

Frontline Armours Unmasking the Masks – A Review

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Abstract

COVID-19, declared pandemic by the World Health Organisation (WHO) in 2020, is caused by the Severe Acute Respiratory Syndrome Corona Virus- 2 (SARS-CoV-2). More than 200 countries and union territories were affected all around the globe. The disease that initially began with symptoms of respiratory tract infections, then exhibited a wide range of symptoms from high fever, dry cough to severe hypoxia with ARDS, sometimes resulting even in multi organ failure. The transmission of COVID-19 primarily through the respiratory droplets and close contact with the affected individuals, affected a significant number of health care professionals and support staffs apart from the general

population. An alarming number of doctors and other health care workers affected in certain countries brought out the importance of personal protection of the health care workers. Various protective equipments, from PPEs to facemasks are being utilised to safeguard the health care workers and in turn prevent further transmission in hospitals. This paper highlights the utility of face masks, their significance in warding off infection, use, care and disposal of the same.

Keywords: Facemask, COVID 19 Infections

Introduction

The end of 2019 saw an unexplained surge in pneumonia cases that spread in Wuhan, China. This led to the outbreak of a viral pandemic in a scale that has not been

seen since a century last. On February 11, 2020, the International Committee on Taxonomy of Viruses (ICTV) labelled this virus as SARS-CoV-2 and the WHO announced a standard format of Corona Virus Disease-2019 (COVID-19) for the pandemic^[1]. All 3, the SARS-CoV, MERS-CoV and the SARS-CoV-2, come under the β subgroup of the corona virus family^[2]. Biophysical and structural evidences suggest that SARS-Cov-2 binds to ACE-2 with an affinity that is 10-20 folds higher than the previous SARS-CoV^[3]. Several properties of this virus make prevention difficult namely, non-specific features of the disease, the infectivity even before onset of symptoms in the incubation period, transmission from asymptomatic people, long incubation period, tropism for mucosal surfaces such as the conjunctiva, prolonged duration of the illness and transmission even after clinical recovery. The greatest risk in COVID-19 is transmission to healthcare workers^[4]. Infection preventive and control (IPC) measures that may reduce the risk of exposure include the following: use of face masks; regular hand washing with soap or disinfection with hand sanitizer containing at least 60% alcohol (if soap and water are not available); avoidance of contact with infected people and maintaining an appropriate distance as much as possible^[5]. Face masks help in prevention of spread of the infection to a large extent. The appropriate use of facemasks and respirators is important to provide the desired level of protection; however, it requires knowledge, training, and supervision. Compared with other types of PPE, adherence with facemask and respirator use is traditionally low, despite expert recommendations. The methods of use, benefits and disadvantages of masks is elicited below.

Face Masks

Initially in 1897 Johann von Mikulicz Radecki described a surgical mask composed of one layer of gauze, After that mask has undergone various variations in layers, size, filters, materials used etc^[6]. Different types of masks have been used since then for various purposes.

Different types of Mask

Dust mask: A dust mask is a flexible, moulded, disposable mask made of paper pad. It is worn for comfort against non-toxic dusts generated by house dusting, grass mowing, gardening, sweeping, brickwork, fibre glass and during sand storms. This mask does not offer any protection against COVID-19 and should not be used^[7]

Single layer face mask: The single layer face mask is made up of a single layer of non-woven fabric or wood

pulp tissue paper and is generally used in the food processing industry. It is to be used only for single use and should never be washed and reused^[7]

Cloth Masks: Commonly used by the general population in developing countries, these masks are made of cloth fabrics and are reused. Rengasamy and colleagues tested the filtration performance of various types of cloth masks and concluded that respiratory protection is minimal by cloth masks but that certain types of cloth fabric may have more protective value than others^[8].

Generally, the filtration capacity improved when the number of threads increased in the gauze and the mesh become finer compared to course gauze with lower thread counts and also with increasing the number of layers in the mask^[9]. Certain types of cloth provides better protection than other; e.g. fine muslin (loosely-woven cotton fabric) was better than the gauze, gauze padded with cotton were better than simple gauze or paper masks and towels were more effective than other fabrics. Cloth masks were generally found to be effective against large particles (>4 μm)^[10]

Surgical mask: Surgical face masks are disposable and generally made up of three or four layers, with two filters that prevent passage of material greater than 1 micron, therefore trapping bacteria of that size or larger. Face masks of this type are claimed to provide protection for a minimum of four hours^[11] FDA recommends that manufacturers demonstrate surgical mask performance in 4 areas: fluid resistance, filter efficiency, differential pressure, and flammability. Two types of filter efficiency tests are recommended: (1) particulate filtration efficiency (PFE) using a non-neutralized aerosol of 0.1 μm latex spheres and (2) bacterial filtration efficiency (BFE) using a non-neutralized $3 \pm 0.3 \mu\text{m}$ Staphylococcus aureus aerosol^[12]

Respirators (N95, N99, N100; FFP1, FFP2, FFP3)

The respirator mask, available in the USA as N95 mask and in the UK as an equivalent FFP ('filtering face piece') mask, is used to prevent the user from inhaling small airborne particles in aerosol-generating procedures (AGPs). It must fit tightly to the user's face. There are three categories: FFP1, FFP2 and FFP3. N is of N95, N99 and N100 types^[13]



Fig 1: A- Dust mask, B- Single layer face mask, C- Cloth Masks, D- Surgical mask, E- N95 and FFP2 Respirator, F- No valve & valve N95 Respirator.

Dr. Checchi et al have reported that respirators have a superior filtration efficiency compared to the surgical masks [14] Respiratory masks are certified N, P and R depending on their ability to offer resistance to oil-based particles. N stands for ‘not oil resistant’, these masks can only be used for particles that do not contain oil. R stands for ‘somewhat resistant to oil’ and has a service life for at about 8 hours, and P stands for ‘strongly oil proof’ which has a service life for at least 40 hours. P and R are only used in industrial settings [7]

| | | FILTRATION OF PARTICLES $\geq 0.3 \mu\text{m}$ | RESISTANCE TO BREATHING | INTERNAL LEAKAGE | USE IN COVID-19 | FILTRATION OF |
|------|-----------|--|-------------------------|------------------|-----------------|---|
| N95 | VALVE | 95% | Moderate | Nil | Not used | Particulate matter pollution, bacteria, viruses, fungi |
| | NON-VALVE | 95% | Mild | Nil | Yes | |
| N99 | VALVE | 99% | Moderate | Nil | Not used | Particulate matter pollution, bacteria, viruses, fungi, oil (up to 8 hours) |
| | NON-VALVE | 99% | Mild | Nil | Yes | |
| N100 | | 99.97% | Severe | Nil | Yes | Particulate matter pollution, bacteria, viruses, fungi, oil (up to 40 hours) |
| FFP1 | | 80% | Mild | 22% | Not used | Low levels of dust eg. Home renovation, hand sanding, drilling, cutting |
| FFP2 | | 94% | Mild | 8% | Yes | Moderate level of dust eg. Construction, agriculture Particulate matter pollution, bacteria, viruses, fungi |
| FFP3 | | 99-99.95% | Moderate to Severe | 2% | Yes | High level of dust eg. Asbestos, pharmaceutical industry dust Particulate matter pollution, bacteria, viruses, fungi |

Fig 2: Respirators and Their Properties

The WHO COVID-19 IPC GDG (COVID-19 IPC Guidance Development Group) considered all available evidence on the COVID-19 virus modes of transmission and on medical mask versus respirator use to protect health workers from infection, its level of certainty, as well as the potential benefits and harms, such as

development of facial skin lesions, irritant dermatitis or worsening acne, or breathing difficulties that are more frequent with respirators [15]

The GDG acknowledged that in general, health workers have strong preferences for highest protection possible to prevent COVID-19 infection and, therefore, place high value on the potential benefits of respirators in settings without Aerosol generating procedures (AGPs),

In the absence of AGPs, WHO recommends that health workers providing direct care to COVID-19 patients, should wear a medical mask (in addition to other PPE that are part of droplet and contact precautions) [15]

In care settings for COVID-19 patients where AGPs are performed (e.g. COVID-19 intensive and semi intensive care units), WHO recommends that health workers should wear a respirator (N95 or FFP2 or FFP3 standard, or equivalent).

Although countries such as Australia, Canada and the United States of America do not recommend the use of face masks for specific population as a means to limit the potential spread of COVID-19, health officials in countries like China, Indonesia, and the Philippines have supported the use of face masks to limit the spread of COVID-19 in the community. Some researchers from Canada felt that often masks are not used properly by the general population and may do more harm than good as it may not cover the eyes, may be ill fitting and people may often touch their eyes and nose while adjusting them. And also masks may give a person a false sense of security and are likely to increase the number of times a person will touch their own face to adjust the mask, etc. So there were contradicting recommendations provided by public health professionals and entities of different countries, which created a lot of confusion and lack of clarity about the effectiveness of wearing face masks in limiting the spread of COVID-19 among those who are not medically diagnosed with COVID-19 globally. Some of the recommendations provided to the public suggest that the incorrect use of face masks may have potential risks which were discussed earlier. These potential risks can be minimized by educating the public about the potential risks and how to correctly use face masks to prevent the risks associated [16].

Masks provide a physical barrier from external viruses and hence reduce the risk of respiratory virus infections. A recent study conducted in Wuhan this year revealed that SARS-CoV-2 can travel up to 4 m (≈ 13 feet) from patients

and can be widely distributed on daily objects (e.g. floors, computer mice, trash cans) The influenza virus RNA in respiratory droplets and coronavirus RNA in aerosols can be prevented by surgical masks. The aerosols in the SARSCoV-2 infection, mainly appears in submicron region (dp between 0.25 and 1.0 µm) and supermicron region (dp > 2.5 µm) and the use of surgical masks or N95 masks can effectively filter out these aerosol particles. Recent statistical evidence and comparison of the incidence of COVID-19 in Hongkong, China with Spain, Italy, Germany, France, U.S., U.K., Singapore, and South Korea has proved that community wide use of may assist in controlling COVID-19 by decreased contact with infected saliva and respiratory droplets from mildly symptomatic patients^[17].

Health care workers (HCW's) are at a high risk of contracting infection due to the close proximity of working and long hours of contact with the infected patients. A recent metaanalysis conducted during the current Covid 19 pandemic proved that usage of masks by the health care workers was instrumental in preventing the risk of infection by 80%. The study revealed that none of the 278 HCWs wearing N95 masks in quarantined areas were infected by SARS-CoV-2 infection, while 10 of the 215 HCWs who did not wear masks in the open areas were infected . Therefore, universal masking of HCWs at clinical settings is likely to provide great benefits for HCWs especially during current COVID-19 pandemic. With the community spread which has begun in the country mandatory universal masking for all is also recommended as a recent COVID19 dynamics modeling study suggested that broad adoption of even relatively ineffective non-medical grade “social” masks may meaningfully reduce the community transmission and reduce peak hospitalizations and deaths during the current COVID-19 pandemic. Since the people with older age, immunosuppressed state and systematic commodities are at higher risk for severe COVID-19 infection prophylactic use of facemasks is also recommended for them^[17].

A recent case control study conducted by Zhang et al found that passengers on an international flight who were always wearing their masks did not contract H1N1, and recently a man wearing a mask at an international flight who tested positive for COVID-19 was reported while the other 25 copassengers and flight attendants were all tested negative, further validating the benefits of wearing masks during public transportations. Wearing of masks reduced

the risk of influenza, SARS, and COVID-19 infection by 45%, 74%, and 96%, respectively, which were consistent with previous meta-analyses during the SARS outbreaks. This implies that proper use of masks has an impact on the effectiveness of preventing respiratory viral infections to a large extent^[17].

The effects of wearing masks on different geographic locations, revealed that wearing masks provided protective effects in both Asian countries and western countries by 69% and 55%, respectively. Both Asian and western countries showed reduced risk for HCWs by the use of face masks. Even for non-healthcare populations, reduced risk of 54% was found in western countries, and a reduced risk of 49% was found in Asia due to the usage of masks. This would suggest that the proper use of masks might play a significant role in public health efforts to suppress the spread of RVIs, regardless of the geographic locations, especially during a pandemic^[17].

| TYPE OF MASK | HEALTH CARE WORKER | TRANSMISSION | HOSPITAL SETTING | ACTIVITY |
|---------------|-------------------------------|--|--|--|
| Medical masks | Health care worker/ Caregiver | Confirmed/ Suspected Community transmission | -Health care facility including primary, secondary, tertiary care levels & outpatient care | - In patient care area, regardless of whether patients are confirmed of COVID-19 or not. - No routine activity among patients - Direct contact or a min distance of <1m cannot be maintained |
| | | | -Community | - Community outreach programs |
| | | | -Home care | -When in direct contact or min distance cannot be maintained |
| | | Sporadic transmission | -Health care facility including primary, secondary, tertiary care levels & outpatient care | - Providing any patient care |
| | Other scenario | | - Health care facility including primary, secondary, tertiary care levels & outpatient care | When in contact with suspected or confirmed COVID-19 cases |
| | | -Health care facilities where aerosol generating procedures are performed - Home care | Performing aerosol generating procedure/ providing care around such procedures performed on suspected or confirmed COVID-19 patients | |

Fig 3: WHO guidelines (June 2020) for use of masks by healthcare workers based on transmission scenario, hospital setting and activity

| WORKER SETTING | ACTIVITY | RISK | RECOMMENDED MASK | ADDITIONAL INSTRUCTIONS |
|--|---|---------------|----------------------------|--|
| Administrative staff | Providing administrative support | No risk | No mask | No contact with patients of COVID-19. They should not venture into areas where suspect COVID-19 cases are being managed. |
| Sanitary staff | Cleaning frequently touched surfaces/ Floor/ cleaning linen | Moderate risk | N95 | |
| Visitors accompanying young children and elderlies | Support in navigating various service areas | Low risk | Triple layer medical mask | No other visitors should be allowed to accompany patients in OPD settings. The visitors thus allowed should practice hand hygiene. |
| CSSD/Laundry | Handling linen of COVID patients | Moderate risk | N95 | |
| Healthcare staff working at quarantine facility | Health monitoring and temperature recording | Low risk | Triple layer masks | |
| | Clinical examination of symptomatic persons | Moderate risk | N95 | |
| Support Staff in Quarantine facility | | Low risk | Triple layer medical masks | |
| ASHAs/ Anganwadi and other field staff | Field surveillance | Low risk | Triple layer masks | Maintain distance of one meter. Surveillance team to carry adequate triple layer masks to distribute to suspect cases detected on field surveillance |
| Laboratory | Sample collection | High risk | N95 | |

Fig 4: Guidelines from MOHFW for requirement of type of mask for healthcare workers other than doctors during COVID-19

Below are a few guidelines suggested for the proper usage of masks

How to properly wear a mask?

1. Clean your hands with soap and water or hand sanitizer before touching the mask.
2. Remove a mask from the box and make sure there are no obvious tears or holes in either side of the mask or any other part of the mask.
3. Determine which side of the mask is the top: The side of the mask that has a stiff bendable edge is the top and is meant to mould to the shape of your nose.
4. Determine which side of the mask is the front: The coloured side of the mask is usually the front and should face away from you, while the white side touches your face.
5. a. Face Mask with Ear loops: Hold the mask by the ear loops. Place a loop around each ear.
b. Face Mask with Ties: Bring the mask to your nose level and place the ties over the crown of your head and secure with a bow.
c. Face Mask with Bands: Hold the mask in your hand with the nosepiece or top of the mask at fingertips,

allowing the headbands to hang freely below hands. Bring the mask to your nose level and pull the top strap over your head so that it rests over the crown of your head. Pull the bottom strap over your head so that it rests at the nape of your neck.

6. Mold or pinch the stiff edge to the shape of your nose.
7. If using a face mask with ties: Then take the bottom ties, one in each hand, and secure with a bow at the nape of your neck.
8. Pull the bottom of the mask over your mouth and chin.
9. Once the mask is secured to your face do not touch your face or adjust the mask. If you do, you MUST wash your hands for 20 seconds with soap and water before touching anything else.

How to remove your mask?

1. Clean your hands with soap and water or hand sanitizer before touching the mask. Avoid touching the front of the mask. The front of the mask may be contaminated. Only touch the ear loops/ties/band. Follow the instructions below for the type of mask you are using.
2. Before removing the mask or touching ear loops/ties/bands, bend forward slightly at the waist so the mask is away from your body and clothing.
3. Face Mask with Ear loops: Hold both of the ear loops and gently lift and remove the mask.
4. Face Mask with Ties: Untie the bottom bow first then untie the top bow and pull the mask away from you as the ties are loosened.
5. Face Mask with Bands: Lift the bottom strap over your head first then pull the top strap over your head.

Disposal of a face mask^[18]

1. After removal or whenever you inadvertently touch a used mask, clean hands by using an alcohol-based hand rub or soap and water if visibly soiled.
2. Replace masks with a new clean, dry mask as soon as they become damp/ humid.
3. Do not re-use single-use masks. Discard single-use masks after each use.
4. Avoid shaking or other activity that may increase the possibility of dispersing droplets in the air.
5. Place the mask in a plastic bag, double bag in a second plastic bag and then throw the double bagged mask in the trash. Do not touch your face until you clean your hands with soap and water or hand sanitizer.

Potential benefits^[15]:

The likely advantages of the use of masks by healthy people in the general public include:

- Reduced potential exposure risk from infected persons before they develop symptoms
- Reminding people to be compliant with other measures (e.g., hand hygiene, not touching nose and mouth).
- Potential social and economic benefits: Amidst the global shortage of surgical masks and PPE, encouraging the public to create their own fabric masks may promote individual enterprise and community integration.
- The safe re-use of fabric masks will also reduce costs and waste and contribute to sustainability.

Disadvantages

1. Inability of the surgical mask to obtain an appropriate seal compared with the N95 respirator²¹. Due to high demand, supply may be limited. They are for single use only.
2. N95 masks have significantly lower air and water vapour permeability than surgical masks. This makes it less breathable while wearing it for prolonged periods. They are also low on the comfort for longer use^[20]
3. The inner surface of the N95 masks are water absorbent leading to the contaminated droplets to be retained in the inner layer^[20]
4. Potential increased risk of self-contamination due to the manipulation of a face mask and subsequently touching eyes with contaminated hands^[21&22]
5. Potential self-contamination that can occur if nonmedical masks are not changed when wet or soiled. This can create favourable conditions for microorganism to multiply.
6. Potential headache and/or breathing difficulties, depending on type of mask used;
7. Potential development of facial skin lesions, irritant dermatitis or worsening acne, when used frequently for long hours²⁵.
8. Difficulty with communicating clearly.
9. A false sense of security, leading to potentially lower adherence to other critical preventive measures such as physical distancing and hand hygiene¹⁶
10. Waste management issues; improper mask disposal leading to increased litter in public places, risk of contamination to street cleaners and environment hazard.

11. Difficulty in wearing them, especially for children, developmentally challenged persons, those with mental illness, elderly persons with cognitive impairment, those with asthma or chronic respiratory or breathing problems, those who have had facial trauma or recent oral maxillofacial surgery, and those living in hot and humid environments¹⁶

Conclusion

This review focuses on the protocols to be followed for the use of face masks by frontline health care professionals, community health workers and general public. The use of personal protective equipment for coronavirus disease (COVID-19) has been controversial, with differing guidelines issued by different agencies. Future studies to explore the efficacy of masks in preventing Covid 19 infections are needed.

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