

Personal protective equipment (PPE) and infection among healthcare workers – what is the evidence?

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Abstract

The worldwide outbreak of coronavirus disease-19 (COVID-19) has already put healthcare workers (HCWs) at a high risk of infection. The question of how to give HCWs the best protection against infection is a priority. Our literature review has indicated that the degree of protection required in looking after people with COVID-19 infection, is dependent on the particular environment to which the HCW is exposed. Covering more of the body could provide better protection for HCWs. Of importance, it is not just the provision of PPE but the skills in donning and doffing of PPE that are important, this being a key time for potential transmission of pathogen to the HCW and in due time from them to others. In relation to face masks, the evidence indicates that a higher-level specification of face masks (N95) seems to be essential to protect HCWs from Coronavirus infection. Evidence specifically around PPE and protection from the COVID-19 virus is minimal and at the level of anecdotal reports only.

Background

The worldwide outbreak of coronavirus disease (COVID-19) has already put healthcare workers (HCWs) at a high risk of infection.¹ The question of how to give HCWs the best protection against infection is a priority. Reports of personal protective equipment (PPE) shortages, with regional and international differences in the approach to deployment of PPE have repeatedly made national media headlines.² During the past few months, as the UK has tackled the coronavirus pandemic, HCWs including doctors and nurses have complained of a lack of adequate PPE kit such as gowns, masks and gloves.

Many readers of this journal have been working closely with patients with COVID-19 in recent weeks, and so have a personal interest in ensuring that such evidence as exists is made available and applied in the everyday clinical setting in the UK and elsewhere.

Types of PPE

The ‘level’ of PPE is matched to the clinical environment and the procedures being undertaken. Generally the levels are categorised as standard, or those that are designed to mitigate against contact, droplet or airborne pathogens and enhanced PPE (full-body) for highly infectious or ‘high-consequence’ pathogens. A Cochrane review evaluated the effect of full-body PPE used by HCWs exposed to highly infectious diseases,

defined as causing such as Ebola Virus Disease, COVID-19 and severe acute respiratory syndrome (SARS).³ The review highlighted eight studies comparing types of whole-body PPE. Key to efficacy was a better fitting gown around the neck, wrists and hands (relative risk, RR 0.08, 95% confidence interval, CI 0.01-0.55), a better cover of the gown-wrist interface (RR 0.45, 95% CI 0.26-0.78). Covering more parts of the body could provide a better protection. For example, a powered, air-purifying respirator with coverall may protect better than an N95 mask with a gown (RR 0.27, 95% CI 0.17- 0.43). However, these conclusions were based on simulation studies with small sample sizes.³

Removal of PPE after patient contact

Removal of PPE is a sequenced procedure, with studies showing that there are high rates of doffing errors even with basic PPE. Considerable contamination can occur during PPE doffing⁴ but simulation training can dramatically improve performance⁵, although the durability of performance is uncertain. Modifications to full-body PPE could reduce contamination when it is being removed, for instance by the provision of ‘grab’ tabs to facilitate doffing of masks or gloves.³

Evidence from SARS

China has considerable experience in dealing with SARS and COVID-19, so we additionally searched the Chinese Biomedicine Literature Database to find articles published in Chinese. Three case-control studies examining PPE and HCWs infection during the SARS outbreak 2002-2004 were found, These included 276 infected HCWs and 2099 non-infected HCWs.⁶⁻⁸ The most commonly used PPEs were masks, followed by gloves, protective clothing, and goggles.⁸ These studies had similar findings that wearing any of: facemasks, gowns, gloves, goggles and footwear when caring for patients with SARS was associated with a lower risk of HCWs infection ($P < 0.05$). The combination of different types of PPEs could reduce the risk of infection. In one study, 16/26 (61.5%) of HWP (involved in SARS patient contact) without PPE were infected, whereas none was infected when using all types of PPEs recommended by WHO.^{7 9}

FFP2 face masks are similar to N95 face masks and both meet the WHO guidance for protection against COVID-19. FFP3 face masks, which are similar to N99 face masks, have a better filter performance based on the minimum filtration of 99%. All these four types of masks can block both liquid and solid aerosols.

N95 face masks, surgical face masks, cotton face masks and disposable face masks were all used by HCWs during SARS outbreak. Compared with those without facemasks, HCWs who wore more than 12-layer cotton masks had a lower risk of infection (OR 0.78, 95% CI 0.60-0.99).⁷ Two studies found that compared without wearing any masks, wearing simple paper face masks did not have a significantly protective effect.^{7 10} Ma *et al* (2004) also found that low-quality face masks (less than 12-layer cotton masks) were associated with a higher risk of infection (OR 76.68, 95% CI 16.74-351.31).⁶ Unsurprisingly, N95 facemasks, were the most efficacious in reducing HCW infection.¹¹

Tight-fitting respirators (such as disposable FFP2 masks and reusable half masks) rely on having a good seal with the wearer’s face. ‘Fit testing’ is, therefore, a critical component to a respiratory protection program whenever HCWs use tight-fitting respirators. Additionally, tight-fitting respirators, including the N95, require a user seal check each time one is put on. In simulation studies, surgical masks had poor face fit and in vivo filtration efficiency compared with N95 masks and N99 masks.^{12 13}

Use of Gloves

With regard to hand covering, although wearing gloves was associated with a lower risk of infection with SARS in some studies (70.2% and 67.3% of subjects wearing gloves),^{7 8} results have been conflicting (47.6% and 37% of subjects wearing gloves).^{10 14} The difference may be caused by the different proportion of HCWs using gloves. A case-control study included 758 HCWs who cared for SARS patients and found that wearing two layers of gloves (‘double gloving’) had a significantly enhanced protective effect compared with wearing a single layer of gloves. Double gloving serves two roles: firstly, it acts as an additional membrane should there be a breach (Using differently coloured gloves for the outer gloves may allow rapid identification of any breaches in glove integrity). Secondly, it reduces the spread of viral droplets during doffing of PPE.¹⁵

However no such additional protective effect was found in wearing double layers of gowns, multi-layered cotton masks, and head and foot coverings.¹⁶

PPE and COVID-19

We have not found any human studies about the protective effect of different forms of PPE used by HCWs exposed to COVID-19 including the use of visors. Evidence specifically around PPE and protection from Covid-19 is at the level of anecdotal reports only. Therefore all the practice in health care systems across the world is being informed by evidence from previous epidemics.

The population as a whole

In 2011, a systematic review explored whether physical interventions could reduce the transmission of respiratory viruses. They found that frequent handwashing, plus wearing gloves, gowns and masks could reduce the spread. Evidence was insufficient to support screening at entry ports or keeping social distancing to reduce respiratory infections spread.¹⁷ This is potentially an important piece of evidence in terms of how COVID-19 virus person to person spread is managed from here in the population at large.

Summary

The degree of protection required in looking after people with COVID-19 infection, is dependent on the particular environment to which the HCW is exposed. Covering more of the body could provide better protection for HCWs. However, the degree of protection required is dependent on the particular environment. Of importance, it is not just the provision of PPE but the skills in donning and doffing of PPE that are important, this being a key time for potential transmission of pathogen to the HCW and in due time from them to others.

As the first wave of the COVID-19 pandemic abates gradually, surely now is the time for an urgent review of what PPE should be used to decrease COVID-19 transmission, based on the evidence to date from health systems that have dealt with the first wave of the pandemic.

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