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*Review Article*

# Side effects of N95 and surgery respirator masks: A narrative review from a nursing perspective

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**Abstract**

One of the major problems of public health is the transmission of respiratory infections in clinical care settings. Healthcare workers (HCWs) are exposed to a wide range of respiratory threats, such as severe acute respiratory syndrome (SARS), influenza A, and COVID-19. Meanwhile, personal protective equipment (PPE) especially N95 and surgical masks play a key role in preventing transmission and infection of respiratory infections in clinical settings. Despite the advantages and uses of surgical and N95 masks, these also have side effects. This literature review was conducted to examine the various side effects of surgical and N95 masks in HCWs. According to the results of this study, the side effects of surgical and N95 masks include skin, respiratory, cardiac, and neurological. In general, although the use of respiratory protection equipment is essential in HCW, the use of surgical and N95 masks adversely affects communication, physiological, and psychological abilities in HCW. In particular, it is severe in vulnerable people, such as pregnant women, and those with respiratory problems, such as chronic obstructive pulmonary disease. Therefore, there is a lack of training guidelines to improve the safety of HCWs.

**Keywords:** Adverse Effects, Health Personnel, Masks, Respiratory Protective Devices, N95 Respirators.

## 1 | Introduction

One of the major problems of public health is the transmission of respiratory infections in clinical care settings [1], which is still the most common occupational disease in developed countries, despite the reduction in the prevalence of skin diseases [2]. Healthcare workers (HCWs) are exposed to a wide range of respiratory threats, including biological and chemical substances, such as viruses and bacteria [3-5]. In recent decades, biological hazards have emerged with the emergence of certain diseases, such as severe acute respiratory syndrome (SARS), influenza A, treatment-resistant tuberculosis [6], and the re-emergence of a new coronavirus called COVID-19 [7] in the 21st century, is an increasing threat to the health of HCWs [6]. Transmission of respiratory infections occurs primarily through contact and drip trays, and surgical masks, gloves, goggles, and eye protectors are used to provide daily care for patients with acute respiratory infections [8, 9]. On the other hand, there are concerns about the transmission of respiratory particles through the air, but the results of these studies are contradictory and unproven [10-14]. However, evidence of the spread of some viruses, such as influenza and COVID-19, has recently been found in aerosols [15, 16].

Meanwhile, personal protective equipment (PPE) plays a key role in preventing transmission and infection of respiratory infections in hygienic settings. Especially in the early stages of epidemics, where usually no medication or vaccine is available [17]. The Centers for Disease Control and Prevention offers advice on the use of gloves, respiratory protection (such as disposable masks and N95), eye protection (such as goggles or facial disposable shields), and non-use of shoe covers to HCWs who come in contact with suspected patients with respiratory infections [18]. The results of a study showed that 21.2% of people reported skin

symptoms due to the use of PPE, specifically gloves, frequent hand washing, and use of various disinfectants and masks, the most common symptoms, include redness, dry skin, itching, rash, clefts, edema, pain, respectively [19]. Among the PPE types, the most popular are HCW, N95, and Surgery Masks [20]. The World Health Organization (WHO) and the Centers for Disease Control and Prevention have also recommended the use of N95 masks to prevent airborne infectious diseases [21, 22]. Due to the protection of the entry of aerosols of more than 0.3 microns by the N95 mask, the results of some studies have shown that there is an advantage to N95 masks over surgical masks. However, this finding has not been conclusively proven [8, 23-25]. With all the benefits and uses of N95 and surgery masks, there are negative physiological effects, such as shortness of breath, headache, and dizziness in patients [26, 27], and complications, such as contact dermatitis (most common) [2, 28, 29], heat around the face, difficulty breathing, acne, and headaches in HCW [30]. Comparing the two masks, a study showed that N95 masks have more permeability and local pressure than other masks, which can be associated with skin symptoms [31]. N95 and surgical masks contain formaldehyde and other preservatives that can contribute to the induction of contact dermatitis [32]. On the other hand, moisture, heat, and friction can aggravate the symptoms [2, 31]. Also, a recent study in China on HCW found that 49% reported mask-related skin reactions, the most common of which were 41.8% of facial skin problems and 17.1% of respiratory problems, respectively [31]. On the other hand, women reported a higher prevalence of skin reactions [19, 31].

Numerous nursing studies have found that the use of surgical masks and N95 respirators can present challenges for nurses. In Australia, a study showed that N95 masks were notably linked to pre-existing skin conditions, with female nurses experiencing a greater impact [33]. Additionally, a study in Iran found that PPE, such as masks, may be associated with headaches among nursing staff [34].

Given the importance of using a variety of masks for HCWs and patients, this literature review was conducted to examine the various side effects of surgical and N95 masks in HCWs.

## 2 | Methods

A thorough research was performed on PubMed and Scopus databases to find relevant articles using specific key terms selected including “side effects", "nursing”, “N95 mask”, and “surgical mask” by using medical subject headings and Boolean operators such as "AND" and "OR". In this study, 200 articles related to N95 masks, PPE, and surgical masks associated with nursing were selected. The articles about ventilation masks, as well as those published before 2000, were excluded. Additionally, to ensure that valuable studies were included, the references of the included articles were searched to identify other related studies. Eventually, the review included 50 studies that were extracted and considered relevant.

## 3 | Results

### 3.1 | Surgery and N95 Masks

In general, the two main types of masks used in health care are surgical and N95 masks. There is conflicting evidence among the results of studies to make it more effective in medical care [35]. Surgery masks are used to protect patients to prevent the transmission of microorganisms and body secretions. Surgical masks are also used to protect HCW from contact with large infectious droplets (> 5mcm) [36]. Respiratory pathogens are more common on the outer and upper surfaces of surgical masks, and the maximum use time for this type of mask is six hours. If you use this type of mask, the risk of getting the disease will increase for more than six hours [37]. The number of bacteria on the surface of surgical masks increases with increasing working time. Surgical masks can be a source of accumulation and transmission of bacteria if used for a long time, so it is recommended that HCWs be able to change their masks at rest. Also, the use of high-filtration masks, such as double-layer masks, is an effective measure to reduce mask contamination [38]. The N95 mask, approved by the National Institute for Occupational Safety and Health, is a type of face respirator [3], which uses a new technology made of propylene fabric and increases the density and performance of the filter. N95 masks filter out at least 95% of particles with a size of 300 nm or more [39, 40]. From a theoretical point of view, the N95 mask is made of four to five layers of polypropylene. The other part consists of one to two electret layers that may cause $CO_2$ to accumulate [35]. Each N95 mask should be on the person's face for a maximum of 12 hours and then replaced. If reused, it should be discarded after five days [41]. Protective breathing devices affect HCW performance and can cause physical, mental, and motor problems and increase anxiety. The use of masks can cause changes in heart rate, blood pressure, body temperature, sweating, and oxygen levels [42]. The most common complication of this type of mask is acne. Whenever nurses close the masks tightly, and as a result of the pressure caused by tightly closing this type of mask in hot and humid conditions, causes acne [39, 40]. N95 Mask has side effects such as headache [40] and tachycardia [43] in users of this mask. However, it has been

reported that such complications are due to poor mask connections [43, 44]. The side effects of N95 masks are presented in Figure 1.

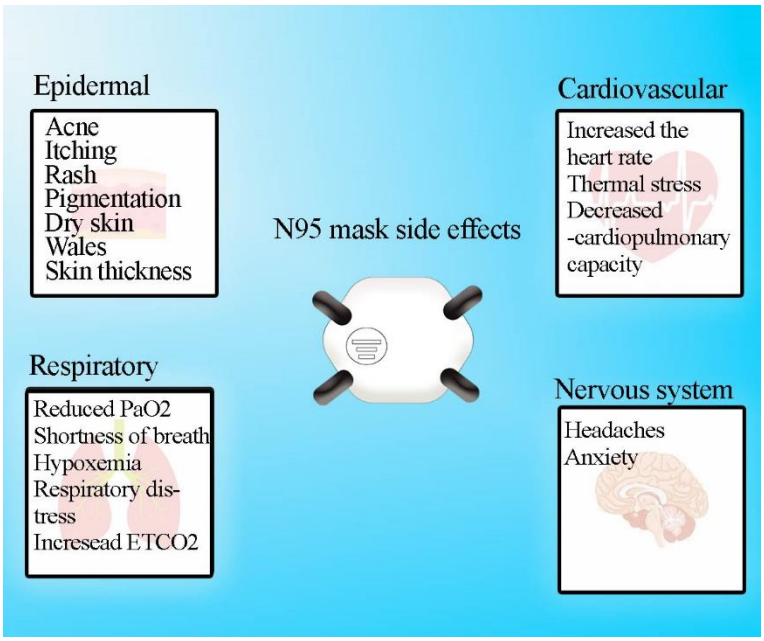


**Figure 1.** Side effects of N95 masks.

### 3.2 | Application of N95 and Surgical Masks

One of the most challenging issues in N95 and surgery masks is the permeability of these masks to viruses. According to studies, the permeability of N95 masks to viral agents may be less than 95%, especially at higher inhalation flow rates. On the other hand, the performance of surgical masks is much lower than that of N95 masks, and viral agents easily pass through them [45]. Due to the lack of sufficient evidence, there is no significant difference between the use of N95 and surgery masks to prevent the transmission of acute respiratory infections to HCWs. However, N95 masks are more efficient than surgical masks due to less permeability [8]. The use of filtering facepiece respirators with an exhalation valve (EV) and active venting system, reduces complications and pressure and ultimately facilitates HCW [46, 47]. Another study found that ambient temperature was an important factor in the comfort and effectiveness of N95 masks among HCWs. Of course, there was no significant relationship between general comfort and room humidity [48].

### 3.3 | N95 and Surgical Masks and COVID-19 Pandemic

In the COVID-19 epidemic, the use of surgical and N95 masks, as one of the most important ways to combat the increase in infection and mortality in normal people and HCWs, due to the important route of disease transmission (respiratory) Was proposed [49]. Therefore, several studies have examined the effectiveness of these two masks on SARS-COV-2. One study found that in people with COVID-19, people who used a simple mask, it was twice as high as in people who used N95 masks [50]. But in another study that looked at the use of these masks in influenza virus disease, there was no difference between using the N95 mask and surgery mask for the disease, which could be due to the different nature of COVID-19 and influenza [51]. However, given that the N95 masks can protect the HCW from over 0.3 mcm of aerosols. On the other hand, the data show that N95 masks are superior to surgical masks in preventing COVID-19 [8, 52]. Therefore, HCWs in the intensive care unit (ICU) due to the production of aerosol particles by aerosol-producing procedures, such as the use of intubation, suction, use of nebulizers, and ventilation modes such as continuous positive airway pressure, bilevel positive airway pressure, and high-flow nasal cannula oxygen pays special attention [24]. In any case, HCWs should use N95 and surgical masks to protect their safety, especially in the ICU [53]. On the other hand, in another study, surgical masks did not effectively HCW protect against SARS-CoV-2. Also, the outer surfaces of surgical masks are more contaminated than the inner surfaces [54]. Also, in nursing care, Li et al., (2021) report that healthcare systems struggle with shortages, leading to competition for supplies and reuse of N95 masks by doctors and nurses for days and weeks [55]. Further, the best compound for the rapid

deactivation of SARS-CoV-2 is Vaporized Hydrogen Peroxide (VHP), which maintains the integrity of the N95 mask under laboratory conditions. In case of shortage of respiratory protection devices, N95 masks can be used up to three times, in case of disinfection with VHP and ultraviolet rays, and also in case of disinfection of N95 masks with dry heat, it can be used up to twice. However, the correct operation of N95 masks must be ensured using qualitative testing tools [56].

### 3.4 | Noncompliance to Application of N95 and Surgical Masks

Although the use of masks in HCW is essential to prevent occupational transmission of nosocomial infections, studies have shown that non-compliance with masks is associated with the side effects of this equipment, especially a variety of masks [57, 58]. In the context of COVID-19 outbreaks, Datta et al., (2022) found that despite a universal masking mandate, compliance with face-mask usage among nursing staff remained inadequate [59]. These include difficulty breathing, physical discomforts, communication problems, overheating, and adverse skin reactions, such as itching, dry mouth, sneezing, pimples, and inability to express facial expressions. On the other hand, breathing with N95 masks can cause tolerating halitosis, patients and clients with hearing problems are unable to communicate with HCW through lip-reading [6, 60, 61].

### 3.5 | Side effects of N95 and Surgical Masks

#### 3.5.1 | Relationship between demographic characteristics and side effects of masks

Based on the results of studies, there is no significant relationship between demographic variables, such as age, sex, height, and weight of people with side effects. Nurses have been using N95 masks for a long time, so the conditions for these masks should be comfortable. There is a significant relationship between ambient temperature and ease of use of these masks, but relative humidity had no effect on comfort, and people complained of shortness of breath and discomfort in the ear lobes. Room temperature is an important factor in the comfort of wearing N95 masks [48]. Wearing masks for a long time, the temperature of the air on the face affects the overall body temperature. The acceptable time to wear respiratory protection devices at a temperature of 18 °C is one hour in the workplace, and with increasing air temperature and continuous work in hospitals, the comfort of HCW is reduced. Also, this increase in temperature affects the useful work time of the HCWs and reduces the acceptable amount of working time [43]. Due to the differences between different people in using masks, people's resistance to pressure is different. As such, some may have higher levels of anxiety. Also, some people can tolerate hot and humid conditions in masks and some cannot. Therefore, due to the uniqueness of each person, the incidence of side effects of surgical and N95 masks varies from person to person [62] and small changes in the design of N95 masks can have many effects on the fit and performance of this type of mask [63].

#### 3.5.2 | Side effects of the skin

There are few studies on skin complications due to the use of face masks by nurses and other HCWs [2, 64]. A study of people who used the N95 mask for 8 hours a day reported skin problems such as acne (59.6%), itching (51.4%), rash (35.8%), pigmentation (7.3%), scarring at the nasal bridge (3.7%), dry skin (1.8%), Wales (0.9%), increased skin thickness (0.9%), runny nose and redness (0.9%), severe asthma (0.9%), and scaling or peeling (0.9%), but those who wore surgical masks did not show any skin problems. These side effects were not related to age, sex, or race [2, 39]. In another study, in addition to N95 masks, surgical masks also caused skin complications, such as dermatitis, acne, and patches [2, 65]. Facial eczema is another side effect of the long-term use of masks, which can be prevented by using creams and ointments and placing a bandage under the edges of the mask [66-68].

#### 3.5.3 | Respiratory side effects

Using N95 masks for four hours or more significantly reduces the amount of $PaO_2$, shortness of breath, hypoxemia, and respiratory distress, and increases chest discomfort [69]. In a study of hemodialysis patients who used N95 masks, 70% had a decrease in $PaO_2$, 19% had varying degrees of hypoxemia, increased chest pressure, and respiratory distress [70]. According to a study by Rebmann et al., 90% of nurses could wear respiratory protection for two 12-hour shifts without any issues. However, the study found that carbon dioxide levels increased when comparing an N95 mask with a surgical mask to only an N95 mask. Despite this, the changes were not considered clinically relevant. Over time, the study found that perceived exertion, perceived shortness of air, complaints of headache, lightheadedness, and difficulty communicating also increased. The study also found that almost one-quarter (22%) of respirator removals were due to reported discomfort. The study observed that N95 adjustments increased over time, but other compliance measures did not vary. However, compliance increased on the second day, except for adjustments, touching under the N95, and eye touches [60].

### 3.5.4 | Side effects of surgical and N95 masks in chronic obstructive pulmonary disease (COPD) patients

Current knowledge based on past studies shows that the use of N95 masks in patients with mild respiratory diseases ($FEV_1 \geq 50\%$) does not cause significant respiratory complications. However, using the N95 mask can increase resistance to flow and dead space. Therefore, the use of an N95 mask is recommended in COPD patients to protect against particulate matter. The use of N95 masks in people with COPD who have an $FEV_1$ of less than 30% should be done with extreme caution due to the increased risk of hypoxic induction and hypercapnic respiratory failure. However, patients with COPD are advised to use N95 masks in the presence of airborne particles, but in severe COPD, which is associated with modified medical research council dyspnea scale score scores ≥3, or $FEV_1 < 30\%$, they should also consider this point, in case of headache, dizziness, and shortness of breath to remove this mask [26, 71].

### 3.5.5 | Cardiovascular side effects

According to studies, the use of respirators increases the heart rate during work in HCW [72-74]. Also, Li et al., (2005) discovered that N95 and surgical facemasks create different microclimate conditions leading to various effects on heart rate, thermal stress, and subjective discomfort among nurses' staff [43]. Fikenzer et al., (2020) also found that wearing N95 and surgical masks among healthy individuals can lead to a decrease in cardiopulmonary exercise capacity and comfort [75].

### 3.5.6 | Nervous side effects

Continued use of N95 masks for more than four hours causes headaches, and in a study, 37.3% of people who used this type of mask had headaches and used painkillers. Also, 32.9% of people had headaches more than six times a month. Therefore, shortening the time of using N95 masks can reduce the frequency and severity of headaches. Causes associated with this complication include hypoxia, hypercapnia, mechanical factors, and stress [40, 76]. Other neurological complications include anxiety in those who wear N95 masks because this factor is related to forms of natural respiration [77]. On the other hand, wearing an N95 mask for an hour does not increase the body's core temperature. Therefore, complaining of respiratory-related thermal discomfort may be rooted in the thermal sensations of the facial skin [78, 79].

### 3.5.7 | Side effects in vulnerable groups

Pregnant women have more respiratory burden due to physiological changes, increased oxygen demand, increased airway resistance, and decreased functional residual capacity due to diaphragm curvature. These have exacerbated the physiological shortness of breath during pregnancy, which can make the use of masks, especially N95, a challenging argument in pregnant women [80, 81]. In this regard, in connection with the protection of the respiratory system in HCWs, there is limited and contradictory information about some viral epidemics. In pregnant HCWs who use N95 masks, the use of this type of mask reduces $VCO_2$ (17.7%), $VO_2$ (13.8%), TV (23%), and VE (25.8%), and reduces gas exchange. and puts extra pressure on the metabolic system to provide the oxygen it needs. Long-term use of N95 masks in pregnant nurses prevents the exchange of sufficient gas and imposes an additional burden on their metabolic system, however, the use of this type of mask prevents the occurrence of dangerous infectious diseases [80]. Due to the low evidence for side effects of surgical and N95 masks in children, as another vulnerable group, however, a study showed that N95 masks in children, if specific to their age, would be acceptable [82].

### 3.5.8 | Side effects of simultaneous use of surgical masks and N95

Using N95 masks during two consecutive work shifts can cause side effects such as shortness of breath, headache, shortness of breath, increased $CO_2$, lightheadedness, and difficulty communicating over time [83]. One of the controversial challenges in using N95 masks is to adjust these types of masks on the face during work, which in turn breaks the chain of infection control. Also, in nurses who use surgical masks on N95 masks, complaints such as nausea, increased $CO_2$, shortness of breath, headache, lightheadedness, difficulty communicating with patients and colleagues, reduced comfort, reduced $O_2$, and Heart rate increased more than people who only use N95 masks [84]. Nurses with higher body mass index reported higher rates of complaints such as hypertension, shortness of breath, discomfort, nausea, warmth when wearing it, headache, lightheadedness, increased heart rate, increased $CO_2$, decreased $O_2$, and vision problems [60]. On the other hand, another study showed that there is no significant difference in heart rate, respiration rate, minute volume, current volume, oxygen, and $CO_2$ saturation through the skin with the simultaneous use of an N95 mask with or without a surgical mask [85].

## 4 | Limitations

This review encountered certain limitations. Despite conducting a thorough search across various databases, it is plausible that not all studies pertaining to this subject were discovered. Furthermore, this review solely focuses on research published in English, potentially disregarding studies written in different languages.

## 5 | Clinical implications to nursing practice

The review of studies on the side effects of N95 and surgical respirator masks can have significant clinical implications for nursing practice. Nurses play a critical role in promoting the use of PPE and ensuring the safety and well-being of patients and HCWs. One key implication is the importance of proper fitting and wearing of N95 and surgical respirator masks to minimize side effects such as skin irritation, pressure injury, and respiratory discomfort. Nurses should educate HCWs on the correct donning and doffing procedures, as well as the proper maintenance of masks to reduce the risk of adverse effects. Additionally, nurses should be vigilant for signs of side effects in patients and HCWs who are required to wear masks for extended periods. They should provide symptom management and support for those experiencing discomfort or adverse reactions, and advocate for alternative PPE options if necessary. Furthermore, nurses should be aware of the potential limitations and biases in the studies reviewed, and utilize a critical appraisal of evidence-based practice to guide decision-making in clinical settings. Collaboration with interdisciplinary teams and ongoing research are essential to addressing gaps in knowledge and improving the understanding of the side effects of respirator masks in healthcare practice.

## 6 | Recommendations for future research

Future research should focus on conducting high-quality, randomized controlled trials to evaluate the impact of different types of respirator masks on side effects. This can help establish a clear causal relationship between mask use and adverse reactions. In addition, many studies reviewed may have focused on the short-term effects of wearing respirator masks. Future research should explore the long-term effects of prolonged mask use on skin health, respiratory function, and overall well-being. Also, studies on respirator mask side effects should include a diverse range of HCWs, patients, and settings to ensure the findings are applicable to a broader population. This can help identify potential differences in side effects based on demographics, occupational roles, and environmental factors. Research should evaluate the effectiveness of interventions aimed at preventing and managing side effects of respirator masks. This can include strategies for proper mask fitting, skin protection, and respiratory support to minimize adverse reactions. Future research should investigate alternative types of PPE that may be less likely to cause side effects while still providing adequate protection. This can help healthcare providers identify the most suitable options for different clinical scenarios. By addressing these recommendations, future research can provide valuable insights into the side effects of N95 and surgical respirator masks and inform evidence-based recommendations for healthcare practice.

## 7 | Conclusions

We examined the side effects of N95 and surgery masks at HCW. A closer look at previous studies reveals that knowledge will help both researchers and health managers. Such knowledge will help to achieve a safer and more efficient human health system, which is associated with a variety of respiratory pathogens. In general, although the use of respiratory protection equipment is essential in HCW, the use of surgical and N95 masks adversely affects communication, physiological, and psychological abilities in HCW. In particular, it is severe in vulnerable people, such as pregnant women and those with respiratory problems, such as COPD. Therefore, there is a lack of training guidelines to improve the safety of HCWs. Also, HCWs, who use surgical and 95 masks at the same time against COVID-19, should be careful about the side effects.

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**Authors' contributions**

Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work: MJG; Drafting the work or revising it critically for important intellectual content: MJG; Final approval of the version to be published: MJG; Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved: MJG.

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## Availability of data and materials

The datasets used during the current study are available from the corresponding author on request.

## Using artificial intelligent chatbots

None.

## References


1. Ilboudo AK, Cissé A, Milucky J, Tialla D, Mirza SA, Diallo AO, et al. Predictors of severity and prolonged hospital stay of viral acute respiratory infections (ARI) among children under five years in Burkina Faso, 2016-2019. *BMC Infect Dis*. 2024;24(1):331.
2. Al Badri F. Surgical mask contact dermatitis and epidemiology of contact dermatitis in healthcare workers. *Curr Allegry Clin IM*. 2017;30(3):183-188.
3. Peterson K, Novak D, Stradtman L, Wilson D, Couzens L. Hospital respiratory protection practices in 6 U.S. states: a public health evaluation study. *Am J Infect Control*. 2015;43(1):63-71.
4. Honarbakhsh M, Jahangiri M, Farhadi P. Effective factors on not using the N95 respirators among health care workers: Application of Fuzzy Delphi and Fuzzy Analytic Hierarchy Process (FAHP). *J Healthc Risk Manag*. 2017;37(2):36-46.
5. Rakhshani T, Nikeghbal S, Kashfi SM, Kamyab A, Harsini PA, Jeihooni AK. Effect of educational intervention based on protection motivation theory on preventive behaviors of respiratory infections among hospital staff. *Front Public Health*. 2024;11:1326760.
6. Kablay IN, Chelule PK. Factors influencing the use of N95 Respirator among Healthcare Professionals at Nyangabgwe Hospital in Botswana. *Botswana J Afr Stud*. 2016;30(1):24-34.
7. Wang C, Horby PW, Hayden FG, Gao GF. A novel coronavirus outbreak of global health concern. *Lancet*. 2020;395(10223):470-473.
8. Smith JD, MacDougall CC, Johnstone J, Copes RA, Schwartz B, Garber GE. Effectiveness of N95 respirators versus surgical masks in protecting health care workers from acute respiratory infection: a systematic review and meta-analysis. *CMAJ*. 2016;188(8):567-574.
9. Elgendy MO, El-Gendy AO, Elgendy SO, Abdelaty LN, Abdelrahim MEA, Abdelrahman MA. Perceptions, Knowledge, and Experiences of Using Face Masks among Egyptian Healthcare Workers during the COVID-19 Pandemic: A Cross-Sectional Study. *Healthcare (Basel)*. 2023;11(6):838.
10. Chung SJ, Ling ML, Seto WH, Ang BS, Tambyah PA. Debate on MERS-CoV respiratory precautions: surgical mask or N95 respirators? *Singapore Med J*. 2014;55(6):294-297.
11. Brankston G, Gitterman L, Hirji Z, Lemieux C, Gardam M. Transmission of influenza A in human beings. *Lancet Infect Dis*. 2007;7(4):257-265.
12. Tellier R. Review of aerosol transmission of influenza A virus. *Emerg Infect Dis*. 2006;12(11):1657-1662.
13. Tang JW, Gao CX, Cowling BJ, Koh GC, Chu D, Heilbronn C, et al. Absence of detectable influenza RNA transmitted via aerosol during various human respiratory activities--experiments from Singapore and Hong Kong. *PLoS One*. 2014;9(9):e107338.
14. Hall CB. The spread of influenza and other respiratory viruses: complexities and conjectures. *Clin Infect Dis*. 2007;45(3):353-359.
15. Blachere FM, Lindsley WG, McMillen CM, Beezhold DH, Fisher EM, Shaffer RE, et al. Assessment of influenza virus exposure and recovery from contaminated surgical masks and N95 respirators. *J Virol Methods*. 2018;260:98-106.
16. Han Q, Lin Q, Ni Z, You L. Uncertainties about the transmission routes of 2019 novel coronavirus. *Influenza Other Respir Viruses*. 2020;14(4):470-471.
17. Rasouli S, Alipouri Y, Chamanzad S. Smart Personal Protective Equipment (PPE) for construction safety: A literature review. *Saf Sci*. 2024;170:106368.
18. Ong SWX, Tan YK, Sutjipto S, Chia PY, Young BE, Gum M, et al. Absence of contamination of personal protective equipment (PPE) by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). *Infect Control Hosp Epidemiol*. 2020;41(5):614-616.
19. Stoeva I, Dencheva M, Georgiev N, Chonin A. Skin reactions among Bulgarian dental students: A self-report questionnaire survey. *Contact Dermatitis*. 2019;81(4):274-279.
20. Ishido H, Oishi R, Yamazaki Y, Inoue S. The effects of a surgical mask and an N95 mask on intelligibility of explicit and ambiguous speech produced in the operating room environment. *Anesthesiol Perioper Sci*. 2024;2(2):1-7.
21. Organization WH. WHO guidelines on tularaemia: epidemic and pandemic alert and response: World Health Organization; 2007.
22. Tablan OC, Anderson LJ, Besser R, Bridges C, Hajjeh R; CDC; Healthcare Infection Control Practices Advisory Committee. Guidelines for preventing health-care--associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. *MMWR Recomm Rep*. 2004;53(RR-3):1-36.
23. Wang Q, Yu C. The role of masks and respirator protection against SARS-CoV-2. *Infect Control Hosp Epidemiol*. 2020;41(6):746-747.
24. Malhotra N, Bajwa SJS, Joshi M, Mehdiratta L, Kurdi M. Second wave of COVID-19 pandemic and the surge of mucormycosis: Lessons learnt and future preparedness: Indian Society of Anaesthesiologists (ISA National) Advisory and Position Statement. *Indian J Anaesth*. 2021;65(6):427-433.
25. Li M, Wang F, Tao M, Zhang Y, Pan R, Gu D, et al. N95 respirators alter facial skin physiological functions and lipidome composition in health care personnel. *Skin Res Technol*. 2024;30(3):e13653.

26. Kyung SY, Kim Y, Hwang H, Park JW, Jeong SH. Risks of N95 Face Mask Use in Subjects With COPD. *Respir Care*. 2020;65(5):658-664.
27. Ramoti N, Siahaan AM, Indharty S, Adella CA. Effect of face masks on dyspnea perception, cardiopulmonary parameters, and facial temperature in healthy adults. *Narra J*. 2024;4(1):e574.
28. Cahill JL, Williams JD, Matheson MC, Palmer AM, Burgess JA, Dharmage SC, et al. Occupational skin disease in Victoria, Australia. *Aust J Dermatol*. 2016;57(2):108-114.
29. Tabary M, Araghi F, Nasiri S, Dadkhahfar S. Dealing with skin reactions to gloves during the COVID-19 pandemic. *Infect Control Hosp Epidemiol*. 2021;42(2):247-248.
30. Ong JJY, Bharatendu C, Goh Y, Tang JZY, Sooi KWX, Tan YL, et al. Headaches Associated With Personal Protective Equipment - A Cross-Sectional Study Among Frontline Healthcare Workers During COVID-19. *Headache*. 2020;60(5):864-877.
31. Zuo Y, Hua W, Luo Y, Li L. Skin reactions of N95 masks and medial masks among health-care personnel: A self-report questionnaire survey in China. *Contact Dermatitis*. 2020;83(2):145-147.
32. Choi ME, Lee WJ, Ko JY, Kim KJ, Kim JE, Kim HS, et al. Facial Dermatoses Associated With Mask-Wearing in the COVID-19 Era: A Nationwide, Cross-Sectional, Multicenter, Questionnaire-based Study. *Ann Dermatol*. 2024;36(2):81-90.
33. McKenna K, Bouchoucha S, Redley B, Hutchinson A. Australian health care workers experience of PPE related side-effects. A cross-sectional survey. *Front Public Health*. 2024;12:1325376.
34. Jafari E, Togha M, Kazemizadeh H, Haghighi S, Nasergivehchi S, Saatchi M, et al. Evaluation of headache associated with personal protective equipment during COVID-19. *Brain Behav*. 2021;11(12):e2435.
35. Gralton J, McLaws ML. Protecting healthcare workers from pandemic influenza: N95 or surgical masks? *Crit Care Med*. 2010;38(2):657-667.
36. Benson SM, Novak DA, Ogg MJ. Proper use of surgical n95 respirators and surgical masks in the OR. *AORN J*. 2013;97(4):457-467.
37. Chughtai AA, Stelzer-Braid S, Rawlinson W, Pontivivo G, Wang Q, Pan Y, et al. Contamination by respiratory viruses on outer surface of medical masks used by hospital healthcare workers. *BMC Infect Dis*. 2019;19(1):491.
38. Zhiqing L, Yongyun C, Wenxiang C, Mengning Y, Yuanqing M, Zhenan Z, et al. Surgical masks as source of bacterial contamination during operative procedures. *J Orthop Translat*. 2018;14:57-62.
39. Foo CC, Goon AT, Leow YH, Goh CL. Adverse skin reactions to personal protective equipment against severe acute respiratory syndrome--a descriptive study in Singapore. *Contact Dermatitis*. 2006;55(5):291-294.
40. Lim EC, Seet RC, Lee KH, Wilder-Smith EP, Chuah BY, Ong BK. Headaches and the N95 face-mask amongst healthcare providers. *Acta Neurol Scand*. 2006;113(3):199-202.
41. Duarte LR, Miola CE, Cavalcante NJ, Bammann RH. Maintenance status of N95 respirator masks after use in a health care setting. *Rev Esc Enferm USP*. 2010;44(4):1011-1016.
42. AlGhamri AA, Murray SL, Samaranayake VA. The effects of wearing respirators on human fine motor, visual, and cognitive performance. *Ergonomics*. 2013;56(5):791-802.
43. Li Y, Tokura H, Guo YP, Wong AS, Wong T, Chung J, et al. Effects of wearing N95 and surgical facemasks on heart rate, thermal stress and subjective sensations. *Int Arch Occup Environ Health*. 2005;78(6):501-509.
44. Lange JH, Priolo G, Mastrangelo G. Respirators and headaches in industrial situations: suggesting a preventative solution. *Acta Neurol Scand*. 2007;116(1):72.
45. Bałazy A, Toivola M, Adhikari A, Sivasubramani SK, Reponen T, Grinshpun SA. Do N95 respirators provide 95% protection level against airborne viruses, and how adequate are surgical masks? *Am J Infect Control*. 2006;34(2):51-57.
46. Seng M, Wee LE, Zhao X, Cook AR, Chia SE, Lee VJ. Comfort and exertion while using filtering facepiece respirators with exhalation valve and an active venting system among male military personnel. *Singapore Med J*. 2018;59(6):327-334.
47. Lin Y-C, Wei H-C, Chen C-P. Thermoregulation and subjective thermal perception of N95 respirator users: Influence of significant workloads. *Build Environ*. 2023;228:109874.
48. Or PP, Chung JW, Wong TK. A study of environmental factors affecting nurses' comfort and protection in wearing N95 respirators during bedside procedures. *J Clin Nurs*. 2018;27(7-8):e1477-e1484.
49. Long Y, Hu T, Liu L, Chen R, Guo Q, Yang L, et al. Effectiveness of N95 respirators versus surgical masks against influenza: A systematic review and meta-analysis. *J Evid Based Med*. 2020;13(2):93-101.
50. MacIntyre CR, Wang Q, Cauchemez S, Seale H, Dwyer DE, Yang P, et al. A cluster randomized clinical trial comparing fit-tested and non-fit-tested N95 respirators to medical masks to prevent respiratory virus infection in health care workers. *Influenza Other Respir Viruses*. 2011;5(3):170-179.
51. Radonovich LJ Jr, Simberkoff MS, Bessesen MT, Brown AC, Cummings DAT, Gaydos CA, et al. N95 Respirators vs Medical Masks for Preventing Influenza Among Health Care Personnel: A Randomized Clinical Trial. *JAMA*. 2019;322(9):824-833.
52. Wang Q, Yu C. The role of masks and respirator protection against SARS-CoV-2. *Infect Control Hosp Epidemiol*. 2020;41(6):746-747.
53. Liew MF, Siow WT, Yau YW, See KC. Safe patient transport for COVID-19. *Crit Care*. 2020;24(1):94.
54. Sommerstein R, Fux CA, Vuichard-Gysin D, Abbas M, Marschall J, Balmelli C, et al. Risk of SARS-CoV-2 transmission by aerosols, the rational use of masks, and protection of healthcare workers from COVID-19. *Antimicrob Resist Infect Control*. 2020;9(1):100.

55. Li Y, Fang F, He M. Exploring the N95 and Surgical Mask Supply in U.S. Nursing Homes During COVID-19. *J Appl Gerontol*. 2021;40(3):257-262.
56. Fischer RJ, Morris DH, van Doremalen N, Sarchette S, Matson MJ, Bushmaker T, et al. Effectiveness of N95 Respirator Decontamination and Reuse against SARS-CoV-2 Virus. *Emerg Infect Dis*. 2020;26(9):2253-2255.
57. Collins AP, Service BC, Gupta S, Mubarak N, Zeini IM, Osbahr DC, et al. N95 respirator and surgical mask effectiveness against respiratory viral illnesses in the healthcare setting: A systematic review and meta-analysis. *J Am Coll Emerg Physicians Open*. 2021;2(5):e12582.
58. Xiang Ong SW, Tang YW, Linn KZ, Huan XW, Lim A, Poon CY, et al. Compliance with face mask use during the COVID-19 pandemic: a community observational study in Singapore. *Singapore Med J*. 2023.
59. Datta R, Glenn K, Pellegrino A, Tuan J, Linde B, Kayani J, et al. Increasing face-mask compliance among healthcare personnel during the coronavirus disease 2019 (COVID-19) pandemic. *Infect Control Hosp Epidemiol*. 2022;43(5):616-622.
60. Rebmann T, Carrico R, Wang J. Physiologic and other effects and compliance with long-term respirator use among medical intensive care unit nurses. *Am J Infect Control*. 2013;41(12):1218-1223.
61. Butler PS. Dental Hygiene Students Reported Physiological Symptoms Associated With Wearing an N95 Respirator Mask. 2023; Master of Science (MS), Thesis, Dental Hygiene, Old Dominion University.
62. Johnson AT. Respirator masks protect health but impact performance: a review. *J Biol Eng*. 2016;10:4.
63. Sandkovsky U, Schwedhelm M, Grayer S, Adelgren E, Rupp M. Small Changes Make a Big Difference in the Fit of N95 Respirators. *Open Forum Infect Dis*. 2017;4(suppl_1):S166.
64. Bui AN, Yu Z, Lee K, Li SJ, Tsiaras WG, Yu SH, et al. A pilot study of the impact of facial skin protectants on qualitative fit testing of N95 masks. *J Am Acad Dermatol*. 2021;84(2):554-556.
65. Yu J, Chen JK, Mowad CM, Reeder M, Hylwa S, Chisolm S, et al. Occupational dermatitis to facial personal protective equipment in health care workers: A systematic review. *J Am Acad Dermatol*. 2021;84(2):486-494.
66. Huh S. How to train health personnel to protect themselves from SARS-CoV-2 (novel coronavirus) infection when caring for a patient or suspected case. *J Educ Eval Health Prof*. 2020;17:10.
67. Hamnerius N, Pontén A, Bergendorff O, Bruze M, Björk J, Svedman C. Skin Exposures, Hand Eczema and Facial Skin Disease in Healthcare Workers During the COVID-19 Pandemic: A Cross-sectional Study. *Acta Derm Venereol*. 2021;101(9):adv00543.
68. Liu Y, Zhao H, Chen H, Li X, Ran C, Sun H, et al. Does mask wearing affect skin health? An untargeted skin metabolomics study. *Environ Int*. 2023;178:108073.
69. Scarano A, Inchingolo F, Rapone B, Festa F, Tari SR, Lorusso F. Protective Face Masks: Effect on the Oxygenation and Heart Rate Status of Oral Surgeons during Surgery. *Int J Environ Res Public Health*. 2021;18(5):2363.
70. Kao TW, Huang KC, Huang YL, Tsai TJ, Hsieh BS, Wu MS. The physiological impact of wearing an N95 mask during hemodialysis as a precaution against SARS in patients with end-stage renal disease. *J Formos Med Assoc*. 2004;103(8):624-628.
71. Kim SH, Heo R, Lee SK, Lee SW, Seo H, Kwon H, et al. The Impact of Wearing a Mask on Oxygenation and Hemodynamics in Patients with Mild to Moderate Chronic Obstructive Pulmonary Disease. *Ann Am Thorac Soc*. 2023;20(3):482-485.
72. Khodarahmi B, Dehghan H, Motamedzadeh M, Zeinodini M, Hosseini SM. Effect of respiratory protection equipments wear on heart rate in different workload. *Int J Environ Health Eng*. 2013;2(1):26.
73. Wang Y, Tse G, Li G. Running with Face Masks or Respirators Can Be Detrimental to the Respiratory and Cardiovascular Systems. *Cardiovasc Innov Appl*. 2021;6(1):45-50.
74. Alroudhan IE, Ganji KK, Hamza MO, Munisekhar MS, Sghaireen MG, Alam MK. Effect of N95 filtering facepiece respirators on dental health professionals with an emphasis on pulmonary function and heart rate: an intrasubject comparison. *Br J Oral Maxillofac Surg*. 2021;59(10):1302-1307.
75. Fikenzer S, Uhe T, Lavall D, Rudolph U, Falz R, Busse M, et al. Effects of surgical and FFP2/N95 face masks on cardiopulmonary exercise capacity. *Clin Res Cardiol*. 2020;109(12):1522-1530.
76. Zhu JH, Lee SJ, Wang DY, Lee H. Effects of Long-Duration Wearing of N95 Respirator and Surgical Facemask: A Pilot Study. *J Lung Pulm Respir Res*. 2014;1(4):97-100.
77. Wu S, Harber P, Yun D, Bansal S, Li Y, Santiago S. Anxiety during respirator use: comparison of two respirator types. *J Occup Environ Hyg*. 2011;8(3):123-128.
78. DiLeo T, Roberge RJ, Kim JH. Effect of wearing an N95 filtering facepiece respirator on superomedial orbital infrared indirect brain temperature measurements. *J Clin Monit Comput*. 2017;31(1):67-73.
79. Lakicevic N, D'Antona G, Paoli A, Bianco A, Maksimovic N, Ostojic S, et al. Behind the mask: Rethinking the use of face masks while exercising. *Sci Sports*. 2021;36(5):430-432.
80. Tong PS, Kale AS, Ng K, Loke AP, Choolani MA, Lim CL, et al. Respiratory consequences of N95-type Mask usage in pregnant healthcare workers-a controlled clinical study. *Antimicrob Resist Infect Control*. 2015;4:48.
81. Toprak E, Bulut AN. The effect of mask use on maternal oxygen saturation in term pregnancies during the COVID-19 process. *J Perinat Med*. 2020;49(2):148-152.
82. Goh DYT, Mun MW, Lee WLJ, Teoh OH, Rajgor DD. A randomised clinical trial to evaluate the safety, fit, comfort of a novel N95 mask in children. *Sci Rep*. 2019;9(1):18952.
83. Garra GM, Parmentier D, Garra G. Physiologic Effects and Symptoms Associated with Extended-Use Medical Mask and N95 Respirators. *Ann Work Expo Health*. 2021;65(7):862-867.

84. Kisielinski K, Giboni P, Prescher A, Klosterhalfen B, Graessel D, Funken S, et al. Is a Mask That Covers the Mouth and Nose Free from Undesirable Side Effects in Everyday Use and Free of Potential Hazards? *Int J Environ Res Public Health*. 2021;18(8):4344.
85. Roberge RJ, Coca A, Williams WJ, Palmiero AJ, Powell JB. Surgical mask placement over N95 filtering facepiece respirators: physiological effects on healthcare workers. *Respirology*. 2010;15(3):516-521.

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