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Review Article

Universal masking during COVID-19 pandemic: Can textile engineering help public health? Narrative review of the evidence

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ABSTRACT

The Coronavirus Disease-2019 (COVID-19) pandemic caused by the virus SARS-CoV-2 is spreading very quickly around the world. In less than 7 months since it became known to the international community, the virus has infected 18 million in more than 180 countries and killing more than 700,000 people. Person-to-person transmission through infected respiratory droplets from patients with symptoms and asymptomatic carriers is the main mode of spread in the community.

There is currently no standard agreed upon drug to treat the disease and the prospect of having a safe and efficacious vaccine might be years away. Thus, public health interventions such as social distancing and hand washing have been introduced and has, to some extent, slowed the progression of the pandemic. Universal masking as a public health intervention is currently mandatory in a vast majority of countries around the world. To avoid personal protective equipment (PPE) shortage crisis for medical staff and other frontline workers, health authorities are recommending the use cloth masks. Although in theory, cloth masks can be helpful to limit the spread of the COVID-19, serious consideration should be given to the choice of textile, the number of layers of cloth used, pre-treatment of the material with water repellent material and other compounds that can enhance the filtration efficiency of the masks without compromising their breathability. This review uses concepts of textile engineering and the theoretical principles of filtration to make suggestions and recommendations to improve the quality and safety of cloth masks for the general public.

1. Background

Since the emergence of COVID-19 in Wuhan city in China in late December 2019, public health authorities around the world have struggled to limit the spread of the infection. The causative agent, SARS-CoV-2, is a respiratory virus belonging to the Coronavirus family and is closely related to 2003 SARS –CoV-1 (Severe Acute Respiratory Syndrome Corona Virus 1) epidemic and 2013 Middle East Respiratory Syndrome (MERS) outbreak (Cheng and Shan, 2020). The virus propagates in the community by human-to-human transmission, either by inhalation of contaminated respiratory droplets or hand to mouth transfer from contaminated surfaces. The distinguishing features of SARS-Cov-2 is that it is highly contagious, with basic reproduction numbers ranging from 1.4 to 7.2 (Liu et al., 2020a, 2020b) and is highly pathogenic, with case fatality rates in the range of 1.4% in New Zealand to 14.9% in the United Kingdom (Dong et al., 2020). Within less than 7 months since its first appearance, Covid-19 has infected 18 million people in more than 180 countries and killed more than 700,000 people (Dong et al., 2020). There is currently no vaccine for Covid-19 and the medical community is desperately trying to find safe and effective drugs to limit disease severity and save lives.

In these circumstances, where a vaccine is not available and curative options are practically inexistent, the medical community has to rely on traditional public health preventative strategies such as testing, case identification, contact tracing, case isolation and quarantine. All of these interventions rely on the premise that our health systems can quickly and efficiently identify infected individuals and ensure that they do not get onto close contact with healthy community members. In practice, this is a near-impossible task, as a significant proportion of cases either do not develop any symptoms or have mild symptoms (Kimball et al., 2020; Pan et al., 2020). This is precisely why governments around the world are recommending universal precautions such

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as hand washing and social distancing, rebranded as physical distancing. The recommendations for spatial separation of 2 m (CDC, 2020a, 2020b) is based on the assumption that large droplets do not travel more than 2 m (≈6 ft) in a horizontal direction. However, review of evidence, although sparse at this time, suggests that respiratory droplets can travel more than 2 m and recently published papers strongly suggest that SARS-CoV-2 can get airborne (Guo et al., 2020). The other most likely circumstance where SARS-CoV-2 can potentially be aerosolized is during invasive dental procedures, such as grinding, polishing and cutting activities on dental tissues in the presence of saliva (Harrel, 2004).

To complement existing measures, Governments in China and other South East Asian countries have recommended universal masking as early as in February 2020 (Leung et al., 2020). The universal use of masks to prevent community transmission of the virus is a subject of intense debate (Eikenberry et al., 2020; Greenhalgh T, n.d.; Greenhalgh et al., 2020; Martin et al., 2020). Since the start of the pandemic, multiple health authorities have consistently advised against the use of masks in the community because of lack of evidence that it offers protection to the healthy person wearing it. However, the lack of conclusive evidence on the effectiveness of masks to protect the persons wearing them does not in any way mean that this practice is totally ineffective or harmful, especially in such a dire pandemic where people are dying by tens of thousands every day. Recent publications have revealed solid data indicating that asymptomatic and pre-symptomatic individuals can be highly contagious (Arons et al., 2020) and can thus transmit the virus. Based on the evolving science on the flow physics and aerodynamic behavior of viral particles (Asadi et al., 2019; Mittal et al., 2020), we suspect that the transmission from asymptomatic carriers of SARS-Cov-2 would most likely be by ingestion or inhalation of respiratory droplets, droplet nuclei or airborne viral particles through casual social interaction such as talking, singing and laughing. In light of these recent findings, governments in the Western world (Canada, 2020; US CDC, 2020a; Sunjaya and Jenkins, 2020; Tanne, 2020) are advising, and in some cases enforcing, the universal use of masks in public places. The public health rationale for universal masking is that people in close contact can not only protect themselves but they are unintentionally protecting each other (Leung et al., 2020).

Global shortage of disposable surgical and respiratory masks is a real and expanding problem, having already created panic in Italy, France and Spain, USA and other countries (Gunia, 2020). Thus, all recommendations for wearing masks in public settings are also accompanied by a caution to keep special medical masks (surgical/FFP2 or N95) exclusively for healthcare and other frontline staff. Current science and guidance indicate that there is a hierarchy of respiratory protection, with some respirators (e.g, N-95) offering higher levels of safety compared to surgical masks which are in turn better than homemade cloth masks (van der Sande et al., 2008). Surgical masks and respirators are two main intervention measures to protect health care personnel. Respirators (N–95 or FFP2) are masks designed to shield the wearer from inhalational hazards by reducing exposure to particles including small particle aerosols and large droplets. (CDC, 2020a, 2020b). On the other hand, surgical masks, protects the wearer from large droplets and splashes and protects people coming close to the wearer from the latter's respiratory emissions. However, there is intense and sometimes passionate debate about the reliability of homemade cloth masks (Eikenberry et al., 2020; Mahase, 2020) to protect both the wearer and the general public in high risk community settings.

2. Cloth masks, are they protective?

Before the pandemic, cloth masks have been used in crowded cities, especially in Asia, to protect against particulate matter pollution. The filtration efficiencies of these masks to protect against non-infectious agents have been investigated thoroughly. The wide variation in filtration efficiency as a function of fabric material used was already demonstrated by Shakya et al. (2017) and Rengasamy et al. (2010, 2018) who studied the filtration efficiency using diesel particles (< 2.5 μm) and NaCl particles (< 1 μm) respectively.

Given the current personal protective equipment crisis in the world, whereby demand far exceeds supply, the only alternative for the general public seems to be the use of cloth masks. In this pandemic situation and in a state of panic, there has been an upsurge of online videos on do-it-yourself (DIY) masks. However, there are legitimate concerns from both health professionals and the general public, on the reliability of cloth masks to offer protection to both the wearer and community members.

A review of the academic literature reveals a number of studies looking at the efficacy of cloth masks at reducing the spread of respiratory infections in the community. One of the most pertinent studies on the efficiency of cloth masks by Davies et al. (2013) evaluated several household materials to assess their ability to physically block bacterial and viral aerosols. The authors of that study used simulated lab experiments to compare the filtration efficiencies of various materials, such as cotton T-shirt, linen, silk, scarf against a standard surgical mask, using 2 test organisms, namely *Bacillus atrophaeus* (diameter: 0.95–1.25 μm) and *bacteriophage MS2* (diameter: 23 nm). For comparison purposes, the SARS-CoV-2 virus is round or oval in shape, with a diameter of approximately 60–140 nm. With respect to the bacteriophage, the mean filtration efficiency of the surgical mask (89.52%) was much higher than tea towel (72%), cotton mix (70.24%), linen (61.67%), silk (54.32%), cotton T-shirt (50.85%) and scarf (48.87%). Furthermore, 21 healthy volunteers were enrolled in the same study to assess whether homemade masks were effective in preventing dispersion of droplets and aerosol, and hence reduce the number of microorganisms expelled by wearers. However, surgical masks were 3 times as efficient as homemade masks in blocking transmission. Interestingly, they also found that homemade masks are better than no masks at all, but cautioned that homemade masks are to be used as a measure of last resort.

MacIntyre et al. (2015) conducted a randomized trial in Vietnam to compare cloth masks with medical masks in their abilities in preventing respiratory infections among healthcare workers. The authors reported that heath care workers using cloth masks have a 7-fold higher risk of acquiring influenza like infections (Relative Risk = 6.64, 95% Confidence Interval 1.45 to 28.65) and 2-fold higher risk of laboratory confirmed viral infection (Relative Risk = 1.72, 95% Confidence Interval 1.01 to 2.94) compared to those using surgical masks.

A recent study by Ma et al. (2020) using avian influenza virus in laboratory setting, showed that homemade masks made of one-layer polyester cloth plus four-layer kitchen paper (Hengan Company, Fujian, China; each layer contains three thin layers of nonwoven) could block 95.15% viral particles in aerosols. For comparison purposes, N95 and surgical masks were able to block 99.98% and 97.14% of the aerosolized viruses respectively. Though the pressure drop was not measured, the authors reported that the cloth mask was more breathable than N95 masks. The authors mentioned the advantage of changing the kitchen paper frequently, but no detail on the structure and washability of the polyester fabric cloth was provided.

Based on a sophisticated laboratory methodology, commonly used by the US National Institute of Occupational Safety and Health (NIOSH) to test respirators, Konda et al. (2020) carried out several experiments to confirm filtration efficiencies of some fabrics, as a function of aerosol particulate sizes in the 10 nm to 10 μm range, which is particularly relevant for respiratory viruses. The authors reported large variability in filtration efficiencies (5–80%) of single layer fabrics for particle size < 300 nm. Interestingly, the filtration efficiencies increased to values higher than 80% when multiple hybrid layers (e.g. cotton-silk, cotton-chiffon, cotton-flannel) were used, though the pressure differential was a bit slightly higher (3.0 Pa) than the N95 and surgical masks (2.2–2.5 Pa). The chiffon used was made of a blend of 90% polyester and 10% spandex, and the flannel composed of 65% cotton and 35%

polyester. The enhanced filtration abilities of hybrids potentially were linked to the combined effect of mechanical and electrostatic filtration modes. A cotton quilt and a tightly woven cotton fabric used alone, led to high filtration efficiencies: 96% (for particle size < 300 nm and > 300 nm) for the cotton quilt composed of 90% cotton, 5% polyester and 5% other fibers, and 82% (for particle size < 300 nm and 98% for particle size > 300 nm) for the tight 100% cotton woven fabric. These encouraging results by Konda et al. confirm the possible use of cloth mask for filtrating wide range of particles (down to 10 nm) including bioareosols (100 nm–1000 nm). This work adds important data to the scientific debate on the possible use of certain cloth masks to filter bioaerosol sized particles, with filtration efficiency close to that of medical masks. Thus, fine fibers, tightly woven fabrics, and fiber surface with electrostatic effects, and hybrid compositions, can potentially result in efficient filtration down to nanometer scale (10 nm), including bioaerosols.

3. Can the filtration performance of cloth masks be improved?

3.1. What is expected of an efficient mask?

With such a dire state of affairs unfolding so quickly, it is imperative to step back, examine the basic scientific principles behind the filtration mechanism of face masks. Ideally a good face mask should have the following properties (A) good filtration capacity for microorganisms for both inhaled and exhaled air, (B) low breathing resistance, (C) hypoallergenic, (D) comfortable to the wearer, and (E) washable and (F) affordable. However, in the context of the Covid-19 pandemic, the most relevant property of the face mask is the ability to filter tiny respiratory droplets, droplet nuclei and aerosolized particles.

3.2. Theory of filtration

Based on previous literature (Hinds, 1999) describing the basic science of filtration, Konda et al. (2020) confirmed the five main mechanisms of filtration by respiratory droplets and bioaerosols, namely; *gravity sedimentation*, *inertial impaction*, *interception*, *diffusion*, and *electrostatic attraction*. For large respiratory droplets, about 10 μm in diameter, gravity sedimentation and inertial impaction are the main modes of filtration. For particles of smaller diameters, diffusion and mechanical interception by the filter fibers is a major mechanism of filtration: electrostatic attraction and binding to the fibers in masks is the foremost method by which bioaerosols in the range of 0.1 to 1 μm are captured through a face mask.

3.3. Size of particles to be filtered and filters used

In the current context of the COVID-19 pandemic, it is important to consider the fate of respiratory droplets in face mask wearing individuals. Currently, the term droplet is often taken to refer to droplets > 5 μm in diameter that fall rapidly to the ground under gravity. Respiratory droplets are produced by various means such as breathing, talking, coughing, sneezing and singing (Toth et al., 2004). On evaporation of respiratory droplets, dried residual of droplets called droplet nuclei that are < 5 μm in diameter, are formed (Setti et al., 2020). By definition, asymptomatic and pre-symptomatic carriers of virus do not cough and sneeze, and therefore do not expel large infected respiratory droplets. Based on our current knowledge of the SARS-CoV-2 virus, there are thus only two remaining avenues for them to infect others: (1) contaminated surfaces spread (2) tiny particles (< 5 μm) airborne spread.

While handwashing can take care of contaminated surface spread, the public health community still needs to address the risk of airborne spread. Based on previously published data on aerosol science (Morawska et al., 2009), Asadi et al. (2020) made a strong and compelling argument that aerosolized viral particles can be generated during a regular face to face conversation between 2 individuals. According to Morawska et al. (2009) particles in the < 0.8 to 2.0 μm range are created during normal breathing while particles < 0.8 μm to 7.0 μm are produced while speaking. A carefully designed homemade face masks should be able to filtrate potential droplets and droplet nuclei produced during casual face to face conversations.

3.4. Medical masks filtration efficiency

The primary purpose of a surgical mask is to help prevent biological particles from being expelled by the wearer into the immediate environment. There are three types of surgical masks (3M, 2020a) capable of up to 98% bacterial filtration efficiency (mean diameter of the aerosol 3.0 μm) - Type I surgical face masks are used to help reduce the risk of the spread of infections via the droplet route (either worn by patients and healthcare workers). Type II and Type IIR surgical masks are principally intended for use by healthcare professionals while the Type IIIR is designed to be additionally fluid resistant to splash and splatter of blood and other infectious materials.

For the respirators, the particulate filtration efficiency is generally measured against an aerosol of sodium chloride. For N95 respirators, particulate filtration efficiency is above 95% for an airflow rate of 85 L/min, with pressure drop reaching 343 Pa and 245 Pa during inhalation and exhalation, respectively, in compliance with the NIOSH 42 CFR Part 84 test protocol (3M, 2020b) FFP2 respirators of the European Union are considered functionally equivalent to N95 respirators (North American Standard) and KN95 respirators of China. However, slightly different criteria are used to certify their performance, such as the filter efficiency, test agent and flow rate, and acceptable pressure drop. However, slightly different criteria are used to certify their performance, such as the filter efficiency, test agent and flow rate, and acceptable pressure drop.

3.5. Fibrous filters used in medical masks

Meltblown polypropylene fibrous nonwoven(s) are included in both surgical and medical respiratory masks (FFP2 or N95) for improved filtration efficiency. These nonwovens have fiber diameters which can reach down to 250 nm, providing high degree of filtration due to the increased impact probability resulting from a greater number of fibers. Additional polypropylene fiber surface electrostatic charges enhance bioaerosol filtration efficiency (Tsai et al., 2002).

The surgical mask is made of 3 layers of nonwoven: Spunbond-melblown-spunbond, wherein the meltblown is the filtration layer and, the outer water repellent spunbond surface is a barrier to outside droplets (Cheng et al., 2020). The FFP2 or N95 masks are composed of a complex multilayered structure made up of several layers of nonwovens, including water repellent nonwoven for bigger particulate filtration, and inner meltblown nonwoven layers for removal of particles in the smaller size range including bioaerosols. Intercalated cotton layers improve moisture absorption.

3.5.1. Fiber characteristics required for cloth masks for improved filtration efficiency

Previous work has shown the dominant role of the fiber characteristics in filtration efficiency of nonwovens. Hence, on basis of similar basis weight, a cloth with increased fiber fineness and surface roughness, specific cross-sections (multi-lobal) and fiber crimp, can lead to higher filtration efficiency (Steffens and Coury, 2007). Decreasing indefinitely the fiber diameter to improve filtration efficiency is however not advisable, since pressure drop will become physiologically unacceptable. Hence, research on electrospun nanofiber webs for filters, should also take into account this last aspect (Payen et al., 2012).

The work carried by Konda et al. (2020) strongly suggests that cloth masks can be used to efficiently filtrate bioaerosol sized particles, with filtration efficiency almost that of surgical masks. The use of fine fibers, tightly woven fabrics, fiber surface with electrostatic charges and hybrid composition, can result in efficient filtration down to nanometer scale (10 nm).

A: Technical advice on fabric selection for Covid-19 filtration

While the results of research of Konda (Konda et al., 2020) and Davies (Davies et al., 2013) open up the perspective of a wide range of textile structures which can ensure efficient filtration higher than 80% of particles ranging from both droplet and droplet nuclei size particles, care must be taken that people do not use any randomly selected textile, since each textile is obtained by specific successive mechanical and chemical processing from fiber to fabric (Mao and Russell, 2015). Fiber nature, *(size, morphology, texturing)* and yarn processing *(yarn type-multifilament or staple yarn, number of filaments/fibers per yarn section, blending of fibers, degree of twisting)*, the weave or knit structure as well as chemical and mechanical finishing *(fabric texturing)*, thermofixation, are important factors which may influence the fabric porosity (Ogulata and Mezarcioz, 2012; Purchas and Sutherland, 2002, Mao and Russell, 2015, Dubrovski and Brezočnik, 2012) pore size, and the fiber surface properties including surface electrostatic charges, and hence the filtration efficiency and breathability of a cloth mask.

In parallel with public health recommendations for universal masking, the quality of cloth mask should also be monitored by using standardized fabric layer combinations already tested for breathability and filtration efficiency. Within recent work of Konda et al. (2020), and others previously cited work, there is evidence that woven and knitted fabric combinations can be effective for bioaerosol filtration (50 nm). In the current context of Covid-19 pandemic, a more robust database should be made available to the general public and manufacturers of face masks on best choice of fabric(s) and number of layers that can be incorporated in face masks for filtration of both respiratory droplets and nuclei (bioaerosols). Based on the science of filtration using textiles and the current pandemic, appropriate fabrics/combinations should be massively produced by major textile manufacturing companies to allow production of face masks by local clothing industry or by individuals (home-made). Hence, locally produced or available fabrics can become a definite resource to produce cloth masks in absence of the sophisticated electret melt blown polypropylene nonwovens used in medical masks. This is an excellent opportunity to bridge the divide between medical research, public health and textile engineering professionals.

B: Engineering modifications into cloth masks

Over the past decade, extensive research have been carried out to enhance particulate matter capture and protection conferred by medical masks. Numerous works have been carried on advanced electrospun nonwoven structures (Ren et al., 2018; Shimasaki et al., 2020) with nanopores and nanofibers which can be produced to efficiently filter viral particles and contaminated respiratory droplets. Particular care must be taken with electrospun webs, since the use of too fine fibers (down to 50 nm) can lead to high pressure drop and breathability hindrance. Moreover, the production of electrospun fibers at industrial scale is also limited to certain countries and cannot cater for global health needs during the Covid-19 pandemic.

In view of the current Covid-19 pandemic, whereby public health authorities are encouraging universal masking, we believe it is timely and relevant to leverage the existing solid body of knowledge on textile technology to enhance the filtration and protection efficiencies of cloth masks. We thus hereby discuss a few possible pathways:

Enhancing repellency of respiratory droplets

Based on the fact that COVID-19 is essentially transmitted by respiratory droplets, it would be sensible to have some sort of super repellent finishing on both sides of the outermost layer for enhanced protection effect for wearer (healthy person) from respiratory droplets, just like some surgical masks (Shen and Leonas, 2005). As an example, Katoh et al. (Katoh et al., 2019) demonstrated the effectiveness of a fluorocarbon-based super-hydrophobic coating on a surgical gown, prevents viral adhesion by allowing droplets of infectious body fluids to roll off easily from the fabric surface Furthermore, the authors reported that high fluid repellency, associated with low sliding angle, is inversely related with viral adhesion. On the theme of super hydrophobicity, recent data (Jonas et al., 2020) have demonstrated that, in addition to fiber surface energy, the innate micro-scale roughness of hydrophobic textiles (such as polyester) can have an impact of water repellency, avoiding the use of nano charges, when a nontoxic fluorinated polymer finishing is applied and yielding small tilting or roll off angles (Zimmermann et al., 2009). Selection of an appropriate textile nature and structure which ensures both filtration efficiency and super repellency when a fluorinated finish is applied, can definitely enhance the protection imparted by the cloth mask.

Moreover, research has shown that water vapor in exhaled air tends to condense and cause obstruction of pores inducing low filtration efficiency, and fogging on googles and faceshields (Hussainy H, 2016). This can lead to significant breathing resistance (Roberge et al., 2012) and increase heart rate, thermal stress, thus creating a subjective perception of discomfort (Li et al., 2005) for the wearer. When respiratory droplets accumulate on the surface of super-hydrophobic fiber filters, they form bigger droplets and subsequently can roll away, minimizing pressure drop (Liu et al., 2019) and improving filtration efficiency.

Benefits of an antimicrobial textile layer

Secondly, there is an abundance of knowledge on chemical compounds, such as quaternary ammonium salts, silver ions (Verma and Maheshwari, 2019) and plant based biochemicals such as quercetin (Maalik et al., 2014), eucalyptus oil, or tea tree oil (Usachev et al., 2013) as well as the bio-based chitosan (Liu et al., 2019) that can confer anti-viral properties to fabrics. We believe that subject to passing human toxicity and ecotoxicity tests, textile manufacturing and processing industries can potentially engineer some of these compounds in fabrics and make these available at reasonable prices to the general public.

However, in this pandemic situation, the most convenient method for virus deactivation seems to be that conferred by NaCl-salt coated fibers. Polypropylene meltblown fibers pre-wetted, and then coated by an aqueous solution of sodium chloride and surfactant, deactivated efficiently the H1 N1 influenza virus (Quan et al., 2017). Increase of osmotic pressure when droplets contact the salt crystals, as well as physical damage of viruses by the crystallized salt, were the main causes of virus deactivation.

These methods can be applied to disposable nonwoven baby wipes which can then be inserted between the inner and outer layers of the home-made cloth mask, to avoid direct contact with skin, but of course the breathability of such masks should be validated.

Enhancing filtration efficiency using cationic charges

One possible way of improving viral particle filtration without blocking fabric pores is by coating the fibers with cationic polymers using padding process (Behary et al., 2015). Such a strategy has already been adopted for filtering of human pathogenic waterborne viruses using cationic polymer polyethyleneimine (PEI) (Sinclair et al., 2019), as well as for efficient filtration of particulate matter (< 2.5 μm) (Liu et al., 2020a, 2020b) and sorption of bacterial lipopeptides (Behary et al., 2015) using cationic chitosan. If this option is chosen in addition to water-repellency, two different layers of fabric can be used for the two different functionalities. However, the benefits from polymer deposition (repellent finish or cationic polymer) should not hinder filtration efficiency brought through textile fiber electrostatic charges.

4. Face shields

Although not directly relevant to the main theme of this paper, it is imperative that we give serious attention to the use of face shields in public, in addition to a face mask. There is no doubt in the medical literature on the effectiveness of face shields as a physical barrier to prevent transmission of the virus to health care workers (Napoli et al., 2020). Research carried by Bischoff et al. (2011) confirmed the higher protection provided by an additional eye protection equipment, when surgical or N95 masks are worn by healthy persons. The use of face shield is an extra tool to enhance protection of for both the wearer, and protection of others from the wearer, would be to wear a face shield. These can be easily made locally using 3D printer, or easily handmade using for example transparent slides or bottles. Worn by an infected or healthy wearer it will radically decrease the transmission of droplets to the healthy wearer, and avoid transocular transmission.

5. Conclusions

The unprecedented COVID-19 pandemic has proven how unprepared and vulnerable our health systems are. Despite all the medical, scientific and technological progress made in the past century since the Spanish flu pandemic in 1918, governments around the world have had to resort to the old traditional model of disease prevention such as isolation, quarantine and lockdowns. The call for universal masking to break the chain of transmission is yet another eloquent example of a simple inexpensive century-old intervention that can be used again, despite all the sophisticated knowledge and technologies that we have at our disposal today. However, there is a risk that the general public can make poor uninformed choice by selecting random types of fabric for their cloth masks, by unintentionally overlooking the fact that each specific textile has its own filtration capacity and breathability.

Contrary to the time of the Spanish flu, we are now in a better position to leverage new science of textile engineering and polymer chemistry to enhance the performance of cloth masks in our battle against Covid-19. In essence, we believe that there is enough basic scientific evidence in the academic peer-reviewed literature to suggest that filtration efficiency and anti-viral properties of non-surgical cloth masks can be substantially improved without major financial investment. Additionally, we also focused on another important component of the universal masking policy: offering protection to the wearer. This is often a neglected part of the whole universal masking policy as it missed a key element of health behavioral science, in that people needs to see how they can protect themselves by adopting a certain behavioral pattern.

Recent works carried confirm the potential use of certain hybrid fabric layer (combinations) for max filtration efficiency of respiratory droplets and bioaerosols. Fiber fineness and electrostatic charges would enhance this filtration. However, the combinations of fabric which confer both efficient filtration and breathability should be carefully selected and recorded in databases for use by companies or individuals.

Based on certain recent research, some proposals are made to enhance the efficiency of cloth masks, though it is concluded that presence of a salt coated fibrous layer, and a face shield would significantly minimize the virus transmission.

While our discussion focused mainly on ways and means to improve the quality of face masks, it is meant to be part of whole package of public health interventions such as self-isolation for COVID-19 positive patients, social distancing and rigorous hand hygiene practices. Public health messaging should caution that wearing a mask should not give them a false sense of protection that can potentially encourage them to engage in other risky behaviors. This paper is meant to trigger some productive conversations among public health practitioners, researchers and policy makers and will hopefully catalyze transdisciplinary research to improve the quality of home-made cloth masks.

CRediT authorship contribution statement

Sanjay Beesoon and Nemeshwaree Behary contributed equally to the manuscript and are therefore co-first authors. Sanjay Beesoon remains the corresponding author.

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