ISBN: 978-81-946587-9-5

4. COVID-19 And Face Protection Masks

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Introduction:

On December 31 of 2019, the Chinese authorities sent an alert message to the World Health Organization about the outbreak of a strange strain of coronavirus (then named as named SARS-CoV-2) causing multiple illness. Subsequently, on 30 January 2020, WHO declared the outbreak a Public Health Emergency of International Concern and then as a pandemic on 11 March 2020. A disease is declared as an epidemic when an outbreak of disease spreads over a wide area, affecting many individuals at the same time to become ill, while the epidemic can potentially become a pandemic when wider geographical areas and significant (or exceptionally high) proportion of the population are affected. The first scenario suggests the spreading of viruses in its pathogenic form from a non-human host to human and causing an epidemic, while the second scenario envisages the spreading of viruses, in its non-pathogenic version from animals to humans and subsequently evolving into pathogenic state.

Viruses - Cause of Concern:

In biology, viruses are regarded as non-living, small infectious agents, which invade living cells (host), multiply inside those cells and causing damages (illness / diseases) to the hosts, e.g. animals, plants, human, bacteria and cause diseases [1]. The viruses are either intracellular (active form) or extracellular (inactive form), adapted to transfer the nucleic acid from one cell to another (Fig. 1). Classification of viruses are based on their (i) structure (simple – made up of nucleic acid and protein shell, complex – made up of nucleic acid, protein shell and lipoprotein envelope) and (ii) type of nucleic acid (DNA or RNA). The nucleic acid can be single or double stranded, protected by a shell containing proteins, lipids, carbohydrates, or their combinations [2, 3]. Occurrences of single-stranded DNA viruses are rare, while twofold stranded DNA viruses are commonly observed whereas in the case of RNA viruses, there are very few cases of twofold stranded RNA viruses and predominantly they are single-stranded.

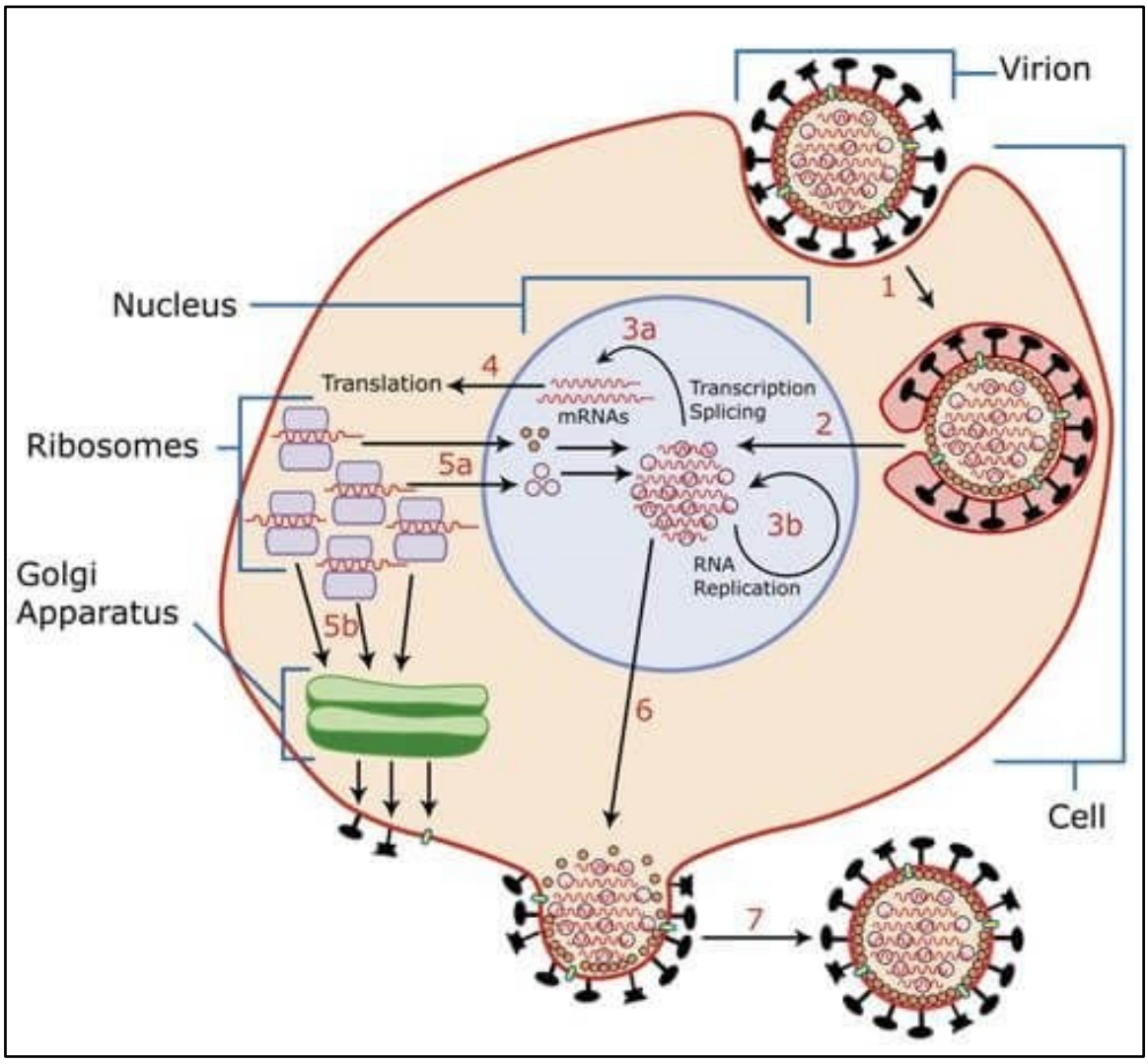


Fig. 1 Action of Virus in Host Cell

A virus attaches to a living cell and injects its nucleic acid into it where the nucleic acid binds to the ribosomes of the cell and stimulates them to produce viral proteins [1, 3]. Multiplication of the viral genome occurs through replication, resulting in a huge number of new copies of the viral RNA or DNA, i.e. new viruses. The host cells are damaged in this process and become no longer beneficial to the viruses, which makes the viruses to leave those cells and target new cells.

DNA Viruses Vs RNA Viruses:

Deoxyribonucleic acid (DNA), double-stranded molecules found in the nucleus, is the major storage for genetic codes that contains information for the functioning and advancement of all

living organisms. DNA virus instils the genetic code specifically to the membrane of the host DNA then with the help of RNA polymerase, the duplication happens in the nucleus and released during the lytic phase of the host cells (multiplication step) with the copies of infection. Since the specificity of the DNA viruses are detected at the transcriptional (constant) level, certain vaccines are effective throughout the years. Ribonucleic acid (RNA) that contains ribose sugar, is usually a single-stranded molecule, instilling the RNA to the host cell cytoplasm. Unlike DNA viruses which must always transcribe viral DNA into RNA to synthesize proteins, RNA can skip the transcription process [4]. DNA here acts as a pattern for RNA and transcribes it into viral proteins. Certain RNA viruses embed transcriptase enzyme that transfer RNA virus to DNA virus and combine with the host DNA thereby following the DNA replication process. Mutation is the major cause of the changes, by RNA polymerase, in the genetic code of the viruses and makes them unstable, replace the protein coat that can confuse the immune system [2, 4]. When RNA viruses attack the human living being, they infuse their RNA into the cytoplasm of the host cells, where RNA can be utilized to integrate proteins and frame the imitations (Fig. 2).

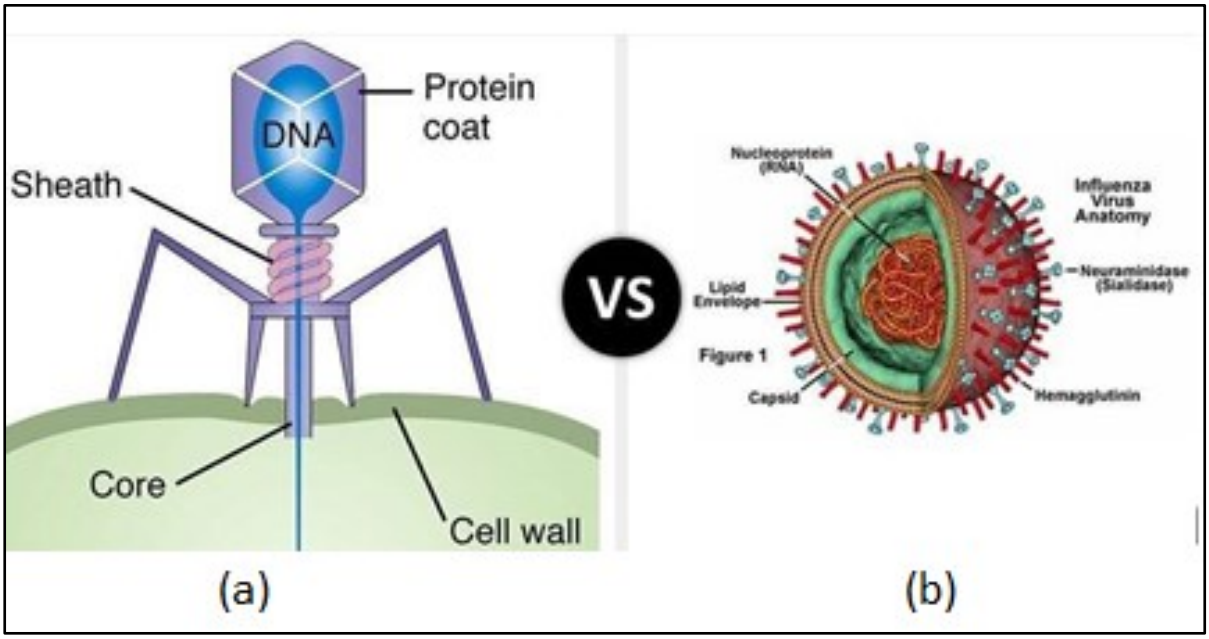


Fig. 2 Schematic Representation of (a) DNA and (b) RNA Viruses

In DNA viruses, there are two stages in the translation procedure first, the mRNAs (messengers) are made (alpha and beta mRNA) subsequently, gamma mRNAs and are interpreted into the cytoplasm, further leading to DNA replication. These stages can't be recognized in the RNA interpretation process of RNA viruses, which interpret mRNAs on

host ribosomes and make viral proteins instantly with higher transformation rates than DNA change rates [5]. This obviously results in faster communication of diseases in the case of those caused by RNA viruses.

Single-stranded RNA viruses that can be further ordered into negative-sense and positive-sense RNA viruses, depending on the sense or polarity of the RNA. Positive (or plus-strand) and negative (or minus-strand or anti-sense) sense RNA viruses are the two types of single-stranded RNA viruses classified based on the type of genome [6]. Both positive and negative sense RNA viruses are infectious and cause diseases in animals and plants. Positive-sense RNA viruses account for a large fraction of known viruses, including many pathogens such as hepatitis C virus, dengue virus, and SARS and MERS coronaviruses, as well as less clinically less serious, common cold.

Coronaviruses:

Coronaviruses are a group of viruses that can cause a range of symptoms including a running nose, cough, sore throat and fever, usually spread through direct contact with infected persons. Coronaviruses, name originating from Latin for crown-spikes on its surface, have helically symmetrical nucleocapsids (nucleic acid and surrounding protein coat), which is uncommon among positive-sense RNA viruses, but far more common for negative-sense RNA viruses.

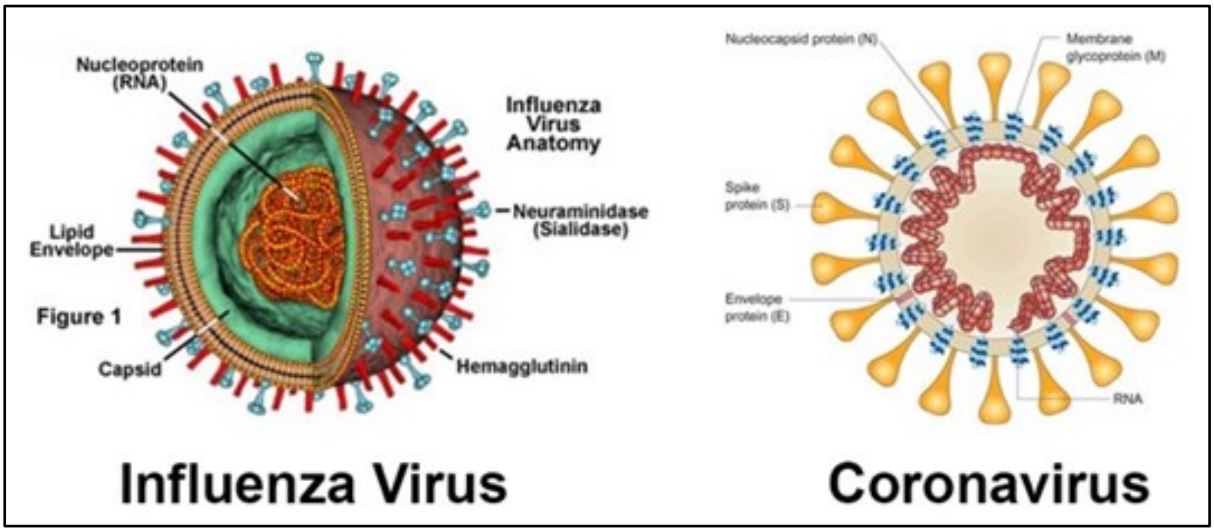


Fig. 3 Schematic Representation of Influenza and Corona Viruses

Human coronaviruses were first identified in the mid-1960s and there are four main sub-groups of coronaviruses, known as alpha, beta, gamma, and delta. Sometimes coronaviruses that infect animals can evolve, make people sick and become a new human coronavirus like MERS-CoV (the beta coronavirus that causes Middle East Respiratory Syndrome), SARS-CoV (the beta coronavirus that causes severe acute respiratory syndrome) and SARS-CoV-2 (COronaVIrus Disease 2019, or COVID-19). Including the newly identified form of the virus, there are a total of seven coronaviruses that can infect humans [1, 7, 8]. All the coronaviruses can be transmitted between humans through close contact. MERS, which was transmitted from touching infected camels or consuming their meat or milk, was first reported in 2012 in Saudi Arabia. SARS was first reported in 2002 in Southern China was thought to have spread from bats that infected civets. Since the virus, nCov 2019, first popped up in Wuhan (China) among the people who had visited a local Huanan seafood market, it is hoped to have spread from animal to humans. In a recent study, the researchers compared the 2019-nCoV genetic sequence and found close relationship (88% of their genetic sequence) with the viruses that originated in bats.

Invariably, many of us get infected due coronaviruses in certain stages with mild to moderate symptoms, respiratory tract illnesses including pneumonia and bronchitis. These viruses are common amongst animals worldwide and rarely, coronaviruses can evolve and spread from animals to humans, the typical cases include MERS and SARS-Cov. It is unclear how the new coronavirus compares in severity, as it causes severe symptoms and death in some patients while causing only mild illness in the case of others (Fig. 4).

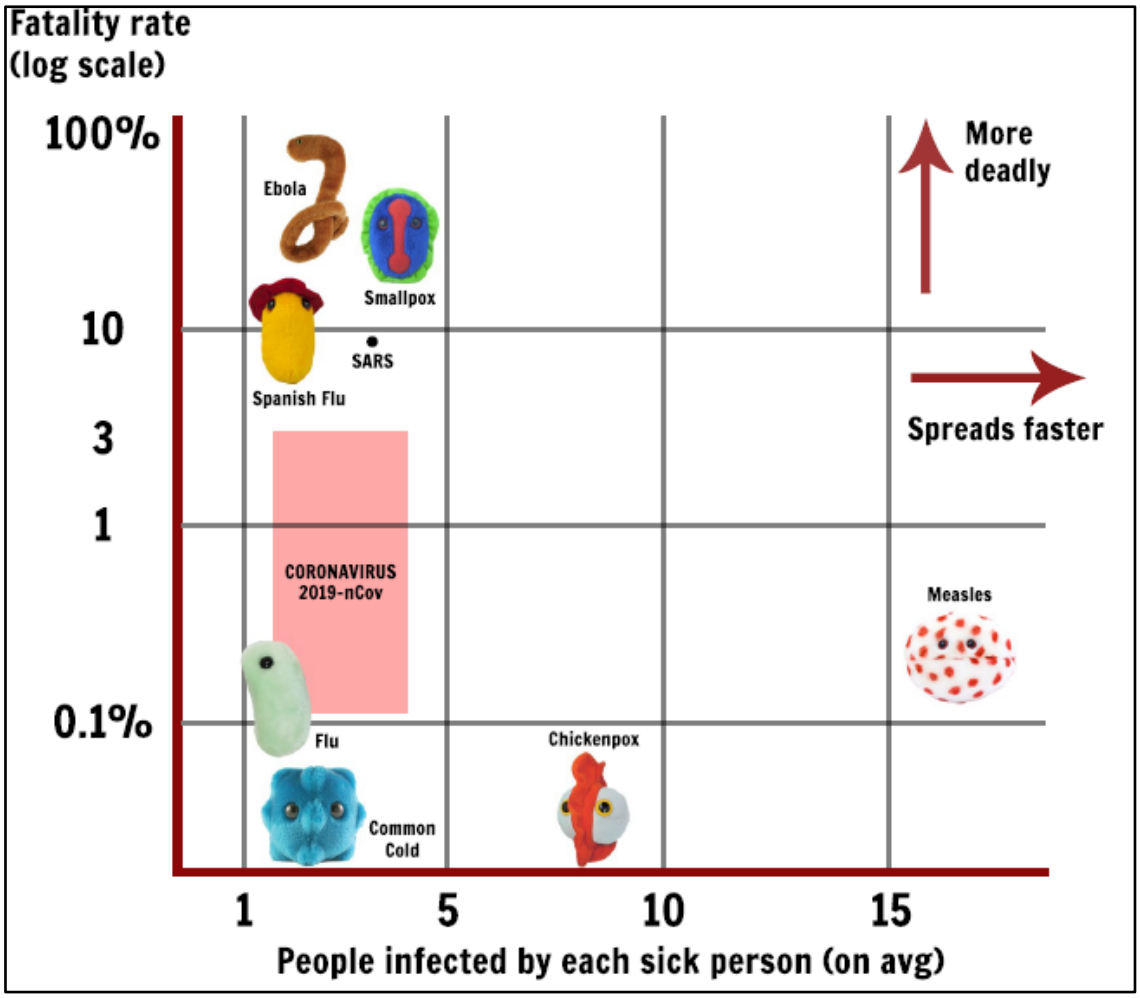


Fig. 4 Impact of Viruses in terms of Spread and Effect [9]

Pandemic effect in humans, by the viruses, are caused by a cycle that involves (i) infection among human, (ii) replication among human and (iii) rapid spread among the human and right now, it is very much unclear how easily the virus spreads from person to person. The human coronaviruses are supposedly spread from an infected person to others through (i) the air - respiratory droplets when a sick person coughs or sneezes, (ii) close personal contact (touching or shaking hands), (iii) an object or surface with viral particles (subsequent human contacts through mouth, nose or eyes before washing your hands) and (iv) rarely from fecal contamination [7]. These viruse particles are pushed into the atmosphere and eventually affect air quality [10]. Poor ventilation, dirty air conditioner or HVAC system help speed up the spread of bacteria and viruses, in general [11, 12].

COVID-19 is said to spread in a country or a space, following a four different stage namely (i) stage 1 – the country is not the source of the pandemic, still reports first few cases of the disease due to virus import; stage 1 happens when the epicentre of virus outbreak unable to

contain the virus spread; (ii) stage 2 – happens when local transmission of the disease are reported, spreading through the people of a particular country itself but possible to identify the trajectory of the virus; (iii) stage 3 – happens when community transmission of the disease is observed and difficult to track the chain of transmission and stage 4 signifies the pandemic reaching the epidemic stage, affecting the masses and the measures to contain the virus and control the affected persons become very difficult.

Masks, Respirators And Ventilators:

Masks are often used by healthcare providers in hospitals and clinics, where the risk of transmitting or catching an illness is high. In healthcare set-up, primarily masks are used to isolate from patients as well as protect the patients from potentially spreading the infections. There are two types of masks used in preventing infections: surgical masks and respirator masks.

Surgical masks (also known as dusk mask, procedure mask, medical mask or simply face mask) are basically small pieces of cloth used to keep the germs from their coughs and sneezes to themselves, or to prevent picking up infections from others (Fig 5 (a)). Surgical masks provide a physical block to protect the mouth and surrounding areas and often used as an integral part of the system where multiple barriers are used including surgical gown, gloves, eye-protection systems [12, 13, 14]. Surgical masks potentially can protect against droplet-spread infections, like influenza and other common respiratory infections but not designed to protect the wearer from inhaling smaller airborne bacteria or virus particles, e.g. mycobacterium tuberculosis [12]. Since the medical face masks are designed to stop water droplets, they are fit loosely, and may leave a gap between the edges of the cover and skin, making the masks less effective at protecting against smaller particulates that sneak around the edges. Heavier drops of water are less likely to skirt around the edges of the masks, and if a mask gets soiled, it can make things worse instead of better.

Due to shortage of surgical masks and respirators in the present COVID-19 situation, a new type of protective mask, “barrier mask” (Fig. 5 (b)), has come into the use, as Do-It-Yourself practice, to be worn by healthy people, healthcare professionals and others who are at the risk of exposure.

Fig. 5 (a) Surgical Mask, (b) Barrier Masks

Face masks and respirators, both, are capable of providing protection against airborne particles though they are different in their design and function [13, 14].Respirators are similar to face masks in shape and often indistinguishable but much more capable of safeguarding against tiny airborne particulate pollutants including pathogens.A respirator usually takes the form of a partial or full face-mask that is secured in place with a strap to filter the airborne microbes, viruses. In certain cases respirator masks are reusable also [14, 15].

Two of the most common respirator masks are N-95 masks and N-99 masks, which, when used correctly, prevent 95 % and 99 %, respectively of airborne particles from entering mouth or nose of the wearer [13]. N-95 and N-99 respirator masks can protect against airborne illnesses like measles, chickenpox, or tuberculosis and situations when the mode or pattern of disease spread is uncertain and ensure high level of protection. However, continuous use of respirator, which is essential to remain protected, leads to discomfort to the wearer and may lead to physiological impacts [9, 14]. Structure of a respirator is precisely engineered so that the mask (respirator) fits tightly against the face, reducing the gap. While industrial-grade respirators leave practically no gap with face, the wildfire smoke masks - often designed to reduce pollution down to tolerable levels instead of eliminating - save lungs from the strain of a sealed respirator. The filtering material in the respirators is denser enough to safeguard against PM2.5 (particles or droplets in the air that are 2.5 microns or less in size) particulate pollutants caused by vehicular exhausts, smokes and industrial emissions.

Though masks and ventilators are functionally different, often, they are used interchangeably, since both are used as breathing aids [15]. A respirator is a mask-like device that filters fine particles from inhaled air, whereas the ventilator is a machine that assists or performs the breathing process, whoever needs critical care but does not facilitate the breathing function

(Fig. 6). On the other hand, ventilator is a device that aids or performs the breathing process in the case of patients whose respiratory function is impaired for various reasons including COVID-19. Ventilator is a complex assisting system that uses compression system to force air (oxygen) into the lungs of a patient with reversing action taken care by automatic contraction of lungs.

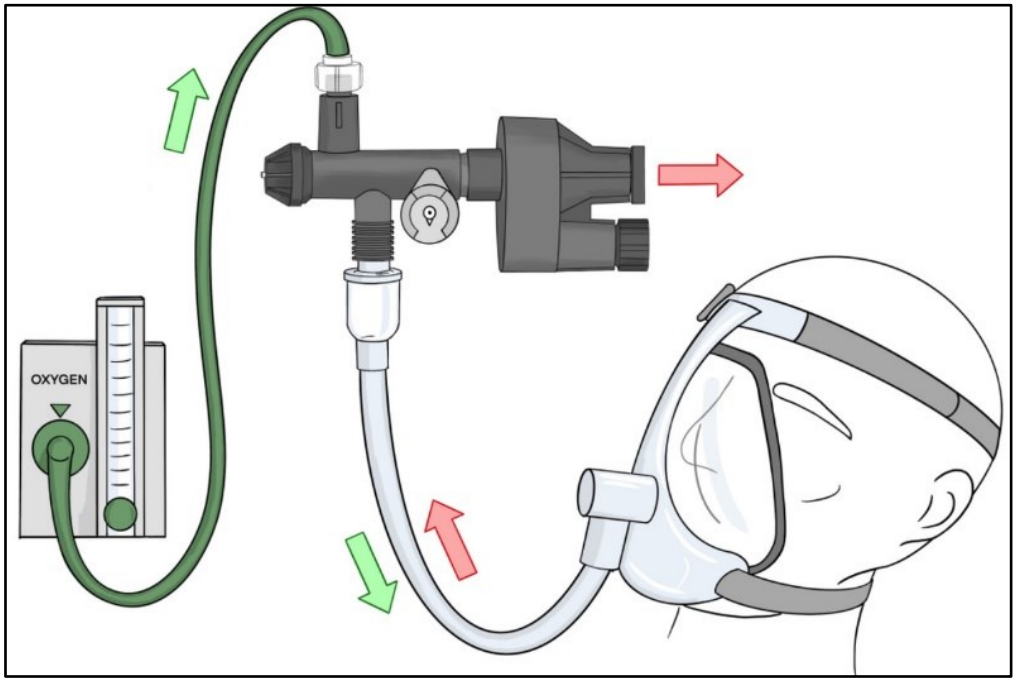


Fig. 6 Schematic Representation of a Ventilator

[Ref: https://chicago.suntimes.com/coronavirus/2020/3/31/21201997/]

Design Features And Testing Of Masks And Respirators:

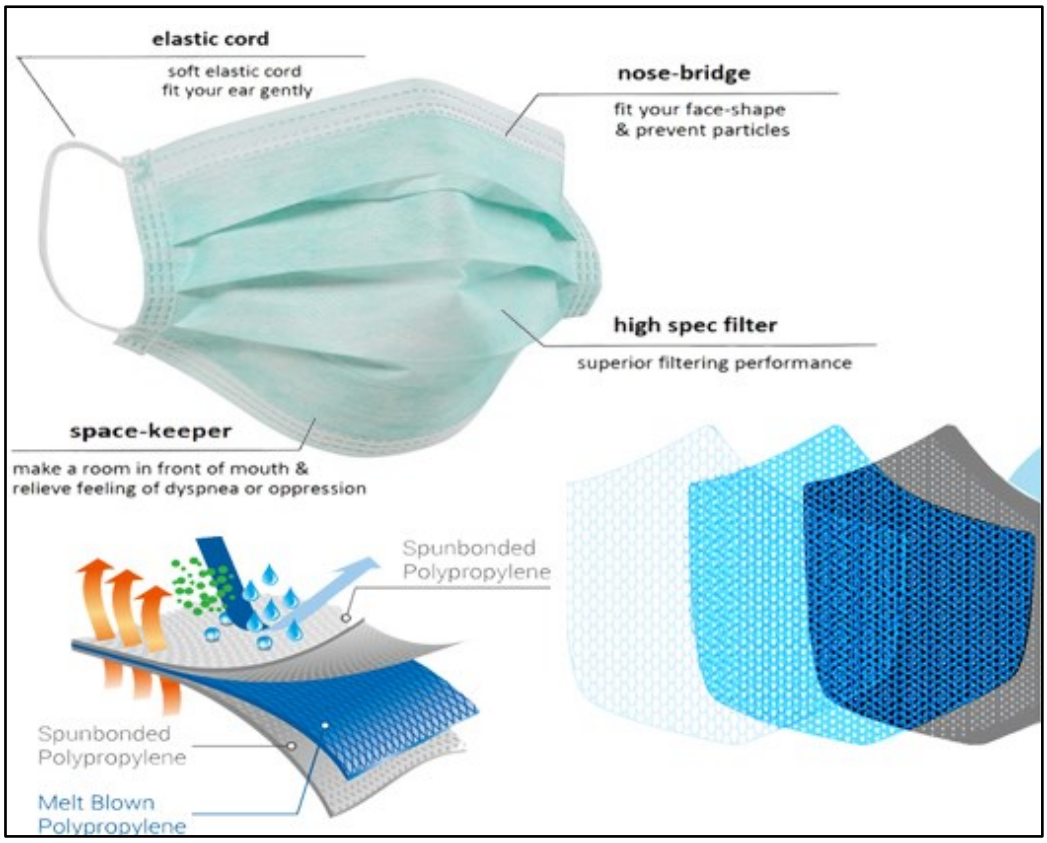
Surgical masks are made of a nonwoven fabrics created using a melt blowing process. They came into use during the 1960s and largely replaced cloth facemasks [9, 12]. While the facemask are effective in blocking splashes and large-particle droplets, by design, do not filter or block very small or tiny particles in the air, transmitted through coughs / sneeze. For those with chronic illness, wearing a face mask can be especially important for stopping dust mites, mould spores, and pollens, while exposure to pathogens cannot be ruled out if the mask is not properly fitted to seal around the face [17, 18, 19].

Thin surgical masks, meant for healthcare professionals, don't offer much in the way of protection but intended to stay away from pathogens that might spread during medical procedures.The fact that these masks fit loosely around the face makes it easier for the entry

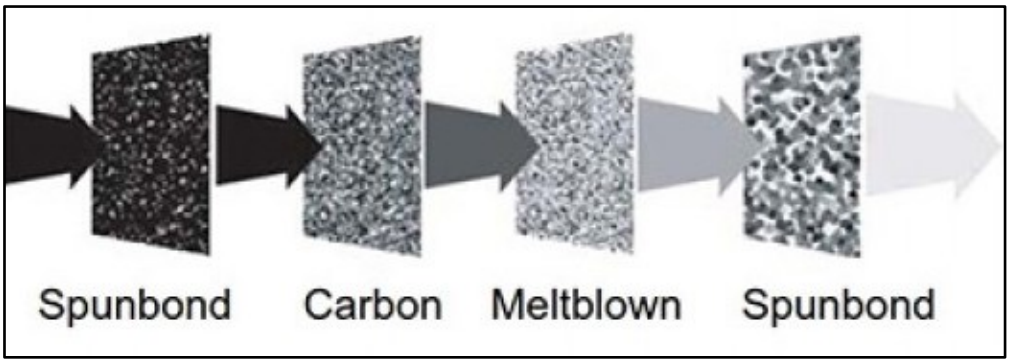
of foreign particulate materials. These masks are single-use devices and should not be worn for more than 3 to 8 hours.

Surgical masks, once made simply with a strip of cloth, are today manufactured using multiple layers (Fig. 7) (two / three / four layers) of thin non-woven fabrics (20 or 25 g/m2) of finer polypropylene fibres with or without filter layer(s) [12, 14]. These surgical masks are available in different styles and grades based on the level of protection expected. Masks are made of polystyrene, polycarbonate, polyethylene, or polyester fibres [20]. The filtration levels of a mask depends on the fibre, method of manufacturing, web structure, and cross-sectional shape of the fibres used.

A 3-ply surgical mask (Fig. 7) has three layers namely, (i) an outer hydrophobic layer, which repels water, blood and body fluids, while wicking inner moisture to evaporate efficiently, (ii) a middle filter layer that is designed to filter bacteria with one or two layers (without affecting breathability and comfort), and (iii) an inner hydrophilic layer, which absorbs water, sweat and spit, where jersey and interlock structures are also suggested [9, 12, 20]. In a 2-ply face mask, both layers are usually made up of polypropylene nonwoven without filter layer [12]. Masks are made by ultrasonically welding the layers together, and stamping the masks with nose strips, ear loops, or knitted / braided / folded-over elastic that go around the head to secure safely [9, 20] to satisfy certain characteristics and functional requirements (Table 1).



(a)



(b)

Fig. 7 (a) Three-Ply and (b) Four-Ply Masks

Quality and performance measures of the masks are recommended by different agencies including Government (FDA, NIOSH, and OSHA) - regarding protection requirements for end users, standardization organizations (ISO and NFPA) for performance requirements and test method providers (ASTM, AATCC) with respect to standardized methods to test and ensure product safety [20, 21]. There are four levels of ASTM certification that surgical

masks are classified in (Table 2), depending on the level of protection they provide to the person wearing them [21].

Table 2 Classification of Surgical Masks – Protection, Property and Uses

Protection Level	Properties and Uses
Minimum Protection	Face masks meant for short procedures or exams without inolving fluid, spray, or aerosol
Level 1	Face masks used for surgical and procedural applications, with a fluid resistance of 80 mmHg
Level 2	Masks with 120 mmHg fluid resistance, provide a barrier against light or moderate aerosol, fluid, and spray.
Level 3	Face masks for heavy possible exposure to aerosol, fluid and spray, with 160 mmHg fluid resistance.

These disposable masks are sterilized at the last stage of manufacturing process. Once surgical masks are made, they must be tested to ensure their safety in various situations. There are five different tests (Table 3) carried out for surgical masks.

Table 3 Suggested Test Methods for Masks

Test Parameter	Method	Need
Bacteria Filtration Efficiency	Tested with an aerosol of *Staphylococcus aureus* at a specified rate (EN, ASTM)	Ensures protection against the infiltration of pathogens
Particle Filtration Efficiency (latex particle challenge)	Spraying an aerosol of polystyrene microspheres	Ensure protection against required size of particles
Breathing Resistance	Measuring air-flow resistance at a given pressure level on both sides of mask	Ensures proper ventilation while the wearer breathes
Splash resistance	Splashed with simulated blood at forces closer to human blood pressure	Ensure protection against splash of liquids to avoid contamination
Flammability	Measures the extent of burning tendency (time and extent)	Ensure Protection from fire accidents in an operating room

Respirators:

A respirator prevents a wearer from inhaling droplets, aerosols, vapours or gases / disinfectants that pose greater health hazards [19, 22, 23]. Respirators of different classes

certified by EU Standards (FFP) or US Standards (N Type) offer high filtration against particles and aerosols. There are two basic types of respirators namely (i) air filtering and (ii) air-supplying (or insulating). Air filtering respirators (such as an N95 respirator) consist of a facepiece and a filtering device, stop contaminants, bacteria from reaching the nose and mouth while air supplying respirators (PAPR) supply the user with clean air from a tank or other uncontaminated sources [9]. Depending on the type of filter, the mask will either be effective only against particles, only against certain gases and vapours, or against particles, gases and vapours. Filtering respirators are sometimes also equipped with an exhalation valve to improve user comfort.

N-Type Respirators:

N95 respirators are one of the products in demand while treating COVID-19 infected patients. N95 respirators are originally developed for industrial applications, which are specialized masks (Fig. 8) that has the capability to filter out at least 95% of particles of the size above 0.3□, if properly fitted (i.e. efficiency depends on proper fit of the respirator, understood in terms of leakage) [17]. N95s respirators (or N95 alpha masks), featuring with exhalation valve suitable for hot or humid environments, are single-use products regulated as class II products under FDA and NIOSH, help the wearer to breathe easily and are also known as the "Bird Flu" mask or "Swine Flu" masks [18]. There are also N99 and N100 respirators (N100s stop at least 99.97% of particles from entering) that are virtually leak-proof.

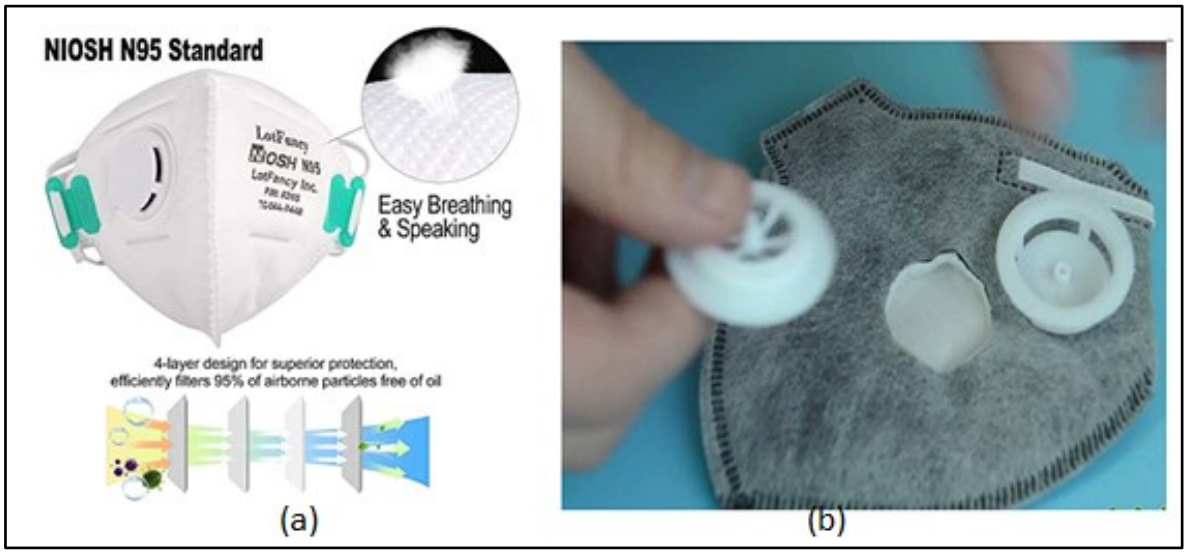


Fig. 8 N-Type Respirators (a) N95 and (b) N95s

A medical N95 respirator consists of multiple layers of nonwoven fabrics, often made from polypropylene. The two outward protective layers of fabrics, having areal densities 20 and 50 g/m2 covering the inside and outside of the mask, are made-up of spun-bonded thermoplastic polymer nonwoven materials, protect against the outside environments act as a barrier to in the exhalation process. Between these spun-bond layers, a high-cohesive needle-punched nonwoven (250 g/m2) is used as the pre-filtration layer. Further, hot calendaring or thermal bonding makes this layer thicker and stiffer enough to be moulded into different shapes. The last filter layer that consists of a high efficiency melt-blown electret (or polarized) nonwoven material, often made-up of sub-micron fibres, decides the filtration efficiency. Sometimes, this layer is thermally bonded to enhance the strength and abrasion resistance values.These layers are combined together with ultrasonic welding with necessary straps and strips, then sterilized as the last step. N95 respirators work by filtering out the particles owing to the tortuous network structure of nonwoven materials used in the assembly, aided by electrostatically charged layer to further attract particles. As particles build up, filtration efficiency of the mask becomes higher and breathing becomes difficult.

N95 respirators are subjected to several tests to ensure their effectiveness, tested after conditioning for 24 hours (38o C, 85% RH). N95 respirators are tested for (i) particle penetration – using charge neutralized sodium chloride aerosol spray (with median particle size of 0.3 micron), (ii) air flow (85 LPM) for moderately high work rates, (iii) breathing resistance – measured at 35 mm or below water column height pressure, and exhalation resistance - at 25 mm or below water column height pressure, (iv) aerosol loading - at least 200 mg, to simulate a high level of exposure and assess clogging tendency. Respirators are also tested for flammability, biocompatibility, fluid resistance, and particulate and bacteria filtration as per the standards of the Food and Drug Administration. With respect to particulate protection, respirators are classified into three categories by EU standard (EN 149:2001) as FFP1, FFP2 and FFP3 and NIOSH Standards – Class N (No oil resistance and specified particulate filtration efficiency), Class R (Oil resistance up to 8 hours with particulate filtration efficiency specified as R95, R99, R100) and Class P (Completely oil-resistant, P95, P99, P100).

FFP Respirators:

Filtering Facepiece Particles Mask, also known as FFP mask, is a half-face mask designed to cover chin, nose and mouth, available in three different grades (Table 4). This EU certified

mechanical-filter respiratory protection mask is capable of giving protection against particulate pollutants, infectious agents (including viruses) in the form of aerosols, droplets or solid particles [24, 25]. The masks can also be equipped with an exhalation valve to enhance the comfort, prevent condensing and settling of moisture in the masks from the exhaled air. Protection levels of FFP respirators are approximately 11 to 16 times higher than surgical masks. Different performance values are also reported for FFP masks in the literature for modified versions. However, the addition of a valve carries the risk of malfunctioning, the risk of infiltration of the virus or toxic dust.

Table 4. Classification of Filtering Facepiece Particle Masks

Type of Filter	**FFP1**	**FFP2**	**FFP3**
Extent of Protection	Least	Medium	Highest
Aerosol Filtration (%) up to 0.6 micron	80	94	99 to 99.95
Internal Leakage (%)	22	8	2
Applications	Dust Mask	Particulates, powders, influenza viruses, bacteria	Fine particles
Ease of Identification	Attached with Yellow elastic band	Attached with Blue elastic band	Attached with Red elastic band

Powered Air Purifying Respirator:

Powered air purifying respirator (PAPR), a personal protective equipment, is often recommended for individuals working in a polluted environment including dust, fumes, smoke, harmful gases or chemical vapours (Fig. 9). It is a power operated equipment that has a fan to provide clean breathable air through the filters (positive airflow through a filter, cartridge, or canister) and supply hoses connected to half or full-face masks or mouth pieces (to a hood or face piece) [26, 27].

PAPR types (types of filter, cartridge or canister) vary depending on the requirement / pollutants present in the environment, differentiated by the colour codes of filters / canisters meant to provide protection from nanomaterials such as dusts, paint mists, etc. Particulate Power Air Purifying Respirators (PPAPR) are used to filter dust, fumes and mists while Combination Respirators are capable of addressing both particulates and gases / vapours. PARPs may be belt mounted, helmet mounted, face mounted or vehicle mounted. The National Institute for Occupational Safety and Health provided guidelines for different

respirator models to ensure the expected levels of performance standards. The correct sequence of donning, doffing and hand hygiene is important to ensure the effectiveness of the PAPR and the N95 masks [27].

Fig. 9 Powered Air Purifying Respirator

Conclusion:

SARS virus, a type of coronavirus that has a size of 100 nm can easily pass through such barriers, like influenza virus (80 to 120 nm). Though the size of the new COVID-19 virus is currently unknown, human coronaviruses are generally about 125 nm well below the cut-off values available for mechanical respirators. However, viruses often travel on top of larger carrier molecules—like globs of mucus—making it easier to filter them. That is the reason the many agencies / administrators recommend to cover the face with home-made masks. In addition, using a surgical mask helps preventing from touching the face since many people do not get infected by breathing the viral particles floating in the air, but by touching mouth and nose with their contaminated hands. Use of high-efficiency particulate air filters in PAPRs provides greater respiratory protection than N95 masks with additional protection to heck and head. Recently developed gas masks protection from chemical, biological, radiological and nuclear threats (CBRN), while MIRA Safety ParticleMax P3 Filter assures protection from pandemics including Ebola, coronaviruses and H1N1. Judicious selection of filter materials coupled with the certain degree of comfort to the wearer would be, essentially, the choice of

many who suffer due to the diseases caused by the viruses and who are involved in providing treatments to the patients.

Acknowledgement:

The author thanks the authors and researchers for making the reports and database available in the Internet, which helped to compile this article for the benefit of the reader during this COVID-19 outbreak.

Reference:

1. http://www.differencebetween.net/science/health/difference-between-parasite-and-virus/
2. https://theydiffer.com/difference-between-dna-and-rna-viruses/
3. Berkeley L Jr., WHO officials scramble to measure size of coronavirus epidemic: 'How big is the iceberg?, 13 Feb 2021
4. https://www.beckman.com/support/faq/research/rna-and-dna-viruses-in-immunotherapy
5. https://diffzi.com/dna-viruses-vs-rna-viruses/
6. https://pediaa.com/difference-between-positive-and-negative-sense-rna-virus/
7. Edwards E., Miller S.G., https://www.nbcnews.com/health/health-news/what-new-coronavirus-n1119081, Jan. 21, 2020
8. https://www.mentalfloss.com/article/616259/do-face-masks-protect-against-coronavirus
9. https://drsarahlarsen.com/2020/01/corona-virus-is-an-rna-virus-difference-between-a-virus-and-bacteria/
10. https://cleanair.camfil.us/2019/11/22/can-commercial-air-filtration-systems-remove-viruses-in-the-atmosphere/
11. https://www.hngn.com/articles/228319/20200309/coronavirus-transmitted-via-air-conditioning-outlets-ducts.htm
12. https://en.wikipedia.org/wiki/Surgical_mask
13. https://www.allure.com/story/difference-between-surgical-and-respirator-masks
14. https://www.cleanairresources.com/resources/respirator-vs-face-mask-what-s-the-difference

15. https://www.wisegeek.com/what-is-the-difference-between-a-respirator-and-a-ventilator.htm

16. https://www.wazoodle.com/blog/face-mask-fabrics/

17. https://smartairfilters.com/en/blog/diy-homemade-mask-protect-virus-coronavirus/

18. https://allergystore.com/blogs/news/best-face-masks-for-bacteria-and-virus

19. https://emag.directindustry.com/which-masks-actually-protect-against-coronavirus/

20. https://www.thomasnet.com/articles/other/how-surgical-masks-are-made/

21. https://www.thomasnet.com/articles/other/how-surgical-masks-are-made/#_Types_of_Masks

22. Cohen J., Do Surgical Masks Stop the Coronavirus?, The Slatest, Jan 2020

23. https://www.mirasafety.com/products/particlemax-p3-virus-filter

24. https://en.wikipedia.org/wiki/FFP_mask

25. https://fast-act.com/when-to-use-a-surgical-face-mask-or-ffp3-respirator/

26. https://www.safeopedia.com/definition/111/powered-air-purifying-respirator-papr

27. Wong A., Wuhan Coronavirus: Can Face Masks Help Protect Us?, Crimes & Tragedies, Health & Medicine, Traveling & Living Abroad,Jan2020.