associations between children wearing masks and COVID-19 incidence;
- mask-wearing behaviours in children;
- 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 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.[19]

PHO Library Services updated searches in Medline, Embase and PsycINFO on June 20, 2022 using the same search strategy from the previous versions of this synthesis (search strategy available upon request). We searched PubMed on July 25, 2022 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, 2022. Eligible studies with evidence consistent with the previous findings were incorporated into the relevant results sections. Any newly added studies with results departing from the previous conclusions have been described in the sections below.

Out of scope for this rapid review are studies investigating the effectiveness of specific mask types, impacts of masking for children with special needs, studies concentrating on adult populations and studies that report on masking in healthcare settings. 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.

Associations between Mask-wearing and COVID-19 Incidence

Main Findings

This update included 12 additional studies related to associations between mask-wearing in children and SARS-CoV-2 incidence in school, childcare and sports settings.[20-31] The evidence from these studies did not change the overall main findings.

Many studies found that mask mandates in schools have been associated with lower incidence of SARS-CoV-2 infection. 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. Studies investigating children playing sports demonstrated inconsistent results related to the impact of mask-wearing on preventing transmission for indoor and outdoor sports. There were relatively consistent results to indicate outdoor sports were associated with decreased COVID-19 incidence compared to indoor sports, regardless of mask-wearing. The impact of masking in summer camp settings was challenging to isolate relative to other prevention measures. Overall, evidence indicated masks were associated with reduced infections; however, there were also instances at overnight camps where, following negative COVID-19 tests combined with other prevention measures, mask requirements were lifted and SARS-CoV-2 incidence remained low.

Indoor School and Childcare Settings

Three reviews (two grey literature sources and one published systematic review) and 32 primary studies investigated SARS-CoV-2 transmission or incidence associated with indoor school and childcare settings, in which mask-wearing was a component of public health measures implemented.

A rapid review by the United Kingdom (UK) Health Security Agency (2021) examined evidence on the effectiveness of face coverings to reduce SARS-CoV-2 in the community.[32] The authors searched up to September 14, 2021 and included 25 studies (two randomized controlled trials and 23 observational studies). This review was not focused on children wearing masks; however, four observational studies reported on face coverings in school and summer camp settings: one assessed the impact of school staff wearing masks,[33] and three included evidence related to children wearing masks (see below).[34-36] Review authors reported overall mixed results for the effectiveness of face coverings in schools and summer camps with two studies suggesting they were associated with reduced transmission and one suggesting no significant effect. Studies were observational in design and additional factors beyond masks could have influenced the results.

An Evidence Summary conducted by the UK Department for Education in January 2022 reported on the use of masks in educational settings.[37] The authors did not describe the methods for this summary; the summary cited the Health Security Agency rapid review described above and several additional published and grey literature sources. The authors reported that masks could contribute to reducing SARS-CoV-2 transmission in public and community settings, mostly due to source control (not specific to schools or children). Evidence of associations between lower incidence of COVID-19 and the use of masks in educational settings was inconclusive, but some studies showed higher rates of COVID-19 in schools without mask requirements for students. The authors also noted that in addition to their function as source control, masking is an inexpensive and easily implemented measure that also acts as visual reminder of safety behaviour and the risks related to COVID-19.

A systematic review by Yuan et al. (2022) investigated factors affecting SARS-CoV-2 transmission in school outbreaks (search up to July 28, 2021).[38] Records of 35 school outbreaks in 12 countries were included, involving 728 secondary cases in children among the 21,600 contacts. Single measures (distancing **or** masking) and combined measures (distancing **and** masking) were both associated with lower secondary attack rates (SAR) in schools, with adjusted odds ratios (aORs) of 0.15 (95% confidence interval [CI]: 0.08–0.28) and 0.25 (95% CI: 0.19–0.32), respectively. Increased population immunity (i.e., from prior infection as most studies were conducted before vaccine rollout) was also associated with lower transmission risk in schools (aOR: 0.57; 95% CI: 0.46–0.71).

This update added ten studies to the previously included 23 primary studies with overall similar findings to the reviews. Researchers conducted most studies in the United States (US), prior to the emergence of the Omicron variant of concern (VOCs). Authors did not specify the types of masks worn by children (i.e., medical mask versus non-medical masks) in any of the studies. In some studies, masking in children was analysed as part of the general measure of universal masking for anyone in schools including adults; therefore, the effect of masking in children was not always isolated. With these considerations in mind, the included studies consistently indicated an association between school masking requirements for children and a reduction in SARS-CoV-2 transmission when compared to no masking requirements.

Eight epidemiological studies directly compared school populations with mask requirements for all students and staff to schools without mask requirements.[23,26-28,39-42] Studies were conducted in Germany, Switzerland and the US, with data collected up to mid–late 2021. Four studies added in this update were conducted in the US[23,26,28] and Germany[27] and, similar to the previous results, found that schools with mask mandates were associated with fewer SARS-CoV-2 cases among students and staff relative to schools without mask mandates. One study by Hughes et al. (2022) suggested an impact of masking on only a portion of the study period. This study assessed schools in Texas for 8 weeks up to October 2021 and found schools without mask mandates reported approximately 2 additional cases/1,000 students and a weekly mean of 37 additional student cases, during weeks 2–6, however cases/1,000 students were not significantly different from schools with mask mandates during weeks 7–8.[28] In primary and secondary schools in Florida (approximately 6,800 schools and 2.8 million students), Doyle et al. (2021) reported in an unadjusted bivariate analysis that the rate of school-related cases in schools with mask mandates for children and staff indoors (1,171/100,000 population) was significantly lower than in schools without a mask mandate (1,667/100,000) ($p<0.01$).[40] Jehn et al. (2021) found in the context of Delta being the dominant strain in two Arizona counties (999 schools), the odds of school-associated outbreaks were over three times higher in schools without a mask mandate compared to schools with a mask mandate (aOR: 3.5; 95% CI: 1.8–6.9).[41] An ecological study by Budzyn et al. (2021) compared school mask requirements for all students across US counties and found that counties without mask mandates experienced greater increases in pediatric COVID-19 case rates than counties with mask mandates: 34.9 cases/100,000 children/day versus 16.3 cases/100,000 children/day ($p<0.001$).[39] In Zurich, Switzerland, children in upper school levels were required to wear masks as of November 2020 and had a 5.1% (95% CI: -0.7 to 9.4) lower than expected seroprevalence by March and April 2021, compared to middle school students who were required to wear masks three months later than the upper level students.[42]

Eight epidemiological studies reported on associations between in-school prevention measures (including masking for children) and reduced school-associated transmission or maintenance of low school-associated transmission.[29,30,36,43-47] Study settings were Germany and the US, with data collected up to mid-2021. Murray et al. (2022) investigated the association between masking young children (age 2 and older) in childcare settings and subsequent childcare program closures, and included reports from 6,654 childcare professionals in 50 US states up to June of 2021.[30] Early adoption and continued masking of young children in childcare settings were both associated with lower adjusted relative risk (aRR) of

program closure due to a COVID-19 case (aRR: 0.87; 95% CI: 0.77–0.99 and aRR: 0.86; 95% CI: 0.74–1.00; respectively). Sombetzki et al. (2021) conducted multivariable analysis of SARS-CoV-2 infections in pre-schools and schools in Germany (August 2020 to May 2021). The strongest predictor of fewer secondary cases per infection was masking among teachers in schools (β=-1.9; 95% CI: -2.9 to -1.0; p<0.001), followed by masking in children (β=-0.6; 95% CI: -0.9 to -0.2; p=0.004).[45] Similar findings of reduced SARS-CoV-2 cases were observed in additional epidemiological studies that investigated mask-wearing in children as a component of infection prevention measures implemented in schools.[36,43,44] While most studies indicated a relatively consistent direction of findings, not all found statistically significant associations.[46,47] For example, Gettings et al. (2021) assessed the impact of prevention strategies implemented in K-5 schools in Georgia, US on the incidence of COVID-19 among students and staff prior to vaccine availability.[46] Mask requirements for staff were associated with 37% decreased incidence (relative risk [RR]: 0.6; 95% CI: 0.47–0.86); however, mask requirements for children were non-significantly associated with incidence reduction (RR: 0.8, 95% CI: 0.50–1.08).[46] Finally, one observational study by Hast et al. (2021) found contrasting results.[48] The authors investigated risk factors associated with SARS-CoV-2 positivity among in-school contacts of COVID-19 cases in 12 Georgia school districts; 717 students and 79 school staff participated in the investigation.[48] SARS-CoV-2 positivity was not associated with general mask use indoors at schools, nor with other factors such as taking the school bus, participating in non-sports extracurricular activities, or gender.[48]

Five studies did not directly investigate associations between infection prevention measures (including children masking) and SARS-CoV-2 incidence, but study authors suggested low school-associated transmission might be attributed to the implementation and adherence to infection prevention measures.[21,49-52] These descriptive results did not provide evidence of association. Studies were conducted in Germany, Japan and the US, with data collected up to mid-2021. Two studies based in Marin County, California, US suggested that comprehensive prevention measures (including masking for all students and staff) in K-8 schools allowed in-person learning to resume September 2020 without increasing in-school SARS-CoV-2 transmission.[49,50] The study authors noted reduced state-level case rates during the time period students returned to in-person learning,[49] and a lack of observed in-school transmission from identified asymptomatic cases.[50] Akaishi et al. (2021) and Hoch et al. (2021) similarly reported low SARS-CoV-2 transmission rates in schools and pre-schools and attributed these findings to the mitigation measures implemented at schools, including universal masking.[51,52]

Four epidemiological studies assessed the elimination of quarantine requirements for students identified as close contacts of confirmed COVID-19 cases in K-12 school settings when both the source and the contact were masked at the time of contact.[24,53-55] This strategy aimed to maximize in-person learning time for students. The studies investigated schools in California, Illinois, Nebraska and North Carolina. Two studies required masked close contacts to complete negative tests to remain in school instead of quarantining after contact with a masked COVID-19 case in school (i.e., test-to-stay [TTS]).[54,55] Nemoto et al. (2021) reported secondary transmission among TTS participants to be 1.5%.[55] Harris-McCoy et al. (2021) reported schools that participated in TTS did not experience increases in COVID-19 incidence compared to schools that did not participate.[54] Boutzoukas et al. (2021) reported on schools that required daily symptom screening for masked close contact student exposures but no testing to avoid quarantine, and detected no cases of in-school transmission in the students who met the criteria to avoid quarantine.[53] Campbell et al. (2022) reported a SAR of 1.7% among 357 exposed students in schools with universal masking policies that did not require quarantine for mask-on-mask exposures, and offered TTS for exposures in which one or both individuals involved in the exposure were unmasked.[24] The authors reported 1,628 school days were saved out of a potential 1,754 days (92%).

Seven modelling studies estimated school-based transmission outcomes for scenarios involving: various masking policies, additional infection prevention measures, school capacity, vaccination coverage and

community transmission parameters.[20,25,56-60] These studies emphasized the importance of masking being implemented in combination with other measures to have meaningful impact. Head et al. (2021) reported that at 70% vaccination coverage, masking in children would reduce infections by >57%, reducing incidence in schools to <50 excess cases per 1,000 students/teachers.[58] Rosenstrom et al. (2021) (preprint), using Delta infectivity data, modelled scenarios extending to the year 2023 to estimate the impact of removing school mask requirements in the context of varying child and adult vaccination levels in North Carolina, US.[60] For example, mask removal from schools in January 2022 would lead to a 47.0% increase in infection rates in the 5–9 year age group (at 50% vaccine uptake in children and adolescents, compared to adults), 43.5% (75% vaccine uptake) and 38.1% (100% vaccine uptake), compared to keeping mask requirements in schools. One study specifically modelled the impact of children wearing masks with varying protective efficacies (i.e., 50% or 70% reduction in transmission and susceptibility) on community Delta transmission.[59] Schools open with no masks would have 80% more infections than the best performing scenarios. Children in schools wearing masks with 50% filtering efficacy would result in a 23% reduction in additional infections in the general population, and 70% filtering efficacy masks would result in a 36% reduction in additional infections, both relative to no masking.

Extracurricular, Outdoor and Other Settings

The update added two studies to the previously included ten primary studies that investigated associations of mask-wearing in children during extracurricular, outdoor or camp activities and COVID-19 incidence. The additional studies related to sports settings have demonstrated inconsistency in the impact of masking for children while playing sports. One previously included study investigated the impact of mask-wearing among pediatric COVID-19 cases in household settings.

Six observational studies based in the US investigated the impact of children masking in the context of sports and overall results were inconsistent related to the impact of mask-wearing during indoor or outdoor sports.[22,31,48,61-63] There were relatively consistent results to indicate outdoor sports were associated with decreased COVID-19 incidence compared to indoor sports, regardless of mask-wearing. Studies involved data collection periods up to March 2021, generally prior to widespread vaccination coverage, especially in children. Bohnert (2021) found no significant correlations between adolescent COVID-19 infection rates and the number of infection control violations (including mask violations) during basketball or swimming events. Roberts et al. (2022) found significantly lower incidence rates among high school athletes playing outdoor compared to indoor sports. For indoor sports, there was no significant difference in incidence between masked and unmasked high school athletes. Sports involving close contact versus those that allow distance between athletes demonstrated greater impact than masking on COVID-19 incidence rates. In a survey of high school athletic directors (991 schools and 152,484 athletes) Watson et al. (2021) found that mask-wearing while playing sports was associated with reduced COVID-19 incidence for indoor sports, but did not impact COVID-19 incidence for outdoor sports.[64] Sasser et al. (2021) reported a lower incidence rate for outdoor settings compared to indoor settings; however, this finding was not statistically significant and overall there was no significant impact of masking on COVID-19 incidence for outdoor or indoor sports.[62] The study by Hast et al. (2021), also described in the indoor setting section above, investigated risk factors associated with SARS-CoV-2 positivity among in-school contacts of COVID-19 cases.[48] SARS-CoV-2 positivity was not associated with several factors, including general use of masks indoors. However, SARS-CoV-2 positivity was associated with participation in school sports (OR: 3.5–6.4) and unmasked time playing sports (OR: 4.3–9.0) in elementary/middle/high school students. Close-contact indoor sports (i.e., wrestling, basketball) were the most common activities reported among 15 cases identified among sports players.[48] Finally, Krug et al. (2021) described multiple prevention measures implemented for a youth hockey league, including masking at all times indoors, except for players on the ice or on the bench.[61] The combined measures maintained low league-associated transmission in the context of high community transmission.

Four observational studies investigated child masking in the context of camps.[35,65-67] Three US-based studies assessed overnight camps (i.e., long-term groups that were largely isolated from community contacts), and one study involved a survey of different types of camps (i.e., day camps, overnight camps, combinations). All studies involved children masking to some degree at camps, although always in combination with other infection prevention measures. Overall, these studies indicate masks were associated with reduced infections at camps; however, there were instances at overnight camps in which mask requirements for campers were lifted and COVID-19 incidence remained low. For example, an analysis of survey results reporting on masking and other measures at 486 US camps (multiple types) in the summer of 2020 found when campers wore masks at all times, there was a reduced risk of infection in campers (risk ratio [RR]: 0.36; 95% CI: 0.14–0.95).[35] Two studies reported successful lifting of mask requirements for overnight campers following repeat negative tests and other combined prevention measures.[65,67] Van Naarden Braun et al. (2021) reported on prevention measures and COVID-19 cases at nine camps run by the same organization, where mask requirements were lifted in stages based on negative tests; there was high vaccination coverage (>93% of eligible persons ≥12 years).[67] Nine laboratory-confirmed COVID-19 cases (at four camps) occurred, with no secondary transmissions during camp. During the summer of 2020, a seven-week camp in New Hampshire also lifted mask requirements based on negative test results, maintained daily temperature/symptom screening and enhanced hygiene measures, and did not identify any positive cases from subsequent symptom-based tests for the remainder of the camp.[65]

An outbreak analysis from an overnight camp in Georgia found that mask-wearing in index cases (i.e., during the infectious period upon returning home from camp-based outbreak) reduced the risk of secondary household cases (OR: 0.2; 95% CI: 0.1–0.6) in univariate analysis; however, this was not significant in the multivariable analysis (aOR: 0.5; 95% CI: 0.2–1.3). [68] Liu et al. (2021) investigated 15 pediatric SARS-CoV-2 index cases and 50 associated household contacts in Los Angeles, US, from December 2020 to February 2021.[69] Pediatric index case being masked (SAR=17%; 95% CI: 7–37) was associated with a lower secondary transmission rate compared to index cases being unmasked (SAR=48%; 95% CI: 31–66) (p=0.02). Other factors associated with lower SARS-CoV-2 included households with four or more bedrooms compared to those with fewer than four bedrooms, and households that reported increased hand hygiene compared to those that did not report increased hand hygiene.

Mask-wearing Behaviour

Main Findings

This update included four additional studies related to mask-wearing behaviours and adherence in children, evidence from these studies did not substantively change the main findings.[22,29,70,71]

Pediatric adherence to mask policies was similar in school (range from individual studies: 43%–97%) and community settings (34%–96%), with increased adherence as age increases.

School Settings

We included 13 observational studies that investigated mask-wearing behaviours and adherence in school settings.[29,34,48,71-80] Study settings were China, Turkey and the US (11 of the studies were performed in US).

Overall, adherence to mask mandates was moderate to high in the included studies (range from individual studies: 43%–97%), which included direct observation and self-reporting by children and parents) and adherence increased by age.[29,34,48,71-80] For example, Falk et al. (2021) investigated mask-wearing

behaviour in 17 rural K-12 schools (4,876 students and 654 staff; August to November 2020) in Wisconsin, US.[75] Using 37,575 teacher-made observations, mask-wearing adherence ranged from 92.1% to 97.4%, with lower compliance towards the end of the observation period. 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 at all times in the classroom, hallways or stairwells.[76] Mask-wearing adherence 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%). In a prospective, multi-school staff survey of mask-wearing adherence among 1,000 students in Atlanta, Georgia, US (4-week period starting August 17, 2020), Mickells et al. (2021) reported that appropriate mask use by all students was reported by teachers 76.9% of the time.[79] The adherence increased by grade level ($p<0.001$), from 56.3% (pre-K) to 87.6% (Grade 2).

Several studies examined mask use across ethnic communities, where mask use was typically higher among Hispanic and Black children.[34,74,80] For example, in a survey of parental attitudes towards the implementation of public health measures in schools reopening in the US, 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.[80] Most respondents were from the South (41.1%), followed by the West (23.6%), the Midwest (19.9%) and the Northeast (15.4%). 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 parents (66.9%; 95% CI: 54.2–79.5) and white parents (62.5; 95% CI: 57.9–67.1).

Community Settings

We included nine observational studies that investigated adherence to community mask-wearing in children.[22,68,70,81-86] Researchers performed studies in Canada, China, Panama, Saudi Arabia and the US. Compared to school settings, compliance with mask mandates was similar in community settings (range from individual studies: 34%–96%; includes direct observation and self-reporting by children and parents), with increased compliance as age increased.

Four studies demonstrated that mask-wearing adherence increased with age.[68,81,85,86] For example, in an observational study of mask-wearing in public settings in Toronto, Ontario and Portland, Oregon (June to August 2020), Atzema et al. (2021) reported on 36,808 people, including 14,350 aged 11–30 years (39.0%) and 1,329 aged 0–10 years (3.6%).[85] Compared to adults, 0–10 year-olds were less likely to wear a mask (aOR<1). Mandatory mask-use settings were associated with increased mask use (aOR: 79; 95% CI: 47.4–135.1). Younger age, males, Torontonians, and transit settings were associated with lower adjusted odds of wearing a mask. Beckage et al. (2021) assessed adherence to mask policies among people (n=1,004 observations) entering public businesses in Vermont, US (May 2020).[83] Mask use increased with 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: 2.7; 95% CI: 1.16–6.36). In a study of 216 index patients (7–19 years) in the US, Chu et al. (2021) reported that as age increased, so did mask-wearing compliance (OR: 1.4; 95% CI: 1.2–1.6).[68]

Factors Affecting Mask Use in Children

We included six studies that reported on the factors associated with mask use in children, with studies from Canada, China, Germany, South Korea and the US.[83,87-91] The primary factors linked to low adherence to mask-wearing included (primarily from surveys): 1) reporting masks were uncomfortable, 2) reporting masks were unattractive, 3) perceived low risk of infection, and 4) negative attitudes toward mask use. In a survey of 957 parents and non-parents performed prior to mask mandates in

Germany during August 2020, Betsch et al. (2021) reported that a majority of parents agreed that children should wear masks in schools.[88]

Agreement was higher in:

1. those who lived in urban areas with bigger class sizes
2. those who felt they were at higher risk of infection
3. those with greater trust in institutions
4. males

Two studies employed the Theory of Planned Behaviour (TPB) to explain factors associated with wearing a mask.[90,91] TPB focuses on a person's attitudes (i.e., perceptions of pros and cons of mask-wearing), subjective norms (i.e., desire to meet societal norms of mask-wearing), and perceived control (i.e., personal capacity to wear a mask). In a survey of 866 parents of school-aged children in Canada and the US (August 2020), Coroiu et al. (2021) reported that 43.5% of parents had children with pre-existing conditions (e.g., allergies, skin sensitivity, asthma) that made wearing masks for extended periods challenging.[90] The intention for parents (with or without children with pre-existing conditions) to get their children to wear masks was impacted by negative attitudes toward mask use (β=-0.20; p=0.006), societal norms (β=0.41; p=0.002), and perceived control (β=0.33; p=0.006). Societal norms (β=0.50; p=0.004) and intentions (β=0.28; p=0.003) predicted mask use in children (attitudes and perceived control: p>0.05).

Potential Negative Impacts of Mask-wearing

Main Findings

This update included seven additional studies related to potential respiratory, cognitive, communication and dermatological impacts of mask-wearing in children.[92-98]

There is little objective evidence for reduced respiratory function in children who wore masks, with commonly reported complaints being subjective. There was no evidence of negative cognitive impacts and there were mixed results for studies on the psychological, communicative and dermatologic impacts of pediatric mask-wearing.

Respiratory

We included eight primary studies that investigated pediatric mask-wearing and impact on respiratory function, with studies performed in Belgium, Canada, France, Germany, Italy and Saudi Arabia.[81,96,98-103] There was no objective evidence of impaired respiratory function in children wearing masks during experiments, only reports of subjective complaints.

In five experimental studies, there was no evidence of adverse respiratory impacts to children wearing masks.[96,98,100,101,103] In a study of 22 children wearing N95 masks with or without an exhalation valve, Lubrano et al. (2021) reported no significant differences in oxygen saturation or pulse rate during normal play.[101] In a cohort study of 47 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 carbon dioxide, oxygen saturation, pulse rate or respiratory rate during 30 minutes of usual play with or without a mask.[100] In a double-blinded study, Shaw et al. (2021) investigated the performance of 26 hockey players (n=26; mean age: 11.7±1.6 years) wearing a surgical mask or a sham mask (control).[103] The authors

specifically measured heart rate, arterial oxygen saturation and tissue oxygenation after various strenuous exercises. Wearing a mask had no effect on heart rate, arterial oxygenation and performance in hockey players, with minor reduction in muscle oxygenation. Walach et al. (2022) attempted to measure the CO_2 content of inhaled air among healthy children wearing surgical masks or filtering face piece (FFP2) respirators while at rest (n=45; mean age: 10.3±2.6 years). The authors reported inhaled CO_2 levels were elevated in children wearing either mask type relative to no masks, however there were no significant changes in breathing frequency, pulse or oxygen saturation while children were wearing masks. [98]

In three surveys of children who wore masks, the primary complaint was breathing discomfort.[81,99,102] In a multicenter longitudinal study, Maison et al. (2021) performed a survey of the impacts of using face masks on asthma course and mental health in pediatric patients.[102] The survey included 19 preschoolers (<6 years; male: 78.9%), 82 school-aged children (6–12 years; male: 75.6%) and 12 adolescents (13–18 years; male: 50.0%). At the time point of this assessment, all age groups complained of mask-related breathing difficulties (proportion by age group or mask type not reported). The types of masks worn varied by age group: <6 years (FFP2 respirator, 0%; surgical mask, 0%; cloth mask, 100%), 6–12 years (FFP2, 3.8%; surgical mask, 35.4%; cloth mask, 60.8%) and 13–18 years (FFP2, 8.3%; surgical mask, 41.7%; cloth mask, 50.0%).

Psychological

We included one systematic review and three primary studies on the potential psychological impacts of wearing masks in children, with studies performed in China, France and Germany.[99,102,104-107] In a systematic review of 13 studies, Freiberg et al. (2021) reported that only two of the 13 studies reported increased anxiety, increased stress and loss of concentration in children who wore masks.[106]

Some studies reported on possible self-reported psychological distress associated with mask use,[99,102,105] while some studies reported higher levels of self-reported anxiety in children that did not wear masks.[104,107] These studies were based primarily on self-reported symptoms, rather than standardized tools for assessing potential psychological impacts in children. For example, in a survey of parents (representing 25,930 children) in Germany, Schwarz et al. (2021) examined the side effects of wearing masks in children (0–17 years).[105] 68% of respondents said children reported at least one complaint while wearing masks. 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%). Children wore masks for an average of 270 minutes per day. A major limitation of this study was that the authors did not ensure that the reported complaints related to mask use or not.[105] In contrast, in a survey of 386,432 children 12 to 18 years old in China, Xu et al. (2021) reported that students that did not adhere to all mask-wearing practices were more likely to experience anxiety (aOR: 2.0; 95% CI: 1.74–2.22).[107] There were decreased odds of having anxiety symptoms in students who adhered to proper mask-wearing (aOR: 0.7; 95% CI: 0.62–0.74).

Cognition and Communication

Eight studies were included that reported on potential cognitive and communication impacts of wearing masks in children, with studies performed in Canada, France, Germany, Italy, Singapore and the US.[92,93,97,99,108-111] The included studies did not demonstrate that there were cognitive impacts associated with wearing masks.

Seven of the included studies were experimental and investigated the ability of children to infer emotions and impacts on speech intelligibility and memory.[92,93,97,108-111] For example, in an experiment including 81 children (median age: 9.9±1.84 years) in Wisconsin, US, Ruba and Pollak (2020) assessed a child's ability to make inferences about emotions from subjects not wearing any facial coverings,

wearing sunglasses to cover the eyes, or wearing surgical masks to cover the mouth.[108] The authors found that children were able to infer the subject's emotions (restricted to negative emotions; e.g., sadness, fear, anger) even when parts of the face were covered. For the main effect of covering, children were more accurate when faces were uncovered than when faces were covered by a mask ($p<0.001$) or shades ($p<0.001$ There was no difference between accuracy when faces were covered by masks or shades ($p>0.25$). The experiment was conducted using images in a controlled setting and thus does not account for other contextual factors that children may draw from to infer emotions. In a randomized controlled trial, Schlegtendal et al. (2022) investigated the cognitive performance of students in 65 Grade 5–7 students who wore a mask and 65 who did not wear a masks during regular school lessons.[109] After two school lessons, in which students performed digital cognitive tests, there were no significant differences in cognitive performance between both groups. In a simulation study involving 140 students (3–17 years) in Ontario, Coelho et al. (2022) reported that older children who wore masks were more likely to report decreased ability to interact with peers ($X^2=13.2$, $p<0.001$) and ability to understand their teachers ($X^2=14.0$, $p<0.001$).[93] The Coelho et al. simulation was performed in August 2020 for two days and may not reflect conditions experienced during in-school instruction.

Dermatological

Six studies reported on potential dermatological impacts of wearing masks in children, with studies performed in France, Germany, India, Italy, Singapore and the US.[94,95,99,105,112,113] Dermatological issues in children who wore a variety of masks for variable periods included increased acne, rashes and allergic symptoms around the mouth area. These studies lacked control groups and/or had small sample sizes, which limited inferences of any potential association with mask-wearing and dermatoses in children.

Three of the included studies investigating dermatological issues and mask-wearing in children were surveys[99,105,112,113] In a survey of 2,954 parents of school-aged children in France (December 2020), Assathiany et al. (2021) reported that 25% to 30% of respondents reported unspecified cutaneous disorders in their children.[99] In a survey of 663 pediatricians, 42.4% reported cutaneous disorders in patients who wore masks. This study did not demonstrate a relationship between mask-wearing in children and dermatoses.

Conclusions

The conclusions of this rapid review have not changed substantively based on new evidence from updated database searches conducted on June 20, 2022. Mask-wearing in children has been associated with reduced incidence of SARS-CoV-2 infections in schools and studies have shown lower 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 imperfect but relatively high compliance in mask-wearing behaviours in children in school and community settings, and compliance increased with age. It is notable that the epidemiological effectiveness of mask-wearing in schools is in the context of imperfect adherence. There was no objective evidence for negative respiratory function in children wearing masks; however, subjective surveys of children wearing masks reported breathing discomfort.

Evidence suggests that mask-wearing in children likely reduces SARS-CoV-2 transmission and infection. In addition, masks (along with other non-pharmaceutical interventions; e.g., physical distancing, hand hygiene) also reduce transmission of other pathogens.[114-116] Along with other public health interventions, mask-wearing contributed to decreased rotavirus and adenovirus transmission among children in China (Zhang et al. 2022).[117] In South Korea, Kim et al. (2022) reported that infections (i.e., adenovirus, human metapneumovirus, human rhinovirus/enterovirus, influenza a/B virus, human parainfluenza virus, respiratory syncytial virus, *Mycoplasma pneumoniae*) were lower during the pandemic, compared to before the pandemic.[118]

The overwhelming majority of the studies in this rapid review were performed prior to the emergence of the Omicron VOC. The applicability of the studies summarized in this review to the current pandemic environment is uncertain. Few studies reported on types of masks used in schools. For additional information on mask-wearing in children, please see recent PHO resources.

- *Optimizing the Use of Masks Against COVID-19* (February 9, 2022)[119]
- *SARS-CoV-2 Omicron Variant and Community Masking* (December 15, 2021)[120]
- *Interim IPAC Recommendations for Use of Personal Protective Equipment for Care of Individuals with Suspect or Confirmed COVID-19* (June 9, 2022)[121]
- *Community Non-medical and Medical Mask Use for Reducing SARS-CoV-2 Transmission* (November 1, 2021)[122]
- *Update on Approach to Adapting Public Health Measures in Schools* (March 18, 2022)[123]

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Citation

Ontario Agency for Health Protection and Promotion (Public Health Ontario). Mask-wearing in children and COVID-19… what we know so far. 2nd ed, 1st revision. Toronto, ON: Queen's Printer for Ontario; 2022.

Disclaimer

Publication History

1st Edition: 2021
2nd Edition: February 2022
1st Revision: August 2022

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