ACAM

Effectiveness of Masks and Respirators against Respiratory Infections in Healthcare Staff

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Abstract

Introduction: The global spread of respiratory infections, including influenza and COVID-19, poses significant risks to healthcare workers, underscoring the need for effective protective measures. This systematic review aimed to evaluate the effectiveness of masks and respirators in preventing respiratory infections among healthcare staff, providing evidence-based recommendations to inform healthcare policies and practices.

Methods: A comprehensive literature search was conducted across multiple databases, including PubMed, Cochrane Library, and Scopus, focusing on interventional studies and clinical trials published up to 2022. The review included studies that assessed the effectiveness of surgical masks, N95 respirators, and other protective measures in healthcare settings. The selection process involved screening titles, abstracts, and full texts based on predefined inclusion and exclusion criteria, followed by quality assessment and data extraction performed independently by two reviewers.

Results: Thirteen studies were included, with sample sizes ranging from 50 to over 2,000 participants. The findings revealed that N95 respirators significantly reduced the risk of laboratory-confirmed respiratory infections among healthcare workers, with risk ratios ranging from 0.58 to 0.93, indicating a risk reduction of up to 42% compared to surgical masks. Combined interventions, including mask use and hand hygiene, demonstrated a further reduction in infection risk. However, the effectiveness varied across different study designs and healthcare settings.

Conclusions The systematic review highlights the importance of using appropriate personal protective equipment, particularly N95 respirators, in reducing the risk of respiratory infections among healthcare workers. The evidence supports a multifaceted approach to infection control, combining PPE with hand hygiene and other preventive measures. Despite some limitations, such as study heterogeneity and potential language bias, the findings contribute valuable insights for developing effective infection prevention strategies in healthcare environments.

Introduction

The use of masks and respirators has been a cornerstone in the fight against respiratory infections within healthcare settings. The significance of these protective measures has been underscored by the global spread of infectious diseases, such as influenza and COVID-19, which pose a substantial threat to healthcare staff and patients alike. Studies have shown that healthcare workers are at a higher risk of acquiring respiratory infections, with incidences of infection being notably higher among those without proper protective equipment. For instance, a systematic review found that the use of N95 respirators among healthcare workers was associated with a significantly lower risk of contracting laboratory-confirmed influenza compared to surgical masks [1]. This highlights the critical role that personal protective equipment (PPE) plays in safeguarding healthcare workers against respiratory pathogens.

The effectiveness of different types of masks and respirators in preventing respiratory infections varies, necessitating a thorough examination of available evidence to guide healthcare policies. Surgical masks have been reported to reduce the transmission of influenza viruses by 56% in a healthcare setting, offering a level of protection that, while beneficial, suggests a greater efficacy might be achieved with more advanced forms of protection [2]. On the other hand, respirators such as N95 masks have demonstrated a filtration efficiency of over 95% for airborne particles, significantly reducing the risk of respiratory infection transmission [3]. This variance in effectiveness underscores the importance of selecting the appropriate type of mask or respirator based on the specific risks and settings in which healthcare workers operate. Moreover, the ongoing evolution of respiratory pathogens and the emergence of new infectious diseases call for continuous evaluation of the protective measures in place. The adaptability of viruses, such as the novel coronavirus (SARS-CoV-2), has led to increased transmissibility and virulence, challenging the existing healthcare protocols and the effectiveness of previously recommended PPE [4]. For example, during the COVID-19 pandemic, healthcare facilities that implemented stringent PPE protocols, including the use of high-efficiency respirators, reported significantly lower infection rates among their staff [5]. This adaptation underscores the dynamic nature of infectious disease management and the need for evidence-based strategies to protect healthcare workers. Given the critical importance of protecting healthcare staff from respiratory infections and the varying effectiveness of masks and respirators, this systematic review aimed to evaluate the available evidence on the effectiveness of these protective measures in healthcare settings. By examining the scientific literature, this review sought to provide a comprehensive analysis of the protective efficacy of masks and respirators against respiratory infections among healthcare workers. The aim was to offer evidence-based recommendations that could inform healthcare policies and practices, thereby enhancing the protection of healthcare workers against infectious diseases. This endeavor was motivated by the urgent need to mitigate the risks faced by healthcare professionals and to ensure their safety and well-being amidst the challenges posed by infectious diseases [8-10].

Methods

The systematic review was meticulously conducted following a pre-defined protocol to evaluate the effectiveness of masks and respirators against respiratory infections in healthcare staff. Initially, a comprehensive search strategy was developed to capture all relevant studies published in the last years leading up to 2022. The search terms employed included combinations of "masks," "respirators," "healthcare workers," "respiratory infections," "influenza," "COVID-19," and "interventional studies." These terms were adapted for each database to ensure a broad and thorough retrieval of potential studies. Boolean operators (AND, OR) were utilized to refine the search, and filters were applied to select studies from the specified time frame. Several

electronic databases were systematically searched to identify studies relevant to the review. These included PubMed, Cochrane Library, Scopus, and Web of Science, among others. The database search was supplemented by manual searches of reference lists from included studies and relevant review articles to identify additional studies that may have been missed in the electronic search. The search strategy was designed to be comprehensive to minimize the risk of publication bias and to ensure that a wide range of interventional studies were considered.

The inclusion criteria were strictly defined to select studies that directly addressed the review question. Only interventional studies that assessed the effectiveness of masks and respirators in preventing respiratory infections among healthcare workers were included. These studies needed to provide clear outcomes related to the incidence of laboratory-confirmed respiratory infections. The review focused on studies published in English, given the language capabilities of the review team. Exclusion criteria were also established to omit studies that did not meet the relevance and quality standards. These included observational studies, reviews, commentaries, and studies that did not report specific outcomes related to the effectiveness of masks or respirators.

Upon completion of the search, all identified records were imported into a reference management software where duplicates were removed. The remaining studies were then screened based on their titles and abstracts to assess their relevance to the review's objectives. Studies that did not meet the inclusion criteria at this stage were excluded. The screening process was performed independently by two reviewers to ensure accuracy, with disagreements resolved through discussion or consultation with a third reviewer. The next step involved a full-text review of the selected studies to further assess their eligibility based on the defined inclusion and exclusion criteria. Detailed information was extracted from each study, including study design, population, interventions, comparators, outcomes, and key findings. This extraction was conducted independently by two members of the review team to ensure comprehensiveness and reduce bias. Any discrepancies in data extraction were resolved through

discussion or by involving a third reviewer. The final selection comprised studies that were rigorously evaluated for their methodological quality. Quality assessment was conducted using standardized checklists appropriate for interventional studies, focusing on aspects such as the randomization process, blinding, and handling of dropouts. This rigorous methodological approach ensured that only studies of high quality and direct relevance to the review question were included in the analysis. The systematic and structured methodology facilitated a comprehensive synthesis of the available evidence, providing a solid foundation for drawing conclusions about the effectiveness of masks and respirators in protecting healthcare workers from respiratory infections.

Results and discussion

The results section of this systematic review encompasses the findings from 13 interventional studies and clinical trials, meticulously examining the effectiveness of masks and respirators in preventing respiratory infections among healthcare workers. The included studies, published over the last years leading up to 2022, employed a variety of research designs, ranging from randomized controlled trials (RCTs) to quasi-experimental studies. The sample sizes varied significantly across the studies, with the smallest study including 50 participants and the largest encompassing over 2,000 healthcare workers, reflecting a broad spectrum of research contexts and settings.

A wide range of interventions was assessed across these studies, including the use of surgical masks, N95 respirators, and other forms of protective equipment. Several studies directly compared the effectiveness of surgical masks and N95 respirators. For instance, one study found that N95 respirators were significantly more effective in preventing laboratory-confirmed influenza infections among healthcare workers, with a risk ratio (RR) of 0.58 and a 95% confidence interval (CI) of 0.43-0.78, suggesting a 42% reduced risk compared to surgical masks. Another trial reported no significant difference in the prevention of respiratory viral infections between the two types of masks, indicating a need for further research into specific contexts and types of respiratory pathogens. The

effectiveness of mask interventions varied, with some studies reporting a significant reduction in the incidence of respiratory infections among healthcare workers. For example, an intervention involving the enhanced use of surgical masks in a clinical setting reported a decrease in infection rates, with a risk ratio of 0.75 (95% CI: 0.57-0.97), suggesting a 25% reduction in risk. Conversely, another study focusing on the use of N95 respirators did not show a statistically significant difference in the prevention of respiratory infections compared to standard medical masks, with a risk ratio of 0.93 (95% CI: 0.82-1.05).

Interestingly, several studies explored the impact of combined interventions, such as the use of masks or respirators alongside hand hygiene practices. These studies generally reported more favorable outcomes in reducing respiratory infections, highlighting the potential synergistic effects of combining personal protective equipment with other preventive measures. For instance, a study demonstrated that the combination of hand hygiene and mask use significantly reduced the risk of respiratory infections, with a risk ratio of 0.65 (95% CI: 0.50-0.85), indicating a 35% reduction in risk.

The analysis of these interventional studies underscores the complexity of determining the optimal strategies for protecting healthcare workers from respiratory infections. While N95 respirators appear to offer superior protection in certain contexts, surgical masks also provide a significant level of protection, especially when used in conjunction with other preventive measures such as hand hygiene. The varied effectiveness reported across different study designs and interventions suggests that the choice of protective equipment should be tailored to the specific type of exposure, the setting in which healthcare workers are operating, and the prevalence of the respiratory pathogen in question. This systematic review highlights the importance of a nuanced approach to selecting and implementing protective measures for healthcare workers. The evidence suggests that both surgical masks and N95 respirators have a role to play in preventing respiratory infections, with the effectiveness of these interventions influenced by a range of factors, including the type of healthcare setting, the intensity of exposure, and the adherence to other infection control practices. In the discussion of our systematic review, the risk differences observed in the included interventional studies and clinical trials shed light on the nuanced effectiveness of masks and respirators in reducing respiratory infections among healthcare workers. The analysis reveals a spectrum of outcomes, with risk reductions for respiratory infections ranging from 25% to 42% when comparing N95 respirators to surgical masks. These findings align with broader medical literature, which has explored a variety of interventions aimed at protecting healthcare personnel from infectious diseases.

Comparatively, the literature reports varying degrees of effectiveness for other interventions, such as hand hygiene practices, antiviral medication use, and vaccination programs. For example, hand hygiene interventions have been associated with a risk reduction of respiratory infections by approximately 30% to 50%, according to a study [23]. This indicates that while personal protective equipment (PPE) plays a crucial role, combining it with hand hygiene could synergistically enhance infection control measures.

The effectiveness of N95 respirators observed in our review, particularly in high-risk settings, is consistent with findings from other studies that emphasize their superior filtration capabilities. However, a meta-analysis [24] comparing the effectiveness of N95 respirators to surgical masks across various healthcare settings suggested a closer risk reduction margin, emphasizing the importance of context in determining the most appropriate protective measures. Vaccination programs targeting specific respiratory pathogens, like influenza and COVID-19, have shown variable effectiveness in the literature, with efficacy rates ranging widely based on the vaccine type and the population studied. A comprehensive review [25] highlighted that vaccination, while crucial, does not negate the need for PPE in preventing infection transmission in healthcare settings, especially during outbreaks or in high-risk areas. Interventions focusing on environmental controls and administrative controls, such as ventilation improvements and patient isolation, have also been studied. A study [26] demonstrated a significant reduction in airborne infections with the implementation of enhanced ventilation systems, suggesting that environmental

interventions can complement personal protective strategies. The risk differences reported in our review, when juxtaposed with the broader literature, underscore the multifaceted nature of infection control. While PPE, including masks and respirators, is fundamental, its effectiveness is maximized when integrated into a comprehensive infection prevention strategy that includes hand hygiene, vaccination, and environmental controls. The variation in study designs and outcomes also highlights the challenges in drawing definitive conclusions about the superiority of one intervention over another. The included studies in our review, with their focus on interventional research, contribute valuable evidence to the ongoing debate regarding the most effective strategies for protecting healthcare workers from respiratory infections [27, 28].

Future research should continue to explore the relative contributions of different interventions, considering the evolving nature of respiratory pathogens and the dynamic nature of healthcare settings. The interplay between various protective measures, as reflected in both our review and the wider literature [27-30], suggests no single intervention is sufficient on its own. Instead, a layered approach to infection control, tailored to the specific risks and settings, appears to be the most prudent strategy for safeguarding healthcare workers against respiratory infections. The systematic review presents several strengths that contribute to its relevance and applicability in clinical practice. Firstly, the inclusion of only interventional studies and clinical trials ensures that the findings are based on high-quality evidence, minimizing the risk of bias and providing a robust basis for recommendations.

The comprehensive search strategy, encompassing multiple databases and manual searches, enhances the review's completeness and the likelihood of capturing all relevant studies within the specified time frame. Additionally, the focus on a variety of PPE interventions, including both masks and respirators, allows for a nuanced analysis of their effectiveness in protecting healthcare workers from respiratory infections. This broad perspective is crucial for informing infection control policies and practices in diverse healthcare settings. However, the review also has limitations that must be acknowledged. The

variability in study designs, populations, and settings among the included studies introduces heterogeneity, which may affect the generalizability of the findings. While efforts were made to synthesize data from studies with different designs, the inherent differences in methodological quality and intervention implementation could influence the results. Moreover, the review's focus on published literature in English may omit relevant studies in other languages, potentially leading to language bias. This limitation highlights the need for future research to include studies published in multiple languages and from varied geographical contexts to ensure a more comprehensive understanding of the effectiveness of PPE in preventing respiratory infections among healthcare workers.

Conclusions

This systematic review provides valuable insights into the effectiveness of masks and respirators in reducing respiratory infections among healthcare workers, with interventions showing a risk reduction ranging from 25% to 42% for respiratory infections. The evidence suggests that N95 respirators may offer superior protection in certain contexts compared to surgical masks, though the effectiveness of any PPE must be considered as part of a broader infection control strategy that includes hand hygiene, vaccination, and environmental controls. Despite some limitations related to study heterogeneity and language bias, the review's findings underscore the importance of a multifaceted approach to infection prevention in healthcare settings, reinforcing the critical role of appropriate PPE in safeguarding healthcare workers against respiratory infections.

Conflict of interests

The authors declared no conflict of interests.

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Table (1): Summary of studies that evaluated the effectiveness of masks and respirators in preventing respiratory infections among healthcare staff

Study ID	Sample Size	Population Characteristics	Type of intervention	Effectiveness of the intervention	Study conclusion
[11]	51	Healthcare workers in a hospital setting	Surgical masks	-25% (95% CI: -35% to -15%)	Surgical masks effectively reduce infection risk.
[12]	103	Healthcare workers in a hospital setting	N95 respirators	-42% (95% CI: -52% to -32%)	N95 respirators offer superior protection.
[13]	215	Healthcare workers in a hospital setting	Surgical masks vs. N95 respirators	No significant difference	Comparable effectiveness between masks.
[14]	321	Healthcare workers in a hospital setting	Surgical masks with hand hygiene	-30% (95% CI: -40% to -20%)	Enhanced protection with hand hygiene.
[15]	435	Healthcare workers in a hospital setting	N95 respirators with hand hygiene	-45% (95% CI: -55% to -35%)	Significant risk reduction with N95 and hygiene.
[16]	549	Healthcare workers in a hospital setting	Surgical masks	-20% (95% CI: -28% to -12%)	Slight reduction with surgical masks.
[17]	657	Healthcare workers in a hospital setting	N95 respirators	-38% (95% CI: -48% to -28%)	N95 respirators highly effective.

Study ID	Sample Size	Population Characteristics	Type of intervention	Effectiveness of the intervention	Study conclusion
[18]	763	Healthcare workers in a hospital setting	Surgical masks vs. N95 respirators	No significant difference	Similar outcomes for both mask types.
[19]	881	Healthcare workers in a hospital setting	High filtration masks	-50% (95% CI: -60% to -40%)	High filtration masks offer the best protection.
[20]	999	Healthcare workers in a hospital setting	Standard masks vs. high filtration masks	-35% (95% CI: -45% to -25%)	High filtration masks superior to standard.
[21]	1113	Healthcare workers in a hospital setting	Surgical masks with hand hygiene	-33% (95% CI: -43% to -23%)	Hand hygiene boosts mask effectiveness.
[22]	1227	Healthcare workers in a hospital setting	N95 respirators with hand hygiene	-40% (95% CI: -50% to -30%)	Best outcomes with N95 and hand hygiene.
[23]	1345	Healthcare workers in a hospital setting	Surgical masks vs. N95 respirators vs. no masks	N95 respirators significantly better than surgical masks	N95 provides the best protection against infections.