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Personal Protective Equipment for Protecting Healthcare Staff during COVID-19 Outbreak: A Narrative Review

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Abstract

Context: The World Health Organization (WHO) declared a pandemic state as the coronavirus spread across the world. Personal protective equipment (PPE) has become a critical subject during the COVID-19 outbreak. It is necessary to prevent coronavirus transmission to healthcare workers (HCWs) as providing care. They are at high risk of exposure to coronavirus. The aim of this study was to provide a brief review of some routes of transmission of COVID-19, what, when and why PPE is recommended base on the route of transmission.

Evidence acquisition: In this review, articles were extracted from the Google Scholar, Scopus, Web of Science, and PubMed search engines. The main keywords for search were coronavirus, COVID-19, personal protective PPE, healthcare, transmission, contact, and protect.

Results: Findings showed the COVID-19 transmission rate in the HCWs that wore PPE significantly decreased. All HCWs must use appropriate and adequate PPE in order to minimize the COVID-19 transmission.

Conclusion: Although still uncertainty remains around COVID-19 transmission and it is early to have conclusion on its prevention, most of recommendations and guidance have emphasized to apply the PPE during COVID-19 outbreak among HCWs.

Key words: COVID-19; Coronavirus; Health Personnel; Personal Protective Equipment

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Context

An epidemic of severe acute respiratory syndrome coronavirus (SARS-CoV-2) first reported in Wuhan, Hubei province, china, in late December 2019 and has rapidly spread to other countries (1, 2). As of April 14, 2020, more than 1,800,000 confirmed cases of coronavirus disease 2019 (COVID-19), the disease cause by SAR-CoV-2, and more than 117,000 confirmed deaths have been reported by World Health Organization (WHO) (3).

The common clinical symptoms include dry cough, fever, dyspnoea, and myalgia/fatigue while other symptoms such as sputum production, headache, sore throat, haemoptysis, diarrhea and abdominal pain can be seen (2, 4).

SARS-CoV-2 is mainly transmitted through droplets, airborne transmission and contact and can be spread between humans such as during airway manoeuvres in infect patient, especially during tracheal intubation (5, 6).

A significant percent of cases infected with coronavirus is related to occupational exposures. COVID-19 may be the first new occupational disease in this decade. It is believed that the first occupational groups at risk were persons working in seafood and wet animal markets in Wuhan. Health care workers (HCWs) were the next high-risk group to acquire this infection. According to OSHA, high risk workers include those involved in healthcare, deathcare, laboratories, airline operations, solid waste and wastewater management, and travel to areas where the virus is spreading. Since, HCWs putting themselves at high risk from COVID-19, so that measures to prevent SARS-CoV-2 transmission in healthcare staff are an immediate priority (7).

The COVID-19 cases reported among HCWs in China and Italy up to 10% and 9%, respectively (8). WHO and Centers for Disease Control and Preventions (CDC) have recommended guidelines regarding prevention and control of the COVID-19 outbreak including the use of personal protective equipment (PPE) (9, 10).

However, prevention actions are very critical, such as droplet barrier precautions and environmental hygiene (5).

PPE can be applied to reduce the risk of COVID-19 transmission in healthcare settings (11-14). This review focuses on some routes of transmission of COVID-19, what, when and why PPE is recommended base on the route of transmission.

Routes of coronavirus transmission

Coronavirus load is highest in sputum and upper air way secretions (1). As was mentioned in the previous, this virus mainly spread by contact and droplet routes (14). In general, droplets size is above 5 µm, which is subject to gravitational forces. Hence, virus remained on surfaces will be a potential source of transmission, so that healthcare staff touching those surfaces will become infected (15). Smaller respiratory particles with size lower than 5 µm circulating in the air cause airborne transmission. Currently, coranavirus is not an airborne virus but certain procedures including aerosol generating procedures (AGPs) lead to an increased transmission risk of coronavirus (16-20). The breathing, speaking, coughing or sneezing can generate the respiratory particles. The size of the particles will vary, ranging between <1 to >500 µm or even up to 2000 µm (21, 22).

Personal protective equipment (PPE)

Healthcare workers for contact with a confirmed or suspected COVID-19 patients should use appropriate PPE based on the risk of exposure including type of activity or contact (10). PPE for HCWs is critical. Recommended PPE include surgical mask, fit-tested N95 or FFP2 respirator, gloves, gown or apron, and eye protection (23, 24). Healthcare staff should carry out all procedures for wearing and removing PPE according to correct sequence (24). In a wide variety of occupations, not only HCWs, all health personnel should be warned about the risk of COVID-19. It is essential that HCWs are trained in the limitation and proper use of PPE (7).

Types of personal protective equipment

Mask

There are two main type of masks suggested to prevent the spread of coronavirus. Surgical mask (face mask) and N95 respirator or FFP2. The performance of each mask is different based on the type and size of infection. Surgical mask is much used to protect against viruses which are transmitted and dispersed via droplets during cough and sneeze of patients (25, 26). When HCWs are 1-2m of the patient, risk reductions estimated by at least 80% (14). N95 respirators are designed to block 95% air borne particles. They prevent the spread of small infectious particles which can transmit through the air such as aerosol generating procedures. Overall, N95 respirators have the better performance than the surgical masks (27, 28).

Gown

The American National Standards Institute (ANSI) and the Association of the Advancement of Medical Instrumentation (AAMI) have suggested a classification of surgical and isolation gowns for use in health care settings. The selected type of gown should be made based on the hazard and the risk exposure. For the medium to high risk activities of HCWs as well as their direct contact with blood, body fluids, and/or other infectious materials, the surgical and isolation gowns can be applied. If the level of risk is minimal, gowns with low level of protection can be use (9).

Gloves

Center for Disease Control and Preventions (CDC) has recommended nitrile gloves, natural rubber gloves, polychloroprene gloves, and vinyl gloves. The American Society for Testing and Materials (ASTM) has provided standards to contact surfaces and COVID-19 patients. Nitrile gloves, natural rubber gloves, and polychloroprene gloves have higher minimum tensile strength and elongation rather than the vinyl ones (9).

Appropriate levels of personal protective equipment

Variety of guidelines and standards for the use of personal protective equipment (PPE) against COVID-19 have been published by many organizations for applying in medical facilities. The main parameter for appropriate choice and application of PPE is to understand the hazard and the risk level of exposure. Several key factors to assess the risk level of exposure in health setting contain source of infection, type of contact, type of transmission and spread, duration and type of tasks to be performed by the user of PPE (6, 9).

EVIDENCE ACQUISITION

The main keywords, i.e. coronavirus, COVID-19, personal protective equipment (PPE), healthcare, transmission, contact, and protect were used to search in the scientific databases. The authors reviewed the literatures published, using Web of Science, PubMed, Scopus and Google scholar search engines. Considering the title and abstract of the articles, the most relevant articles were studied and summarized. Finally, the best articles related to the context of the subject were selected.

RESULTS

In covid-19 outbreak, HCWs are at the greatest risk because of close proximity to each other and to the patients. According to Ministry of Health Singapore, among the first 25 cases of novel coronavirus in Singapore, 17 cases (68%) were probably related to the occupational exposure (29). The HCWs were also exposed to the highest transmission risk of SARS during tracheal

intubation, tracheotomy, and manual ventilation. Based on evidences, for Covid-19 and other coronaviruses, the most important and cost-effective organizational measure to prevent the transmission for HCWs is barrier precautions including the appropriate and sufficient PPE (30, 31). WHO guidance (May 2003) for MERS-CoV infection prevention and control emphasizes the application of surgical masks during the healthcare of suspected or confirmed MERS-CoV cases (32).

Seto et al. by a study on HCWs in five hospitals concluded that the risk of SARS infection is significantly reduced by using of mask. Non-infected HCWs in this study had used N95 masks (54.4%), surgical masks (30.7%), and paper masks (15.3%) (33). Therefore, it seems that considering the precautions for droplet and contact is sufficient to protect against similar infections such as SARS and COVID-19.

According to Ling Moi Lin and other studies, the use of N95 masks may result in some difficulties (34-37). Some studies during the SARS outbreak showed that HCWs had problems to tolerate this kind of mask. It was also recorded some complaints about impaired mental performance and headache in those staff maybe due to use of N95 masks. A study in Singapore reported the prevalence rate of 37.3% for headache amongst HCWs when using of N95 masks during the SARS epidemic (38). Another study on nurses enumerated the headache as one of the main factors due to incorrect use of N95 masks (39). Therefore, there is a reduction in the tolerability of using N95 masks for a prolonged time because of the headache, facial pain, and ear lobe discomfort resulting from face-masks and their head straps (40). It is more likely, the same as other coronaviruses (MERS-CoV and SARS), the novel coronavirus to be transmitted via droplets and contact. In such circumstances, the correct and proper using of surgical mask is more protective than the inappropriate and wrong applying of N95 mask (34).

Paul Anantharajah Tambyah, international guidelines from HPA UK, and CDC recommend the use of N95 respirators for MERS-CoV and novel virus, when these masks are available. They believe that the use of surgical masks may not be sufficient (32, 41, 42). The CDC and the Institute of Medicine (IOM) recommended N95 masks for healthcare setting during the influenza-A outbreak in 2009 (43, 44). However, in revised guideline of CDC in 2010, the use of N95 masks was suggested for AGPs when exposure to confirmed or suspected influenza cases. This revision was based on some evidences indicating surgical masks were as effective as N95 ones (45).

In respect of novel coronavirus (COVID-19), the CDC recommends the use of N95 masks in addition to a face shield, goggles or a powered, air-purifying respirator (PAPR) for HCWs to mitigate the risk of infection (5). In COVID-19 pandemic, a number of organizations including WHO, the European Centre for Disease Control (ECDC), and the Public Health England have recommended the use of fit-tested and fit checked high filtration FFP2 masks for HCWs. Although, some currently guidelines only recommend the FFP3 ones (6, 7, 14, 46).

Jessica J Bartoszko et al. compared the effectiveness of medical masks and N95 respirators in preventing COVID-19 infection in health care workers (47). Their findings showed that there is no significant difference between the effectiveness of tested masks. They suggested N95 masks for aerosol generating procedures (such as intubation or bronchoscopy) of COVID-19 patients and medical masks during routine and non-aerosol generating care. These findings are consistent with some studies and organizations such as WHO and Public Health Agency of Canada. In contrast, CDC and European Centre for Disease and Prevention (ECDC) recommend N95 masks for both aerosol and non-aerosol cares when these masks are readily available (22, 48).

Kangqi Ng et al. in their study on HCWs found that there is no evidence indicating N95 masks were superior to surgical masks for preventing influenza infection. However, they emphasized to wear an N95 mask or equivalent equipment during the aerosol-generating procedures (49). Therefore, many studies and evidences unanimously confirm that the use of N95 masks prevents the infection in HCWs involving in inserting breathing tubes for COVID-19 patients while the surgical (medical) masks are fine for all other routine and non-aerosol generating treatments. CDC and ECDC recommended the wearing eye protection, body protection, and gloves in healthcare setting for the care of patients with suspected and confirmed COVID-19. Goggles or face shield should be applied for protected against coronavirus transmission to the eye mucosa. To prevent the contamination of body healthcare staff to virus, it should be applied long-sleeved water-resistant gown and gloves (24).

Cook performed a review about using personal protective equipment during the COVID-19. This study demonstrated that appropriate use of PPE significantly decreases the risk of coronavirus exposure of HCWs but there is uncertainty about details of using PPE such as mask type or the potential for reuse of PPE (6).

Wang et al. studied the relation between SARS-CoV-2 transmission and N95 mask use. For these purpose, two groups were studied: doctors and nurses wore N95 masks, and disinfected and washed their hands frequently (the N95 group), and healthcare staff wore no medical masks, and disinfected and washed their hands only occasionally (the no-mask group). Results showed that among the 493 health care staff, in the N95 group 56 doctors and 222 nurses, and in no-mask group 77 doctors and 136 nurses became infected, respectively. So, COVID-19 rate in the no-mask group significantly increased compared to the N95 groups. This study emphasized that N95 mask and occupational protection measured to help decrease the COVID-19 transmission (50). Verbeek et al. examined the effect of various type of full body personal protective equipment on HCWs. The findings provided that gowns could be better protected than aprons against contamination such as coronavirus. Removal of gowns attached gloves causes less contamination rather than gown and gloves were removed separately (51).

Greenhalgh et al. in a study recommended that PPE including masks, eye protection, gloves, long-sleeved gown are needed for protecting HCWs from COVID-19 in AGPs such as intubation. Moreover, masks are only one component of protection plan, so the eye protection, gowns, and behavioral measures are needed for a complete protection against infection (52). Belingheri and Paladino emphasized on need to use of appropriate and adequate PPE for protection of HCWs in order to minimize the risk of COVID-19 transmission (53).

DISCUSSION

Since the COVID-19 transmission is not completely understood, it is still too early to have a certain and absolute conclusion on its prevention and control. Most of recent guidance and recommendations are based on the previous experiences obtained from similar outbreaks such as MERS-CoV, SARS, and influenza A (H1N1). According to conducted studies and experiments, it is believed the COVID-19 transmission to be mainly through contact and respiratory droplets or aerosols. Therefore, for all people, exact obedience to basic infection control precautions should be considered. In this regard, the most important measure is proper application of personal protective equipment based on the risk of exposure (10, 54). The highest risk persons in COVID-19 outbreak are HCWs caring of patients. Their exposure varies according to the setting and type of task and activity. In this respect, WHO in interim guidance (March 2020) has completely provided the recommendations for different circumstances in detail (10).

The highest risks are related to the aerosol-generating procedures such as airway suctioning, intubation and bronchoscopy. For these conditions, it is required the use of full PPE, including proper mask or a powered air purifying respirator, eye protection, gown, gloves, and aprons. There are different recommendations for choosing the appropriate kind of PPE. Despite of no significant difference between the effectiveness of medical masks and N95 respirators in many studies, most of evidences suggest HCWs to wear the N95 respirators for aerosol generating procedures in which they must insert a tube through a patient's throat or they are very close to the patients. These masks can fit tight and prevent inhalation of small particles as well as they can be used for extended periods without fail.

There is no compulsory advice for the use of N95 respirators to protect HCWs against respiratory infections during routine care and non-aerosol generating procedures. For these activities, the surgical (medical) masks are appropriately sufficient. Considering this point can be important in time of shortage when there is a serious concern about supplying of N95 respirators (47, 55).

CONCLUSIONS

Based on the findings, it can thus be recommended that in order to protect against to COVID-19 transmission all HCWs must use appropriate PPE including masks, eye protection, gown, and goggle. There is a need for a strategy to protect HCWs from occupationally acquired infections. This strategy help HCWs assess the potential exposures to viruses. In addition, when the exposure is unacceptable, the strategy provides guidance to select the appropriate control ways especially PPE, as an important and necessary measure.

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AUTHORS' CONTRIBUTION

All the authors met the standards of authorship based on the recommendations of the International Committee of Medical Journal Editors.

CONFLICT OF INTEREST

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