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Key considerations in mass masking during the COVID-19 outbreak: a scoping review

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Abstract

Background

Many countries are gradually returning to normalcy after varying periods under lockdown following the coronavirus disease (COVID-19) pandemic. In the transitional period from lockdown to resumption of work and thereafter, hygiene-oriented measures including face mask usage will need to be continued by the public. Though mass masking has been suggested to block transmission of COVID-19 infection, there are key considerations that need attention when this strategy is adopted by the general public on a mass scale for a considerable period of time. This study aims to review research evidence pertaining to key considerations related to mass masking by the general public during the COVID-19 outbreak.

Methods

We carried out a scoping review and identified relevant literature until 30thof September 2020 searching databases and other sources comprehensively. This scoping review was registered under Open Science Framework and is available on osf.io/vj9a6.

Results

A total of 42 articles were included in this scoping review. Consensus statements and guidelines were common. Evidence specific to COVID-19 is limited.

Conclusion

There is no conclusive evidence of benefits from introduction of mass masking as a single intervention in preventing transmission of viral-borne respiratory infections. However, beneficial effects are noted when mass masking is always combined with other non-pharmacological measures and when used by symptomatic patients as a means of source control of the disease. Evidence of mass masking on preventing transmission of viruses from asymptomatic persons is not available. In addition, cloth masks and homemade masks have varying degrees of effectiveness; however, the protection conferred is inferior compared to that of respirators and surgical masks.

Key words: Covid-19; Prevention; Respiratory viral infection; Mass masking; Effectiveness of masks

Introduction

From time to time, mankind has been significantly affected by disease pandemics that have had a major impact on all aspects of lives and livelihoods world over. The COVID-19 pandemic was the most recent pandemic that has caused a major burden on all healthcare systems in most countries, as observed particularly with epidemics of this century which appear to spread faster and further due to marked increase in international travel and trade.[1]

In prevention and control of this contagious pandemic, the health authorities worldwide focused on pharmacological and non-pharmacological interventions. Pharmacological interventions that received attention were repurposing of drugs (identifying new uses for already approved drugs that are outside the scope of the original medical indication), antibodies and vaccines and, were the costlier and more time-consuming interventions. Often when a new virus strain emerges leading to a pandemic state, inevitably there is a delay in development of, or in the availability of specific vaccines as was seen in the case of COVID-19 pandemic. In this context, non-pharmacological interventions took precedence over their pharmacological counterparts, in reducing disease transmission rapidly and at little cost.[2]Thus, globally, many countries adopted hygiene-oriented measures namely, social distancing, respiratory etiquette and

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hand washing for prevention and control of the COVID-19 outbreak.[3]With regard to face mask use, however, there was much debate among the scientific community for[4,5]and against[6,7]wearing masks leading to confusion among the general public. Recently however, the Centres for Disease Control and Prevention (CDC),[8] the World Health Organization (WHO)[9]and the Canadian Public Health Agency recommended the public to use face masks, including cloth masks,[10]in situations where maintaining physical distancing is difficult. This recommendation was based on reports ofCOVID-19 transmission by pre-symptomatic individuals.[11]

With limited capacities for increasing production, current and impending shortage of masks is inevitable globally. In this background, it is imperative that attention is paid to: ensuring effectiveness of mass masking in controlling COVID-19 transmission, introducing specifications for masks if it is an effective mechanism, ensuring sustainable production, maintaining an uninterrupted supply and distribution chain that reaches all communities, reinforcing correct use, identifying environmentally-friendly, safe and widely available materials as alternatives to increase face mask production, identifying a pragmatic approach to safely dispose used masks on a large scale and conducting of research which aim to fill gaps in evidence pertaining to mask production, usage, wear and disposal. Evidence-based recommendations need to be made to policy makers, mask manufacturers, distributors and end-users on these aspects for several reasons.

Due to the increasing unavailability of safe masks of the required quality, there has been an increase in makeshift alternatives which offer little or no protection.12 In addition; there can be a significant negative impact on the environment due to increased improper mask disposal and unforeseen economic consequences with no substantial gain in disease control. Therefore, this scoping review aims to compile evidence on mass masking along with key considerations related to mass masking among the general public in preventing and controlling COVID-19 outbreak.

Methods

Arksey and O'Malley (2005) framework was used to carry out this review and for the review we followed "PRISMA extension for scoping reviews (PRISMA-ScR) checklist under the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines".
A comprehensive search was carried out on Google Scholar and on Pub Med, Central and MEDLINE databases. Search was conducted for literature from the inception of digital data bases until 30th of September 2020 using the terms, "mass masking", "effectiveness of masks", "randomized trials on face masks", "cloth masks for COVID-19 rational usage", "mask disposal", and "mass decontamination". Search also included the official websites of the WHO (https://www.who.int/), the European Centres for Diseases Control (ECDC) (https://www.ecdc.europa.eu/en), and the CDC (https://www.cdc.gov/). In addition, the preprint server, BioRxiv was searched as well. During literature search strategy was refined further. This scoping review was registered under Open Science Framework and is available on osf.io/vj9a6.

Inclusion and exclusion criteria

All the literature related to masks published in English language up to 30thSeptember 2020, including basic research, epidemiological studies, clinical studies, reviews, guidelines and expert's comments were included for this review. Guidelines and documents issued by government institutions and international organizations were also perused. Those which did not contain the complete article were excluded.

Article selection and data extraction

Three persons independently reviewed titles, abstracts and the full documents. Consensus was obtained for disagreements through consultation of a fourth reviewer. Extracted information for the review included topic, study methods, findings and conclusions.

Before discussing the evidence available, a brief recap of types of masks that are commercially available is necessary. There are three main types: surgical masks, air filtering respirators and cloth masks. Cloth masks are made of a wide variety of material and have no formal testing standard. Surgical masks have a multi-layered structure composed of non-woven fabric: a leak-proof layer, a filter layer with high density, and a layer in direct contact with the skin3. Surgical masks often do not fit tightly to the face and are held in place with a flexible metal clip over the nose. Air filtering respirators are also made of the same multi-layered non-woven fabric as the surgical mask but are often composed of polypropylene, have dimensions that are more fixed, with an additional pre-filtration layer than the surgical masks. As per the standards of the National Institute of Occupational safety and Hygiene in USA (NIOSH), filtering respirators can be classified as the N95, N99 and N100 masks, which can block 95%, 99% and 99.97% respectively, of particles with a median diameter of 0.3 µm (CDC, 2020).[6]

Evidence of masks in preventing COVID-19 transmission from infected persons to the environment or to other people, is scarce. Hence, evidence relevant to influenza, Influenza-Like-Illness (ILI) and other corona viruses is useful to understand the place of facemask use in preventing COVID-19 transmission.

Results

For data extraction, 42 articles including guidelines were selected. Fig 1 given below provides a summary of the process followed for article identification, screening and selection.

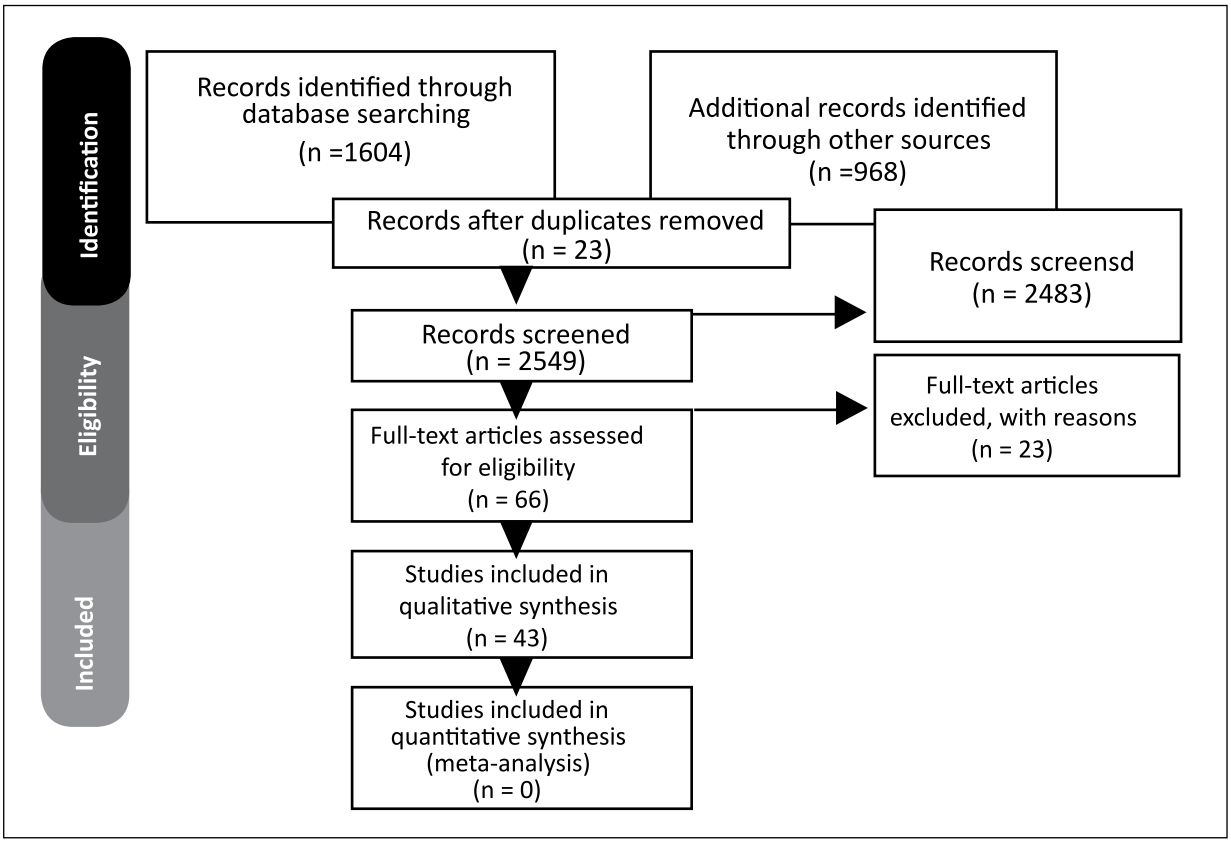

Fig 1: Summary of the process adopted for article identification, screening and selection

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement.PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Evidence in this scoping review is summarized under five sub themes:

- Face mask use in community settings /non healthcare settings
- Mask use as a source control
- Effectiveness of different types of face masks
- Undesirable effects of face mask use
- Rational use, decontamination, reuse and disposal of face mask

Face mask use in community settings / non-healthcare settings

There are several studies on the use of masks in non-healthcare settings where mask usage to prevent respiratory infections have been evaluated and these are presented in Table 1a (evidence on mass-masking in protecting against respiratory infections) and Table 1b (evidence on mask usage combined with other non-pharmacological measures in protecting against respiratory infections) given below. The settings evaluated include households, universities and airplanes. Available evidence shows an observed reduction in transmission of respiratory borne viral infections due to mask use alone. However, a significant beneficial effect of mask use is observed when masks are used in combination with other measures such as hand washing and physical distancing.

(Table 1a)

In addition, due to limited availability of anti-viral drug stocks, NPIs other than face mask use such as personal protective measures (hand hygiene), environmental measures (surface decontamination), physical distancing measures, and travel restrictions often are the only interventions available for disease control.[19] Table 1b given below presents the evidence on mask usage combined with other non-pharmacological measures in protecting against respiratory infections.

(Table 1b)

Mask use as a source control strategy

The function of masks is two dimensional: masks can protect the wearer from exposure and can also prevent transmission of the respiratory infection from the wearer to others. The latter is referred to as 'source control'. Available evidence suggests that medical mask use can reduce bacterial and viral shedding from symptomatic patients. A study specific to COVID-19 showed inadequate filtering of COVID-19 through cotton and medical masks from patients with symptoms.[27]

This study (n=4) examined the effectiveness of surgical and cotton masks in blocking SARS–CoV-2 in a controlled comparison among four patients. They concluded that both surgical and cotton masks were found to be ineffective in preventing the spread of COVID-19 virus to the environment and external mask surface through coughing. However, there has been much debate in response to this paper around the small sample size and the analyses used. Evidence is not available on the effectiveness of mask use by pre-symptomatic and asymptomatic persons as a source control method. Table 2 given below presents evidence pertaining to mask usage as a source control strategy.

(Table 2)

Effectiveness of different types of masks

Due to the shortage of medical masks during the pandemic of COVID-19, the general public was recommended to use cloth and/or homemade masks. Some experts however, advised to use homemade masks with caution due to variability of materials used in mask production and the protection offered therein. Scientific evidence demonstrated that homemade masks are generally less effective than medical masks. In addition, studies have shown that surgical masks and N95 masks both reduce the spread of respiratory diseases. However, surgical masks were more comfortable than N95 though the N95 masks were more effective than surgical masks in preventing air leakage during cough. Both were unable to prevent leakage from sideways. A study involving COVID-19 patients showed that cotton masks are unable to filter SARS-CoV-2 virus.[33] Table 3 given below presents the evidence on effectiveness of different types of masks.

(Table 03)

Apart from factors such as type of mask, number of layers and the materials used, mask fit is also an important determinant of protection. Mask fit is particularly important because faces differ in sizes and shapes. Facial characteristics of the wearer may lead to an improper fit, with the ability to form an effective barrier between the wearer and the contaminated environment being compromised.[38, 39] Unsatisfactory seal can allow leakage of contaminants into the breathing space of the wearer, even though the appropriate mask or respirator is used. Therefore, additional factors that need to be considered to decide the protective effect of masks are mask fit, level of air leakage from the mask and adherence level to proper wearing and disposal of mask.

Undesirable effects of mask use

It is found that when masks are used inappropriately, risk of infection can be increased due to self-contamination. Maintaining hand hygiene is paramount to reduce infection transmission. Table 4 given below presents evidence on undesirable effects of mask use.

(Table 4)
Other undesirable effects related to mask use in literature are.[43]

- False assurance to the wearer which leads to a reduction in the compliance for other disease prevention and control measures
- Inappropriate usage including frequent adjustments, repeated use of single-use masks and incorrect disposal
- Difficulties in communication leading to communicators unconsciously positioning themselves closer to each other
- Exhaled air going into the eyes leading to discomfort and frequent adjustments of the mask
- Perceived difficulties in breathing, being short of air and light headedness leading to repeated adjustments, touching face, nose and mouth and incorrect use, all of which can introduce respiratory-borne pathogens through contaminated hands.

Rational use, mask decontamination, reuse and disposal

Literature related to mask disposal is scarce. Recommendations on mask disposal are largely based upon expert opinion. Used masks are potentially infected medical waste and should be treated similar to the disposal of other bio-medical waste. Disposal of non-reusable triple layer masks used by patients, close contacts and healthcare workers in the hospital setting and disposal of cloth masks used in the community by the general public should be through either deep burial or burning. However, before burning or burial, masks need to be disinfected.

In households, the following method can be used to dispose of used face masks. After taking off the mask from the face, it should be folded in half 'inwards', then again folded in half and this folding should be repeated until it becomes like a roll. After placing the folded mask as a roll into a zip-lock bag or grocery shopping bag, the bag can be put into a garbage bin after securing the bag tightly. The bin should have a closed lid. Disposal of masks correctly should be done immediately after discarding without any delay.[44]

Waste management of masks needs priority attention and the current mechanisms in place need to be further strengthened and improved in order to handle the increased load of used face masks. This system improvement has to be coupled with proper waste management protocols which can be implemented in both rural and urban settings.

There are many disinfection methods used globally and they can be broadly categorized as chemical, radioactive, or temperature-based methods. These methods carry out disinfection or sterilization of microorganisms through several mechanisms: protein denaturation (alcohols, heat), disruption of DNA/RNA (ultraviolet rays, peroxides, oxidizers), and cellular disruption (phenolic, chlorides, aldehydes). However, none have been extensively investigated to be used effectively for the inactivation of SARS-CoV-2.45However, disinfection may be done using household disinfectants such as sodium hypochlorite solution (1%) or adequate concentrations of quaternary ammonium.[45] Although decontamination methods carry out viral inactivation, they also lead to several disadvantages as well. Physical integrity of the components within the respirator may be compromised when microwave irradiation, microwave-generated steam and moist heat incubationare used.[46, 47]Methods which use chemicals such as chlorine can cause residual odor and if exposed to moisture, can release chlorine gas.[46, 48]Table 5 given below presents the evidence on rational use, mask decontamination, reuse and disposal.

(Table 5)

This scoping review used 42 studies for extraction of data and reported evidence onFace mask use in community settings /non healthcare settings, Mask use as a source control, Effectiveness of different types of face masks, Undesirable effects of face mask use and Rational use, decontamination, reuse and disposal of face mask. Review included clinical trials as well as expert views and sample sizes of some clinical trials were small. The studies specific to virus causing COVID-19 was limited.

Articles published only in English were included in the review which will affect the validity of the findings. Not including the articles providing only the abstract is also a limitation. However, we could include evidence not only from the peer review articles but other gray literature also.

Conclusions

Many cluster randomized trials assessing the effectiveness of mass masking have not shown it as a beneficial measure per se in prevention of respiratory-borne viral infections. Masks can synergize protective effect when combined with other non-pharmacological measures.Mass masking may be beneficial as a source control measure when worn by symptomatic patients where social distancing is not possible, especially in unavoidable public gatherings. Evidence of mass masking on prevention of transmission of viruses from asymptomatic persons is not available. Effectiveness of cloth masks and homemade masks varies widely. Protection provided from cloth and homemade masks was inferior compared to N95 respirators and surgical masks against aerosol particles and droplets. Inappropriate use of masks without complying with hand hygiene and other disease prevention and control methods may increase the risk of infection due to self-contamination. Wearing medical masks by the community may result in shortage of masks for frontline health workers. The duration of wearing masks must be in accordance to the supplier's recommendations.

Abbreviations

CDC: Centers for Disease Control and Prevention
CI: Confidence Interval
CRI: Clinical Respiratory Illness
CT: Computerized Tomography
DNA: Deoxyribo Nucleic acid
E: Education only
ECDC: European Centres for Diseases Control
E+HS: Education with alcohol-based hand sanitizer
E+HS+M: Education with hand sanitizer and face masks
FFP: Filtering Face Piece
HW: Hand washing
HW+FM: Hand washing with surgical masks
ILI: Influenza-like-Illness
M: Masks only
MERS: Middle East Respiratory Syndrome
MH: Masks and hand hygiene
MIH: Mask wearing with Instant Hand hygiene
NIOSH: National Institute for Occupational Safety and Health
NPIs: Non-Pharmacological Interventions
RNA: Ribo Nucleic Acid
OR: Odd Ratio
RR: Relative Risk
RT-PCR: Reverse Transcription-Polymerase Chain Reaction
SARS: Severe Acute Respiratory Syndrome
URTI: Upper Respiratory Infections
USA: United State of America
WHO: World Health Organization

Authors' contributions

MW identified the requirement of the review and decided the methodology of the scoping review. MW, involved in deciding key words and initial data bases to search, literature search, selection of the research articles, data extraction, finalizing the manuscript and guiding the team. RS, AM and NY involved in the literature search, selection of research articles, data extraction and preparing the manuscript. All authors read and approved the final manuscript and are responsible for the content of the manuscript.

Table1a: Evidence of mass masking in protecting against respiratory infections in non-healthcare setting

Study	Methods	Results	Conclusion
MacIntyre et al., 2009 [13]	Carried out a prospective cluster randomized trial to compare surgical masks, non–fit-tested P2 masks, and no masks in prevention of influenza-like illness (ILI) in households. Self-reported adherence of face mask use was obtained. Adults (n=286) exposed to children with symptomatic respiratory illness in 143 households participated during winter in 2006 and 2007.	The risk of ILI was not significantly different between the groups wearing masks and the control group. Among the mask wearing groups, <50% wore masks most of the time. The householders who adhered to mask use had a significantly lower risk of ILI infection.	Adherence to face mask use was poor and face mask use was not effective against control of ILI. Mask use might reduce transmission during a severe influenza pandemic provided there is good adherence.
Zhang et al., 2013 [14]	There were several reports of influenza A H1N1pdm09 virus infection in two flights, one from New York to Hong Kong and the other, from Hong Kong to Fuzhou, China in May 2009. Following these reports, the transmission of influenza A H1N1pdm09 virus infection among passengers in these two flights was assessed.(The term 'pdm09' denotes a serotype of influenza).	Symptoms were observed only among travellers of the New York to Hong Kong flight. Nine travellers with illness were compared with a control of 32 travellers without symptoms for the exposure. During the entire fight, none of the travellers with the illness wore masks compared to 47% of controls.	Wearing masks was associated with a decreased risk of influenza infection.
Barasheed et al., 2016 [15]	Conducted a systematic review to compile evidence on the compliance and effectiveness of masks in protecting against respiratory-borne infections in places of mass gathering. •Articles- 25 •Pooled sample - 12,710 (37% were females) •Age- 11-89 year olds	The overall compliance of mask use ranged between <1%-93% (mean-50%). Effectiveness of masks was assessed in 13 studies. Protection against respiratory infections was significant with the pooled relative risk [RR] being 0.89(95%CI: 0.84-0.94, p<0.01). However, the study end points varied widely.	46% wore face masks in mass gatherings. Adherence among healthcare workers was high (72%).In mass gatherings, masks may provide protection against respiratory infections. However, protection against specific infections through mask usage needs to be proven.
Liang et al., 2020 [16]	A systematic review and meta-analysis was conducted to evaluate the effectiveness of face masks in preventing laboratory-confirmed respiratory virus transmission	In non-healthcare settings a protective effect was found which was significant (pooled OR=0.53 (95% CI = 0.36–0.79, I 2 = 45%)	There is evidence of the enhanced protective effects conferred by wearing masks in all settings

Eikenberry et al., 2020 [17]	Mathematical models have been used to study disease transmission dynamics. One of these models, the Susceptible-Exposed-Infected-Removed (SEIR) model was used to assess the impact of mask use by the general and asymptomatic public. COVID-19 data of New York and Washington in USA were used for this study.	Nearly 80% (immediate and almost universal) usage of 50% effective masks, reduced 17-45% of predicted deaths over 2 months, and the daily mortality rate by 34-58%in New York. When disease transmission rates are low or declining, even using masks which are only 20% effective may be beneficial. With less baseline transmission (as in Washington), 80% use of such masks could reduce deaths by 24–65% (peak deaths 15–69%), compared to 2–9% mortality reduction in New York (peak death reduction 9–18%).	Mass masking may be helpful to reduce community transmission and burden of the pandemic. Benefit is highest when mask use is universal and when combined with other non-pharmacological measures.
Cheng et al., 2020 [18]	The effect of universal mask use was assessed in controlling (COVID-19) among patients with respiratory symptoms in outpatient settings or wards. Analysis was done for confirmed cases in 'mask-off' and 'mask-on' settings. Incidence of COVID-19 in an area in Hong Kong (with community-wide masking) was compared with similar non-mask-wearing countries. Compliance of face mask usage was also monitored.	The COVID-19 incidence in the area in Hong Kong (129.0 per million population) was significantly lower (p<0.001) than that of Spain (2983.2), Italy (2250.8), Germany (1241.5), U.S.A (1102.8)) and South Korea (200.5). The compliance of face mask usage by the general public in Hong Kong was almost 97% (95.7%-97.2%). In recreational 'mask-off' settings, 11 COVID-19 clusters were observed while in workplace 'mask-on' settings only 3 such clusters were seen (p=0.036)	Mass masking may provide protection against COVID-19 through reduction in the emitted amount of infected saliva and respiratory droplets from asymptomatic or people with mild COVID-19 infection. .

Table 1b: Evidence on mask usage combined with other non-pharmacological measures in protecting against respiratory infections

Study	Methods	Results	Conclusion
Cowling et al., 2009 [20]	Investigated the effect of hand hygiene and masks in preventing household influenza transmission through a cluster randomized, controlled trial. 407 presenting to outpatient clinics with ILI (positive for influenza A or B virus by rapid testing-index patients) and 794 household members (contacts) were participants. The interventions were: • Lifestyle education (control-134 households) • Hand hygiene (136 households) • Surgical masks + hand hygiene (137 households) Outcome assessed: Influenza virus infection confirmed by RT-PCR or clinically after 7 days	1 week after the interventions, 8% of contacts (in 259 households) were RT-PCR positive for influenza virus. Reduction of influenza transmission was not significant in the groups with hand hygiene with or without facemasks compared to the control group (lifestyle education only). Reduction in the RT-PCR–confirmed influenza was seen when interventions were implemented within 36 hours of symptom onset in index patients (in 154 households) that can be attributable to facemask use and hand hygiene (adjusted odds ratio, 0.33[95% CI, 0.13-0.87]). Adherence to interventions was variable.	Hand hygiene and masks are effective against household transmission of influenza if implemented within 36 hours of symptom onset in the index patients, suggesting the importance of non-pharmacological interventions in pandemic and inter-pandemic influenza control.
Simmerman et al., 2011 [21]	Assessed the effectiveness of several non-pharmacological interventions (NPI) against influenza transmission. The NPIs adopted inhouseholds with a febrile, influenza-positive child were assessed. Households were randomized as: • "Hand washing (HW)" and • "Hand washing with paper surgical masks (HW+FM)" • Controls The households were paid a visit on 1st, 3rd, 7th, and 21st days. Serum and respiratory swabs were taken from household members and they were tested for influenza.	• 16.5% (n=991) of 5,995 pediatric patients with ILI were influenza positive (April 2008 to August 2009) • 16.3% (95% CI 12.4–20.2%) of secondary cases were asymptomatic • Secondary attack rate was 21.5% Hand-washing frequency was; • 4.7 episodes/day among 'HW' group, • 4.9 times/day among 'HW+FM' group • 3.9 times/day among controls (p=0.001). The odds ratios for secondary influenza infection among the 'HW' group (OR=1.20; 95% CI 0.76–1.88) and the 'HW+FM' group (OR=1.16; 95% CI 0.74–1.82) were not significant.	Hand washing and mask use did not reduce influenza transmission. Poor adherence to mask use, sharing of living arrangements, differences in the frequency of hand washing and transmission of influenza prior to the intervention may have brought about this result.

Suess et al., 2012 [22]	The efficacy, acceptability, and tolerance of non-pharmacological measures in households with influenza index patients were evaluated through a cluster randomized controlled trial during 2009/2010 and 2010/2011. Households with an index influenza positive case without respiratory illness during the preceding 2 weeks n=84) were grouped as: • "Masks and hand hygiene" (MH group-28 households) • "Masks only" (M group-26 households) • "None of the above" (control group-30 households). Outcome assessed: laboratory-confirmed influenza infection in a household contact. Adherence and tolerability of the interventions were assessed daily.	The total secondary attack rate was 16% (35/218). Intention-to-treat analysis showed no statistically significant effect of 'M' and 'MH' on secondary infections. Compared to the control group, secondary infection in the pooled 'M' and 'MH' groups was significantly lower (adjusted odds ratio 0.16, 95% CI, 0.03-0.92). Odds ratios were significantly lower for the 'M' group with per-protocol analysis (adjusted odds ratio, 0.30, 95% CI, 0.10-0.94). Adherence was good among children, adults, contacts and index cases except the 'MH' index cases in 2010/11.	Use of non-pharmacological interventions (facemasks and hand hygiene) can reduce household transmission of influenza.
Aiello et al., 2012 [23]	The use of face masks and hand hygiene in reducing influenza-like illness (ILI) and laboratory-confirmed influenza in natural settings was assessed via a randomized controlled trial. During the influenza season, 1,178 young adults were grouped as: • "Face mask and hand hygiene" • "Face mask only"' and • 'Control" The effect of these interventions on influenza A/B infection and on ILI during a 6 week period was estimated usingdiscrete-time survival models with generalized estimating equations.	The ILI rate was significantly reduced in 3 weeks with maximum reduction (75%) observed in the final week (rate ratio [RR] was 0.25, 95% CI 0.07-0.87). Compared to the control, intervention groups showed cumulative influenza rate reductions during the period with no statistical significance.	Mask use combined with hand hygiene may reduce ILI and confirmed influenza in community settings. At the beginning of an influenza pandemic, these measures should be recommended in crowded settings.

Saunders-Hastings et al., 2017 [24]	A meta-analysis was conducted to assess the effectiveness of personal protective measures in preventing influenza transmission in pandemic situations.	Protection from hand hygiene was significant (OR=0.62; 95% CI 0.52–0.73; I2=0%) while that of mask use was not significant (OR=0.53; 95% CI 0.16–1.71; I2=48%) against the 2009 pandemic influenza	Protection by face masks was not significant. Hand hygiene showed a significant protection. There was no evidence on effectiveness of respiratory etiquette.
Chu et al., 2020 25 al., 2017 [24]	Investigated the impact of physical distancing, face masks and eye protection on virus transmission in healthcare and community settings through a systematic review of 72 studies across the world and a meta-analysis with 44 studies. Compared distances between people and COVID-19 infected patients of ≥1 m (≥3.3 feet); • With smaller distances • With or without a face mask on the patient, • With or without a face mask, eye protection, or both on the exposed individual Outcome assessed: risk of COVID-19, SARS, or MERS transmission (confirmed or probable)to people in healthcare or community settings.	Use of protective wear for the eyes, face masks and maintenance of physical distance were reassuring, feasible and acceptable among most.	Risk of infection with COVID-19, SARS and MERS was lower with wearing face mask, use of eye protective wear and with maintenance of >1m physical distance.
Larson et al., 2020 [26]	Compared the impact of 3 household interventions on the incidence and secondary transmission of upper respiratory infections (URTI) and influenza and the knowledge on transmission of URTIs among 509 primarily Hispanic households. The three interventions were: • "Education only" – 'E' • "Education with alcohol-based hand sanitizer" – 'E+HS' • "Education with hand sanitizer and face masks" – 'E+HS+M' Participants reported symptoms on two occasions per week. Nasal swabs were collected from those with ILI.	Nearly 5,034 URIs was reported of which 669 were ILI (13.3%). Age, sex, birth location, education, and employment were significantly associated with infection rates. Symptomatic cases among households with hand sanitizer use ('E+HS' and 'E+HS+M') was significantly lower (p<0.01) compared to the group without ('E' only). Improvement of knowledge was significantly high in the hand sanitizer groups (E+HS' and 'E+HS+M') (p<0.0001). Secondary transmission rate was associated with wearing masks irrespective of the level of compliance, level of crowding, education level of caretakers and the age of the index cases.	When considering the rate at which URTIs were reported, there was no additional benefit from using face masks or hand sanitizer compared to targeted education. Secondary transmission was less among those who wore masks.

Table2: Evidence on facemask use for source control

Study	Methods	Results	Conclusion
Canini et al., 2010 [28]	Investigated the effectiveness of masks among index cases in minimizing influenza transmission through large droplets produced during coughing, among households through a cluster randomized trial in France from2008–2009. Household members with a positive rapid influenza A test and having symptoms less than 48 hours were recruited. In the intervention arm index cases wore surgical masks for five days.	Out of 148,nearly 16% of contacts in the intervention group and out of 158, nearly 16% in the control group were positive for influenza-like infection. Adherence to the intervention was good.	Results showed no trend to suggest that face masks are effective despite various sensitive analyses.
Milton et al., 2013 [29]	Assessed the total number of viral RNA copies in exhaled breath and cough aerosols to determine whether the RNA copies in fine particle aerosols represent infectious virus. In addition,determined whether surgical masks can reduce the virus shed into aerosols by seasonal influenza-infected persons. Samples of exhaled particles, one with a mask and another without a facemask were collected in two size dimensions ('coarse'>5 µm, 'fine'≤5 µm) from 37 volunteers within 5 days of seasonal influenza.	More viral copies were found in fine particles than in coarse particles (8.8 times 95% CI 4.1 to 19). Surgical masks reduced viral copies in the fine fraction by 2.8 fold (95% CI 1.5 to 5.2) and in the coarse fraction by 25 fold (95% CI 3.5 to 180). There was an overall 3.4 fold (95% CI 1.8 to 6.3) reduction in viral aerosol shedding.	Fine particle aerosols are abundant of viral copies and play an important in transmission of seasonal influenza. Wearing surgical masks by patients can reduce viral shedding in aerosols.
MacIntyre et al., 2016 [30]	Investigated whether mask usage by ILI patients protect their non-sick contacts from acquiring the infection. 245 index cases with ILI were randomized to medical mask group (n=123) and control group (n=122). Around 43 index cases in the control arm had used masks during the study period. Outcomes among household members of mask-wearing index cases (mask group) were compared with household members of non-mask-wearing index cases (no-mask group).	Rate of clinical respiratory illness (relative risk (RR) was 0.61, 95% CI 0.18-2.1), ILI (RR 0.32, 95% CI 0.03-3.1) and laboratory-confirmed viral infections (RR=0.97, 95% CI 0.06-15.5) were consistently lower in the mask arm compared to the control group. However, this was not significant. Protective effect was significant for symptomatic respiratory illness in the "mask group" compared to the "no- mask" group.	Medical mask use is potentially beneficial for source control.

Leung et al., 2020 [31]	Explored the importance of aerosol and respiratory droplets in transmitting coronaviruses, influenza viruses and rhinoviruses. The viruses were measured in exhaled breath and the efficacy of surgical masks against transmission of these viruses was assessed. Among the participants (n=246), 122 (50%) were not wearing and 124 (50%) were wearing face masks. Nearly 50% (n=123) were infected by at least one respiratory virus.	Protection provided by common fabric materials against particles containing virus in exhaled air is marginal. Masks significantly decreased influenza virus RNA detection in respiratory droplets and coronavirus RNA detection in aerosols. Effectiveness of masks was far less in blocking rhinovirus droplets of any size and blocking small influenza droplet.	Aerosol transmission is a possible mode for coronavirus transmission, similar as for the influenza and rhinoviruses. Wearing surgical masks by individuals with symptoms is effective in prevention of transmission of human coronaviruses and influenza viruses.
Wang, Pan and Cheng, 2020 [32]	Retrospective data (from 2 to 22 January 2020) were used from hospital staff working in 6 departments of Wuhan University in China. Self-protection practices of medical staff (doctors and nurses) were noted: (1) Health workers in 3 units–'N95 respirators+disinfection+frequent hand cleaning' (2) Health workers in 3 units – disinfection + occasional hand cleaning only Suspected COVID-19 cases underwent chest CT scans and molecular diagnosis. • Confirmed COVID-19 – 28 • Suspected COVID-19 – 58	Among 278 health workers who used N95, no one got infected. Among 213 of non-mask users, 10 were infected. This difference was statistically significant ($p<0.001$).	N95 masks, disinfection and hand washing seems to be helpful in reducing the risk of COVID-19 infection among doctors and nurses.

Table 3: Evidence on effectiveness of different types of masks

Study	Methods	Results	Conclusion
Dato, Hostler and Hahn, 2006 [34]	Masks were designed using Hanes heavyweight 100% pre-shrunk cotton t-shirt material after boiling for 10 minutes, air drying to maximize shrinkage and sterilizing. Microscopic dust and other aerosols in the air were used as challenge agents. The designed mask was initially screened with the short version of a qualitative Bitrex fit test. The best performers of the above test were retested using a quantitative fit test to measure the fit factor whilst simulating occupational activities. The aerosol concentrations inside and outside the masks were measured.	One author achieved a fit factor of 67 for the mask with a panel face size of 4, with a good fit and minimal leakage which offered significant protection against the aerosol challenge.Fit factor for N95 is 100. Two other authors achieved fit factors of 13 and 17 for panel face size of 10 with a slightly larger inner layer.	Although hand-fashioned masks can provide protection and good fit, it can be less effective when made by untrained users due to variations in material, assembly, facial structure, cultural practices, handling and non-availability of easy, definitive tests to demonstrate effectiveness.

Loeb et al., 20093[54]	Non-inferiority randomized controlled trial among 446 nurses in emergency departments, medical units, and pediatric units in 8 tertiary care hospitals in Ontario where the effectiveness of the surgical mask was assessed compared with the N95 respirator. Participants were randomized to a fit-tested N95 respirator or a surgical mask during work in caring for patients with febrile respiratory disease during influenza season. Laboratory-confirmed influenza was the primary outcome measured through PCR or a 4-fold rise in haem-agglutinin titres.	Influenza infection was detected in 50 nurses (23.6%, n=225) who wore surgical masks compared to 48 (22.9%, n=221) who wore N95 respirators (absolute risk difference, −0.73%; 95% CI; −8.8% to 7.3%; p=0.86), the lower confidence limit being inside the non-inferiority limit of −9%.	Protection conferred by surgical masks against influenza appears to be similar (non-inferior) to that of the N95 respirator. However, these findings are applicable to routine care in the health care setting N95 respirators are recommended for settings where more aerosols are generated such as during intubation or bronchoscopy.
Rengasamy, Eimer and Shaffer, 2010[36]	Assessed the aerosol penetration of common fabric materials used to produce sweatshirts, t-shirts, towels, scarves, and cloth masks in 2010. The materials assessed were cotton, polyester, cotton/polyester, and polyester/nylon. These were tested using poly-disperse and mono-disperse aerosols (20–1000 nm).	These materials had the following penetration levels for the two aerosols used: • Poly-disperse – 40 - 90% • Mono-disperse - 98% The penetration levels for the fabrics were higher than that of the N95 masks.	Cloth masks and masks made from cotton, polyester, cotton/polyester, and polyester/nylon conferred minimal respiratory protection.
Hui et al., 2012[37]	Experiments were performed by measuring the exhaled air distances and directions during coughing by a human patient simulator (HPS- which simulates a human patient lying at 45° with and without wearing a surgical mask or N95 mask from Medical Education Technologies Inc., Sarasota, FL) in a negative pressure hospital isolation room setting resembling actual hospital environment. Expelled air dispersion distances during coughing were measured.	In moderate lung injury (mild coughing efforts) the corresponding distances were reduced to 55 (no mask), 27 (surgical mask) and 14 cm (N95), respectively, $p < 0.001$. In severe lung injury (with poor coughing effort), the distances were further reduced to 30 (no mask), 24 (surgical mask) and 12 cm (N95). Lateral dispersion distances during normal cough were 0 (no mask), 28 (surgical mask) and 15 cm (N95).	N95 masks were more effective than surgical masks in preventing air leakage during cough. However, neither mask type was able to entirely prevent leakages from the side, though the effect was more considerable in surgical masks compared to N95 masks.

Davies et al., 2013 [38]	Assessed the efficacy of homemade masks and surgical masks in protecting wearers against microorganisms in a study involving 21 healthy volunteers (12 men and 9 women) aged between 20 and 44 years. The organism used was Bacillus atrophaeus (0.95-1.25µm larger than SARS-CoV-2) and Bacteriophage MS2 (MCIMB10108, 23 nm smaller than SARS-CoV-2). Also assessed 'mask fit' using a commercial 'fit test'. Tested materials- 100% cotton t-shirt, scarf, tea towel, pillowcase, antimicrobial pillowcase, vacuum cleaner bag, cotton mix, linen and silk materials.	A significant difference in the mask fit between homemade masks and surgical masks (p=0.001) was seen. Surgical masks blocked transmission 3 times more than homemade masks. Filtration rates were; • Homemade masks - 49%-86% • Surgical masks - 89% Effectiveness of homemade masks with cotton blend material was 78% and 56% of surgical masks for B. atrophaeu and for Bacteriophage MS2.	Homemade masks should be the last resort, but it would be better than no protection.
MacIntyre et al., 2015 [39]	Compared cloth masks to medical masks in hospital healthcare workers with regard to their efficacy in a cluster randomized trial conducted in Vietnam in 2015. 1,607 healthcare workers with≥18 years working in high-risk wards were randomized to: cloth masks, medical masks or control group (usual practice, which included high proportion using a mix of medical, cloth and N95 masks). Masks were worn on every shift for 4 weeks. Measured outcome-Clinical respiratory illness (CRI), ILI, and laboratory-confirmed respiratory virus infection.	All infection outcomes were highest in the cloth mask arm. ILI (RR=6.64, 95% CI 1.4-28.7) and laboratory-confirmed virus (RR=1.72, 95% CI 1.01 to 2.94) were higher in the cloth mask group compared with the medical mask group. Particle penetration was 97% for cloth masks and 44% for medical masks.	Cloth masks are not effective against ILI or for influenza and should not be recommended for healthcare workers.
Jung et al., 2014 [40]	Evaluated the filtration efficiencies of different mask types using the Korean Food and Drug Administration (KFDA) and NIOSH protocol. 44 brands which fall into four types of masks (anti-yellow sand, medical, quarantine and general) and handkerchiefs were tested using an automatic filter tester.	Mask types showed a wide range of penetration and pressure drops. Quarantine masks had the highest filtration efficiency while the lowest was observed in handkerchiefs and general masks.	General mask type and handkerchiefs offered minimal protection against airborne aerosols. There was no significant difference in penetration between the two protocols used (p>0.05).
Ma et al., 2020 [41]	Evaluated the efficacy of three face mask types (N95, medical mask and homemade masks) with instant hand wiping. The avian influenza virus was used to imitate the coronavirus.Real-time RT-PCR was carried out. A formula containing water and 'soap powder or sodium hypochlorite' was used for hand wiping. (Homemade masks had a single layer of polyester material with four layers of kitchen paper.	Instant hand wiping with the formula-soaked wet towel removed 98.4%, 96.6% and 99.9% of virus from the hands. N95, medical and the homemade mask blocked 99.9%, 97.1%, and 95.1% of the virus in aerosols.	Mask wearing with instant hand hygiene (MIH) may slow the exponential viral spread. Experience of seven countries fighting with COVID-19 support this strategy.

Table 4: Evidence on undesirable effects of mask use

Study	Methods	Results	Conclusion
MacIntyre et al., 2015 [39]	Assessed the protection of contacts when medical masks are used by sick individuals with ILI-related respiratory infections in 6 hospitals.	ILI and laboratory-confirmed respiratory viral infections were higher among healthcare workers who used cloth masks on a continuous basis compared to standard practice.	Moisture retention, poor filtration by re-using cloth masks may result in increased risk of infection.
Rosner et al., 2020 [42]	A cross sectional study was conducted among healthcare professionals, located in New York City, who worked in the hospital during the COVID-19 pandemic.	A total of 343 healthcare professionals were in reported adverse effects from prolonged mask use with headaches being the most common complaint (n=245). Skin breakdown was experienced by 175 respondents and acne was reported in 182. Impaired cognition was reported in 81respondents. Previous historyof headaches (n=98), skin sensitivity (n=164), and acne (n=121) were found in some.	Prolonged use of N95 and surgical masks by healthcare professionals during COVID-19 has mentioned effects such as headaches, rash, acne, skin breakdown and impaired cognition in the majority of those surveyed.

Table 5: Evidence on rational use, mask decontamination, reuse and disposal

Study	Methods	Results and Conclusion
Feng et al., 2020 [12]	Compared face mask use recommendations given by eight countries.	Masks were recommended to be worn by symptomatic individuals, healthcare workers and vulnerable populations such as the elderly and people with underlying medical conditions. This recommendation was observed in almost all countries. However, discrepancies were observed in the recommendations made for mask use by the general public in community settings. Universal face mask usage was recommended only if supplies are available. However, this has not been encouraged as the effectiveness against SARS-CoV-2 virus was questionable. Another reason for discouraging widespread usage was to preserve limited supplies for healthcare workers.
Eikenberry et al., 2020 [17]	Compartmental model for assessing the community-wide impact of mask use by the general, asymptomatic public, a portion of which may be asymptomatically infectious.	Suggested that almost universal use of masks which are not completely effective may contribute to reducing community transmission of COVID-19. This may also prevent peaks in hospitalizations and deaths. The impact on epidemiologic outcomes was highly nonlinear which indicates that mask use can synergize protective function when used with other non-pharmacological measures. Mask use was useful to prevent asymptomatic transmission as well as preventing illness in healthy persons. Thus, usage by the general public has a high potential to limit community transmission of COVID-19,provided the synergistic effect through using other hygiene measures is capitalised on along with a high degree of compliance.

Supehia et al., 2018[49]	An Observational study done. 382 observations were completed over a period of 4 weeks with a mean observation time of 42 (±11) min. Overall compliance for wearing a face mask/respirator was good. During the 1st week, 74 (81.3%) were wearing triple layered mask with an increased use of respirators and double layered masks; in the 4th week, it was 19 (21.8%) and 9 (10.3%), respectively. It had been observed that 17 (15.3%) were using cloth mask during the 3rd week. Of 374, 60 did not wear any type of mask.	The study highlights that clear guidelines need to be formulated for rational use of face masks. Reinforcement should be done through appropriate information, strict monitoring, auditing and disciplinary measures.
Lepelletier et al., 2020 [50]	Review on French position for the rational use of respiratory protective equipment for healthcare workers	Filtering Face Piece (FFP) masks should be reserved for healthcare workers involved in aerosol generation procedures conducted on COVID-19 suspected or confirmed patients. The duration of wearing should be in accordance to the instructions given by manufacturers. Ideally, it should be <8h in a single day, with 4h for surgical masks and 8h for FFPs. Both surgical and FFPs have to be worn while examining and should be changed between patients. Re-use of masks is not recommended for healthcare workers due to the increased risk of contamination.
Ogoina, 2020 [51]	A personal perspective on the mandatory policy requiring everyone going out in public to wear face masks by the Federal Government of Nigeria.	The new policy has brought about widespread misuse and abuse of face masks in Nigeria as well. There is an urgent need for intensive sensitization of the general public on appropriate use and disposal of face masks.
van der Linden and Savoie, 2020 [52]	Data were obtained from a rolling sample survey conducted in April in 2020 among 2,194 Canadians. The aim was to see whether Canadians had a higher chance of wearing masks following appeals based on collective-interest or self-interest.	Canadians have significantly adopted wearing of masks in public and this was to protect others from COVID-19 as opposed to protecting themselves. Findings are potentially useful in terms of designing broader public health policies in relation to COVID-19, especially to elicit compliance.
Rubio-Romero et al., 2020 [53]	A rapid review was conducted in which the main publications and other information available online have been analysed.	Disinfection and reuse can be considered for disposable FFPs but not for surgical masks. Most commonly used methods for disinfection were “hydrogen peroxide vapour, ultraviolet radiation, moist heat, dry heat and ozone gas”. Hydrogen peroxide vapor treatment appears to be the best method and is being broadly recommended. Soapy water, alcohol, immersion in bleach, ethylene oxide, ionizing radiation, microwave radiation, high temperature, autoclave and steam are not fully recommended. Homemade masks were not recommended to undergo disinfection as the risk of infection may be increased due to any increase in the humidity and diffusion of liquids which promote virus retention.

Nazeeri et al., 2020 [54]	Intervention to recover efficiency by more effective drying, which was achieved with a vacuum chamber. Drying was done at pressures of < ~6 mBar (0.6 kPa).	New drying method preserved the filtration efficiency (decrease was 2% from the pre-washing value). It was sustained even after 5 cleaning and drying cycles for 3 models of N95 masks. This study used inexpensive and commonly available vacuum chambers and made evident the possibility of reducing filtration performances of masks by other sources of moisture, even though it appears dry.

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