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*A Review*

# Reusability of face-masks: Facing the pandemic

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■ **ABSTRACT :** An unhealthy person can act as carrier to transmit the pathogens like virus, bacteria through respiration, if proper face covering in the form of face mask is not used by them to block the spreading of tiny droplets. Studies show that an infectious aerosol remains in the air for more than 6 hours after release. Respiration via inhalation or exhalation accompanied with sneezing or coughing by infected people gathered in group at society or park or any other public places is one of the common modes of transmission of this pandemic due to COVID19. Understanding the importance of taking adequate preventive actions like frequent cleaning of hands, using face masks that provide concealment to nose and mouth without any gap for air leakage can assist in protecting the individual, family and community at large from this deadly virus. This review article highlights various facets related to face mask and how they act as barrier against such harmful pathogens.

■ **KEY WORDS:** Face mask, COVID 19 pandemic, Properties, Function, Material, Efficiency

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To prevent and manage infectious diseases such as respiratory disorders, the primary line of defense ought to be to stop exposures by using different control measures like isolation, quarantine, limiting or closing group/cluster gatherings, or using victimization native exhaust ventilation. Once such measures don't seem to be effective or absolutely possible; measures like metabolic enhancement, process hygiene/cough rules and hand-washing or sanitizing maybe helpful. Personal protection for respiratory tract will provide the last line of defense. Within the workplace scenario, the Occupational Safety and Health Administration (OSHA), in its Federal Regulation 29, Part 1910.134, stated that any business which is run during pandemic situations should provide respirators to employees so that their exposure to all types of hazards will be minimized, some of the hazards include fumes, dust, vapors. These standards also extend to workers who are working in environments where tuberculosis exposure is likely. The performance of respirators or medical masks depends on the potency of the filter *i.e.* how well its able to collect mobile particles and how well it prevents outpouring of the fine particles from the face piece.

## Filtration theory of airborne particles:

Filters utilized in the respirators and medical masks should permit the user to breath and the micro particles should not clog the air ways making it difficult to breathe. Once the particles adhere to the mask fibres it will be a problem for air flow. Respirators and medical masks filters are usually composed of mats of nonwovens and fibrous material like wool felts, fibreglass papers or polypropylene. The fabric composed will create a tortuous path and varied mechanisms resulting in the adhesion of the particles to the fibres while not essentially obstruction of the open spaces which still permit the air flow simply across the filters (Revoir and Bien, 1997).

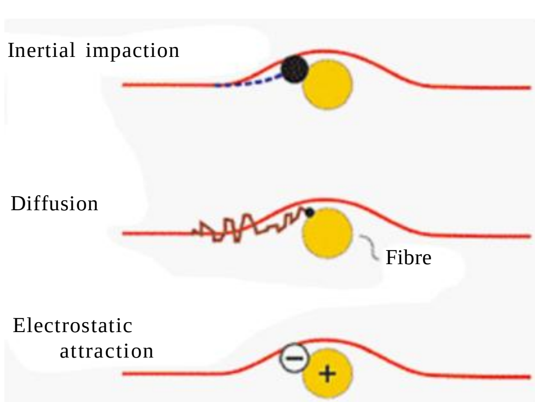
The model postulates that mechanical phenomenon impaction is effective for aerosol particle that is approximately one micrometer and larger. Such particles have enough inertia that they can't simply flow around the respirator fibres, rather than flowing through the filter material, the massive particles deviate from the air ways streamline and touch the fibres and will persist with or be caught in them. For a lot of smaller particles those who are zero to one micrometer and smaller diffusion is considered a good filteration mechanism.

**Materials and components used in medical masks:**

The filtering materials of medical masks are usually non-woven. These materials were initially natural fibres, but later stages with greater prominence with the introduction of the artificial or synthetic thermoplastics in particular polypropylene, about forty years ago. Spun bonded polypropylene could be a material of structure within the class of non-woven textile material. The salient advantages of non-woven technology is that the ability to supply materials or structures at considerably lower value than the older fabric generating techniques of weaving or knitting of spun yarns.

One the particles are trapped by a filter, they're tightly held through van der Waals bonding and alternative

Filtration mechanisms



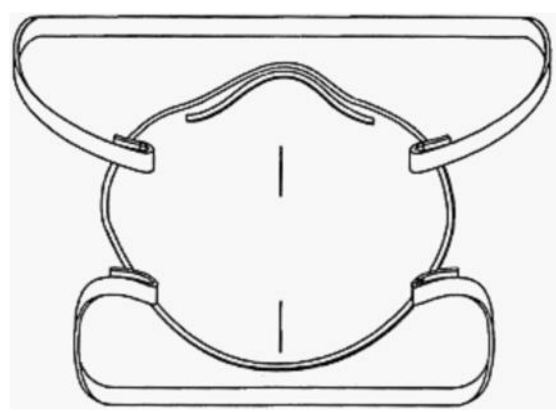

forces to the fibres, which makes it difficult to the trapped particles to escape or flee. However, multiplied/ increased loading becomes a haul once enough particles are captured to start to block the open spaces or areas of the woven or non woven network. This blockage leads to a buildup in pressure drop and a rise in resistance that eventually makes it troublesome to breathe while wearing a respirator. Heavy loading of filters might also increase the power to dislodge particles that have already been captured. Little or no analysis has been conducted on the characteristics of filters in relation with loading, it need further extensive research to overcome this situation.

**Face-pieces:**

The face pieces of negative pressure respirators embody filtering. Face pieces and elastomeric full and half facemasks that use interchangeable filter components (BLS, 2002). N9 filtering respirators face masks and half masks elastomeric respirators cover the wearers nose and mouth whereas full face mask additionally defend the eyes by also protecting the eyes.

**N95 respirators:**

Most filtering face piece respirators are factory made solely within the N95 configuration, for different health care settings. The term N95 respirators have become similar to N95 filtering face piece respirators.



Wearers of negative-pressure respirators should be shaven as facial hair has been shown to interfere with the protection fringe and sealing off the respirator, and they should be fit-tested to ensure/confirm that the respirator properly seals to the face.

| **Table 1 : Functions performed by respirators and masks** | |
|---|---|
| Currently available masks | Function |
| Respirator (all NIOSH- approved N95 or better) | – Blocks particles < 100 µm from being inhaled |
| Surgical N95 | – Blocks particles < 100 µm from being inhaled<br>– Reduces the transfer of respiratory droplets to others<br>– Blocks blood or other potentially infectious materials from reaching the wearer's skin, mouth, or mucous membranes<br>– Keeps droplets and larger particles from being inhaled<br>– Requires filtration of all air reaching the mouth/nose for 5 µm particles and larger |
| Medical mask | – Reduces the transfer of respiratory droplets to others<br>– Blocks blood or other potentially infectious materials from reaching the wearer's skin, mouth, or mucous membranes<br>– Keeps droplets and larger particles from being inhaled. Requires filtration of all air reaching the mouth/nose for 5 µm particles and larger |
| Woven cotton (or other fabric masks) and improvised protection | – Reduces the transfer of respiratory droplets to others |

Published studies examined that the total inward leakage of the respirators which are worn by the subjects who are properly fit tested and trained with a totally practical N95 filtering face piece. These studies have that about ninety five percentage of the subjects have atleast 80-90 per cent protection from the test particulate contaminants. In alternative words the respirators allowed not more than 10- 20 per cent of the contaminants to have passed through the wearers mask (CDC, 1998 and Coffey *et al.*, 1999).

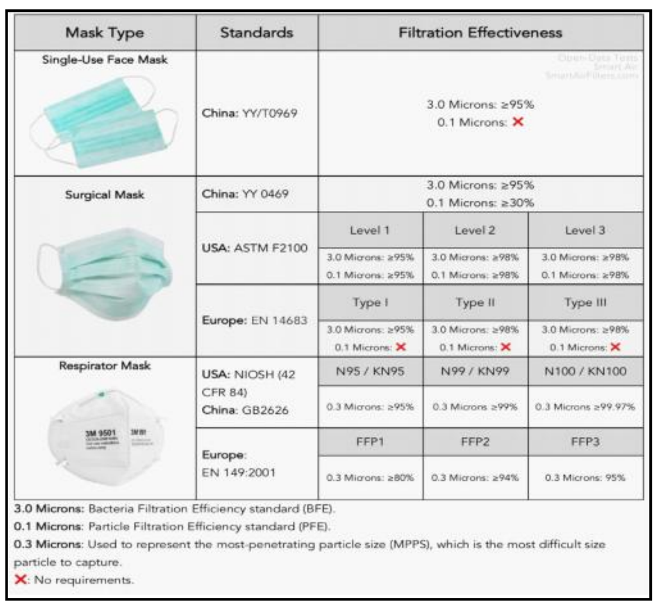
## Properties of medical masks:

The loose fitting of the most medical masks leaves gaps that would permit substantial stuff escape and contaminants leaking into and from the mask. Masks approved by Federal Drug Agency for medical use are designed to be worn by an infected person, health-care employees, or member of the general public to reduce or scale back the transfer of body fluids which will unfold infection. Medical masks are also used as barriers against illness transmission by fluids, particularly blood, and large droplets and those are designed to stop the release large droplets to surrounding environment, generated by the wearer. They're not designed or approved for the aim of protecting the wearer against entry of infectious aerosolized gaseous particles potentially surrounding the wearers mask.

Surgical masks were initially designed to protect the operating field from contaminants which are generated by the wearers are of two types: flat-pleated or duck-billed in shape, conforming to the bridge of the nose with a flexible piece, affixed to the head with two ties and pre-molded, conforming to the bridge of the nose with a flexible piece, and adhering to the head with a single elastic.

The masks are tested using a 0.1 µm polystyrene latex sphere aerosol test and Staphylococcus aureus filtration test in accordance with American Society for Testing and Materials (ASTM) standards (ASTM, 2001 and 2003).

The innermost layer get in touch with with the wearer's face and is created of nonwoven, air-laid paper material which is resistant to liquid and designed to be soft. It is meant to avoid facial hair, perspiration, and saliva from meddling with or exiting the facemask. The second layer is made-up of nonwoven, liquid-resistant,



| Mask Type | Standards | Filtration Effectiveness | | |
|---|---|---|---|---|
| Single-Use Face Mask | China: YY/T0969 | 3.0 Microns: ≥95%<br>0.1 Microns: ✕ | | |
| Surgical Mask | China: YY 0469 | 3.0 Microns: ≥95%<br>0.1 Microns: ≥30% | | |
| | USA: ASTM F2100 | Level 1 | Level 2 | Level 3 |
| | | 3.0 Microns: ≥95%<br>0.1 Microns: ≥95% | 3.0 Microns: ≥98%<br>0.1 Microns: ≥98% | 3.0 Microns: ≥98%<br>0.1 Microns: ≥98% |
| | Europe: EN 14683 | Type I | Type II | Type III |
| | | 3.0 Microns: ≥95%<br>0.1 Microns: ✕ | 3.0 Microns: ≥98%<br>0.1 Microns: ✕ | 3.0 Microns: ≥98%<br>0.1 Microns: ✕ |
| Respirator Mask | USA: NIOSH (42 CFR 84)<br>China: GB2626 | N95 / KN95 | N99 / KN99 | N100 / KN100 |
| | | 0.3 Microns: ≥95% | 0.3 Microns ≥99% | 0.3 Microns ≥99.97% |
| | Europe: EN 149:2001 | FFP1 | FFP2 | FFP3 |
| | | 0.3 Microns: ≥80% | 0.3 Microns: ≥94% | 0.3 Microns: 95% |

**3.0 Microns:** Bacteria Filtration Efficiency standard (BFE).
**0.1 Microns**: Particle Filtration Efficiency standard (PFE).
**0.3 Microns**: Used to represent the most-penetrating particle size (MPPS), which is the most difficult size particle to capture.
✕: No requirements.

melt blown, polypropylene material designed to act as a barrier against bacterium, body fluids, and particulate contaminants. The outer-most layer is created of nonwoven, liquid-resistant, thermo-bond, polypropylene cloth designed to be the primary contact filter barrier layer against body fluids and liquid particulate contaminants from outside the wearer's medical mask. The three-ply thick structure is amalgamated through ultrasonic heat-sealing. The medical mask is secured to the wearer's head and face by either ear loops or head ties. The mask might have a nose piece manufactured from malleable aluminum wire. Masks with splash visors have associated with antifog treated plastic screen.


While high performance surgical masks can exceed 99 per cent filtration efficiency at 0.1 µm, there aren't any pass/fail criteria for filtration. The test data is an indicator of quality, and masks which are needed to perform atleast as good as other masks currently present on market. The Association of Peri operative Registered Nurses suggests that surgical masks ought to filter bacterium at least 0.3 µm in size for normal use and 0.1 µm in size to be used in optical, laser surgery, or they should offer 90 to 95 per cent bacterial filtration potency (AORN, 2005). Whereas there is no methodology to check the fit of surgical masks, fit of any sort of respiratory protection is vital in preventing airborne and mobile diseases. As most surgical masks are not designed to fit tightly or suit to every face, air will take the path of least resistance and bypass the mask surface if there is a gap between the mask and face.

When placed on an infectious patient, a medical mask might contain the patient's respiratory secretions, cut back the un-fold of spread of particles to others. Likewise once a patient is not carrying a medical mask; medical personnel might choose to do a mask to limit mucous membrane contact with infectious and contagious droplets. There is no evidence; however, that mask use by either infectious patients or tending personnel can prevent influenza transmission (CDC, 2004).

**Non-surgical masks and alternative materials:**

Several gauze or plain-woven cotton masks are out there additionally to FDA-approved medical masks. Masks of this designs/styles were used extensively throughout the severe out breaks. Additionally, in emergency settings, workers, staff and therefore public have typically protected their airways without delay with readily available materials (such as sheet or towel materials) or used non-approved disposable facemasks available at hardware stores as a means of respiratory protection.

Early reusable surgical masks were manufactured from plain woven linen, which solely redirected exhaled air away from the surgical wound. Cloth surgical masks, sometimes made of cheesecloth (McNett, 1949), were replaced within the early 1960s with the synthetic materials described earlier that also provide bacterial filtration and improved filtration potency.

When materials are utilized in combinations with improvised makeshift techniques to improve the face fit e.g., nylon hosiery, leakage can be reduced (Cooper *et al.,* 1983). Tests conducted in animals have shown that tightly fitted six-layer gauze masks reduce the incidence of contamination with infectious diseases like bacilli by 90 to 95 per cent (Lurie and Abramson, 1949). However, regulative standards need that a mask must not permit blood or alternative potentially infectious materials to surf through or reach the wearer's skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time that the protective equipment will be used (OSHA, 1992).

The engineering styles of textile structures such as, fabrics for parachutes, apparel, facemasks, and geotextiles may be a complicated task for development.

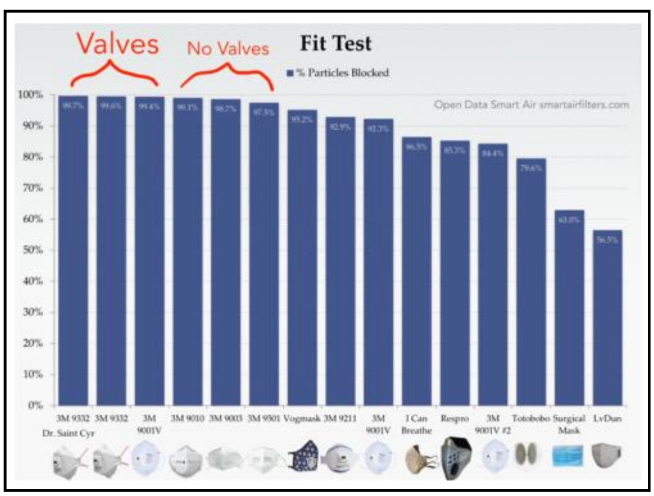
For example, the linear density of the fibres used to make the yarn in the fabric and the thread density (*i.e.*, the number of threads per unit area in the fabric) significantly influence the tensile strength, durability, air permeability, and flexural rigidity of the resulting woven fabric. Thus, if one tries to increase the fabric tensile strength by increasing the thread density, it will make the fabric stiffer and reduce its air permeability.

Thus, in the case of a respiratory protection against contagious diseases, the first step would be to identify and spot the key requirements, such as functionality (protection against virus), comfort, fit, and reusability (cleaning and decontamination); these subjective requirements are translated into appropriate objective properties of the mask that can be measured, such as filtration capability. These properties in the design are achieved through the appropriate choice of materials, such as cotton, polyester, polypropylene, blends, bioactive fibres, and fabrication technologies like weaving, knitting, and nonwovens.

**Important tips for understanding mask ratings:**

– Three randomised studies have found surgical masks and N95 masks are just as effective as each other at preventing virus transmission. They hypothesize the main reason for this is that any mask can reduce the hand-to-face contact, although we don't know this for sure.

– If you are wearing a mask with a valve then you are protected, because valve does not transport any outside air into the mask. Fit test data have found that masks with valves are often among the highest scorers.




– Tests have found that DIY masks can filter a percentage of virus-sized particles. While they're not as effective as surgical or N95 masks at filtering viruses, they can still provide some benefit. They can also reduce hand-to-face contact.

Because it is not clear that woven cloth masks can meet either FDA or NIOSH standards, and without better testing and more research, cloth masks or improvised protection generally have not been recommended in the literature as effective personal protective devices against infection.

**Summary and conclusion :**

The major differences between medical masks and respirators are their intended uses and levels of protection. A medical mask is intended to protect others from large droplets exhaled or released by the wearer. It is also designed to protect the wearer's respiratory tractfrom splashes of body fluids that may unexpectedly occur in the clinical setting. In contrast, a respirator is designed to protect the wearer from hazardous contaminants in the air. Most N95 filtering face—piece respirators are not designed to protect the wearer from splashes of body fluids. However, some N95 filtering face-piece respirators (called surgical N95 respirators) have this additional feature and are certified by NIOSH as well as regulated by FDA. Medical masks and N95 filtering face-piece respirators are considered disposal devices and are not designed for either extended use or reuse after cleaning and disinfection.

When selecting a personal protective device for healthcare workers and the public for protection against an airborne infection, an N95 filtering face-piece is likely to be both the least expensive and the most widely available NIOSH-certified respirator for such protection. A full face-piece air purifying respirator, a PAPR, and an airline respirator are examples of alternatives with increasing levels of protection for the wearer. However, some of these alternatives may be considered prohibitive in terms of cost, training required, ease of use, or availability in sufficient quantities to protect healthcare workers and the public in the event of a pandemic.

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