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A meta-analysis evaluating the effect of N95 respirators in healthcare and non-healthcare providers on laboratory-confirmed respiratory virus infection

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ABSTRACT A meta-analysis was implemented to estimate the effect of facemasks in healthcare providers and non-healthcare providers on laboratory-confirmed respiratory viral infection. Methodology A systematic literature search conducted until March 2022 included 29 studies with a total of 18,489 participants at the start of the investigation. Among them, 9,569 people were utilizing facemasks, while 8,920 served as the control group. The Egger regression test was employed to evaluate the presence of publication bias, with a significance level of P<0.05. The odds ratio (OR) was evaluated at a 95% confidence interval (CI) using both the random effects and fixed effects models using the dichotomous method to evaluate the influence of facemasks in healthcare providers and non-healthcare providers on laboratory-confirmed respiratory viral infection. Facemasks had significantly lower laboratory-confirmed respiratory viral infection (LCRVI) between healthcare providers (OR, 0.31; 95% CI, 0.19-0.51, p<0.001), and between non-healthcare providers (OR, 0.58; 95% CI, 0.49-0.69, p<0.001) compared with control. N95 masks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers (OR, 0.67; 95% CI, 0.48-0.94, p=0.02), and no significant difference between non-healthcare providers (OR, 1.15; 95% CI, 0.94-1.41, p=0.017) compared with surgical masks. Facemasks shown a notable reduction in laboratory-confirmed respiratory viral infection among healthcare practitioners and non-healthcare providers, in comparison to the control group. Healthcare personnel who wore N95 masks had a notably reduced incidence of laboratory-confirmed respiratory virus infection. On the other hand, there was not a significant difference in the incidence of infection between non-healthcare professionals who wore surgical masks and those who did not wear any masks at all. Additional research is necessary to authenticate these discoveries.

INDEX TERMS Surgical mask, healthcare providers, post-surgery, N95 mask and respiratory virus transmission.

I. INTRODUCTION

Facemasks are advised for respiratory aerosol ventilation and infections spread by droplets, but recommendations vary between guidelines. The airborne transmission and droplet theories that have become ingrained in clinical practise recently are more sophisticated than preconceived notions. The anxiety around the 2019 coronavirus disease (COVID-19) is gradually growing [1]. Contact and droplet transmission are the key methods for the propagation of respiratory viral diseases. A recent research indicates that the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) can remain viable and capable of spreading through aerosols for several hours[2]. Therefore, when trying to halt the spread of respiratory illnesses, the use of masks as appropriate personal protective equipment is frequently taken into account. It has been demonstrated that viruses or dust particles larger than the size of the micropores are blocked by the micropores in masks [3]. The N95 mask materials' 8 m diameter micropores might effectively halt the transmission of pathogens [4]. Although the aforementioned research suggest a positive role for masks, there is still debate about how masks affect the transmission of respiratory viruses identified in labs [5]. Smith et al. demonstrated that insufficient data existed to determine whether surgical masks or N95 masks are more effective at defending healthcare workers from acute respiratory infections in clinical settings [6]. Six more meta-analyses concluded that using a facemask to protect yourself from the 2009 flu pandemic has no statistically significant defensive benefit [7]. Masks did not continue to have a substantial impact on the spread of influenza in 7 investigations, according to Xiao et al [5]. Wearing a mask, according to Jefferson et al., dramatically inhibited the spread of the coronavirus that causes severe acute respiratory syndrome [8]. However, there is currently conflicting information regarding the effectiveness of mask use in preventing the spread of respiratory viruses. Consequently, we carried out the present systematic review and meta-analysis to evaluate the efficacy of face masks in mitigating the transmission of respiratory viruses.

II. METHODOLOGY

A. STUDY SELECTION

The primary goals of the meta-analysis were to evaluate the effect of facemasks on laboratory-confirmed respiratory viral infections in healthcare providers and non-healthcare providers using statistical tools such as mean difference (MD), odds ratio (OR), frequency rate, or relative risk at a 95% confidence interval (CI). These goals were accomplished by comparing the prevalence of respiratory viral infections in both groups. The literature review consisted of more than just the English language. The research did not include any studies that found no relationships between the variables, such as letters, editorials, opinion articles, and review articles. The inclusion criteria, on the other hand, were not bound in any way by the type of study or the size of the study. Figure 1 shows the meta-analysis model.

B. ELIGIBILITY AND INCLUSION CRITERIA

Eligibility for the study was determined by looking at the impact that facemasks have, both on people who work in healthcare and on people who don't work in healthcare, on the prevalence of laboratory-confirmed respiratory viral infections. Therefore, in order to produce a summary, information was pulled from an evaluation of the facemasks worn by healthcare providers and non-healthcare providers on laboratory-confirmed respiratory virus infection compared with control, and information was extracted from an evaluation of the N95 mask vs the surgical mask.

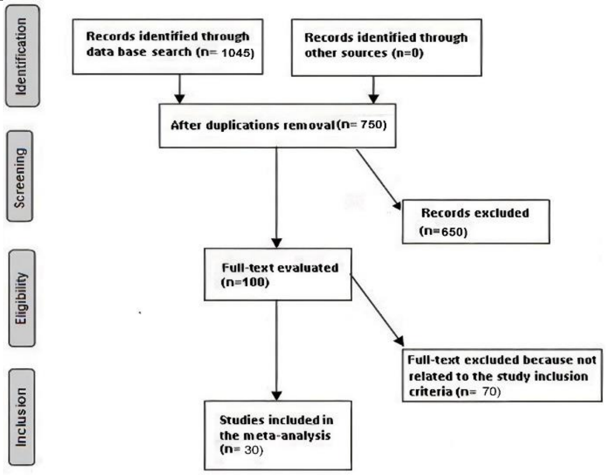


FIGURE 1. Diagram illustrating the mode of meta-analysis.

III. IDENTIFICATIONS OF STUDIES

The search technique followed the protocol by applying the PICOS concept. The key components of PICOS were P (population): healthcare providers and non-healthcare providers; I (intervention/exposure): facemask; C (comparison): facemasks compared with control and N95 mask compared with surgical masks; O (outcome): laboratory-confirmed respiratory viral infection between healthcare providers and non-healthcare providers S (study design): without any limitation [10] 10 .A comprehensive and concise literature review was conducted on MEDLINE/PubMed, Google Scholar, Embase, OVID, Cochrane Library, up until March 2022, utilizing specific search terms such as facemasks, surgical masks, healthcare professionals, post-surgery, N95 mask, and respiratory virus transmission, as outlined in Table 1. In order to get rid of duplicates, the research papers were categorized using the EndNote software. In addition, all of the titles and abstracts were subjected to a comprehensive analysis in order to get rid of any information that did not point to any risk factors or the effect of the facemask on the outcomes that were being investigated. Relevant data on this subject was gathered from the other topics.

TABLE I
Search Strategy for Each Database

Database	Search strategy
Pubmed	#1 "facemask"[MeSH Terms] OR "respiratory virus transmission"[MeSH Terms] OR "N95 mask" [All Fields] #2 "surgical mask"[MeSH Terms] OR "healthcare providers"[All Fields] #3 #1 AND #2

Embase	'facemask'/exp OR 'respiratory virus transmission'/exp OR 'N95 mask'/exp #2 'surgical mask'/exp OR 'healthcare providers'/exp #3 #1 AND #2
Cochrane library	#1 (facemask):ti,ab,kw OR (respiratory virus transmission):ti,ab,kw OR (N95 mask):ti,ab,kw (Word variations have been searched) #2 (surgical mask):ti,ab,kw OR (healthcare providers):ti,ab,kw (Word variations have been searched) #3 #1 AND #2

IV. SCREENING OF STUDIES

The study and information regarding the topic were incorporated in a conventional manner. The traditional form included the last name of the first author, their place of employment, the duration of the study, the study design, the sample size, the type of subjects, their demographics, the categories used, the mode of treatment, the qualitative and quantitative evaluation methodologies, the information source, the primary outcome evaluation, and the statistical analysis are all included in this evaluation. [10]. Following the standards that were stated in the Cochrane Handbook for Systematic Reviews of Interventions Version 5.1, the "risk of bias tool" was applied in order to evaluate the quality of the methodology. In order to maintain the integrity of the technique, the primary author addressed any disagreements that developed during the literature collecting process by engaging in a discussion with the two reviewers [11].

V. STATISTICAL ANALYSIS

The odds ratio (OR) was estimated using a dichotomous approach in the statistical analysis, either with a random influence or fixed effect model. The calculation included a 95% confidence interval (CI). The heterogeneity scale was initially established with four values: 0%, 25%, 50%, and 75%. These values corresponded to the levels of no, low, moderate, and extreme heterogeneity, respectively. The I2 index scale was initially evaluated between 0-100% [12]. I2 was used to determine if the influence was random or fixed. If Iwas less than 50%, fixed influence was assumed. A p-value of 0.05 or less was obtained after subgroup analysis and pooling of the first results. The Egger regression test utilizes funnel plots of the logarithm of odds ratios in relation to standard errors to assess publication bias, specifically when the p-value is greater than or equal to 0.05 [10]. This sensitivity analysis included only the effect of facemasks in healthcare providers and non-healthcare providers on stopping respiratory virus transmission compared with control, and N95 masks compared with a surgical mask. Regarding sensitivity analysis, the facemask was compared to the control group, whereas the N95 mask was compared to the surgical mask. "Reviewer manager version 5.3" was utilized in order to carry out the comprehensive statistical analysis. Values of p with two tails were utilized by the Nordic Cochrane Centre, which is a component of The Cochrane Collaboration and is located in Copenhagen, Denmark.

VI. RESULTS

Among the 1045 unique reports, a meta-analysis included a total of 29 studies that met the inclusion criteria between 2004 and 2021 [13-41]. The meta-analysis study comprised a total of 18,489 participants at the commencement of the trial, with 9,569 individuals utilizing facemasks and 8,920 individuals serving as the control group. All studies evaluated the effect of facemasks in healthcare providers and non-healthcare providers on laboratory-confirmed respiratory viral infection. 14 studies reported data stratified to the laboratory-confirmed respiratory viral infection between healthcare providers comparing facemask to control, 12 studies reported data stratified to the laboratory-confirmed respiratory viral infection between non-healthcare providers comparing facemask to control, 7 studies reported data stratified to the laboratory-confirmed respiratory viral infection between healthcare providers comparing N95 mask to surgical mask, and 2 studies reported data stratified to the laboratory-confirmed respiratory viral infection between non-healthcare providers comparing N95 mask to surgical mask. In the studies that were chosen, the sample size ranged from 32 to 5180 participants over the course of the research. Every piece of information pertaining to these 29 studies can be found in Table 2. Facemasks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers (OR, 0.31; 95% CI, 0.19-0.51, $p<0.001$) with moderate heterogeneity as 71%, and between non-healthcare providers (OR, 0.58; 95% CI, 0.49-0.69, $p<0.001$) with heterogeneity denoted as low (I2 = 49%) compared with control as shown in Figures 2-3. N95 masks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers (OR, 0.67; 95% CI, 0.48-0.94, p=0.02) with low heterogeneity as 47%, and no significant difference between non-healthcare providers (OR, 1.15; 95% CI, 0.94-1.41, p=0.017) with no heterogeneity (I2 = 0%) compared with surgical masks as shown in Figures 4-5. Because there aren't enough reports on factors like group age, ethnicity, and gender, these factors haven't been taken into account in the pooled data. The results of the quantitative measurement's Egger regression analysis funnel plots did not demonstrate any publication bias (p=0.89). However, issues like inadequate methodology were found in the chosen randomised dressings-led trial.

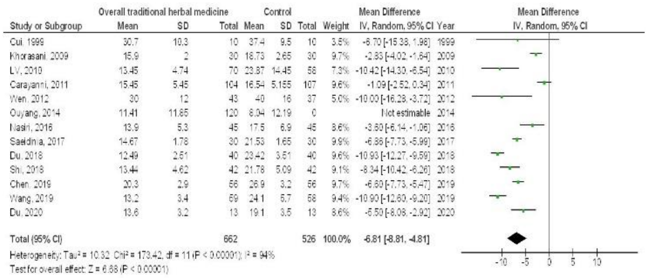
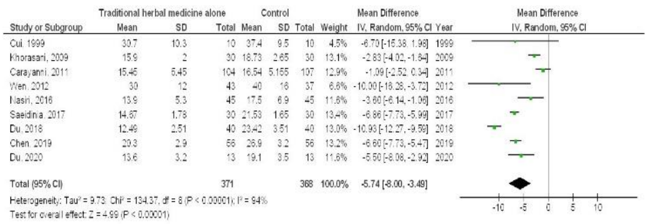


FIGURE 2. A forest plot of the serum phosphate levels change in adults undergoing hemodialysis with the phosphate-specific diet compared to the



control.

FIGURE 3. The effect's forest plot of the traditional herbal medicine alone compared to standard treatment on wound healing time in personals with burn wound ulcers.

TABLE II
Characteristics of Studies

Study	**Country**	**Total**	**Mask**	**Control**	**Type of virus**	**Population**
Teleman, 2004 [13]	Singapore	86	36	50	SARS	Health care workers
Wu, 2004 [14]	China	375	94	281	SARS	Population
Loeb, 2004 [15]	Canada	32	23	9	SARS	Health care workers
Ma, 2004 [16]	China	473	293	180	SARS	Health care workers
Yin, 2004 [17]	China	257	246	11	SARS	Health care workers
Wilder-Smith, 2005 [18]	Singapore	89	24	65	SARS	Health care workers
Nishiura, 2005 [19]	Vietnam;	115	43	72	SARS	Employees and Relative
Cowling, 2008 [20]	China	266	61	205	Influenza virus	House hold
Cowling, 2009 [21]	China	537	258	279	Influenza virus	House hold
Loeb, 2009 [22]	Canada	446	221	225	Influenza virus	Health care workers
Canini, 2010 [23]	France	296	148	148	Influenza virus	Health care workers
Larson, 2010 [24]	USA	340	166	174	Respiratory virus	Health care workers
Aiello, 2010 [25]	USA	834	347	487	Influenza virus	Student
MacIntyre, 2011 [26]	Australia	1922	1441	481	Respiratory viru	Health care workers
Jaeger, 2011 [27]	USA	63	20	43	H1N1	Health care workers
Suess, 2012 [28]	Germany	151	69	82	Influenza virus	House hold
Aiello, 2012 [29]	USA	762	392	370	Influenza virus	House hold
MacIntyre, 2013 [30]	Australia	1097	581	516	Respiratory virus	Health care workers
Zhang a, 2013 [31]	China	164	152	12	H1N1	Health care workers
Chokephaibulkit, 2013 [32]	Thailand	256	239	17	H1N1	Health care workers
Zhang b, 2013 [33]	China	41	15	26	H1N1	Population
Barasheed, 2014 [34]	Australia	164	75	89	H1N1	Population
Sung, 2016 [35]	USA	1831	911	920	H1N1	Population

Zhang, 2017 [36]	China	80	52	28	Respiratory virus	Health care workers
Wang, 2020 [37]	China	493	278	215	SARS-CoV-2	Household
Radonovich, 2020 [38]	USA	5180	2512	2668	SARS-CoV-2	Household
Ng, 2021 [39]	Singapore	662	51	611	SARS-CoV-2	Health care workers
Rodriguez-Lopez, 2021 [40]	Colombia	223	98	125	SARS-CoV-2	Health care workers
Li, 2021 [41]	China	1414	724	690	SARS-CoV-2	Health care workers
	Total	**18649**	**9570**	**9079**		

VII. CONCLUSION

This meta-analysis comprised 18489 subjects at the beginning of the study; 9569 were using facemasks, and 8920 were controlled [13-41]. Facemasks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers, and between non-healthcare providers compared with control. N95 masks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers, and no significant difference between non-healthcare providers compared with surgical masks. However, due to the small sample size of some of the studies chosen for the meta-analysis—7 out of 29 studies had a sample size of less than 100 subjects—the analysis of the results must be done carefully. It is advised that further research be conducted in order to confirm these findings or possibly to significantly increase confidence in the effect assessment epically the effect of N95 compared with a surgical mask on laboratory-confirmed respiratory viral infection between non-healthcare providers with its very low number of selected studies (2 studies). This meta-analysis's primary objective was to provide and evaluate all available evidence about the effect of facemasks in healthcare providers and non-healthcare providers on laboratory-confirmed respiratory viral infection. The physical barrier that is provided by a facemask has the ability to effectively prevent the respiratory tract from coming into touch with the virus, hence reducing the likelihood of respiratory virus infections to occur. [42]. For the community that was at a high risk of severe illness during the 2009 H1N1 outbreak, the Centers for Disease Control and Prevention (CDC) issued interim recommendations for the use of facemasks and respirators for the purpose of preventing the spread of the virus. On the other hand, the CDC recommended the use of respirators by health care providers who are not at an increased risk of severe illness due to the high probability of getting infected. SARS-CoV-2 can spread widely on commonplace items including flooring, computer mice, and trash cans and can travel up to 4 m (about 13 feet) from victims [43]. Surgical masks have the ability to reduce coronavirus RNA in aerosols and respiratory droplets [44]. Surgical masks or N95 masks can effectively remove the SARS-CoV-2 aerosol, which primarily appears in the submicron area (between 0.25 and 1.0 m) and supermicron region (> 2.5 m), from the air that is inhaled [45], could be efficiently cleaned out from the inhaled air by surgical masks or N95 masks [46]. However, the meta-analysis result showed that N95 was more effective than the surgical mask in healthcare providers however in non-healthcare providers the surgical mask has a relatively lower infection rate but is still non-significant since the number of studies found was only 2 studies. That could be because healthcare providers use masks properly compared to non-healthcare providers, in addition, the securing feeling effect of the N95 mask when non-healthcare providers wear it made them do things that could increase their infection rate compared to surgical masks. In order to evaluate the prevalence of COVID-19 in Hong Kong, China, in comparison to other countries such as Spain, Italy, Germany, France, the United States of America, the United Kingdom, Singapore, and South Korea, a comparative analysis was carried out. On the basis of this comparison, it was discovered that the usage of masks across the community could potentially assist in the management of COVID-19 by limiting the release of contaminated saliva and respiratory droplets from individuals who are only minimally symptomatic [47]. Through the present COVID-19 pandemic, healthcare providers are facing the hazards of close contact with infective subjects [48]. By March 19, 2020, there were more than 2,600 infected healthcare professionals in Italy, or 8.3% of all cases [49]. So, universal masking of healthcare providers at clinical locations is likely to deliver great advantage for healthcare providers; particularly through the present COVID-19 pandemic. Furthermore, the research conducted by Sokol demonstrated that the use of surgical masks in every patient room resulted in a reduction in the incidence of hospital-acquired respiratory virus infections experienced by all employees and visitors [50]. The accumulated data showed that individuals who are older, in a state of immunosuppression, and who have systematic co-modifications are at a higher risk for severe COVID-19 infection [51-60]. As a result, it is imperative that these individuals be safeguarded with appropriate measures (such as wearing a facemask) throughout the ongoing pandemic occurrence. In addition, individuals who live in close proximity to individuals who are at a high risk of contracting respiratory virus illnesses should seriously consider wearing face masks. Not only that, but the research that was carried out on the general public revealed that there were considerable defensive affects [14]. During influenza pandemics, large numbers of facemasks were required to be used for extended periods of time in order to protect people from getting infected [61]. N95 respirator use is likely to result in discomfort, including headaches [61]. An earlier study [62] found that the likelihood of developing a clinical respiratory illness was negatively associated to the degree of compliance with wearing a N95 respirator. N95 respirators are uncomfortable, making it challenging to guarantee high compliance in all investigations. With regard to laboratory-confirmed respiratory virus infection, this study demonstrated a correlation between the effects of facemasks used by healthcare personnel and those worn by those who were not employed in the healthcare industry. To pinpoint the precise clinical difference in the outcomes and closeness, more research are still needed. Furthermore, our meta-analysis studies were unable to establish a connection between age, ethnicity, or gender and the outcomes. Other meta-analyses with similar results also suggested this[63-72]. In summary, Facemasks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers, and among non-healthcare providers compared with control. N95 masks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers, and no significant difference between non-healthcare providers compared with surgical masks. Facemasks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers, and among non-healthcare providers compared with control. N95 masks had significantly lower laboratory-confirmed respiratory viral infection between healthcare providers, and no significant difference between non-healthcare providers compared with surgical masks. The small sample sizes of several of the chosen studies reported in the meta-analysis, however, call for careful results analysis and suggest the need for further research to support these findings or maybe have a substantial impact on confidence in the effect evaluation epically the effect of N95 compared with a surgical mask on laboratory-confirmed respiratory viral infection between non-healthcare providers with its very low number of selected studies.

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