

COVID-19 and Personal Protective Equipment (PPE)

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In December 2019, a novel coronavirus infection was detected in Wuhan, Hubei Province, China. The virus responsible for the current outbreak was originally called novel coronavirus, now renamed SARS-CoV-2, due to its relationship with the SARS virus (viral agent responsible for the epidemic in China in 2002-2003). COVID-19 poses a greater threat to the older demographic and those that suffer from other illnesses such as diabetes, cancer, respiratory issues such as asthma and cardiovascular disease.

Due to the high rate of transmission of the disease, the WHO declared the epidemic a Global Health Emergency on January 30, 2020 and released various health alerts.

Initially it was thought that the droplet transmission is the most likely mode, however recommendations were later upgraded to airborne and contact transmission as well, due to the infection rates of disease. It was also noted that the contagiousness is very much higher than SARS

virus, and transmission of the virus can occur even before a patient shows symptoms or even a few days after they have made a full recovery. This situation was alarming and therefore, the use of Personal Protective Equipment (PPE) as a measure of mitigating the transmission of the virus in the current pandemic situation was considered to be of utmost importance for all personnel (especially medical/military/laboratory) who have

the risk of exposure to the virus. The protection of our frontline health workers is paramount, and PPE, including medical masks, respirators, gloves, gowns, and eye protection, must be prioritized for health care workers and others caring for COVID-19 patients.

Personal Protective Equipment (PPE)

The use of medical PPE extends back to the 17th century. During the bubonic plague, doctors wore a wide-brimmed hat (to defend the head), and a mask with a protruding beak extending from the nose carrying aromatic herbs (for protecting from fatal miasmatic smells) (Figure 1).

In general, PPE includes skin and eye protective equipment (medical/surgical face masks, face shields, gloves, coveralls, isolation gowns, aprons, safety shoes, helmets, and goggles) and respiratory protective equipment (respirators; i.e. N95 or FFP2 or FFP3 standard or equivalent). One of the fundamental principles of occupational health and safety is that PPE should be considered



Figure 01 : “Trust him, he’s a doctor”
An engraving of a plague doctor, circa 1656. Image via Wissen Media.



Figure 02 : (a) NIOSH- Approved N95 mask and (b) PAPR for bearded personnel

as the last line of defense, after other measures have been taken. On the other hand, the selection process of proper PPE can be tedious and time-consuming, as the specifications for PPE are technical. The better selection is achieved when the user can understand the technical details about the PPE. As far as designing of a PPE for a particular task is concerned, factors such as the following should be taken into consideration :

- Suitability and appropriateness for the risks involved
- Ensuring of compatibility in situations where the user is required to wear more than one item of PPE
- Effectiveness in mitigating the risks
- Comfort for the wearer
- Compliance with legislative standards of manufacture (EN and CE requirements)

Finally, the readiness of the PPE for the given task is achieved *via* completion of a local hazard analysis and risk assessment, coupled with a thorough review of a facility's capability to respond to significant incidents. A summary of currently available PPE options is described below.

Surgical face masks and respiratory PPE

A primary route of transmission of COVID-19 is likely to be via respiratory droplets and therefore the spread of the disease can be reduced by limiting contacts of infected individuals via physical distancing and other measures. The majority of evidence indicate that transmission of the virus through infected droplets can be reduced by wearing face masks. Therefore, it is the responsibility of every citizen to comply with the requirement to wear protective masks in public places to reduce the transmission of the disease and thereby attenuate the death toll and negate the impact on the economy.

As far as face masks are concerned, the N95 respirators (Figure 2a) (the equivalent in Europe is FFP2 respirators) are recommended for health workers who are conducting aerosol- generating procedures during clinical care of COVID-19 patients, while surgical masks are recommended for non-aerosol generating procedures. The importance of masks for health worker protection was emphasized in the early phases of the global pandemic in hospitals all around the world. Due to these recommendations, the world witnessed an elevated spike in surgical masks usage which resulted in a severe shortage of surgical masks. Various strategies were recommended to address this severe shortage, and one such recommendation was to reduce the use of surgical masks and explore options to re-use respirators after sterilization. According to the Occupational Safety and Health Administration (OSHA) regulations, health care

workers (HCW) must be properly fit-tested with either a qualitative or quantitative device to ensure the mask makes a proper seal with the wearer's skin and offers adequate protection. Users must be clean shaven for mask use as well as for the fit test. HCW with beards can use a powered air-purifying respirator (PAPR) with a hood (Figure 2b), since these function without the need for a tight skin seal and therefore do not require fit testing.

It is better to discuss more on the difference between N95 and surgical masks. N95 designation is from National Institute for Occupational Safety and Health (NIOSH), meaning it is actually a dust mist respirator which filters out 95% of small particles, but is not resistant to oil (N= Not; 95= 95% filtration efficiency).

A surgical mask (Figure 3) on the other hand, is a loose-fitting, disposable device that creates a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate environment. Even though surgical masks can prevent inhalation of large droplets and sprays, their ability to filter submicron-sized airborne particles are limited. As SARS-CoV-2 is also embedded in aerosols <5 µm in diameter, it cannot be determined



Figure 03 : Surgical mask



Figure 04 : (a) disposable patient examination gloves (b) disposable isolation gown (front and back view) (c) coverall (front and back view)

whether they are always effective. This has been experimentally proven in a case-control study comparing the protective effect of surgical masks and N95 respirators against SARS among healthcare workers in five Hong Kong hospitals. Surgical masks are not intended to be used more than once and should be discarded if the mask is damaged or soiled, or if breathing through the mask becomes difficult.

Currently, there is a global shortage of surgical masks and N95 respirators and because of this, it was recommended for healthy people to wear a cloth to cover the face in public. The use of cloth masks is a simple, economic and sustainable alternative to surgical masks. This approach will pave the way to reserve disposable surgical masks and N95 respirators for health care facilities all around the world.

(a) Contact PPE

Surgical gloves

Medical gloves (Contact PPE) (Figure 4a) are used by health

care personnel to prevent them from coming into physical contact with the virus. Medical gloves are disposable and include patient examination gloves and surgeon’s gloves. It is recommended to change the gloves when they become torn or heavily contaminated. It is also a practice to use double gloves so that the outer glove can be discarded when they become soiled or torn.

(b) Disposable gowns

Under contact PPE, several fluid-resistant and impermeable protective clothing options are available in the marketplace for healthcare personnel (HCP). These include isolation gowns (Figure

4b) and coveralls (Figure 4c). Non Sterile, disposable patient isolation coveralls are used for routine patient care in healthcare settings and they are suitable for use by frontline health workers of COVID-19. Coveralls provide a 360-degree protection because they are designed to cover the whole body, including the back and lower legs, and sometimes the head and feet as well. HCP unfamiliar with the use of coveralls must be trained and have practiced prior to using it. On the other hand, many health care personnel tend to use clothing that have a hood integrated into a zip-up gown or full jumpsuit-type clothing, with a face shield worn along with an N95 (Figure 5a) or with surgical mask (Figure 5b)



Figure 05 : Hood integrated into a full jumpsuit-type clothing, with a face shield worn along with (a) N95 and (b) surgical mask



Figure 06 : Eye wear safety includes (a) eye goggles and (b) face shields

for better protection. Even if it is more difficult to put on respirators with coveralls, it may protect better than a mask worn with a gown. However, this PPE is not that user friendly as this is usually associated with increased difficulty in putting on and removing.

Eye Protection

Eye protection is strongly recommended for workers who may be at risk of acquiring infectious diseases via ocular exposure. Eye protection provides a barrier to infectious materials entering the eye and is often used in conjunction with other personal protective equipment (PPE) such as gloves, gowns, masks or respirators. There is a wide variety in the types of protective eyewear, and appropriate selection should be based on a number of factors including the extent of the hazard. Eye protection must be comfortable and allow for sufficient peripheral vision and must be adjustable to ensure a secure fit. Eye safety wear includes eye goggles (Figure 6a), face shields (Figure 6b), full-face respirators and safety glasses.

In general, goggles are available in various styles to fit adequately over prescription glasses with minimal gaps. However, to be efficacious, goggles must fit properly (from the corners of the eye across the brow).

The downside of the goggles are that they do not provide splash or spray protection to other parts of the face. For this purpose, face shields have been introduced which can provide protection to other

facial areas. To provide a better face and eye protection from splashes and sprays, a face shield should have crown and chin protection and wrap around the face to the point of the ear. This reduces the



Figure 07 : Medical staff members wear protective clothing as they arrive with a patient at the Wuhan Red Cross Hospital in China on Jan. 25.

likelihood that a splash could go around the edge of the shield and reach the eyes. Eye goggles can also be worn alone or with a face shield. Medical staff members wearing protective clothing that include eye goggles, surgical face mask and coverall are depicted in Figure 7.

Even if PPE provides protection against diseases there are so many other issues associated with the use of PPE. Masks could induce contact dermatitis as well as contact urticarial due to adhesives, rubber in straps, metals in clips and the possibility of free formaldehyde released from the non-woven polypropylene. The tighter and

more secure N95 masks can cause significant skin damage due to the pressure on anatomic points like the bridge of the nose and across the zygoma. Additionally, due to the accumulation of moisture there can be severe skin damages and irritations. Therefore it is of utmost important to recognize the occupationally induced skin conditions due to the use of PPE, and to take preventive measures to mitigate the long term skin issues and other related complications. In addition the long term use of respirators and surgical masks can affect the oxygen intake which may cause further health issues. Therefore it should be emphasized that prolong use of these PPE can also pose a serious health hazard to healthcare workers and general public.



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