

# EFFECTS OF MASKS ON THE HEALTH OF SCHOOLCHILDREN

*An Annotated Bibliography from the Penn Medicine Center for Evidence-based Practice*

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## Summary

- While there is moderate to strong evidence that end-tidal CO<sub>2</sub>, respiratory rates, and heart rates are increased by wearing face masks, there is no evidence connecting this to adverse health effects. This can be explained by physiologic compensation methods that the body uses to adapt to the changes in inhaled air.
- There is evidence from survey studies that wearing masks may cause some adverse effects, such as headaches, in school-age children. This evidence is of low to very low quality because of risk of bias in self-selected samples and because of indirectness.
- Systematic reviews on the effectiveness of masks conclude that they are able to prevent respiratory infections, but their effect in a school setting is small and not statistically significant. N95 masks are more effective than medical/surgical masks and cloth masks. The protective effect of masks for schoolchildren is additive to the effects of other interventions such as improving ventilation of classrooms and requiring teachers and staff to wear masks. We found no evidence on the effectiveness of masks for the subgroup of children who have been vaccinated.
- Guideline developers took various positions on masking of schoolchildren. None of the guidelines included in this limited bibliography considered adverse health effects to be sufficient reason for opposing masks.

*A CEP Annotated Bibliography is an expedited search for evidence and a presentation of selected articles intended to address a particular issue for Penn Medicine stakeholders. Searches are systematic but not necessarily comprehensive, and the results must not be taken as definitive. Additional studies may exist, including studies whose findings may differ from those cited in this report or identify significant limitations in their clinical applicability. Some citations may be to material supplied by drug or device manufacturers, published online, or in "grey literature." Readers should be aware that such material is not peer-reviewed, and CEP does not assess the methodological quality of studies cited in this report. The studies are informative and may provide important perspectives, but their validity and reliability has not been evaluated or confirmed. If you have specific questions about any of the studies cited here, or you wish to commission a full Evidence Review or Evidence Advisory on this or a related topic, please [contact CEP](#).*

## Introduction

The use of face masks is a widely-recommended means of reducing the transmission of SARS-CoV-2, the virus that causes COVID-19 disease. Since masks obstruct the flow of air during inhalation and exhalation, there is concern that use of masks could have adverse physiological effects. The purpose of this report is to find evidence on the effect of wearing cloth masks on inhaled or end-tidal carbon dioxide (CO<sub>2</sub>) levels in school-age children (subgrouped to ages 6-12 and ages 13-18 if evidence permits) and their consequential effects on children's health.

CO<sub>2</sub> measurement of room air is sometimes used as a measure of ventilation in closed spaces including classrooms. Please contact CEP for a list of references on this topic.

## Previous CEP reports

Please see <https://www.uphs.upenn.edu/cep/COVID/indexCOVID.html> for a complete catalog of CEP reports on COVID-19-related topics.

## Results

### Masks and inhaled carbon dioxide

While a study directly measuring the effect of surgical masks and FFP2 masks on CO<sub>2</sub> content of inhaled air in children was retracted by journal editors after its publication, there are several other studies reporting that masks increase levels of inhaled CO<sub>2</sub>, including one other study of children. A systematic review of this evidence concluded that the increase in CO<sub>2</sub> retention was statistically significant. Considering the finding that N95 masks had a larger effect on CO<sub>2</sub> levels than medical/surgical masks as a dose-response effect, the GRADE of this evidence would be moderate to high, depending on whether one considers the increase in CO<sub>2</sub> to be large.

Proving an increase in inhaled CO<sub>2</sub> does not prove that masks are harmful to health. None of the articles reporting increased CO<sub>2</sub> concentration reported harms to the study subjects. According to the systematic review, masking resulted in an increased heart rate while exercising compared to exercising without a mask, but the increased heart rate is not itself an adverse effect: it is a mechanism that the body uses to compensate for the increased CO<sub>2</sub> level. Subjects' blood oxygenation levels decreased while masked, but this difference was not statistically significant. Decreases in exercise performance were also statistically insignificant.

Reference	Findings and comment
<b>Studies of children</b>	
18	Both medical/surgical masks and FFP2 masks increase CO <sub>2</sub> retention in children at rest. <u>This article was subsequently retracted by the journal editors, based on concerns about applicability of the measurement device and the public health implications of the findings.</u>
19	N95 masks without exhalation valves increase end-tidal CO <sub>2</sub> and respiration rate in children at rest and during exercise but did not significantly decrease oxygen saturation.
29	Medical/surgical masks increase respiration and heart rate in children while walking, but did not cause oxygen desaturation or respiratory distress. <i>CEP NOTE: authors did not report baseline so we cannot determine the effects of masking while at rest. Study also included a group of infants (age 2-24 months) who did not perform the walking test.</i> <i>CEP NOTE: reference 21 comments on this article.</i>

Reference	Findings and comment
35	Only two studies of masks for children had been published as of November 2020. Both tested N95 respirators rather than medical/surgical masks or other face coverings. End-tidal CO <sub>2</sub> levels were increased by about 10 percent, but no adverse physiological effects were observed. Some children reported subjective breathing difficulties.
<b>Studies of adults</b>	
25	<u>Systematic review</u> : Medical/surgical and N95 masks caused small and statistically insignificant negative effects on exercise performance. CO <sub>2</sub> retention was significantly increased with all types of masks, and there was a consistent trend towards decreased arterial oxygen saturation with all types of masks. Heart rate was significantly increased with use of an N95; increases with other types of masks were not statistically significant. Subjects reported significant increases in perceived exertion when wearing a mask. Only 1 of the 22 included studies involved children. 18 of the 22 studies involved healthy volunteers.
8	<u>Systematic review</u> : The incidence of self-reported adverse effects of personal protective equipment on health care workers is high (average reported rate 78%). Headaches, skin reactions, and breathing discomfort were common. The review did not attempt to link adverse effects to specific pieces of PPE such as masks, and it did not distinguish between respirators, N95 masks, medical/surgical masks, and other face coverings. No adverse effects related to CO <sub>2</sub> retention were mentioned in the evidence tables.
11	Cloth face masks decrease oxygen saturation and increase CO <sub>2</sub> retention in adults during exercise, but did not cause adverse health effects.
13	Medical/surgical masks decrease oxygen saturation and increase CO <sub>2</sub> retention in adults during exercise. Some subjects experienced shortness of breath.
24	Medical/surgical masks and cloth masks did not decrease oxygen saturation, respiration rate, or heart rate in adults during exercise. End-tidal CO <sub>2</sub> was increased and end-tidal oxygen was decreased. Subjects perceived a shortness of breath while wearing a mask.
27	KN95 masks and valved respirators caused significant increases in CO <sub>2</sub> levels in resting adult subjects, exceeding NIOSH standards for 8-hour exposure but not for 15-minute exposure. The clinical significance of these increases remains debatable. Increases in CO <sub>2</sub> were smaller with use of a powered air-purifying respirator.
31	Medical/surgical masks and cloth masks did not decrease oxygen saturation or CO <sub>2</sub> tension in adults at rest or during exercise. Heart rate was increased during exercise with a medical/surgical mask compared to no mask, but this difference may not be clinically significant.
41	Very broad narrative review discussing the mechanism of CO <sub>2</sub> toxicity, and the effects of masks on both inhaled CO <sub>2</sub> levels and on prevention of respiratory infections.

## Masks and schools

We have summarized findings of other articles relating COVID-19 prevention in the school setting below. This is not intended to be a comprehensive list of articles on COVI-19 and schools.

Reference	Findings and comment
3	Authors devised a model to predict risk of in-school transmission as a function of infection rate in the community, viral infectiousness level, and effectiveness of mitigation measures. In a high-infectiousness scenario (delta variant), the authors suggest use of masks within the school may be indicated when the community incidence rate exceeds 4 cases per 100,000 residents per day.
4	Authors devised a model to predict infection rates in a school classroom as a function of room ventilation and vaccination rate. No thresholds for recommending masking are suggested.
6	Tracer study of aerosol dispersion in classrooms. Authors identify two situations that could worsen infection rates and make suggestions for mitigating them.
7	Authors describe a strategy for monitoring and adjusting classroom ventilation.
10	Evaluation of air purifiers for reducing aerosols in classrooms.

16	Commentary noting that children with cleft and craniofacial conditions and other persons who cannot or should not wear masks may face psychosocial challenges because they are not masked when other children are required to.
17	Survey of parents in France reporting type and frequency of problems experienced by their children when wearing masks in school. The number of responses was large. 82% of parents reported that their child experienced one or more physical adverse effects, most frequently headache and speech difficulties; and 67% reported that their child experienced one or more behavioral changes as the result of wearing a mask. CEP NOTE: Health care workers also reported headaches as a frequent adverse effect of mask-wearing (see references 8, 12)
22	The average rate of proper compliance with a mask mandate in parochial schools in metropolitan Atlanta was 77%.
28	Public opinion survey in Germany on mask mandates in schools. 43% of respondents supported mask mandates in the classroom, with little difference between respondents who were parents of school-aged children and those who were not. Parents were slightly more supportive of mask mandates for teachers and of mask mandates for children while they were outside the classroom. Support for mask mandates was significantly higher in large cities than in small towns. Women were significantly more likely than men to support mask mandates. There was a correlation between COVID-related knowledge and support for mask mandates.
30	Results from a dedicated registry for reporting adverse effects of masks for children. Note that respondents are self-selected, so reported rates of adverse effects probably overestimate true rates. [published in German with English abstract—project website (with English version) is at <a href="https://co-ki-masken.de/en/current-survey/">https://co-ki-masken.de/en/current-survey/</a> ]
34	Survey of US middle and high school students: compliance with mask mandates is 60%-70% in classrooms and hallways, and decreases to about 40% in bathrooms, cafeteria, and school buses.
43	Letter describing possible ways that masks can harm school performance. Authors do not discuss mask mandates or take a position for or against them.
44	Commentary on the benefits and harms of masks in a school setting. Author speaks favorably of masking but does not state whether or not he endorses a mandate for masking in schools.
45	While the title of the letter asks “should children wear masks,” the author does not really answer the question. It is noted that the Portuguese ministry of health recommended masks for children over 10 years old in indoor leisure settings, but their recommendations for school settings were not reported.
47	Authors suggest that masks with ear loops may have deform the ears and cause adverse cosmetic effects.
48	Commentary article from Italian doctors early in the pandemic. Authors recommend masks for children older than 2 while evidence on the safety and effectiveness of masks is obtained.

## Mask effectiveness

There is direct evidence on the effectiveness of masks from a study of schools (reference 20) and indirect evidence from a systematic review and meta-analysis of multiple non-school studies (reference 50). Based on that evidence, we conclude that masking may have a small effect in preventing schoolchildren from contracting COVID-19 disease but the effect is not statistically significant. The quality of the evidence is low, and there is now an additional degree of indirectness since most of the evidence predates the wide availability of vaccines against the SARS-CoV-2 virus. Studies outside the school setting conclude that N95 masks are more effective than medical/surgical masks or cloth masks. Reference 33 reports that mask mandates reduced COVID-19 disease rates, but studied only broad mandates and did not test whether mandates in schools had an effect. Furthermore, during the period studied, many schools were closed to in-person learning.

Reference	Findings and comment
Cochrane review	
50	<p>There is low certainty evidence from nine trials that wearing a mask may make little or no difference to the outcome of influenza-like illness (ILI) compared to not wearing a mask (risk ratio (RR) 0.99, 95% confidence interval (CI) 0.82 to 1.18). There is moderate certainty evidence that wearing a mask probably makes little or no difference to the outcome of laboratory-confirmed influenza compared to not wearing a mask (RR 0.91, 95% CI 0.66 to 1.26).</p> <p>Harms were poorly measured and reported, but discomfort wearing medical/surgical masks or N95/FFP2 respirators was mentioned in several studies.</p> <p>None of the included mask studies were carried out in school settings.</p> <p><i>CEP NOTE: scope of the review included all respiratory viruses, including SARS-Co-V-2.</i></p>
Other studies with direct applicability to the school setting	
20	<p>Regression analysis of COVID-19 incidence in Georgia schoolchildren. Variables found to have significant effect on incidence rates include mask requirement for teachers and staff (risk ratio 0.63, 95% CI 0.47-0.85), and ventilation improvements (RR 0.61, 95% CI 0.43-0.87). The effect of a mask requirement for students was moderately sized but not statistically significant (risk ratio 0.79, 95% CI 0.50-1.08), as was the effect of handwashing stations (RR 0.88, 95% CI 0.76-1.01). The following variables did not significantly affect incidence: private vs. public school, rural vs. metropolitan setting, hybrid vs. 100% in-person learning model, six foot separation of desks, barriers around desks, and students per classroom.</p> <p><i>CEP NOTE: the effectiveness of masks for vaccinated schoolchildren cannot be determined from this study, because it predated the approval of SARS-Co-V-2 vaccines for persons under 18.</i></p>

## Guidance

Our search identified several European guidelines relating to masks for schoolchildren. While they reported that children may find masks uncomfortable, inconvenient, and/or distracting, none identified any harmful effects from masks on children's health. The guidelines disagreed on whether schoolchildren should be required to wear masks.

Source	Recommendations and comment
ASPHER, EAP (EU) 32	<p>No recommendations for or against mask requirements in schools.</p> <p>Systematic review found a lack of evidence on the effectiveness of masks for children.</p> <p>Masks are less effective for children than they are for adults. Effectiveness can vary by a factor of almost three, based on the degree of compliance with instructions for wearing the mask properly and consistently.</p> <p>In the few studies that exist on the subject, children mainly complain of the heat and humidity induced by masks.</p> <p>Masks should be appropriately sized and designed.</p> <p>No recommendations for or against medical/surgical masks vs. cloth masks.</p> <p>N95 and FFP2 respirators are not recommended for children (except if there is a specific medical indication), because they are not sized to fit children and they are less comfortable.</p>
Germany 38	<p>Studies to find out if wearing masks might impose risks did not find essential problems: alterations of respiratory parameters due to an increased airway resistance remained within normal limits in healthy adults and even in asthmatics whose disease was well controlled.</p> <p>Children 10 years or older can use masks efficiently when they have been informed beforehand appropriate to their age. Under these conditions they can also be obliged to wear masks in certain situations, for example while walking through the school building to their desk in class. To limit the period of wearing a mask normally they will be allowed to remove the mask when sitting in class and keeping their distance.</p> <p>Children in primary schools may use masks, but they should not be obliged to wear them and children in kindergartens should not use masks. This exemption of younger children does not expose school and kindergarten teachers to additional risks since the infectivity with SARS-CoV-2 is age-dependent and increases with age reaching adult values only after 12 years of age.</p>

Source	Recommendations and comment
SIP (Italy) 42	<p>Use of masks is recommended for children over 3 years old.</p> <p>Facial mask may be uncomfortable but they not have an impact on healthy children aged over 3 years. Surgeons daily wear face coverings for many hours without coming to harm.</p> <p>The effectiveness of masks in preventing spread of coronavirus diseases has been documented in a systematic review of clinical studies.</p> <p>The prolonged use of medical masks, when properly worn, does not cause carbon dioxide intoxication nor oxygen deficiency in healthy children.</p> <p>There is no scientific evidence showing that use of masks alters the gut microbiome.</p>

ASPHER– Association of Schools of Public Health in the European Region, EAP–European Academy of Paediatrics  
 Germany–Intersociety guidance endorsed by eight pediatric specialty societies  
 SIP–Italian Pediatric Society

## Bibliography

[NOTE: there are no references 1 and 2 in this set]

3. Giardina J, Bilinski A, Fitzpatrick MC, Kendall EA, Linas BP, Salomon J, et al. When do elementary students need masks in school? Model-estimated risk of in-school SARS-CoV-2 transmission and related infections among household members before and after student vaccination. medRxiv. 2021:2021.08.04.21261576.

<http://medrxiv.org/content/early/2021/08/07/2021.08.04.21261576.abstract>

**Background** While CDC guidance for K-12 schools recommends indoor masking regardless of vaccination status, final decisions about masking in schools will be made at the local and state level. The impact of the removal of mask restrictions, however, on COVID-19 outcomes for elementary students, educators/staff, and their households is not well known.

**Methods** We used a previously published agent-based dynamic transmission model of SARS-CoV-2 in K-12 schools to simulate an elementary school with 638 students across 6 scenarios: combinations of three viral infectiousness levels (reflecting wild-type virus, alpha variant, and delta variant) and two student vaccination levels (0% and 50% coverage to reflect potential authorization in this age group). For each scenario, we varied observed community COVID-19 incidence (0 to 50 cases/100,000 people/day) and mitigation effectiveness (0-100% reduction to in-school secondary attack rate), and evaluated two outcomes over a 30 day period: (1) the probability of at least one in-school transmission, and (2) the increase in total cases among students, educators/staff, and their household members between in-person and remote instruction.

**Results** Over 30 days in the simulated elementary school, the probability of at least one in-school SARS-CoV-2 transmission and the number of projected infections in the immediate school community varied widely. In one scenario with the delta variant and no student vaccination, assuming that baseline mitigation measures of simple ventilation and handwashing reduce the secondary attack rate by 40%, if decision-makers seek to keep the monthly probability of an in-school transmission below 50%, additional mitigation (e.g., masking) would need to be added at a community incidence of approximately 4/100,000/day. Once students are vaccinated, thresholds shift substantially higher.

**Limitations** The interpretation of model results should be limited by the uncertainty in many of the parameters, including the effectiveness of individual mitigation interventions and vaccine efficacy against the delta variant, and the limited scope of the model beyond the school community. Additionally, the assumed case detection rate (33% of cases detected) may be too high in areas with decreased testing capacity.

**Conclusion** Despite the assumption of high adult vaccination, the risks of both in-school SARS-CoV-2

transmission and resulting infections among students, educators/staff, and their household members remain high when the delta variant predominates and students are unvaccinated. Mitigation measures or vaccinations for students when available can substantially reduce these risks. These findings underscore the potential role for responsive plans, where mitigation is deployed based on local COVID-19 incidence and vaccine uptake.

4. Mikszewski A, Stabile L, Buonanno G, Morawska L. The Vaccination Threshold for SARS-CoV-2 Depends on the Indoor Setting and Room Ventilation. medRxiv. 2021:2021.07.28.21261300.

<http://medrxiv.org/content/early/2021/07/29/2021.07.28.21261300.abstract>

Background Effective vaccines are now available for SARS-CoV-2 in the second year of the COVID-19 pandemic, but there remains significant uncertainty surrounding the necessary vaccination rate to safely lift occupancy controls in public buildings and return to pre-pandemic norms. The aim of this paper is to estimate setting-specific vaccination thresholds for SARS-CoV-2 to prevent sustained community transmission using classical principles of airborne contagion modeling. We calculated the airborne infection risk in three settings, a classroom, prison cell block, and restaurant, at typical ventilation rates, and then the expected number of infections resulting from this risk at varying levels of occupant susceptibility to infection.

Results We estimate the vaccination threshold for control of SARS-CoV-2 to range from a low of 40% for a mechanically ventilation classroom to a high of 85% for a naturally ventilated restaurant.

Conclusions If vaccination rates are limited to a theoretical minimum of approximately two-thirds of the population, enhanced ventilation above minimum standards for acceptable air quality is needed to reduce the frequency and severity of SARS-CoV-2 superspreading events in high-risk indoor environments.

6. Rencken GK, Rutherford EK, Ghanta N, Kongoletos J, Glicksman L. Patterns of SARS-CoV-2 Aerosol Spread in Typical Classrooms. medRxiv. 2021:2021.04.26.21256116.

<http://medrxiv.org/content/early/2021/04/26/2021.04.26.21256116.abstract>

Although current industry guidelines to control the spread of SARS-CoV-2 (COVID-19) have adopted a six-foot (~1.8m) spacing between individuals indoors, recent evidence suggests that longer range spread is also responsible for infections in public spaces. The vehicle for long-range spread is smaller droplets or particles, termed bio-aerosols, or aerosols for short, which have a large surface area to volume ratio such that aerodynamic drag is much larger than gravity forces. The aerosols remain suspended in air for extended time periods and they essentially move with air currents. Prediction of the danger to occupants in a closed room when exposed to an infected individual requires knowledge of the period of exposure and the concentration level of aerosols in the breathing zone of an occupant. To obtain an estimate of the concentration level, a common assumption is well-mixed conditions within an interior space. This is obtained from a mass balance between the level of aerosol produced by an infected individual along with the airflow rate into and out of the entire space. In this work, we use computational fluid dynamics, verified by experimental results, to explore the aerosol concentration distribution in a typical classroom for several common conditions and compare these results to the well-mixed assumption. We use a tracer gas to simulate the flow and dispersion of the aerosol-air mixture. The two ventilation systems examined, ceiling diffusers and open windows, yield average concentrations at occupant breathing level 50% greater than the well mixed case, and some scenarios yield concentrations that are 150% greater than the well mixed concentration at specific breathing-level locations. Of particular concern are two conditions: horizontal air flow from an open window in line with a row of seating and, second, an infected individual seated near a sealed cold window. For the former, conditions are improved if a baffle is placed inside the open window to direct the air toward the floor, creating a condition similar to displacement ventilation. In

the latter, the cold air flowing down along the cold window recirculates aerosols back into the breathing zone. Adding window covers or a portable heater below the window surface will moderate this condition.

7. Stabile L, Pacitto A, Mikszewski A, Morawska L, Buonanno G. Ventilation procedures to minimize the airborne transmission of viruses at schools. medRxiv. 2021:2021.03.23.21254179. <http://medrxiv.org/content/early/2021/03/24/2021.03.23.21254179.abstract>

Reducing the transmission of SARS-CoV-2 through indoor air is the key challenge of the COVID-19 pandemic. Crowded indoor environments, such as schools, represent possible hotspots for virus transmission since the basic non-pharmaceutical mitigation measures applied so far (e.g. social distancing) do not eliminate the airborne transmission mode. There is widespread consensus that improved ventilation is needed to minimize the transmission potential of airborne viruses in schools, whether through mechanical systems or ad-hoc manual airing procedures in naturally ventilated buildings. However, there remains significant uncertainty surrounding exactly what ventilation rates are required, and how to best achieve these targets with limited time and resources. This paper uses a mass balance approach to quantify the ability of both mechanical ventilation and ad-hoc airing procedures to mitigate airborne transmission risk in the classroom environment. For naturally-ventilated classrooms, we propose a novel feedback control strategy using CO<sub>2</sub> concentrations to continuously monitor and adjust the airing procedure. Our case studies show how such procedures can be applied in the real world to support the reopening of schools during the pandemic. Our results also show the inadequacy of relying on absolute CO<sub>2</sub> concentration thresholds as the sole indicator of airborne transmission risk.

8. Galanis P, Vraka I, Fragkou D, Bilali A, Kaitelidou D. Impact of personal protective equipment use on health care workers' physical health during the COVID-19 pandemic: a systematic review and meta-analysis. Am J Infect Control. 2021. <https://doi.org/10.1016/j.ajic.2021.04.084>

**Background** During the COVID-19 pandemic, health care workers (HCWs) caring for patients with coronavirus disease 2019 (COVID-19) in high-risk clinical settings have been obliged to wear personal protective equipment (PPE).

**Aim** To assess the impact of PPE use on HCWs' physical health during the COVID-19 pandemic. Also, we examined factors related with a greater risk of adverse events among HCWs due to PPE use.

**Methods** We applied the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines and the Cochrane criteria for this systematic review and meta-analysis. We searched PubMed, Medline, Scopus, ProQuest, CINAHL and pre-print services (medRxiv) from January 1, 2020 to December 27, 2020.

**Findings** Our review included 14 studies with 11,746 HCWs from 16 countries. The estimated overall prevalence of adverse events among HCWs was 78% (95% CI: 66.7-87.5%) with a range from 42.8% to 95.1% among studies. The prevalence of adverse events was higher for the studies with poor quality compared to those with moderate quality (83.5% vs. 67.1%), while increased sample size was related with decreased prevalence ( $p < 0.001$ ). The most frequent adverse events were headache (55.9%), dry skin (54.4%), dyspnoea (53.4%), pressure injuries (40.4%), itching (39.8%), hyperhidrosis (38.5%), and dermatitis (31.0%). Among others, the following factors were related with the risk of adverse events among HCWs due to PPE use: female gender, younger age, obesity, diabetes mellitus, smoking pre-existing headache, longer duration of shifts wearing PPE, increased consecutive days with PPE, and increased exposure to confirmed or suspected COVID-19 patients.

**Conclusion** The frequency of adverse events amongst HCWs due to PPE use is very high. Further studies should be conducted since the limitations of this review do not allow us to infer conclusive results especially in case of risk factors for the occurrence of adverse events. Healthcare facilities should take the necessary precautions and change the working conditions during the COVID-19 pandemic to prevent adverse events associated with PPE use and minimize harm to HCWs.



10. Curtius J, Granzin M, Schrod J. Testing mobile air purifiers in a school classroom: Reducing the airborne transmission risk for SARS-CoV-2. medRxiv. 2020:2020.10.02.20205633.

<http://medrxiv.org/content/early/2020/12/24/2020.10.02.20205633.abstract>

Airborne transmission of SARS-CoV-2 through virus-containing aerosol particles has been established as an important pathway for Covid-19 infection. Suitable measures to prevent such infections are imperative, especially in situations when a high number of persons convene in closed rooms. Here we tested the efficiency and practicability of operating four air purifiers equipped with HEPA filters in a high school classroom while regular classes were taking place. We monitored the aerosol number concentration for particles > 3 nm at two locations in the room, the aerosol size distribution in the range from 10 nm to 10 μm, PM10 and CO<sub>2</sub> concentration. For comparison, we performed similar measurements in a neighboring classroom without purifiers. In times when classes were conducted with windows and door closed, the aerosol concentration was reduced by more than 90 % within less than 30 minutes when running the purifiers (air exchange rate 5.5 h<sup>-1</sup>). The reduction was homogeneous throughout the room and for all particle sizes. The measurements are supplemented by a calculation estimating the maximum concentration levels of virus-containing aerosol from a highly contagious person speaking in a closed room with and without air purifiers. Measurements and calculation demonstrate that air purifiers potentially represent a well-suited measure to reduce the risks of airborne transmission of SARS-CoV-2 substantially. Staying for two hours in a closed room with a highly infective person, we estimate that the inhaled dose is reduced by a factor of six when using air purifiers with a total air exchange rate of 5.7 h<sup>-1</sup>.

11. Braga F, Espinosa G, Monteiro A, Marinho B, Drummond E. Physiological Effects of Exercising at Different Intensities Wearing TNT or Double-layer Cotton Facemasks Compared to Not Wearing a Mask. medRxiv. 2020:2020.12.11.20203224.

<http://medrxiv.org/content/early/2020/12/17/2020.12.11.20203224.abstract>

We compared the physiological differences between exercising wearing a TNT or a double-layer-cotton (DLC) facemask (FM) and not wearing a mask (NM). Sixteen volunteers underwent 4 sets (S) of 2 sequential bouts (B). B1 and B2 corresponded to light and moderate intensity cycling, respectively. FMs were used as follows: S1: NM; S2: TNT or DLC; S3: DLC or TNT; and S4: NM. Metabolic, pulmonary, and perceptual variables were collected. The main results are expressed as effect sizes and confidence intervals (ES 95%CI) for TNT and DLC unless otherwise indicated. Compared to NM, FM increased the duty cycle (B1=1.110.58-1.61] and 1.530.81-2.18]; B2=1.270.63-1.84] and 1.930.97-2.68]) and decreased breath frequency (B1=0.590.23-0.94] and 1.430.79-2.07], B2=0.390.05-0.71] and 1.330.71-1.94]). Only B1 tidal volume increased (0.330.09-0.56] and 0.620.18-1.05]) enough to avoid a ventilation reduction with TNT but not with DLC (B1=0.520.23-0.79]; B2=0.840.44-1.22]). Both FMs reduced oxygen saturation in B1 (0.56 0.07-1.03] and 0.69 0.09-1.28]) but only DLC did so in B2 (0.66 0.11-1.13]). Both end tidal CO<sub>2</sub> (B1=0.230.05-0.4] and 0.710.38-1.02]; B2=0.560.2-0.9] and 1.200.65-1.68]) and mixed-expired-CO<sub>2</sub> (B1=0.740.38-1.08] 1.711.03-2.37], B2=0.940.45-1.38] and 1.780.97-2.42]) increased with FMs. Ventilatory adaptations imposed during FM exercising influenced blood-lung gas exchange. Larger ESs were seen with DLC. No adverse changes to human health were observed.

- Facemasks affect the breathing pattern by changing the frequency and amplitude of pulmonary ventilation.
- The augmented ventilatory work increases VO<sub>2</sub>, VCO<sub>2</sub>, and RPE and promotes non-concerning drops in SpO<sub>2</sub> and CO<sub>2</sub> retention.
- Increased inspiratory and expiratory pressure can account for the reduction in pulmonary physiological dead space.

12. Ramírez-Moreno JM, Ceberino D, González-Plata A, Rebollo B, Macías-Sedas P, Ramchandani RH, et al. Mask-associated de novo headache in healthcare workers during the

Covid-19 pandemic. *Occup Environ Med* 2021;78:548-554

<http://dx.doi.org/10.1136/oemed-2020-106956>

**Introduction** The pandemic caused by the new coronavirus (COVID-19) has led to changes in the development of health care activities by health professionals. We analysed whether there is an association between the appearance of “de novo” headache according to the type of mask used, the related factors, as well as the impact of the headache on health professionals.

**Method** cross-sectional study in a tertiary hospital in Extremadura, Spain. We administered an online questionnaire to healthcare workers during the period of maximum incidence of COVID-19 in our setting. Results n=306, 244 women (79.7%), with an average age of 43 years (range 23-65). Of the total, 129 (42.2%) were physicians, 112 (36.6%) nurses and 65 (21.2%) other health workers. 208 (79.7%) used surgical masks and 53 (20.3%) used filtering masks. Of all those surveyed, 158 (51.6%) presented “de novo” headache. The occurrence of headache was independently associated with the use of a filtering mask, OR 2.14 (IC95% 1.07-4.32), being a nurse OR 2.09 (IC95% 1.18-3.72) or another health worker OR 6.94 (IC95% 3.01-16.04) or having a history of asthma OR 0.29 (IC95% 0.09-0.89). Depending on the type of mask used there were differences in headache intensity. And the impact of headache in the subjects who used a filtering mask was worse in the all aspects evaluated.

**Conclusions** The appearance of “de novo” headache is associated with the use of filtering masks and is more frequent in certain health care workers, causing a greater occupational, family, personal and social impact.

13. Bar-On O, Gendler Y, Stafler P, Levine H, Steuer G, Shmueli E, et al. Effects of Wearing Facemasks During Brisk Walks: A COVID-19 Dilemma. *J Am Board Fam Med*. 2021;34(4):798-801 <https://dx.doi.org/10.3122/jabfm.2021.04.200559>.

**BACKGROUND:** During the Coronavirus disease 2019 (COVID-19) pandemic, wearing facemasks became obligatory worldwide., **OBJECTIVES:** The objective of this study was to evaluate the effects of facemasks on gas exchange., **METHODS:** Healthy adults were assessed at rest and during slow and brisk 5-minute walks, with and without masks. We monitored O<sub>2</sub> saturation, end-tidal carbon dioxide (EtCO<sub>2</sub>), and heart and respiratory rates. Participants graded their subjective difficulty and completed individual sensations questionnaires., **RESULTS:** Twenty-one participants with a median age of 38 years (range, 29-57 years) were recruited. At rest, all vital signs remained normal, without and with masks. However, during slow and brisk walks, EtCO<sub>2</sub> increased; the rise was significantly higher while wearing masks: slow walk, mean EtCO<sub>2</sub> (mmHg) change +4.5 +/- 2.4 versus +2.9 +/- 2.3, P = .004; brisk walk EtCO<sub>2</sub> change +8.4 +/- 3.0 versus +6.2 +/- 4.0, P = .009, with and without masks, respectively. Wearing masks was also associated with higher proportions of participant hypercarbia (EtCO<sub>2</sub> range, 46-49 mmHg) compared with walking without masks, though this was only partially significant. Mean O<sub>2</sub>-saturation remained stable (98%) while walking without masks but decreased by 1.2 % +/- 2.2 while walking briskly with a mask (P = .01). Mild desaturation (O<sub>2</sub> range, 93% to 96%) was noted during brisk walks among 43% of participants with masks, compared with only 14% without masks (P = .08). Borg's scale significantly increased while walking with a mask, for both slow and brisk walks (P < .001). Sensations of difficulty breathing and shortness of breath were more common while walking with masks., **CONCLUSION:** While important to prevent viral spread, wearing facemasks during brisk 5-minute walks might be associated with mild hypercarbia and desaturation. The clinical significance of these minor gas exchange abnormalities is unclear and should be further investigated.

14. Christakis D, Fontanarosa PB. Notice of Retraction. Walach H, et al. Experimental Assessment of Carbon Dioxide Content in Inhaled Air With or Without Face Masks in Healthy Children: A Randomized Clinical Trial. *JAMA Pediatr*. Published online June 30, 2021. *Jama, Pediatr*. 2021:e213252 <https://dx.doi.org/10.1001/jamapediatrics.2021.3252>.

16. Reitz RJ,3rd, Kotha VS, Gutai JR, Baus I, Bona BA, Kumar AR, et al. Mask on, Mask off: The Role of Comprehensive Craniofacial Care in Addressing Patient Safety and COVID-19 Mandates during School Reopening. *Plast Reconstr Surg*. 2021;148(2):351e-2e <https://dx.doi.org/10.1097/PRS.00000000000008116>.

17. Assathiany R, Salinier C, Bechet S, Dolard C, Kochert F, Bocquet A, et al. Face Masks in Young Children During the COVID-19 Pandemic: Parents' and Pediatricians' Point of View. *Front pediatr*. 2021;9:676718 <https://dx.doi.org/10.3389/fped.2021.676718>.

Background: In countries with high SARS-CoV-2 circulation, the pandemic has presented many challenges on different fronts, affecting lives and livelihoods; efforts to keep schools open are among the most important. In France, to keep schools open, wearing a face mask has been mandatory for children from age 6 years since November 2020. Objective: To evaluate the acceptability and tolerance of this measure by children as well as both parents and pediatricians. Setting: Parents registered on the website of the French Association of Ambulatory Pediatrics and pediatricians members of this association. Participants: All parents and pediatricians who agreed to take part in the survey. Results: Among the 2,954 questionnaires for the parents' survey, the reasons for wearing a mask were understood by 54.6% of parents, most of whom (84.6%) explained the reasons to their children. The parents applied this measure because it was mandatory (93.4%) even if they disagreed (63.3%). When interviewed by parents, children said they were usually embarrassed (80.9%) by the mask. The main symptoms or changes of behavior attributed to the mask according to parents were headache (49.0%), speaking difficulties (45%), change in mood (45.2%) and breathing discomfort (28.1%). Among the 663 pediatricians who responded, many agreed with mandatory mask-wearing at age 6 years (67.7%). Overall, 15% of pediatricians systematically asked about the mask tolerance during the consultation. During the medical consultation, when the parents complained about the mask (64.3%), the main drawbacks were related to fog on glasses (reported by 68.2% of pediatricians), breathing discomfort (53.1% of pediatricians), cutaneous disorders (42.4% of pediatricians) and headaches (38.2% of pediatricians). Conclusion: Despite the many inconveniences reported, children agree to wear the mask better than their parents think. Pediatricians should sufficiently take the opportunity during the consultation to further explain the reasons for wearing the mask because their pedagogical role is crucial.

18. Walach H, Weikl R, Prentice J, Diemer A, Traindl H, Kappes A, et al. Experimental assessment of carbon dioxide content in inhaled air with or without face masks in healthy children: a randomized clinical trial. *Jama Pediatr*. 2021 <https://dx.doi.org/10.1001/jamapediatrics.2021.2659>.

19. Lubrano R, Bloise S, Marcellino A, Ciolli CP, Testa A, De Luca E, et al. Effects of N95 Mask Use on Pulmonary Function in Children. *J Pediatr*. 2021 <https://dx.doi.org/10.1016/j.jpeds.2021.05.050>.

OBJECTIVE: To assess whether use of an N95 mask by children is associated with episodes of desaturation or respiratory distress., STUDY DESIGN: Twenty-two healthy children were assigned at random to 1 of 2 groups: one group wearing N95 masks without an exhalation valve and the other group wearing N95 masks with an exhalation valve. We tracked changes in partial pressure of end-tidal carbon dioxide (PETCO<sub>2</sub>), oxygen saturation, pulse rate, and respiratory rate over 72 minutes of mask use. All subjects were monitored every 15 minutes, the first 30 minutes while not wearing a mask and the next 30 minutes

while wearing a mask. They then performed a 12-minute walking test., RESULTS: The children did not experience a statistically significant change in oxygen saturation or pulse rate during the study. There were significant increases in respiratory rate and PETCO<sub>2</sub> in the children wearing an N95 mask without an exhalation valve, whereas these increases were seen in the children wearing a mask with an exhalation valve only after the walking test., CONCLUSIONS: The use of an N95 mask could potentially cause breathing difficulties in children if the mask does not have an exhalation valve, particularly during a physical activity. We believe that wearing a surgical mask may be more appropriate for children.

20. Gettings J, Czarnik M, Morris E, Haller E, Thompson-Paul A, Rasberry C, et al. Mask Use and Ventilation Improvements to Reduce COVID-19 Incidence in Elementary Schools - Georgia, November 16-December 11, 2020. *MMWR Morb Mortal Wkly Rep.* 2021;70(21):779-84 <https://dx.doi.org/10.15585/mmwr.mm7021e1>.

To meet the educational, physical, social, and emotional needs of children, many U.S. schools opened for in-person learning during fall 2020 by implementing strategies to prevent transmission of SARS-CoV-2, the virus that causes COVID-19 (1,2). To date, there have been no U.S. studies comparing COVID-19 incidence in schools that varied in implementing recommended prevention strategies, including mask requirements and ventilation improvements\* (2). Using data from Georgia kindergarten through grade 5 (K-5) schools that opened for in-person learning during fall 2020, CDC and the Georgia Department of Public Health (GDPH) assessed the impact of school-level prevention strategies on incidence of COVID-19 among students and staff members before the availability of COVID-19 vaccines. Among 169 K-5 schools that participated in a survey on prevention strategies and reported COVID-19 cases during November 16-December 11, 2020, COVID-19 incidence was 3.08 cases among students and staff members per 500 enrolled students. Adjusting for county-level incidence, COVID-19 incidence was 37% lower in schools that required teachers and staff members to use masks, and 39% lower in schools that improved ventilation, compared with schools that did not use these prevention strategies. Ventilation strategies associated with lower school incidence included methods to dilute airborne particles alone by opening windows, opening doors, or using fans (35% lower incidence), or in combination with methods to filter airborne particles with high-efficiency particulate absorbing (HEPA) filtration with or without purification with ultraviolet germicidal irradiation (UVGI) (48% lower incidence). Multiple strategies should be implemented to prevent transmission of SARS-CoV-2 in schools (2); mask requirements for teachers and staff members and improved ventilation are important strategies that elementary schools could implement as part of a multicomponent approach to provide safer, in-person learning environments. Universal and correct mask use is still recommended by CDC for adults and children in schools regardless of vaccination status (2).

21. Can Very Young Children Safely Wear Surgical Masks? *Am J Nurs.* 2021;121(6):14 <https://dx.doi.org/10.1097/01.NAJ.0000753600.17712.45>.

Researchers find no evidence of adverse respiratory effects.

22. Mickells GE, Figueroa J, West KW, Wood A, McElhanon BO. Adherence to Masking Requirement During the COVID-19 Pandemic by Early Elementary School Children. *J Sch Health.* 2021;91(7):555-61 <https://dx.doi.org/10.1111/josh.13033>.

BACKGROUND: Top public health experts and organizations strongly recommend universal masking for children older than 2 years old during the COVID-19 pandemic, but speculate it may be difficult for young children. This study sought to assess the usage of cloth face masks in grades pre-K-2 and identify associated characteristics and adverse events. It is the first data to assess mask wearing by young children in school., METHODS: This online, prospective, observational, survey in multiple schools within a single school district in a major metropolitan area measured adherence to face covering mandates by students in grades pre-K-2 as measured by percentage of day with appropriate face mask wearing per report via daily

teacher surveys for the first 4 weeks of school., RESULTS: The primary outcome was percent of the day that the entire class was wearing their masks appropriately. Of the estimated almost 1000 students and 1048 classroom days reported, the mean percentage of the school day with appropriate mask usage was 76.9%., CONCLUSIONS: For a majority of the day while conducting in-person instruction, children in grades pre-K-2 are able to adhere to mask wearing as a key mitigation strategy for limiting SARS-CoV2 infection spread and possible future use.

24. Doherty CJ, Mann LM, Angus SA, Chan JS, Molgat-Seon Y, Dominelli PB. Impact of wearing a surgical and cloth mask during cycle exercise. *Appl Physiol Nutr Metab.* 2021;46(7):753-62 <https://dx.doi.org/10.1139/apnm-2021-0190>.

We sought to determine the impact of wearing cloth or surgical masks on the cardiopulmonary responses to moderate-intensity exercise. Twelve subjects (n = 5 females) completed three, 8-min cycling trials while breathing through a non-rebreathing valve (laboratory control), cloth, or surgical mask. Heart rate (HR), oxyhemoglobin saturation (SpO<sub>2</sub>), breathing frequency, mouth pressure, partial pressure of end-tidal carbon dioxide (PetCO<sub>2</sub>) and oxygen (PetO<sub>2</sub>), dyspnea were measured throughout exercise. A subset of n = 6 subjects completed an additional exercise bout without a mask (ecological control). There were no differences in breathing frequency, HR or SpO<sub>2</sub> across conditions (all p > 0.05). Compared with the laboratory control (4.7 +/- 0.9 cmH<sub>2</sub>O mean +/- SD), mouth pressure swings were smaller with the surgical mask (0.9 +/- 0.7; p 0.05). Dyspnea was similar between the control conditions and the surgical mask (p > 0.05) but was greater with the cloth mask compared with laboratory (+0.9 +/- 1.2) and ecological (+1.5 +/- 1.3) control conditions (both p < 0.05). Wearing a mask during short-term moderate-intensity exercise may increase dyspnea but has minimal impact on the cardiopulmonary response. Novelty: Wearing surgical or cloth masks during exercise has no impact on breathing frequency, tidal volume, oxygenation, and heart rate However, there are some changes in inspired and expired gas fractions that are physiologically irrelevant. In young healthy individuals, wearing surgical or cloth masks during submaximal exercise has few physiological consequences.

25. Shaw KA, Zello GA, Butcher SJ, Ko JB, Bertrand L, Chilibeck PD. The impact of face masks on performance and physiological outcomes during exercise: a systematic review and meta-analysis. *Appl Physiol Nutr Metab.* 2021;46(7):693-703 <https://dx.doi.org/10.1139/apnm-2021-0143>.

Face masks are promoted for preventing spread of viruses; however, wearing a mask during exercise might increase CO<sub>2</sub> rebreathing, decrease arterial oxygenation, and decrease exercise performance. A systematic review and meta-analysis was conducted on the impact of wearing a mask during exercise. Data sources included SPORTDiscus, PubMed, and Medline. Eligibility criteria included all study designs comparing surgical, N95, or cloth masks to a no mask condition during any type of exercise where exercise performance and/or physiological parameters were evaluated. Healthy and clinical participants were included. Mean differences (MD) or standardized mean differences (SMD) with 95% confidence intervals were calculated and pooled effects assessed. Twenty-two studies involving 1573 participants (620 females, 953 males) were included. Surgical, or N95 masks did not impact exercise performance (SMD -0.05 -0.16, 0.07] and -0.16 -0.54, 0.22], respectively) but increased ratings of perceived exertion (SMD 0.33 0.09, 0.58] and 0.61 0.23, 0.99]) and dyspnea (SMD 0.6 0.3, 0.9] for all masks). End-tidal CO<sub>2</sub> (MD 3.3 1.0, 5.6] and 3.7 3.0, 4.4] mm Hg), and heart rate (MD 2 0,4] beats/min with N95 masks) slightly increased. Face masks can be worn during exercise with no influences on performance and minimal impacts on physiological variables. PROSPERO registration: CRD42020224988. Novelty: Face masks can be worn during exercise with no impacts on performance and minimal impacts on physiological variables.

27. Rhee MSM, Lindquist CD, Silvestrini MT, Chan AC, Ong JJY, Sharma VK. Carbon dioxide increases with face masks but remains below short-term NIOSH limits. *BMC Infect Dis*. 2021;21(1):354 <https://dx.doi.org/10.1186/s12879-021-06056-0>.

**BACKGROUND AND PURPOSE:** COVID-19 pandemic led to wide-spread use of face-masks, respirators and other personal protective equipment (PPE) by healthcare workers. Various symptoms attributed to the use of PPE are believed to be, at least in part, due to elevated carbon-dioxide (CO<sub>2</sub>) levels. We evaluated concentrations of CO<sub>2</sub> under various PPE., **METHODS:** In a prospective observational study on healthy volunteers, CO<sub>2</sub> levels were measured during regular breathing while donning 1) no mask, 2) JustAir R powered air purifying respirator (PAPR), 3) KN95 respirator, and 4) valved-respirator. Serial CO<sub>2</sub> measurements were taken with a nasal canula at a frequency of 1-Hz for 15-min for each PPE configuration to evaluate whether National Institute for Occupational Safety and Health (NIOSH) limits were breached., **RESULTS:** The study included 11 healthy volunteers, median age 32 years (range 16-54) and 6 (55%) men. Percent mean (SD) changes in CO<sub>2</sub> values for no mask, JustAir R PAPR, KN95 respirator and valve respirator were 0.26 (0.12), 0.59 (0.097), 2.6 (0.14) and 2.4 (0.59), respectively. Use of face masks (KN95 and valved-respirator) resulted in significant increases in CO<sub>2</sub> concentrations, which exceeded the 8-h NIOSH exposure threshold limit value-weighted average (TLV-TWA). However, the increases in CO<sub>2</sub> concentrations did not breach short-term (15-min) limits. Importantly, these levels were considerably lower than the long-term (8-h) NIOSH limits during donning JustAir R PAPR. There was a statistically significant difference between all pairs ( $p < 0.0001$ , except KN95 and valved-respirator ( $p = 0.25$ )). However, whether increase in CO<sub>2</sub> levels are clinically significant remains debatable., **CONCLUSION:** Although, significant increase in CO<sub>2</sub> concentrations are noted with routinely used face-masks, the levels still remain within the NIOSH limits for short-term use. Therefore, there should not be a concern in their regular day-to-day use for healthcare providers. The clinical implications of elevated CO<sub>2</sub> levels with long-term use of face masks needs further studies. Use of PAPR prevents relative hypercapnoea. However, whether PAPR should be advocated for healthcare workers requiring PPE for extended hours needs to be evaluated in further studies.

28. Betsch C, Korn L, Felgendreff L, Eitze S, Thaiss H. School opening during the SARS-CoV-2 pandemic: Public acceptance of wearing fabric masks in class. *Public Health Pract (Oxf)*. 2021;2:100115 <https://dx.doi.org/10.1016/j.puhip.2021.100115>.

**Objectives:** Policy decisions regarding mask wearing in schools in times of the SARS-CoV-2 pandemic will likely be made despite a lack of scientific data. Public acceptance is therefore an important indicator to inform the communication activities that accompany the introduction of a new policy. The goal was to assess acceptance and relevant target groups for communication activities., **Study design:** Cross-sectional online survey embedded in the regular German COVID-19 monitoring., **Methods:** Besides sociodemographic information, trust in institutions, knowledge about COVID-19 and protective behaviors, as well as risk perceptions, we assessed public acceptance of school-related mask policies of parents and non-parents (total N = 957)., **Results:** In the absence of mandatory mask policies in schools in Germany in August 2020, the general agreement with mask wearing in school was low. Those living in bigger cities or communities - where class sizes are usually larger - agreed more with mask wearing in class; those who felt a greater risk, had greater trust in institutions, or felt higher self-efficacy in fighting the outbreak also wanted children to wear a mask in class. Women were more likely than men to disagree with mask wearing in class. Agreement was highest that policies should uniformly apply for all institutions within a state/province and should not be regulated at the school level or federal/country level., **Conclusions:** Implementing mask policies in school will require intense communication. Acceptance of these policies from teachers and pupils should be considered as well. Women seem to be an important target group as

they supported mask wearing in class less than men. Women's roles in controlling infectious diseases in school should therefore receive special attention and support. Copyright © 2021 The Author(s).

29. Lubrano R, Bloise S, Testa A, Marcellino A, Dilillo A, Mallardo S, et al. Assessment of Respiratory Function in Infants and Young Children Wearing Face Masks During the COVID-19 Pandemic. *JAMA netw open*. 2021;4(3):e210414

<https://dx.doi.org/10.1001/jamanetworkopen.2021.0414>.

Importance: Face masks have been associated with effective prevention of diffusion of viruses via droplets. However, the use of face masks among children, especially those aged younger than 3 years, is debated, and the US Centers for Disease Control and American Academy of Physicians recommend the use of face mask only among individuals aged 3 years or older., Objective: To examine whether the use of surgical facial masks among children is associated with episodes of oxygen desaturation or respiratory distress., Design, Setting, and Participants: This cohort study was conducted from May through June 2020 in a secondary-level hospital pediatric unit in Italy. Included participants were 47 healthy children divided by age (ie, group A, aged 24 months to ≤144 months). Data were analyzed from May through June 2020., Interventions: All participants were monitored every 15 minutes for changes in respiratory parameters for the first 30 minutes while not wearing a surgical face mask and for the next 30 minutes while wearing a face mask. Children aged 24 months and older then participated in a walking test for 12 minutes., Main Outcomes and Measures: Changes in respiratory parameters during the use of surgical masks were evaluated., Results: Among 47 children, 22 children (46.8%) were aged 24 months or younger (ie, group A), with 11 boys (50.0%) and median (interquartile range IQR) age 12.5 (10.0-17.5) months, and 25 children (53.2%) were aged older than 24 months to 144 months or younger, with 13 boys (52.0%) and median (IQR) age 100.0 (72.0-120.0) months. During the first 60 minutes of evaluation in the 2 groups, there was no significant change in group A in median (IQR) partial pressure of end-tidal carbon dioxide (Petco<sub>2</sub>; 33.0 32.0-34.0] mm Hg; P for Kruskal Wallis = .59), oxygen saturation (Sao<sub>2</sub>; 98.0% 97.0%-99.0%]; P for Kruskal Wallis = .61), pulse rate (PR; 130.0 115.0-140.0] pulsations/min; P for Kruskal Wallis = .99), or respiratory rate (RR; 30.0 28.0-33.0] breaths/min; P for Kruskal Wallis = .69) or for group B in median (IQR) Petco<sub>2</sub> (36.0 34.0-38.0] mm Hg; P for Kruskal Wallis = .97), Sao<sub>2</sub> (98.0% 97.0%-98.0%]; P for Kruskal Wallis = .52), PR (96.0 84.0-104.5] pulsations/min; P for Kruskal Wallis test = .48), or RR (22.0 20.0-25.0] breaths/min; P for Kruskal Wallis = .55). After the group B walking test, compared with before the walking test, there was a significant increase in median (IQR) PR (96.0 84.0-104.5] pulsations/min vs 105.0 100.0-115.0] pulsations/min; P < .02) and RR (22.0 20.0-25.0] breaths/min vs 26.0 24.0-29.0] breaths/min; P < .05)., Conclusions and Relevance: This cohort study among infants and young children in Italy found that the use of facial masks was not associated with significant changes in Sao<sub>2</sub> or Petco<sub>2</sub>, including among children aged 24 months and younger.

30. Schwarz S, Jenetzky E, Krafft H, Maurer T, Martin D. [Corona child studies "Co-Ki": first results of a Germany-wide register on mouth and nose covering (mask) in children]. *Monatsschr Kinderheilkd*. 2021;1-10 <https://dx.doi.org/10.1007/s00112-021-01133-9>.

Background: Narratives about complaints in children and adolescents caused by wearing a mask are accumulating. There is, to date, no registry for side effects of masks., Methods: In the context of the www.co-ki.de multi-study complex, an online registry has been set up where parents, doctors, pedagogues and others can enter their observations. On 20 October 2020, 363 doctors were asked to make entries and to make parents and teachers aware of the registry., Results: By 26 October 2020, a total of 20,353 people had taken part in the survey. The group of parents alone entered data on a total of 25,930 children. The average reported wearing time of masks was 270min per day. Of the respondents 68% reported that children complained about impairments caused by wearing the mask. Side effects included irritability (60%), headache (53%), difficulty concentrating (50%), less happiness (49%), reluctance

to go to school/kindergarten (44%), malaise (42%) impaired learning (38%) and drowsiness/fatigue (37%). Discussion: This world's first registry for recording the effects of wearing masks in children is dedicated to a new research question. A bias with respect to the preferential documentation of particularly severely affected children or persons who are fundamentally critical of protective measures cannot be ruled out. The frequency of use and the spectrum of symptoms registered indicate the importance of the topic and call for representative surveys, randomized controlled trials with various masks and a renewed risk-benefit assessment of mask obligation in the vulnerable group of children.

31. Shein SL, Whitticar S, Mascho KK, Pace E, Speicher R, Deakins K. The effects of wearing facemasks on oxygenation and ventilation at rest and during physical activity. PLoS ONE. 2021;16(2):e0247414 <https://dx.doi.org/10.1371/journal.pone.0247414>.

BACKGROUND: Facemasks are recommended to reduce the spread of SARS-CoV-2, but concern about inadequate gas exchange is an often cited reason for non-compliance., RESEARCH QUESTION: Among adult volunteers, do either cloth masks or surgical masks impair oxygenation or ventilation either at rest or during physical activity?, STUDY DESIGN AND METHODS: With IRB approval and informed consent, we measured heart rate (HR), transcutaneous carbon dioxide (CO<sub>2</sub>) tension and oxygen levels (SpO<sub>2</sub>) at the conclusion of six 10-minute phases: sitting quietly and walking briskly without a mask, sitting quietly and walking briskly while wearing a cloth mask, and sitting quietly and walking briskly while wearing a surgical mask. Brisk walking required at least a 10bpm increase in heart rate. Occurrences of hypoxemia (decrease in SpO<sub>2</sub> of  $\geq 3\%$  from baseline to a value of  $\leq 5$  mmHg from baseline to a value of  $\geq 46$  mmHg) in individual subjects were collected. Wilcoxon signed-rank was used for pairwise comparisons among values for the whole cohort (e.g. walking without a mask versus walking with a cloth mask)., RESULTS: Among 50 adult volunteers (median age 33 years; 32% with a co-morbidity), there were no episodes of hypoxemia or hypercarbia (0%; 95% confidence interval 0-1.9%). In paired comparisons, there were no statistically significant differences in either CO<sub>2</sub> or SpO<sub>2</sub> between baseline measurements without a mask and those while wearing either kind of mask mask, both at rest and after walking briskly for ten minutes., INTERPRETATION: The risk of pathologic gas exchange impairment with cloth masks and surgical masks is near-zero in the general adult population.

32. Lopes H, Middleton J, De Guchtenaere A, Hadjipanayis A. COVID-19 and the Use of Masks by Children. Statement From the Association of Schools of Public Health in the European Region and the European Academy of Paediatrics. Front pediatr. 2021;9:580150 <https://dx.doi.org/10.3389/fped.2021.580150>.

Despite the fact that the use of masks and respirators in adults has already reached a consensus in almost all countries and for situations in which they are recommended, this is not the case for the use of mask by children. This statement, regarding the usage of mask by children, has been jointly produced by the Association of Schools of Public Health in the European Region (ASPHER) and the European Academy of Paediatrics (EAP). It provides recommendations on the size of the mask, the material and ergonomics of children's masks. The authors also discuss the psychological dimension of children when they are asked to wear a mask. Moreover, they tackle the difficulties of children with disabilities.

33. Krishnamachari B, Morris A, Zastrow D, Dsida A, Harper B, Santella AJ. The role of mask mandates, stay at home orders and school closure in curbing the COVID-19 pandemic prior to vaccination. Am J Infect Control. 2021;49(8):1036-42 <https://dx.doi.org/10.1016/j.ajic.2021.02.002>.

BACKGROUND: COVID-19 has quickly spread throughout the world, necessitating assessment of effective containment methods. The purpose of this study was to examine the impact of government mandated school closures, stay at home orders and mask requirements METHODS: Cumulative incidence rates were



calculated at 14-day intervals until the day of the first vaccine administration in the country. Rate ratios were calculated using negative binomial regression while investigating the effects of adjusting for several sociodemographic and medical factors RESULTS: Faster implementation of mask mandates was consistently shown to be protective. States with mask mandates made at three to six months had a 1.61 times higher rate than those who implemented within one month (adjusted rate ratio=1.61, 95% confidence interval: 1.23-2.10, P = .001). States with mask mandates made after 6 months or with no mandate had a 2.16 times higher rate than those who implemented within 1 month (adjusted rate ratio=2.16, 95% confidence interval: 1.64-2.88, P < .0001). In contrast, both stay at home orders and school closures had no significant influence on disease trajectory., DISCUSSION: The benefits of mask mandates are apparent, especially when mandates were issued within a month. The impact of school closing and stay at home orders were less clear., CONCLUSIONS: Our results suggest that of the different physical distancing measures implemented by the government, mask mandates are the most important.

34. COVID-19 Stats: Percentage of Middle and High School Students Aged 13-21 Years Attending In-Person Classes Who Reported Observing Fellow Students Wearing a Mask All the Time,\* by School Setting and Activity - United States, October 2020. MMWR Morb Mortal Wkly Rep. 2021;70(6):223 <https://dx.doi.org/10.15585/mmwr.mm7006a5>.

35. Eberhart M, Orthaber S, Kerbl R. The impact of face masks on children-A mini review. Acta Paediatr. 2021;110(6):1778-83 <https://dx.doi.org/10.1111/apa.15784>.

AIM: Face masks are essential during the COVID-19 pandemic, and the United Nations Children's Fund and the World Health Organization, recommend that they are used for children aged six years and older. However, parents are increasingly expressing concerns about whether these might be physically harmful. This mini review assessed the evidence., METHOD: We conducted a narrative review on the effects of mask wearing on physiological variables in children, using PubMed, the Cochrane Library and the World Health Organization COVID-19 Database up to 7 November 2020. The lack of paediatric studies prompted a second search for adult studies., RESULTS: We only found two paediatric studies, published in 2019 and 2020. The 2020 study was not related to COVID-19. Only one study, performed with N95 respirators, collected medical parameters, and this did not suggest any harmful effects of gas exchange. The eight adult studies, including four prompted by the pandemic and one on surgeons, reported that face masks commonly used during the pandemic did not impair gas exchange during rest or mild exercise., CONCLUSION: International guidelines recommend face masks for children aged six years and older, but further studies are needed to provide evidence-based recommendations for different age groups.

38. Huppertz H, Berner R, Schepker R, Kopp M, Oberle A, Fischbach T, et al. [Use of masks by children to prevent infection with SARS-CoV-2]. Monatsschr Kinderheilkd. 2020:1-5 <https://dx.doi.org/10.1007/s00112-020-01090-9>.

After initial reluctance masks have emerged as an important means of restricting the spread of SARS-CoV-2, the new coronavirus causing COVID-19. Other simple measures are keeping a distance of at least 11/2m from other persons and observing hygiene recommendations, including washing or even disinfecting the hands, coughing into the crook of the arm and remaining at home when sick. Combining the initial letters of the German words for the three measures (Abstand-Hygiene-Alltagsmaske, distance-hygiene-face mask) the acronym AHA was formed, a colloquial German word meaning that the speaker understood the information presented. This acronym was later extended by the letter "L", initial letter of "Luften" meaning air ventilation for indoor rooms and arriving at AHA-L, recommended by the federal German Health Institute the Robert Koch Institute. In fact, masks including surgical masks and face coverings can form an effective barrier against the spread of the virus: protecting other people from droplets expelled from the throat of the speaker wearing a mask and even in part protecting the wearer from inhaling

droplets emanating from other peoples' throats. Studies to find out if wearing masks might impose risks did not find essential problems: alterations of respiratory parameters due to an increased airway resistance remained within normal limits in healthy adults and even in asthmatics whose disease was well controlled; however, many adults expressed their unease with masks describing them as cumbersome and inconvenient. Emotional resistance against masks made it increasingly more difficult for them to use a mask. Efficient application of masks requires, in addition to a logical explanation of its effect, the evocation of empathy for vulnerable people who can be protected from catching a possibly deadly disease. In children there are very few data on adverse effects of wearing a mask although there is ample experience in children with serious diseases compromising defense against infectious agents acquired via respiratory mucus membranes; however, when using masks appropriately in children relevant adverse effects have not been reported and are not to be expected. Masks should only be used in children when they are healthy and awake and can remove the masks themselves anytime they like. Children 10 years or older can use masks efficiently when they have been informed beforehand appropriate to their age. Under these conditions they can also be obliged to wear masks in certain situations, for example while walking through the school building to their desk in class. To limit the period of wearing a mask normally they will be allowed to remove the mask when sitting in class and keeping their distance. Children in primary schools may use masks, but they should not be obliged to wear them and children in kindergartens should not use masks. This exemption of younger children does not expose school and kindergarten teachers to additional risks since the infectivity with SARS-CoV-2 is age-dependent and increases with age reaching adult values only after 12 years of age.

41. Atangana E, Atangana A. Facemasks simple but powerful weapons to protect against COVID-19 spread: Can they have sides effects? *Results Phys.* 2020;19:103425  
<https://dx.doi.org/10.1016/j.rinp.2020.103425>.

In the last few months, the spread of COVID-19 among humans has caused serious damages around the globe letting many countries economically unstable. Results obtained from conducted research by epidemiologists and virologists showed that, COVID-19 is mainly spread from symptomatic individuals to others who are in close contact via respiratory droplets, mouth and nose, which are the primary mode of transmission. World health organization regulations to help stop the spread of this deadly virus, indicated that, it is compulsory to utilize respiratory protective devices such as facemasks in the public. Indeed, the use of these facemasks around the globe has helped reduce the spread of COVID-19. The primary aim of facemasks, is to avoid inhaling air that could contain droplets with COVID-19. We should note that, respiration process is the movement of oxygen from external atmosphere to the cells within tissue and the transport of carbon dioxide outside. However, the rebreathing of carbon dioxide using a facemask has not been taken into consideration. The hypercapnia (excess inhaled content of CO<sub>2</sub>) has been recognized to be related to symptoms of fatigue, discomfort, muscular weakness, headaches as well as drowsiness. Rebreathing of CO<sub>2</sub> has been a key to concern regarding the use of a facemask. Rebreathing usually occur when an expired air that is rich in CO<sub>2</sub> stays long than normal in the breathing space of the respirator after a breath. The increase of the arterial CO<sub>2</sub> concentration leads to symptoms that are aforementioned. Studies have been conducted on facemask shortages and on the appropriate facemask required to reduce the spread of COVID-19; however no study has been conducted to assess the possible relationship between CO<sub>2</sub> inhalation due to facemask, to determine and recommend which mask is appropriate in the reduction of the spread of the coronavirus while simultaneously avoid CO<sub>2</sub> inhalation by the facemask users. In the current paper, we provided a literature review on the use of facemasks with the aim to determine which facemasks could be used to avoid re-inhaling rejected CO<sub>2</sub>. Additionally, we presented mathematical models depicting the transport of COVID-19 spread through wind with high speed. We considered first mathematical models for which the effect air-heterogeneity is neglected, such that air flow follows Markovian process with a retardation factor, these models considered two different

scenarios, the speed of wind is constant and time-space dependent. Secondly, we assumed that the wind movement could follow different processes, including the power law process, fading memory process and a two-stage processes, these lead us to use differential operators with power law, exponential decay and the generalized Mittag-Leffler function with the aim to capture these processes. A numerical technique based on the Lagrange polynomial interpolation was used to solve some of these models numerically. The numerical solutions were coded in MATLAB software for simulations. The results obtained from the mathematical simulation showed that a wind with speed of 100 km/h could transport droplets as far as 300 m. The results obtained from these simulations together with those presented by other researchers lead us to conclude that, the wind could have helped spread COVID-19 in some places around the world, especially in coastal areas. Therefore, appropriate facemasks that could help avoid re-inhaling enough CO<sub>2</sub> should be used every time one is in open air even when alone especially in windy environment.

42. Villani A, Bozzola E, Staiano A, Agostiniani R, Del Vecchio A, Zamperini N, et al. Facial masks in children: the position statement of the Italian pediatric society. *Ital J Pediatr.* 2020;46(1):132 <https://dx.doi.org/10.1186/s13052-020-00898-1>.

Facial masks may be one of the most cost-effective strategies to prevent the diffusion of COVID 19 infection. Nevertheless, fake news are spreading, alerting parents on dangerous side effects in children, such as hypercapnia, hypoxia, gut dysbiosis and immune system weakness. Aim of the Italian Pediatric Society statement is to face misconception towards the use of face masks and to spread scientific trustable information.

43. Nobrega M, Opice R, Lauletta MM, Nobrega CA. How face masks can affect school performance. *Int J Pediatr Otorhinolaryngol.* 2020;138:110328 <https://dx.doi.org/10.1016/j.ijporl.2020.110328>.

44. Spitzer M. Masked education? The benefits and burdens of wearing face masks in schools during the current Corona pandemic. *Trends Neurosci Educ.* 2020;20:100138 <https://dx.doi.org/10.1016/j.tine.2020.100138>.

Face masks can prevent the spread of the virus SARS-CoV-2, in particular as this spread can occur from people with no symptoms. However, covering the lower half of the face reduces the ability to communicate, interpret, and mimic the expressions of those with whom we interact. Positive emotions become less recognizable, and negative emotions are amplified. Emotional mimicry, contagion, and emotionality in general are reduced and (thereby) bonding between teachers and learners, group cohesion, and learning - of which emotions are a major driver. The benefits and burdens of face masks in schools should be seriously considered and made obvious and clear to teachers and students. The school's specific situation must also inform any decision regarding face mask use. Copyright © 2020. Published by Elsevier GmbH.

45. Dias JV, Contreiras M, Oom P. SARS-CoV-2 Pandemic: Should Children Wear Masks? *Acta Med Port.* 2020;33(10):711 <https://dx.doi.org/10.20344/amp.14787>.

47. Zanotti B, Parodi PC, Riccio M, De Francesco F, Zingaretti N. Can the Elastic of Surgical Face Masks Stimulate Ear Protrusion in Children? *Aesthetic Plast Surg.* 2020;44(5):1947-50 <https://dx.doi.org/10.1007/s00266-020-01833-9>.

In this period of the Covid-19 pandemic, a protective mask has become a common object of use to contain virus transmission. The imminent need for masks has led many governments to produce them, including surgical masks with elastic loops or masks with side cuts at the ears. Among those on the market, surgical masks with elastic loops are the ones most chosen by parents for their children. These elastics cause constant compression on the skin and, consequently, on the cartilage of the auricle, leading to

erythematous and painful lesions of the retroauricular skin when the masks are used for many hours a day. Pre-adolescent children have undeveloped auricular cartilage with less resistance to deformation; prolonged pressure from the elastic loops of the mask at the hollow or, even worse, at the anthelix level can influence the correct growth and angulation of the outer ear. In fact, unlike when using conservative methods for the treatment of protruding ears, this prolonged pressure can increase the cephaloauricular angle of the outer auricle. It is important for the authorities supplying the masks to be aware of this potential risk and for alternative solutions to be found while maintaining the possibility of legitimate prevention of the potential spread of the virus. Level of Evidence V This journal requires that authors assign a level of evidence to each article. For a full description of these evidence-based medicine ratings, please refer to the table of contents or the online instructions to authors [www.springer.com/00266](http://www.springer.com/00266).

48. Esposito S, Principi N. To mask or not to mask children to overcome COVID-19. *Eur J Pediatr.* 2020;179(8):1267-70 <https://dx.doi.org/10.1007/s00431-020-03674-9>.

It has been reported that asymptomatic people can transmit the new coronavirus disease 2019 (COVID-19) and become important sources of COVID-19. To reduce the role of asymptomatic or poorly symptomatic people in COVID-19, universal use of face masks in addition to hand hygiene and safety distance seems extremely useful. Consequently, preparing the healthy child to use face masks is strongly needed. To obtain maximal compliance, reasons for mask wearing without attempts of removing must be clearly explained. Moreover, child's will must not be forced. Conclusion: On the basis of clinical findings, we think that the universal use of facial masks seems necessary when people have to go out in their everyday lives. In addition to the availability of masks of different sizes capable of adapting perfectly to the face, it is necessary that the use of masks in children is preceded by a strong parental work and school lessons on this issue and other hygiene topics with the main aim to obtain child cooperation. What is Known: \* Asymptomatic people can transmit and become important sources of COVID-19. \* Asymptomatic cases are common also in pediatrics. What is New: \* Universal use of face masks for success against COVID-19 seems necessary also in pediatric age when people have to go out in their everyday lives. \* In addition to the availability of masks of different sizes capable of adapting perfectly to the face, it is necessary that the use of masks in children is preceded by a strong parental work and school lessons with the main aim to obtain child cooperation.

50. Jefferson T, Del Mar CB, Dooley L, Ferroni E, Al-Ansary LA, Bawazeer GA, et al. Physical interventions to interrupt or reduce the spread of respiratory viruses. *Cochrane Database Syst Rev.* 2020 Nov 20;11(11):CD006207. <https://doi.org/10.1002/14651858.CD006207.pub5>

**BACKGROUND:** Viral epidemics or pandemics of acute respiratory infections (ARIs) pose a global threat. Examples are influenza (H1N1) caused by the H1N1pdm09 virus in 2009, severe acute respiratory syndrome (SARS) in 2003, and coronavirus disease 2019 (COVID-19) caused by SARS-CoV-2 in 2019. Antiviral drugs and vaccines may be insufficient to prevent their spread. This is an update of a Cochrane Review published in 2007, 2009, 2010, and 2011. The evidence summarised in this review does not include results from studies from the current COVID-19 pandemic. **OBJECTIVES:** To assess the effectiveness of physical interventions to interrupt or reduce the spread of acute respiratory viruses. **SEARCH METHODS:** We searched CENTRAL, PubMed, Embase, CINAHL on 1 April 2020. We searched ClinicalTrials.gov, and the WHO ICTRP on 16 March 2020. We conducted a backwards and forwards citation analysis on the newly included studies. **SELECTION CRITERIA:** We included randomised controlled trials (RCTs) and cluster-RCTs of trials investigating physical interventions (screening at entry ports, isolation, quarantine, physical distancing, personal protection, hand hygiene, face masks, and gargling) to prevent respiratory virus transmission. In previous versions of this review we also included observational studies. However, for this update, there were sufficient RCTs to address our study aims. **DATA COLLECTION AND ANALYSIS:** We used standard methodological procedures expected by Cochrane. We used GRADE to assess the certainty

of the evidence. Three pairs of review authors independently extracted data using a standard template applied in previous versions of this review, but which was revised to reflect our focus on RCTs and cluster-RCTs for this update. We did not contact trialists for missing data due to the urgency in completing the review. We extracted data on adverse events (harms) associated with the interventions. MAIN RESULTS: We included 44 new RCTs and cluster-RCTs in this update, bringing the total number of randomised trials to 67. There were no included studies conducted during the COVID-19 pandemic. Six ongoing studies were identified, of which three evaluating masks are being conducted concurrent with the COVID pandemic, and one is completed. Many studies were conducted during non-epidemic influenza periods, but several studies were conducted during the global H1N1 influenza pandemic in 2009, and others in epidemic influenza seasons up to 2016. Thus, studies were conducted in the context of lower respiratory viral circulation and transmission compared to COVID-19. The included studies were conducted in heterogeneous settings, ranging from suburban schools to hospital wards in high-income countries; crowded inner city settings in low-income countries; and an immigrant neighbourhood in a high-income country. Compliance with interventions was low in many studies. The risk of bias for the RCTs and cluster-RCTs was mostly high or unclear. Medical/surgical masks compared to no masks We included nine trials (of which eight were cluster-RCTs) comparing medical/surgical masks versus no masks to prevent the spread of viral respiratory illness (two trials with healthcare workers and seven in the community). There is low certainty evidence from nine trials (3507 participants) that wearing a mask may make little or no difference to the outcome of influenza-like illness (ILI) compared to not wearing a mask (risk ratio (RR) 0.99, 95% confidence interval (CI) 0.82 to 1.18). There is moderate certainty evidence that wearing a mask probably makes little or no difference to the outcome of laboratory-confirmed influenza compared to not wearing a mask (RR 0.91, 95% CI 0.66 to 1.26; 6 trials; 3005 participants). Harms were rarely measured and poorly reported. Two studies during COVID-19 plan to recruit a total of 72,000 people. One evaluates medical/surgical masks (N = 6000) (published *Annals of Internal Medicine*, 18 Nov 2020), and one evaluates cloth masks (N = 66,000). N95/P2 respirators compared to medical/surgical masks We pooled trials comparing N95/P2 respirators with medical/surgical masks (four in healthcare settings and one in a household setting). There is uncertainty over the effects of N95/P2 respirators when compared with medical/surgical masks on the outcomes of clinical respiratory illness (RR 0.70, 95% CI 0.45 to 1.10; very low-certainty evidence; 3 trials; 7779 participants) and ILI (RR 0.82, 95% CI 0.66 to 1.03; low-certainty evidence; 5 trials; 8407 participants). The evidence is limited by imprecision and heterogeneity for these subjective outcomes. The use of a N95/P2 respirator compared to a medical/surgical mask probably makes little or no difference for the objective and more precise outcome of laboratory-confirmed influenza infection (RR 1.10, 95% CI 0.90 to 1.34; moderate-certainty evidence; 5 trials; 8407 participants). Restricting the pooling to healthcare workers made no difference to the overall findings. Harms were poorly measured and reported, but discomfort wearing medical/surgical masks or N95/P2 respirators was mentioned in several studies. One ongoing study recruiting 576 people compares N95/P2 respirators with medical surgical masks for healthcare workers during COVID-19. Hand hygiene compared to control Settings included schools, childcare centres, homes, and offices. In a comparison of hand hygiene interventions with control (no intervention), there was a 16% relative reduction in the number of people with ARIs in the hand hygiene group (RR 0.84, 95% CI 0.82 to 0.86; 7 trials; 44,129 participants; moderate-certainty evidence), suggesting a probable benefit. When considering the more strictly defined outcomes of ILI and laboratory-confirmed influenza, the estimates of effect for ILI (RR 0.98, 95% CI 0.85 to 1.13; 10 trials; 32,641 participants; low-certainty evidence) and laboratory-confirmed influenza (RR 0.91, 95% CI 0.63 to 1.30; 8 trials; 8332 participants; low-certainty evidence) suggest the intervention made little or no difference. We pooled all 16 trials (61,372 participants) for the composite outcome of ARI or ILI or influenza, with each study only contributing once and the most comprehensive outcome reported. The pooled data showed that hand hygiene may offer a benefit with an 11% relative reduction of respiratory illness (RR 0.89, 95% CI 0.84 to 0.95; low-certainty evidence), but with high heterogeneity. Few trials

measured and reported harms. There are two ongoing studies of handwashing interventions in 395 children outside of COVID-19. We identified one RCT on quarantine/physical distancing. Company employees in Japan were asked to stay at home if household members had ILI symptoms. Overall fewer people in the intervention group contracted influenza compared with workers in the control group (2.75% versus 3.18%; hazard ratio 0.80, 95% CI 0.66 to 0.97). However, those who stayed at home with their infected family members were 2.17 times more likely to be infected. We found no RCTs on eye protection, gowns and gloves, or screening at entry ports. **AUTHORS' CONCLUSIONS:** The high risk of bias in the trials, variation in outcome measurement, and relatively low compliance with the interventions during the studies hamper drawing firm conclusions and generalising the findings to the current COVID-19 pandemic. There is uncertainty about the effects of face masks. The low-moderate certainty of the evidence means our confidence in the effect estimate is limited, and that the true effect may be different from the observed estimate of the effect. The pooled results of randomised trials did not show a clear reduction in respiratory viral infection with the use of medical/surgical masks during seasonal influenza. There were no clear differences between the use of medical/surgical masks compared with N95/P2 respirators in healthcare workers when used in routine care to reduce respiratory viral infection. Hand hygiene is likely to modestly reduce the burden of respiratory illness. Harms associated with physical interventions were under-investigated. There is a need for large, well-designed RCTs addressing the effectiveness of many of these interventions in multiple settings and populations, especially in those most at risk of ARIs.

## Appendix. Literature Searches

Searches were completed in August 2021.

**Table 1. medRxiv preprint search**

Search	Syntax	Hits	Retrieved	Included
1	mask and dioxide limit to posted dates between 01 Jan 2020 and 21 Aug 2021	130	–	–

**Table 2. MEDLINE search**

Search	Syntax	Hits	Retrieved	Included
1	(mask and dioxide).mp.	1,033	–	–
2	(mask* and (child* or school*)).ti.	727	–	–
3	1 or 2	1,741	–	–
4	limit 3 to yr="2020 -Current"	188	37	–

mp: keyword (title, abstract, subject heading)