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REVIEW ARTICLE

Face masks for respiratory viral illness prevention in healthcare settings: a concise systemic review and meta-analysis

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ABSTRACT

Background and Objectives: There are conflicting views regarding face mask guidelines amongst healthcare staff to prevent transmission of coronavirus disease 2019 (COVID-19), influenza and other respiratory viral infections (RVIs). We conducted a thorough meta-analysis to statistically compare mask use versus no mask use efficacy for RVIs in healthcare settings.
Materials and Methods: Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines were used for selecting researches published between 2003 and June 2022 from different databases, including Publisher Medline (PubMed), Web of Science, etc.; 6 studies qualified for inclusion. Data was pooled from *in vivo* randomized control, case-control and observational studies dealing with the relationship between face mask use and no use by patients or health personnel and RVI prevention in healthcare setups.
Results: The fixed and random-effects model was carried out to determine pooled odds ratios (ORs) and their respective 95 percent confidence intervals (CIs). The results revealed that wearing a face mask significantly reduced the risk of contracting a respiratory viral illness in hospital settings, with pooled OR (95% CI) of 0.11 (0.04 to 0.33) (probability value (P) <0.08).
Conclusion: Masks largely succeeded in stopping respiratory virus transmission, as evidenced by the meta-analysis of 6 studies (a total of 927 individuals).

Keywords: Mask; Coronavirus; Influenza; Respiratory; Healthcare settings; Health personnel

INTRODUCTION

Respiratory pathogens, namely viruses, are responsible for a broad spectrum of infections that spread via direct or indirect contact between humans. Human coronaviruses, influenza viruses, measles, rhinoviruses that cause the common cold, and a few other viruses have transmission potential via aerosols, which accumulate in indoor air and linger for hours (1). Large respiratory droplets fall closer to the source and have an aerodynamic diameter of more than 5 micrometres (2, 3). At the same time, fine aerosols have aerodynamic diameters of less than or equal to 5 micrometres.

The wearing of face masks as well as hand hygiene practices, together aim to prevent aerosol, droplet, and contact transmission (4). These collaborative practices are directed to combat transmission of influenza viruses. Little is known about the extent of transmission prevention with these practices against other respiratory viral infections, including coronavirus disease 2019 (COVID-19) (5-7). Novel respiratory viruses, such as severe acute respiratory syndrome-associated coronavirus 2 (SARS-CoV-2),

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responsible for COVID-19, along with emerging variants, have brought to light the need for non-pharmaceutical measures, in terms of respiratory personal protective equipment (rPPE), to reduce transmission risks, especially in hospital settings (8-11). The risk of respiratory viral illnesses can be decreased by using a face mask as a physical barrier to keep the respiratory tract from coming into contact with external viruses (12). According to a new study, severe acute respiratory syndrome coronavirus 2 can spread far onto common objects and it can travel up to 4 meters from patients (13). Medical face masks have varying permeabilities and thicknesses, potentially protecting the wearer from droplets. They have varying abilities in lowering influenza virus ribonucleic acid (RNA) and coronavirus RNA in respiratory droplets and aerosols, respectively (14). They are not, however, specialized in protecting the wearer from nuclei of airborne pathogens, as is the case with N95 (non-oil; 95 percent efficacy) respirators (15). Regrettably, N95 respirator users often complain of discomfort accompanied by headaches and other concerns upon prolonged usage. This makes it challenging to properly don or doff the gear, further reducing compliance and possibly raising infection rates among non-compliant users.

On the contrary, surgical masks are loose-fitting apparatuses that offer a simple barrier between the user's mouth-nose area and the environment (16, 17). They are made to sit more loosely on the face, limit contamination, and lessen the spread of microorganisms between wearers (18). But, N95 respirator masks are intended to be worn for protection against not just large droplets but also airborne nuclei (19). These respirators undergo stringent inspections in terms of tentative filtration measurements, breathing resistances, and fitting tests, before they can be certified for use as rPPE against aerosols (20).

Although some protocols and standardized guidelines have been placed out for rPPE usage in healthcare facilities, they are not backed up with competently concrete evidence as they should be (11). Carrying out tests to explore the efficacies of masks against viral respiratory particles has shown to be a challenge with many hurdles. Also, there are many loopholes in establishing conditions for justified efficacy calculations in various settings (21).

This meta-analysis focuses on the efficacy of face masks by comparing ‘mask use’ versus (vs.) ‘no mask use’ in respiratory viral infections. It will aid healthcare municipalities and policy-makers in defining rPPE guidelines based on our mentioned pieces of evidence on face mask efficacies against respiratory viruses in healthcare settings and based on various gaps in the available knowledge. It aims to explore the evidence presented in these studies and analyze data to assess the extent of masking versus absence of masking for the prevention of not only COVID-19 spread, but also influenza and other respiratory viruses.

MATERIALS AND METHODS

The “Preferred Reporting Items for Systematic Reviews and Meta-Analysis” (PRISMA) guidelines were used to report this Meta-Analysis (22).

Criteria for selection of research studies. A thorough search method was developed to find qualifying studies published before June 2022 in various electronic databases, including Publisher Medline (PubMed), Web of Science and the Google Scholar database. Relevant keywords and terms for the search in databases were used to search for published articles (refer to Annexure 1 for search details). In addition, the references of all relevant papers and reviews were searched to find more studies with full texts relevant to this meta-analysis. Exclusion of duplicate works was carried out, and further independent screening was done by two authors (Hiba Sami, Safiya Firoze) who meticulously retrieved relevant full-text articles. The two authors discussed and further evaluated the screened works with a third reviewer (Parvez A Khan.) to draw up a final consensus. The details of the study selection are mentioned in Fig. 1.

From the 1231 publications obtained from various databases, we carried out some eligibility assessments, whereby 366 references were excluded due to duplication and 806 were not in parallel with our inclusion criteria. Our meta-analysis was aimed at healthcare settings and not public settings; hence, 53 research studies were factored out on this basis, leaving six focused researches for our study.

Inclusion criteria. We included the studies with the following criteria: i) Studies dealing with the relationship between any type of face mask and prevention of respiratory viral infections; ii) Diagnosis/detection of the respiratory virus having laboratory and/or strong clinical evidence accompanied by epidemiologic ev-

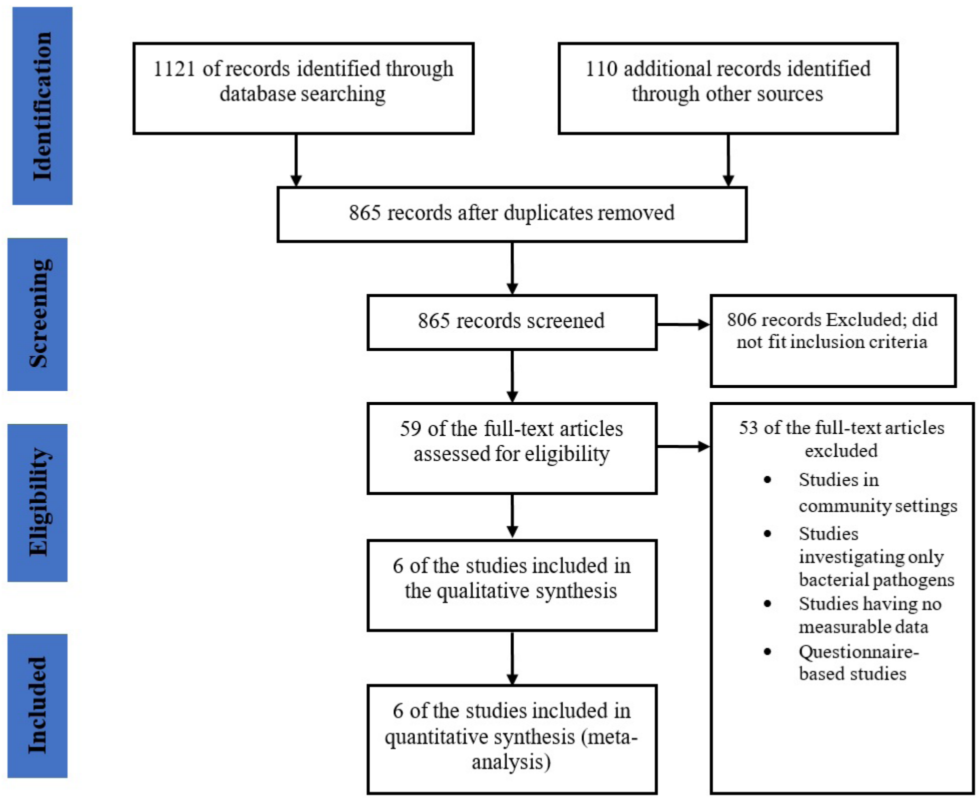


Fig. 1. Screening and selection of studies.

idences; iii) Only *In vivo*, Randomized control trials (RCT), Case-control and observational studies were included iv) health-care setup studies were included, including patients or health-care workers.

Exclusion criteria. Editorials, Meta-Analyses, and review articles; duplicate publications or overlapping studies; *In vitro* and simulation studies; studies involving only bacterial pathogens; and studies involving community settings were excluded.

Quality assessment of studies. All of the included RCT and observational studies were thoroughly examined for techniques that could lead to bias. The Jaded Scale tool was used to assess the risk of bias in RCTs (23). Newcastle Ottawa scales were used to assess the risk of bias in observational studies (24). Three reviewers (Parvez A Khan, Hiba Sami, and Safiya Firoze) conducted separate assessments, and differences were resolved through a panel discussion with other reviewers.

Statistical analysis. The effectiveness of mask use in preventing RVI transmission in hospitals was evaluated using odds ratios (ORs) and their related 95% confidence intervals (CI). A meta-analysis was performed using the random-effects model to generate pooled ORs and 95% CIs. The inverse approach, which used inverse variance weighting, was used for pooling. All eligible studies were utilised in the meta-analysis to generate pooled ORs for all respiratory infections (influenza, COVID-19, and SARS). Studies that reported the number of respiratory infections among different types of face mask groups and the control group were eligible. The Z-test was used to determine the significance of the estimated pooled ORs. A p-value of 0.05 was deemed significant. The I^2 statistic, tau2, and Q test of heterogeneity were used to analyse study heterogeneity. The heterogeneity was considered as insignificant when the Q test's p-value was >0.10 and I^2 <50%.

RESULTS

The outline of the systemic search process undertaken to screen for relevant, unique articles is provided in Fig. 1. Ultimately, in confluence with our inclusion criteria, six final key researches were extracted, consisting of 1 randomized control trial and five observational and cohort studies (Table 1) (12-14, 25-27). They were published between 2003 and 2020 and investigated healthcare workers (HCWs) or patients above 18 years in hospital settings. Overall, the number of participants ranged from 7 to 493, and the use of mask versus no mask was assessed for effectiveness in protecting from respiratory viruses. Among the six studies investigated, three investigated just SARS CoV-2, 1 studied influenza virus, 1 studied SARS, and 1 investigated human coronavirus, seasonal influenza virus, and rhinovirus.

Quality of studies. Strong inter-rater agreement was found for the included studies' qualities. Table 2 summarizes the listed studies' quality ratings according to the Jadad scale (23) and Newcastle-Ottawa Scale (24). Fig. 2 presents funnel plots that evaluate the possibility of publishing bias.

Protective effect of mask-wearing in respiratory viral infections. Masks largely succeeded in stopping respiratory virus transmission by the meta-analysis of 6 studies (a total of 927 individuals). Wearing a mask significantly decreased the chance of developing respiratory viral infections; the pooled OR was 0.11, and the 95 percent confidence interval was between 0.04 and 0.33 ($I^2 = 50\%$, M H (Mantel-Haenszel) Random-effect model) (Fig. 3).

DISCUSSION

This thorough meta-analysis that pooled RCT, case-control, cohort, and observational studies of the facemask's efficacy in preventing the spread of respiratory diseases concentrated solely on hospital settings without combining data from community settings and the findings indicated that wearing masks can reduce the incidence of RVIs in general but the number of such studies available for comparison was limited.

Previously, Liang et al. (28) and Offeddu et al. (29) conducted comparable meta-analyses to investigate the effectiveness of wearing masks in the prevention of RVIs, and their findings indicated that doing so could greatly lower the risk of RVIs with an OR of 0.35 and 0.13 respectively. Our meta-analysis also found an OR of 0.11 supporting their findings. Donning face masks reduced the risk of transmission of

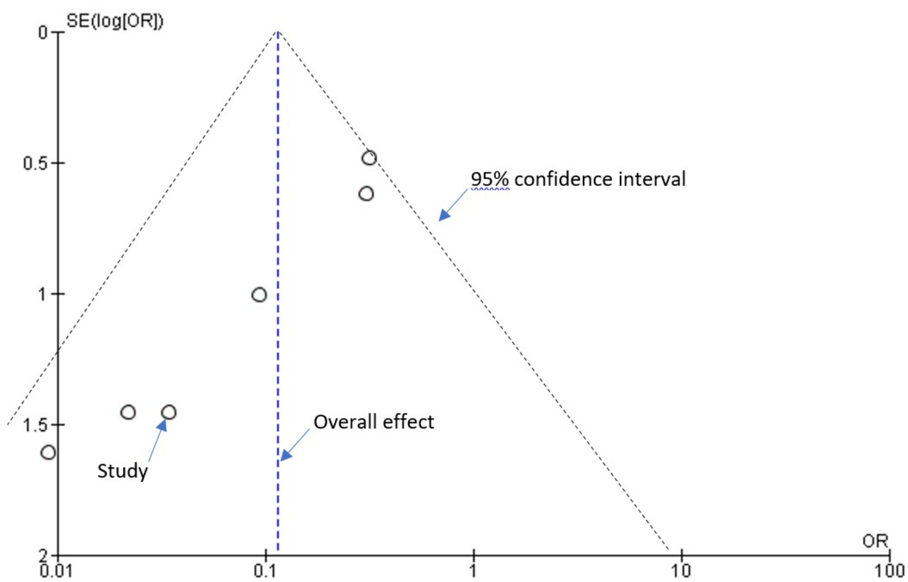
Table 1. Various *in vivo* studies comparing mask use and no mask use in respiratory diseases (n=6)[a]

Study	Year	Region	Virus studied	Mask used	Study type	Population studied	Finding and inference	Ref
Leung et al.	2020	Hong Kong	Human Coronaviruses, Seasonal Influenza virus and Rhinovirus	Surgical Mask vs. No Surgical Mask	Randomized Control Trials (RCT)	Health Care Workers	Influenza and coronavirus RNA detection was significantly less in the participants wearing surgical face masks than in exhaled breath samples of participants wearing no mask.	(14)
Wang et al.	2020	China	SARS-CoV-2	N95 respirator vs no mask	Cohort	Health Care Workers	COVID-19 rate was much higher in the doctors/nurses from the no mask arm, even though they were at a lower risk than the N95 respirator arm.	(25)
Guo et al.	2020	China	SARS-CoV-2	N95 respirator occasional use/ continuous use at work/ mask use	Case-control study	Health Care Workers	One risk factor was not wearing an N95 respirator (OR: 5.20; 95% CI, 1.09 to 25.00). Continuously donning respirators or masks has been reported to be effective (OR: 0.15).	(13)
D F Johnson et al.	2009	Australia	Influenza	No mask vs. N95 respirator	Observational study	Hospital Setting	Influenza virus was not detected in RT-PCR of the VTM from the ISPs taken from N95 mask wearers and surgical mask wearers. Hence, both masks showed similar effects when used by influenza patients for transmission prevention.	(12)
Kim et al.	2020	South Korea	SARS-CoV-2	Surgical mask, N95, and KF94 mask	Observational study	Hospital Setting	There was higher dissemination of SARS-CoV-2 from the cough samples when surgical masks were worn, compared with N95 and its equivalent mask, which showed much lower dissemination. Hence, SARS-CoV2 particle filtration was more effective with N95 and its equivalent masks.	(26)
Seto et al.	2003	Hong Kong	SARS-CoV	Paper mask, Surgical mask, and N95	Case-control Study	Health Care Workers	Workers who donned N95 respirators or surgical masks were strongly linked to being non-infected. However, this was not the case for staff who wore paper masks, for which the risk was not significantly reduced.	(27)

[a] RNA = ribonucleic acid, N95 = non-oil- 95 percent efficacy, SARS-CoV-2 = severe acute respiratory syndrome-associated coronavirus 2, COVID-19 = coronavirus disease 2019, OR = odds radio, CI = confidence interval, RT-PCR = reverse transcription- polymerase chain reaction, VTM = viral transport medium, ISP = influenza sample plate, KF94 = Korean filter-94 percent filtration efficacy, SARS-CoV = severe acute respiratory syndrome-associated coronavirus

Table 2. Quality scoring of the studies included (n=6)

Jadad Scale for Reporting Randomized Control Trials (RCT)				
Study	Randomization	Blinding (0-2)	An account of all patients' fate (0-1)	Total (0-5)
Leung et al., 2020	2	0	1	3
Newcastle-Ottawa Scale for Cohort Studies and Case-Control studies				
Study	Selection	Comparability	Outcome	Total (0-9)
Wang et al., 2020	4	1	3	8
Kim et al., 2020	1	2	2	5
Guo et al., 2020	4	2	3	9
D F Johnson et al., 2009	4	0	3	7
Seto et al., 2003	4	2	2	8



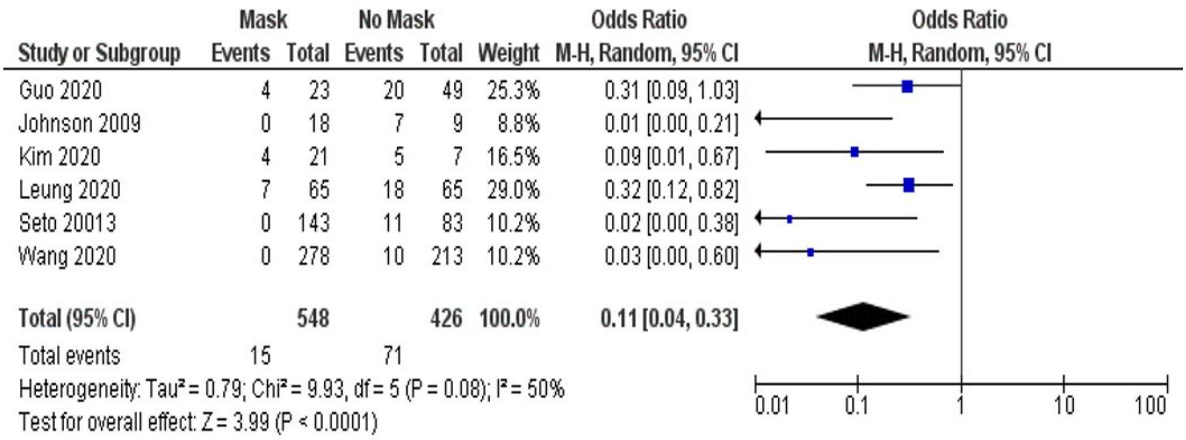
[b] SE = standard error, OR = odds ratio

Fig. 2. Funnel Plot: wearing a mask and respiratory viral infections (n=6)[b]

COVID-19, influenza, SARS and other respiratory viral illnesses. This was consistent with Liang et al.'s previous meta-analysis. Even though their results seemed to be similar to ours, they did not follow the PRISMA checklist as strictly as we did. They were quite lenient in choosing their studies, which merely represented largely non-homogenous data with varying population types and study designs. For instance, in one of their included studies, Teleman et al. (30), the study itself was a meta-analysis, and included factors other than masking, such as 'hand washing.' 'gloves' and 'gowns'. We kept our study choices solely as individual researches (not systemic reviews or meta-analyses) with study designs that were as similar as could be, so as to limit the chances of unmatched data.

When frontline HCWs are dealing with patients who may be at risk of RVIs like COVID-19, the authors advise vigorous masking (N95 respirators wherever available, or else at least surgical masks with additional personal protective equipment (PPE)). The meta-analysis has demonstrated that although there aren't many papers available, there are some researches which have managed to evidently prove the usefulness of surgical masks and N95 respirators in preventing the spread of viral respiratory diseases in hospitals.

Given the discomfort associated with face mask usage, it is challenging to maintain subject compliance during all the researches comparing the effects



[c] M-H = Mantel-Haenszel, CI = confidence interval, Tau^2 = between-study heterogeneity, Chi^2 = chi-squared test, df = degrees of freedom, I^2 = heterogeneity level, Z = standard score, P = probability

Fig. 3. Forest Plot showing the effect of mask-wearing in protecting against respiratory viral infections[c]

of masking. The studies' results comparing mask subgroups to no-mask control groups may be impacted by mask adjustment, frequent removal, manipulation, re-application, and the reduced compliance linked with face mask use (31). The N95 respirator's capacity to filter aerosol particulates sets it apart from surgical masks in experimental lab tests, with optimal compliance, but the inconvenience of donning these face masks at work may prevent healthcare professionals from strictly adhering to mask application regulatory guidelines (32).

Face masks and respirators for respiratory aerosols are advised to prevent infectious diseases spread by droplets. Despite the presumption that droplet transmission predominates, there is strong evidence that many respiratory viruses can be spread through the air, including the measles virus (33), influenza virus (3), respiratory syncytial virus (RSV) (2), human rhinovirus (hRV) (34), adenovirus, enterovirus, SARS and Middle East respiratory syndrome (MERS)-associated coronaviruses (35, 36).

In a previous work, Fischer et al. used several mask types and optic calibrations to compare droplet counts during speech (37). Their studies showed that medical masks and N95 respirators are comparably efficient in lowering droplet emission. Contrarily, there was no statistically significant difference in the droplet count between a speaker wearing a cloth mask and one who wasn't. Similar research using a standardized optical calibration method to see droplets while coughing evaluated effects of masking (38). According to the findings of these tests, both N95 and surgical masks effectively reduce droplet emission in the surroundings, during coughing and speech; though surgical masks are more likely to allow particulates to leak through loose gaps around the mask. The findings of Fischer et al. and of this meta-analysis show the value of the face masks in the healthcare setting, especially when managing patients at risk of infection respiratory dissemination.

The studies examined heterogeneous sets of viral diseases, which may have limited the specificity of their findings when compared to a pandemic like COVID-19. However, coronaviruses and other respiratory viruses, including influenza, have droplet sizes of about 4.7 micrometres or less (39). It is reasonable to infer some overlap between the effects of other RVIs and coronavirus-2, given the similarity in infection site, cellular entrance and particle size.

The risk of respiratory virus infections can be decreased by using a mask as a physical barrier to keep the respiratory system from contracting external viruses (12). Comparing the prevalence of COVID-19 in Hong Kong, China with that in South Korea, Italy, France, the United States, the United Kingdom, Germany, Singapore, and Spain revealed that mask use among the general public may control COVID-19 by reducing the infectious saliva and respiratory droplet emissions from patients with mild symptoms (40). Surgical masks have been shown to reduce the amount of influenza virus RNA in respiratory droplets and coronavirus RNA in aerosols (14).

Limitations. The study has a few drawbacks. First, some participants may take additional precautions to prevent RVIs in addition to wearing masks, such as maintaining good hand hygiene and using gloves, goggles, or full-face shields. Nevertheless, this was only available in a few studies. A shortcoming of the current meta-analysis is that the reviewed studies did not all employ the same types of masks or indicate whether the usage of the mask was consistent all through the investigation. Due to the small number of comparable randomized trials and observational studies, there is a possibility of publication bias that we are incapable of assessing. Only a small number of studies met the criteria for inclusion, which is another factor. Finally, these studies did not take into account vaccination statuses (41). Beyond the purview of this analysis, further research is necessary to determine the impact of vaccines on PPE effectiveness.

CONCLUSION

Overall, this study indicates sufficient evidence to support using face masks (N95 and medical) to stop the spread of respiratory virus diseases in hospital settings. Wearing masks was associated with fewer viral infectious episodes for healthcare workers compared with no mask use. Overall, using masks successfully avoided RVIs, particularly COVID-19, SARS, and influenza. Additionally, N95 masks as well surgical masks were all successful in preventing RVIs. This shows that to lower the risk of RVIs, healthcare workers and patients should be urged to wear masks in the hospital. Further studies are required, particularly in front-line healthcare delivery settings, as evidenced by the methodological quality, bias risk, and dearth of original studies.

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