In this pandemic and panic of COVID-19 what should doctors know about masks and respirators?

Sundeep S Salvi

Director, Pulmocare Research and Education (PURE) Foundation, Pune, India

The Corona virus disease-19 (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome coronavirus-2 (SARS-Cov-2) that spreads via aerosol and contact from an infected person. As on 4th of April 2020, more than 1.1 million people have been infected across 203 countries, with over 58,000 deaths and the numbers are increasing rapidly.

The SARS-Cov-2 is the seventh human corona virus identified. It is a highly infective virus that spreads very rapidly from person-to-person via four different routes:

- 1. Aerosol droplets: when the infected person coughs or sneezes or for that matter even talks (especially loudly while giving a speech), tiny microscopic droplets of virus laden aerosols are released into the air. Millions of viruscontaining droplets between the size of 0.1 – 900 microns (99% of which are less than 10 microns and 97% of which are less than 1 microns) are released into the air with each cough at a speed of around 40 Km/hr. The larger droplets travel up to a distance of 2 meters and fall to the ground within seconds, but the finer aerosols travel distances of up to 6 meters^{1,2} and remain suspended in the air for at least 10 mins in well ventilated areas, and in enclosed spaces such as flights, buses or poorly ventilated halls and rooms, it can remain suspended for several hours. The sneeze also produces similar sized droplets, but they are released at a faster speed of around 160 Km/hr and the finer aerosols also travel a distance of up to 6 meters and can remain suspended in the air for a long period of time.
- 2. Physical contact: After coughing, sneezing or talking, the virus-laden droplets from an infected person not wearing a mask may land on various surfaces directly, or indirectly by the infected hand touching these surfaces. They can survive on plastic (phones, laptops, bottles, stethoscopes) for up to 72 hours, stainless steel up to 48 hours, cardboard for 24 hours and on copper for up to 4 hours³ from where they can get transmitted to other humans. When an uninfected person's hand touches these virus containing droplets and then touches the face, mouth, nose or eyes, the virus reaches the respiratory tract, where it infects the cells and multiplies into millions of virions before it gets released into the air in the form of droplets to infect others.
- The faeco-oral route: The SARS-Cov-2 virus is known to be shed into the feces, especially in children, from where it can reach the respiratory tract by soiled hands touching the mouth or nose. This route of transmission is however, uncommon.
- 4. Airborne route: This mode of transmission, like the influenza virus, where the virus is released from the human body during talking, coughing, sneezing or even breathing remains airborne before it can infect others is not known. In an analysis of over 75,000 COVID cases in China, airborne transmission was not reported.⁴ However, a recent paper in Nature Medicine⁵ showed presence of seasonal corona viruses (not the SARS Cov-2 virus) such as OC43 and HKU1 in the exhaled breath, suggesting a possible mode of transmission by this route too.

Preventing the spread of the SARS-Cov-2 virus from man-to-man is the only way to effectively control this pandemic. The chain of transmission via the aerosol droplets and physical contact has to be stopped. Based on previous experiences with the SARS and influenza epidemics, the WHO, National and Local Health bodies along with the media have constantly being informing people to protect themselves by practicing social distancing, staying indoors, washing hands regularly with soap and water for at least 20 seconds or using an alcohol containing disinfectant (at least 60%), and wearing a mask. Hand washing alone was shown to reduce the risk of SARS virus transmission by 55%, wearing a mask by 68% and hand-washing, wearing a mask, gloves and a protective gear, all together by 91%.⁶

Wearing a mask is therefore a very important mode of preventing the aerosol spread of COVID-19. However, the directives and advisories coming from the global and national health authorities regarding wearing of a mask has been inconsistent and confusing with mixed messages. The WHO, US Centre for Disease Control (CDC) and The Ministry of Health and Family Welfare, Government of India, earlier issued a directive that not everybody should wear a mask; only people who are caring for a COVID-19 patient or a suspected COVID-19 patient, or a person who has respiratory symptoms should wear a mask. The Surgeon General of the US also advised people to stop buying masks. This advisory seems to have been largely based on the fact that masks were and still are in severe short supply, even for the frontline healthcare workers such as doctors and nurses, and therefore their use had to be rationed. They argued that there was no scientific evidence for any beneficial effect for healthy people wearing masks. However, it has been also argued that absence of evidence of effectiveness should not be equated to evidence of ineffectiveness, especially when facing a novel pandemic situation with limited alternative options.⁷

There is now a growing body of evidence to suggest that asymptomatic transmission occurs in the community. Infected people can shed the virus via aerosol droplets even 2.5 days before they start developing symptoms. Asymptomatic transmission accounted for 66% (range: 45-84%) in a Singaporean cluster and 77% (range: 65-87%) in the Tianjin cluster.⁸ A recent case study from China⁹ showed the importance of wearing a face mask in preventing the spread of the infection, where one patient unaware that he had the COVID-19 infection travelled from point A to point B by bus (39 passengers) during which he did not wear a mask and from point B to point C by another minibus (14 passengers), where he wore a mask. In the first journey 5 other people caught his infection, while in the second journey nobody got infected. A risk assessment model for an influenza epidemic demonstrated that if people do not wear a mask, around 35% of the people will catch the influenza infection, if 50% of the people wear a mask and adhere to it, or if the efficacy of the mask is 50%, the prevalence of infection will reduce by 50%, and if 80% of the people wear the mask and adhere to it, the risk of transmission will be negligible.¹⁰

Countries that have a culture of wearing masks routinely, such as Hong Kong, Singapore, South Korea and Taiwan seem to have shown a flatter curve on the COVID-19 trajectory (Figure 1). They wear masks as a show of consideration for others and social responsibility and to protect others from catching the infection. The case report from China mentioned earlier, clearly suggests that wearing a mask protects others from catching the infection.

into filters. N95, N99, N100, FPP2, and FFP3 masks all filter the corona virus effectively. The only caveat is that the mask should not have any leakage. A fit test is therefore necessary before donning these masks.

Each country has their own certification standard for each mask type, e.g. USA [NIOSH 42CFR Part 84], Europe [149:2001, China [GB2626]. As of now, India does not have any certification standard or certifying body for respiratory masks. The European Union classifies respirator masks into FFP1, FFP 2 and FFP3 where FFP stands for Filtering Face Piece. N95 is roughly equivalent to FFP2 and N99 is roughly equivalent to FFP3 masks. FFP1, FFP2 and FFP3 are also called P1, P2 and P3.

Although N95 and similar masks are efficient in protecting the wearer against viruses, they are not easy to breathe and often get moist and hot after wearing it for more than 30 minutes. They are therefore not meant for routine household use or while travelling outside, they are mainly meant for health care providers who come in close contact with the COVID19 patients.

VALVE VERSUS NON-VALVE N95, N99 RESPIRATORS (FIGURE 6):

N95 and other respirator masks are also available with a valve and without a valve. The valve N95 mask respiratory are not suitable for patients suffering with COVID-19 as during exhalation they will allow the virus to pass out easily and can potentially infect neighboring people. The differences between the valve and non-valve spacers are given in Table 2.

FAKE N95 MASKS:

Taking advantage of the severe short supply of masks, many dubious companies are making fake N95 masks. On 31st March 2020, more than 12,000 fake N95 masks were seized in Bengaluru. They were made up of fabric used in the manufacture of vests and collar canvas. The company had already sold 70,000 fake N95 masks for 1.05 Crore rupees and were lobbying to win a government contract for 10,000 masks¹²

A respirator that has N95 written besides it is not enough to certify its validity. It is often made with cheap fabric and duplicate parts to dupe the consumer. The situation is similar across the world and fraud alerts have been issued by several Governments.

The N95 mask should be NIOSH approved and CE certified. NIOSH has a website which has a list of certified licenses holders to manufacture the N95 mask. The important thing to identify is the TC number on the particular mask. A genuine N95 respirator mask should have all the markings mentioned in Figure 7.

EXTENDED USE AND LIMITED REUSE OF N95 MASKS:

Ideally the N95 respiratory masks are only for single use, and this should be the standard practice whenever possible. If N95 masks are not available, the next option is to look for FFP2 respirator masks. N99, N100 and FFP3, although will fulfill the purpose of filtering the virus, they are not very comfortable to wear over a long period of time (make breathing difficult) and are therefore not recommended. With the recent COVID-19 pandemic, N95 and FFP2 masks are in severe short supply. Healthcare providers at the front end who are treating COVID-19 patients need an N95 mask for self-protection. In this situation, many research groups have experimented with different ways of extending its use without compromising on the protection that it offers. The Centres for Disease Control (CDC), USA is currently formulating guidelines for extended use and re-use of N95 masks

A key consideration for extended use and re-use is that it must maintain its fit and filtration function. The sterilizing method must eliminate the virus threat, be harmless to the end user and retain respiratory integrity. It can only be used by the same wearer and should not be shared with others. If the N95 mask is soiled or damaged or it makes breathing difficult (because of filter clogging), it should be discarded and no attempts should be made to sterilize it for reuse.

The different ways of sterilizing and reusing the N95 mask are as follows -

- Air drying: This is a simple way of reusing the N95 respirator mask. Drying the mask kills the virus, but it takes at least 48 hours to dry. Therefore, drying in a clean, dry place for 72 hours (3 days) is one way of reusing the mask. The only issue is that you have to wait for 3 days to reuse it. If you have four N95 masks, wear one every day and then keep it for drying, until the fourth when it can be reused. Keep the mask in a paper bag away from direct sunlight and ultraviolet rays. If in the meantime, the mask becomes soiled, damaged or difficult to breath, you need to discard it. Needless to say, always practice hand hygiene before removing and wearing it again the next time.
- Heat in an oven: Heating at 70 degrees C for 30 mins kills the virus. There should be no contacting metal, and check if the N95 material used is not inflammable, if it is, do not heat in oven. You can hang the mask in the oven by using a wooden clip. This work has been done by the Stanford University team, USA and up dated on 25th March 2020.13
- Dry heat in a rice cooker: Put the N95 mask in a traditional electric rice cooker without putting any water inside for 3 mins, until the temp is 149 -164 degrees C.¹⁴
- Chemical sterilization with H2O2: Researchers from Duke University in the USA reported that using H2O2 (480 ppm) in a specially designed chamber for 45 mins sterilizes the filter without destroying it. It takes a total duration of 4 hrs. The paper describing the method has been accepted in the Journal of Applied Biosafety as on 26th March 2020.¹⁵

At around the same time (27th March 2020), researchers from the Yale University, USA too have reported effective disinfection of the N95 mask with H2O2. Their paper is currently being peer reviewed.¹⁶

Attempts made for cleaning the mask with soap and warm water or alcohol or bleach or exposure to ultraviolet radiation or isopropranolol or

Based on these emerging observations, the Centre for Disease Control, USA as of 3rd April 2020 is reviewing its policy and is considering a recommendation to encourage broader use of face masks in the community. The Ministry of Health and Family Welfare is also likely to revise its advisory and recommend all people to wear a mask. On 3rd April 2020, the Government of India initiated the Mission PPE (Personal Protective Equipment), where 5 billion cloth masks, 500 million surgical masks and 500 million gloves will be procured soon.

Doctors, health care providers, policy makers and lay people have very little information about masks. Whatever knowledge they have is all picked up from media. The fear and panic created by COVID-19 has led people to buy all sorts of masks even without having any knowledge about them. The news in the media that N95 masks are the most protective masks led to a panic buying spree by lay people and stocking them at home. As a result, the frontline health care workers are facing severe shortages of these masks. This has also led to a lot of fake masks being introduced into the market and many people, including healthcare providers are wearing them inadvertently. Many do not even know which mask to wear, how to wear and how to remove. Doctors and nurses themselves are not wearing the right masks. This lack of knowledge is creating confusion and harm in the community.

This review is intended to inform the readers about the different types of masks available, who should wear which mask and the latest information that is available on the role of masks in preventing the spread of COVID-19.

THE DUST MASK (FIGURE 2)

A dust mask is a flexible, moulded, disposable mask made of paper pad. It is worn for comfort against non-toxic nuisance dusts generated by house dusting, grass mowing, gardening, sweeping, brickwork, fiberglass, and during sand storms.

This mask does not offer any protection against COVID-19 and should not be used. Unfortunately, a lot of people wear this mask with the belief that it is protecting them.

THE SINGLE LAYER FACE MASK (FIGURE 3)

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.

It offers no protection against corona virus and is not recommended for use. Unfortunately, a lot of people also wear this mask, little knowing that it is not offering them any protection against the Corona virus.

SURGICAL MASK OR MEDICAL MASK (FIGURE 4):

The Surgical mask, also called procedure mask, medical mask or face mask was introduced in the 1890s for surgeons to wear it during the operation or other health care workers during any medical procedure. Contrary to popular belief, the surgical mask was never intended to protect the surgeon from catching the patient's infection. The mask was always meant to protect the patient in case the surgeon coughed or sneezed during the surgery. However, the surgical mask does protect the surgeon from blood and body fluid splashes entering into their nose and mouth from the surgical site during surgery.

The surgical mask is made up three layers. The innermost layer is made up of an absorbent material that absorbs moisture from the wearer's breath, the middle layer is made up of a melt-blown material that acts as a filter, and the outer layer is made up of material that repels liquid. The pleats are intended to increase the surface area so that the nose and the chin can also be adequately covered. It is held in place by strings either looping around the ears or tied behind. There are varying levels of quality for surgical masks and the extent of protection depends on the specification of manufacture. Surgical masks need to conform to the following quality standards: bacterial filtration efficiency >98%, particulate filtration efficiency <99% for 0.1micron particle size, differential pressure that measures ease of breathing <3mm, and fluid resistance of 80 mmHg. In the USA, the FDA sets standards and certifies the surgical masks. As of now, there is no certifying body in India for Surgical Masks.

The surgical mask does not offer a tight fit and there is enough space for the air to leak from all the sides of the mask. It was therefore never designed for self-protection.

Surgical masks are intended to be used only once and then safely disposed. They should never be washed and reused. The life of a surgical mask varies according to its use, but generally lasts for between 3 to 8 hours depending on the environmental humidity, temperature and volume of air breathed.

It is important to know how to wear a surgical mask and how to remove it. Before putting the mask, it is important to clean the hands with soap and water or an alcohol-based hand rub. When wearing the mask, ensure that there is no or minimal gap between the face and the mask. Avoid touching the mask while using it, and if you do, clean your hands with soap and water or alcohol disinfectant. If the mask becomes damp or gets soiled, dispose it off in a closed bin. When removing the mask, remove it from behind without touching the mask and discard it immediately in a closed bin. Again, wash your hands with soap and water or alcohol rub.

Fake surgical masks: Surgical masks are more than just simple material that cover the nose and mouth; they are precise products that are required to meet certain standards in order to provide sufficient protection. Fake surgical masks are flooding the market all over the world and it is important to ensure that one is not wearing one. They often look like the real product and use logos, emblems and registration numbers in an attempt to look like the real product but they do not offer the protection that they are expected to. To recognize fake surgical masks, readers are requested to see this YouTube video.¹¹

RESPIRATOR MASK (N95, N99, N100; FFP1, FFP2, FFP3) (FIGURE 5):

A respirator mask is a tight-fitting mask with a filtration system that prevents the wearer from being exposed to noxious particles, gases, oils or microorganisms, including bacteria, viruses and fungi. It has two specific characteristics, viz: (1) an air filtering system that prevents the passage of noxious substances and microorganisms from entering inside the respiratory tract, and (2) a tight fit, so that air does not leak from the sides into the nose and mouth.

The filter of the N95 mask is made up of millions of microfibers of polypropylene layered on top of each other that have been permanently electrostatically charged. The electrical charge is necessary to retain its ability to filter microorganisms or microparticles.

The respirator masks were first developed for occupational exposure settings to reduce exposure to fine particulate matter pollutants, but they were modified later to cover harmful gases and volatile oils. Respirator masks evolved over hundreds of years in response to multiple crises. The earlier versions were made up of fiber glass and were designed to prevent fine coal dust from entering into the lungs, but this made breathing difficult. In 1972, 3M introduced the first, single-use N95 mask, which instead of fiberglass was made up of very thin layers of fibers by air-blasting melted polymer. They then added an electrostatic charge to the material in order to block very small particles. The breathing was a lot easier with this mask, and it soon became a popular personal protective devise for fine dust exposures. Its first medical application was during the 1990s when it was used by doctors and nurses to protect them from catching drug resistant TB from HIV-infected patients. It was then subsequently used in the SARS outbreak in 2003. Just like how movie films are certified into 'A' for adults, 'PG" for parental guidance and 'U' for universal depending on the amount of adult content, respiratory masks are certified into N, R or P 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' which 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 used only for industrial settings and are not relevant to this discussion. N is further divided into N95, N99, N100 depending on the filtration efficacy (See Table 1). N95 means that this mask can filter off at least 95% of particles which are > 0.3 microns, while N99 means it can filter off 99% of these particles.

microwaving have all been unsuccessful as they damage the electrostatic charge and significantly reduce the filtration capacity.¹⁷

CLOTH MASKS (FIGURE 8):

Surgical masks need to be replaced every day. N95 masks are expensive, not easily available and are largely meant for frontline healthcare providers. For the vast majority of people in the community, especially from developing countries, there is a need for a cheap, easily available, washable and reusable mask. Cloth masks seem to fulfill these criteria. The Office of the Principal Scientific Advisor to the Government of India has recently released a manual for home-made cloth masks.¹⁸ The manual gives advice on how to make homemade cloth masks using an old T shirt or cotton vest (the fabric must be 100% cotton) and how to clean and sanitize the mask on a daily basis. You can take as many layers of the cloth, but the more the number of layers, the more difficult it is to breathe through it. Depending on the thickness of the fabric, two or three layers are appropriate. Cotton masks are also available in many stores across the country.

WHO SHOULD WEAR MASKS AND WHICH ONE?

Community at large (Common man)

Everybody should wear a mask, primarily because this is the best means of preventing the aerosol spread of infection from one person to another (from both asymptomatic and symptomatic infected persons), but also because it offers some protection from catching infection from others (Figure 9).

The N95 mask reduces the transmission of aerosol by 70%, whereas surgical mask reduces transmission by 50% and cotton masks by 40%. Maximum protection from catching the infection from others by the aerosol route is offered by the N95 mask (99%), whereas the surgical mask offers 75-80% protection and the cloth mask by around 50-70%. Wearing any mask is better than wearing no mask, both in terms of transmission and protection.

When outside the house: Everybody must wear a mask during the ongoing pandemic. The surgical mask is the preferred mask, but this needs to be replaced daily or even multiple times daily depending on the time spent outside, the weather and humidity. Surgical masks that become wet, soiled or makes breathing difficult, must be replaced immediately. Hands must be sanitized with ≥60% alcohol disinfectant or soap and water before putting the mask and after removing it. The front end and the back end of the mask should not be touched. The surgical mask should never be washed nor reused anytime. If the surgical mask is not available or is unaffordable, a washable and reusable 3-layer cotton mask should be used. It should be washed everyday with soap and warm water and air dried. The mask should be stored in a clean and dry place. The N95 respirator mask is not recommended for community use. The dust mask and the single layered face mask are not recommended.

When inside the house: If you have respiratory symptoms suggestive of corona virus infection (fever, dry cough, shortness of breath, body ache or loss of smell) you must wear a surgical mask at all times, even while sleeping. It should be replaced preferably at least every 4-8 hours until seen by a physician. Care should be taken not to touch the mask with the hand and should be disposed carefully in a closed bin. If the surgical mask is not available or not affordable, you should wear a disposable three-layered cotton mask, which should be carefully washed and dried. All other members in the family should also wear a surgical mask or a cotton mask depending on availability and affordability. If you are asymptomatic, but have come in close contact with somebody who travelled from abroad, you should wear a surgical mask / cloth mask. If nobody in the house has any respiratory symptoms or no one has been in touch with anyone who travelled from abroad, there is no need to wear a mask. If a person is recovering from COVID-19 infection, he must wear a surgical mask. Everybody else should wear a surgical mask and if this are not feasible, then they should wear a 3-layered cotton mask. Social distancing and hand hygiene must be practiced strictly.

In a clinic setting

In the presence of the ongoing COVID-19 epidemic, all doctors in general practice or specialty outpatient clinics must wear a mask at all times when they see patients. A surgical mask is recommended for the doctor, nurse and all other paramedics, including the receptionist in the clinic. At the reception, all patients with respiratory symptoms or history of travel abroad or history of caring for a COVID-19 or a suspected COVID-19 case must be requested to get his/her own surgical mask or should be given a surgical mask by the clinic. Whenever available and feasible, an N95 mask should be used if you in a highrisk zone of COVID-19 (in a cluster or an area with suspected high numbers of COVID-19 patients). Doctors and other health care workers should not wear a cotton mask. If you are collecting nasal swabs or throat swabs for COVID-19 testing, it is preferable to use an N95 mask and if not available, a surgical mask. Remember hand hygiene is equally important and this should not be neglected at all. Hands should be washed after seeing every patient with soap and water or a alcohol containing hand rub.

In a hospital setting with indoor beds:

All doctors, nurses, paramedics and other helpers in the hospital must wear a surgical mask. Those who are caring for a COVID-19 patient (doctor, nurse, phlebotomist) in a non-ventilated patient, a surgical mask should suffice (but with gloves, gown and eye protection). If an N95 mask is available, that should be used. During aerosol generating procedures, such as tracheal intubation, non-invasive ventilation, tracheostomy, cardiopulmonary resuscitation, manual ventilation before mechanical ventilation and bronchoscopy the N95/ N99 mask or FFP2/FFP3 mask should be worn along with gloves, gown, face shield and safety goggles.

A cloth mask is not recommended for use by any health care worker in a hospital setting. The outcome will be a greater risk of becoming infected yourself and also a greater risk of infecting everyone else around if you are an asymptomatic carrier.

In a retrospective study of 6 hospitals in Wuhan during the beginning of the outbreak of COVID-19, 10 doctors and nurses out of 213 who wore no mask and had usual hand hygiene practices became corona infected, while none of the 278 doctors and nurses who wore an N95 mask and practiced hand hygiene caught the infection.¹⁹ Similar observations have been made in other hospitals.¹⁹ Although this was a retrospective study, it clearly indicates that wearing a mask offers protection against corona infection than not wearing a mask.

Are surgical masks as good as N95 masks for healthcare providers? Most real-world research comparing standard face masks with N95 masks have been in the context of influenza or other viral respiratory conditions and usually based in hospitals. There are no published head-to-head trials of these interventions in severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, and no trials in primary or community care settings. Current guidance is therefore based partly on indirect evidence - notably, from past influenza, SARS and MERS outbreaks - as well as expert opinion and custom and practice.²⁰ A recent systematic review and meta-analysis of surgical masks versus N95 respirator masks by the Chinese Cochrane Centre that included six randomized controlled trials with a total of 9171 healthcare workers showed that there was no difference in the efficacy between surgical masks and N95 masks in preventing laboratory-confirmed influenza, laboratory-confirmed respiratory viral infections, laboratory-confirmed respiratory infection and influenza-like illness.²¹ These studies add to the confidence that surgical masks may fare as well as N95 masks in a hospital setting, but they need to be worn regularly, adhered to proper standards of wearing and removing them, and need to be coupled with adequate hand hygiene measures. To summarize, in the current pandemic of COVID-19, everybody should wear a mask, primarily because it significantly reduces the chances of spreading the aerosol route of transmission, and also because it offers protection against catching the infection. The dust mask and the single-layered cotton mask are not recommended for use, although a large number of people in the community are inadvertently wearing them. A 3-layered surgical mask is the ideal mask for the common man to wear, but these are usually either not affordable (because they can be worn only once and during a day you may need to wear several of these) or not available. A 3-layered cotton mask is a reasonable alternative, although it is not as effective. It is comfortable, washable and reusable. If you are a layperson taking care of a COVID-19 patient in your house, you must wear a N95 mask or if not available a 3-layered surgical mask. Doctors and healthcare providers should not wear a cloth mask. A surgical mask is recommended for doctors, nurses and all paramedics in routine clinical practice. They should be worn properly and disposed properly with good hand hygiene practices. Those doctors and healthcare providers who take throat swabs/nasal swabs of suspected COVID-19 patients or perform aerosol generating procedures should wear a N95 mask. Masks will do their function only if they are worn properly. Hand hygiene is equally important and should not be neglected at all.

The 0.3µm cut off is used for measuring filtration efficacy because that is the most penetrating size into the lungs. The coronavirus is between 0.06–0.14 microns in diameter or 60-140nm. Counterintuitively, viruses of this size are easier to filter than those that are >0.3 microns, because these sized particles follow a Brownian motion (random zig zag) and therefore trap more easily

Table 1: Showing differences between different respirator masks

5						
	N95	N99	N100	FFP1	FFP2	FFP3
% of ≥0.3 µm particles filtered	At least 95%	At least 99%	At least 99.97%	At least 80%	At least 94%	At least
						99–99.95%
Breathing resistance	+	++	+++	+	+	++ to +++
Internal leakage rate permitted	-	-	-	22%	8%	2%
Utility	Protection against particulate matter pollution, bacteria, viruses, fungi	Protection against particulate matter pollution, bacteria, viruses, fungi, oil (8 hrs)	Protection against particulate matter pollution, bacteria, viruses, fungi, oil (40 hrs)	Low levels of dust, e.g. home renovation, hand sanding, drilling, cutting	Moderate level of dust, e.g. construction, agriculture, plastering, particulate matter pollution, bacteria, viruses, fungi	High level of dust, e.g. asbestos, pharmaceutical industry dust, particulate matter pollution, bacteria, viruses, fungi
Suitable for COVID-19	Yes	Yes	Yes	No	Yes	Yes
Color of headband	_	_	_	Yellow	Blue	Red



Countries that do not have a culture of wearing a mask regularly

Countries that have a culture of wearing a mask regularly

Figure 1: Countries that wear a mask routinely have a flatter COVID-19 curve than countries where masks are very rarely worn.

Table 2: Differences between Valve and No valve N95 masks

	Valve N95, N99	Non-Valve N95, N99	
Filtration system	Inside the valve	Built within the fiber	
Weight	Bulkier, heavier	Light-weight	
Ease of breathing out	++	+	
Comfort - Sweaty/ Stuffy	More comfortable	Less comfortable	
Recommendation for people with Lung Dis- ease/Heart Disease	Yes	No	
Suitable for COVID-19 patient	No	Yes	



Figure 2: A dust mask



Figure 5: N95 and FFP2 Respirators



Figure 6: No valve and Valve N95 Respirator





Figure 9: (A) Showing protection against catching infection by different types of masks (B) Showing reduction in transmission by different types of masks

REFERENCES

- 1. Lee J, Yoo D, Ryu S, Ham S, Lee K, Yeo M, Min K, Yoon C. Quantity, Size Distribution, and Characteristics of Cough-generated Aerosol Produced by Patients with an Upper Respiratory Tract Infection. Aerosol Air Qual. Res. 2019; 19: 840-853.
- 2. Zhang B, Zhu C, Zhiming J, Chao-Hsin Lin. Design and characterization of a cough simulator. J Breath Research 2017; 11(1):
- 3. van Doremalen N, Morris DH, Holbrook M, Gamble A, Williamson B, Tamin A, et al. Aerosol and surface stability of SARS-Cov-2 as compared to SARS-Cov-1. New Engl J Med. March 17, 2020; Ahead of Print.
- 4. Ong S, Tan Y, Chia P. Air, surface environmental, and personal protective equipment contamination by SARC-Cov-2 from a symptomatic patient. JAMA 4th March 2020; Ahead of Print.
- 5. Leung N, Chu D, Shiu E, Chan K-H, McDevitt J, Hau B, Yen H-L, Li Y, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nature Medicine 3rd April 2020; Ahead of Print.
- 6. Jefferson T, Mar C, Dooley L, Ferroni E et al. Physical interventions to interrupt or reduce the spread of respiratory viruses; Systematic Review. BMJ 2009; 339: b3675
- 7. Leung C, Lam T, Cheng K. Mass masking in the COVID-19 epidemic: people need guidance. Lancet 2020; 395(10228): P945.
- 8. Tapiwa G, Kremer C, Chen D, Tomeri A, Faes C, Wallinga J, Hens N. Estimating the generation interval for COVID-19 based on symptom onset data. MedRciv 8th March 2020; Ahead of Print.
- 9. Liu X, Zhang S. COVID-19: Face masks and human-to-human transmission. Influenza Other Respir Viruses. 29th March 2020; Ahead of Print.
- 10. Yan J, Guha S, Hariharan P, Myers M. Modeling the effectiveness of respiratory protective devices in reducing influenza outbreak. Risk Analysis 2019; 39: 647-661.
- 11.5 tips to test real versus fake surgical face masks. Gearbest.com March 16, 2020: https://www.youtube.com/watch?v=dC0Hga10nbk. Accessed on 4th April 2020.
- 12. Chaitanya Swami. Coronavirus: 12,300 fake N95 masks seized in Bengaluru. 31st March 2020. https://www.deccanherald.com/city/top-bengaluru-

stories/coronavirus-12300-fake-n95-masks-seized-in-bengaluru-819813. html. Accessed on 4th April 2020.

- 13. Selig Kate. Stanford researchers develop potential method to reuse N95 respirators. Heat disinfection could be conducted in an oven. 31st March 2020. https://www.stanforddaily.com/2020/03/31/stanford-researchersdevelop-potential-method-to-reuse-n95-respirators/. Accessed on 4th April 2020.
- 14. Lin T-H, Chen C-C, Huang S-H, Kuo C-W, Lai C-Y, Lin W-Y. Filter quality of electret masks in filtering 14.6-594nm aerosol particles: Effects of five decontamination methods. Plos One 2017; 12: e0186217
- 15. Schwartz A, Stiegel M, Greeson N, Vogel A et al. Decontamination and reuse of N95 respirators with hydrogen peroxide vapor to address worldwide personal protective equipment shortages during the SARS-Cov-2 epidemic. https://www.safety.duke.edu/sites/default/files/N-95_VHP-Decon-2020. Re-Use.pdf. Accessed on 4th April 2020.
- 16. https://www.rep-am.com/featured/2020/03/28/yale-medicine-researchersdiscover-way-to-clean-reuse-n95-masks/. Accessed on 4th April 2020.
- 17. Viscusi DJ, Bergman MS, Eimer BC, Shaffer RE. Evaluation of five decontamination methods for filtering facepiece respirators. Ann Occup Hyg 2009; 53: 815-27.
- 18. Principal Scientific Advisor to the Government. Masks for curbing the spread of SARS-Cov-2 Coronavirus. A manual on homemade masks. March 30, 2020. http://164.100.117.97/WriteReadData/userfiles/FINAL%20 MASK%20MANUAL.pdf. Accessed on 4th April 2020.
- 19. Wang J, Zhou M. Liu F. Reasons for healthcare workers becoming infected with novel corona virus disease 2019 (COVID-19) in China. J Hospital Infection, 2020; Ahead of Print.
- 20. Greenhalgh T, Chan X, Khunti K, Durand-Moreau Q, Straube S, Devane D, Toomey E, Adishesh A. What is the efficacy of standard face masks compared to respirator masks in preventing COVID-19 type respiratory illness in primary care staff? Centre for Evidence Based Medicine. 24th March 2020; Ahead of Print.
- 21. Long Y, Hu T, Liu L, Chen R, Guo Q, Yang L, Cheng Y, Huang J, Du L. Effectiveness of N95 respirators versus surgical masks against influenza: A systematic review and meta-analysis. J Evid Based Med 13th March 2020; Ahead of Print.