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Joshua Trice and James Mainolfi

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14. ABSTRACT

This paper addresses the question of how effective Do It Yourself (DIY) Personal Protective Equipment (PPE), i.e. face masks, are within the general population in mitigating the spread of COVID-19. It references studies comparing the effectiveness of various materials in DIY masks alongside surgical masks and respirators. This is associated with the Department of Defense's COVID-19 announcement for all Total Force members (military personnel, civilian employees, contractors and their family members) to wear a cloth face covering in public settings where social-physical distancing measures are difficult to maintain, especially in areas of significant community-based transmission.

Studies have shown that holistically – given a variety of factors that are discussed in depth in this paper – a single layer pillowcase or a 100% cotton t-shirt are the most suitable household materials for an improvised (DIY) face mask. This is due to their breathability, fit factor, and their ability to reduce viral particle transmission by up to 50%. In general, using any type of face mask can decrease viral transmission. However, it is important not to focus on a single intervention in the case of a pandemic, but rather to integrate all effective interventions for optimal protection.3

A DIY face mask will not completely eliminate the possibility of infection with COVID-19, particularly given that there are multiple routes of transmission. But the underlying consensus of all research suggests that DIY cloth facemasks are better than nothing at all. It is vital to note that all DIY face masks, regardless of the efficiency of their filtration or seal, will only have partial effectiveness on their own. They must be used in conjunction with other preventative measures, which include: isolation of infected individuals, immunization, maintaining healthy eating/fitness standards, cough and respiratory etiquette, and regular hand hygiene.2,3,8,14

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DIY Face Mask Effectiveness Against COVID-19

Assignment Topic: *[Alternative Masks]*

Assignment Record #: *[4]*

POC: *[Joshua Trice – joshua.trice.4.ctr@us.af.mil and James Mainolfi – james.mainolfi.1.ctr@us.af.mil]*

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Disclaimer*: The intent of this document is to provide scientific evidence to the operational community on the topic of DIY Face Mask effectiveness against COVID-19. It was drafted by a team of scientists within the 711 HPW/RHM Division. This document can be used to help inform commanders and policy makers about DIY Face Mask effectiveness against COVID-19, but it does not replace the Commanders discretion in forming policy and/or guidance. Any questions about this document should be directed to the COVID-19 Med Cell: 711HPW.RHM.MedSTCOVID-19Cell@us.af.mil*

I. Summary:

This paper addresses the question of how effective Do It Yourself (DIY) Personal Protective Equipment (PPE), i.e. face masks, are within the general population in mitigating the spread of COVID-19. It references studies comparing the effectiveness of various materials in DIY masks alongside surgical masks and respirators. This is associated with the Department of Defense's COVID-19 announcement for all Total Force members (military personnel, civilian employees, contractors and their family members) to wear a cloth face covering in public settings where social-physical distancing measures are difficult to maintain, especially in areas of significant community-based transmission.

Studies have shown that holistically – given a variety of factors that are discussed in depth in this paper – a single layer pillowcase or a 100% cotton t-shirt are the most suitable household materials for an improvised (DIY) face mask. This is due to their breathability, fit factor, and their ability to reduce viral particle transmission by up to 50%. In general, using any type of face mask can decrease viral transmission. However, it is important not to focus on a single intervention in the case of a pandemic, but rather to integrate all effective interventions for optimal protection.[3]

A DIY face mask will not completely eliminate the possibility of infection with COVID-19, particularly given that there are multiple routes of transmission. But the underlying consensus of all research suggests that DIY cloth facemasks are better than nothing at all. It is vital to note that all DIY face masks, regardless of the efficiency of their filtration or seal, will only have partial effectiveness on their own. They must be used in conjunction with other preventative measures, which include: isolation of infected individuals, immunization, maintaining healthy eating/fitness standards, cough and respiratory etiquette, and regular hand hygiene.[2,3,8,14]

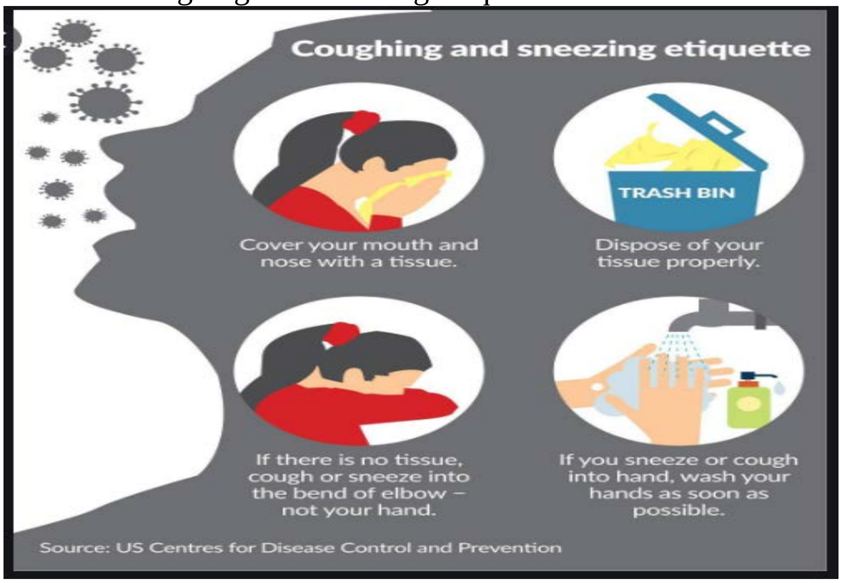
II. Operational Implications of Findings:

***Important notice** - To date, most real-world studies on the efficacy and reliability of face masks, and comparing face masks with respirators, have concentrated on their use by healthcare workers in a hospital setting and/or in the context of influenza or other respiratory conditions, such as air pollution. Additionally, at present there are no published head-to-head face mask trials regarding COVID-19 infection in a community and general public setting, though some trials are underway. Therefore, all current guidance is based partly on indirect and inadequate evidence – notably, from past influenza, SARS and MERS outbreaks – as well as expert opinion, custom, and practice.[7,24] Lastly, combatting the spread of COVID-19 by having the healthy population only wear masks is not supported by current evidence and carries uncertainties and critical risks.[8] However, if mask use is paired with established public health measures – such as social distancing, isolation of infected individuals, and hand hygiene – it can be an effective measure.*

The consensus among researchers has generally been that surgical masks are primarily designed to protect the environment from the wearer, whereas respirators are supposed to protect the wearer from the environment; but newly published research has shown that the former isn't necessarily the case.[1,3,14] Bae et al. (2020) concluded that individuals infected with COVID-19 who were wearing either surgical masks or cotton masks (which includes DIY masks) could still disseminate the virus while coughing as the masks were not sufficient to stop the virus from being emitted into the environment and transferring to the external side of their own mask's surface. This could in turn lead to further transfer of the virus if the wearer touched the outside of their mask before touching another surface or individual.[15]

If additional testing confirms this result, it has the potential to dispel the narrative that surgical or cotton masks can effectively protect the environment from the wearer in the case of COVID-19 and smaller sized microorganisms. If COVID-19 infection is suspected and/or validated by testing, then the infected individual should follow their doctor's, Center for Disease Control and Prevention's (CDC), and World Health Organization's (WHO) quarantine guidelines and should not expect that wearing a mask will prevent them from spreading the virus. If an infected individual chooses to wear either a surgical or cotton mask then proper cough etiquette should be utilized (see Poster 1) in order to create an additional barrier between the individual and the environment, theoretically limiting the transfer of the virus.

Poster 1. Coughing and Sneezing Etiquette[16]



According to the WHO, CDC, and public health researchers, the use of DIY masks and certified masks in the community may create a false sense of security. This can in turn lead to neglecting other essential protective measures, such as hand hygiene practices, physical social distancing, and touching of the face when fidgeting and adjusting the mask. This could also take masks away from those in healthcare who need them most, especially when masks are in short supply.[8] Research has shown that wearing a face mask in public areas may impede the spread of an infectious disease by preventing both the inhalation of infectious droplets and their subsequent exhalation and dissemination; however, the evidence of proportionate benefit from widespread use of face masks is unclear.[2]

<u>Western Military Cultural Implications</u>*:* (all from reference 24)

Problems with adherence to mask/respirator use are also a potential problem. We showed that in Australia, less than half of parents who were randomized to wear a medical mask or respirator while their child was ill adhered with mask wearing.10 There may be adverse effects of wearing masks, which can reduce adherence.28–30 Our study showed significantly higher reported adverse effects of N95 respirators compared to medical masks, consistent with other studies.28 Interestingly, this population of Chinese HCWs reported overall similar rates of discomfort with masks as parents in our household study,10 with higher rates in the N95 group, but it did not affect their adherence with mask/respirator wearing. This suggests that discomfort is not the primary driver of adherence, and rather, cultural acceptability and other behavioural factors may be the main reason for non-adherence. The past experience of Beijing health workers with SARS may also be a factor in the high adherence. This level of adherence may not translate to Western cultural contexts in a normal winter season, especially for N95 respirators; however, adherence can change with perception of risk. During a pandemic, we would expect HCWs to have higher adherence to infection control measures.

Problems with	Medical mask (n = 492)	All N95 (n = 949)	P value
Using the mask/respirator			
None	85.5% (420/491)	47.4% (447/943)	<0.01
Uncomfortable	9.8% (48/491)	41.9% (395/943)	<0.01
Forgot to wear it	0% (0/491)	1.7% (16/943)	<0.01
Patient felt unconformable	0.2% (1/491)	1.8% (17/943)	0.01
Trouble communicating with the patient	3.0% (9/303)	8.0% (62/775)	<0.01
Wearing the mask/respirator			
Headaches	3.9% (11/281)	13.4% (94/701)	<0.01
Skin rash	4.6% (13/281)	5.0% (35/701)	0.81
Difficulty breathing	12.5% (35/281)	19.4% (136/701)	0.01
Allergies	9.3% (26/281)	7.1% (50/701)	0.26
Pressure on nose	11.0% (31/281)	52.2% (366/701)	<0.01
Other	0.7% (2/280)	8.3% (58/701)	<0.01

The WHO has developed a risk-based approach that decision makers can apply when considering implementing/recommending the use of face masks in communities during home care and in healthcare settings in areas that have reported cases of COVID-19. (*Note: The vast majority of face mask studies and policy are geared towards healthcare professionals in hospital settings. The authors of this paper were unable to acquire data for the effectiveness of face masks for use by the general public, as that data is unavailable. This is not to say that these recommendations cannot be applied toward face mask policies for the general public.)

<u>WHO's Risk Based Approach includes these considerations</u>:

1. **Purpose of mask use**: the organization providing guidance on mask use needs to make their rationale and reason for mask use clear; specifically, they must note whether it is intended to be used for source control (used by infected persons) or prevention of COVID-19 infection (used by healthy persons).

2. **Risk of exposure to the COVID-19 virus in the local context (the general population):** the organization providing guidance on mask use must be informed of the current epidemiology in their local area, specifically how widely the virus is circulating (e.g., clusters of cases versus community transmission), and local surveillance and testing capacity (e.g., contact tracing and follow up, ability to carry out testing). The individual using the mask also needs to be conscientious of his/her actions while in close contact with the general public (e.g., community health workers, cashiers, fellow consumers, etc.).

3. **Vulnerability:** the organization providing guidance on mask use must be aware of the vulnerable population and their susceptibility to contract COVID-19. In other words what constitutes risk factors in the local population (e.g. people with comorbidities, such as, but not limited to, cardiovascular disease, respiratory compromise, diabetes mellitus, and the elderly population).

4. **Geographical setting:** the organization providing guidance on mask use must be aware of the setting in which the population lives, to include population density, which distinctly impacts their ability to socially distance (e.g. walking down a narrow hallway in an apartment building), and environmental risks that contribute to the rapid spread of COVID-19 (e.g. confined spaces, camps/camp-like settings, and residences that are not hygienically maintained).

5. **Feasibility**: the organization providing guidance on mask use must be aware of the availability and costs of masks or mask materials in the case of DIY masks, and ability to tolerate these costs.

6. **Type of mask:** the organization providing guidance on mask use must be aware of the types of masks that are available or can be made, to include medical masks and nonmedical mask (see below).

When employing this risk-based decision-making process, the following potential risks should be taken into account as they could gravely impact current military operations:

- Self-contamination that can occur by touching and reusing a contaminated mask.
- Difficulty breathing while wearing a mass, which varies widely depending on the type of material used in the mask.
- False sense of security, which could lead to reduced adherence to other preventive measures – such as social distancing and hand hygiene – that may lead to touching the face under the masks and under the eyes.
- Flawed construction of the mask, leading to an ineffective barrier and likely endangering the wearer given the previously discussed false sense of security created by wearing a mask.
- Diversion of mask supplies away from front-line workers and first-responders, which could create a more dire mask shortage for those who need them most.

- Improper fit, particularly due to anatomical differences that naturally occur within any given population and/or due by flawed construction of mask.
- Financial strain (purchasing a sewing machine and materials to construct the mask).
- Time expenditure (especially if the individual needs to learn how to properly use a sewing machine).

According to the WHO and the CDC, wearing a face mask is one preventative measures that can limit the spread of certain respiratory viral diseases, including COVID-19. Whatever approach is taken, it is important to develop a strong communication strategy to explain to the population the circumstances, criteria, and reasons for decisions. The population should receive clear instructions on when, how, and what masks to wear (see mask management section), and guidance on the importance of continuing to strictly follow all other infection prevention and control measures (e.g., hand hygiene, social distancing, and others).[8]

III. Key Points from Literature:

<u>COVID-19 is spread by four means:</u>[7]

<u>Primary</u>

1. Contact (direct or via a fomite). A fomite or fomes is any inanimate object (such as a dish, doorknob, furniture, or article of clothing) that when contaminated with or exposed to infectious agents (such as bacteria or viruses), can transfer disease to a new host.[21]
2. Respiratory droplet infection (droplets from the respiratory tract of an infected individual that are expelled while coughing or sneezing and transmitted onto a mucosal surface or the conjunctiva of a susceptible individual, or picked up from an environmental surface).

<u>Secondary</u>

3. Airborne (transmission of infectious agents in small airborne particles, particularly during procedures such as intubation), coughing and sneezing can generate aerosol particles.
4. Fecal-oral (transmission of fecal matter into the mouth by any means).

<u>How facemasks work:</u>[2]

- Facemasks reduce aerosol exposure by a combination of the filtering action of the fabric and the seal between the mask and the face.
- The filtration efficiency of the fabric depends on a variety of factors: the structure and composition of the fabric, and the size, velocity, shape, and physical properties of the particles to which it is exposed.
- Although any material may provide a physical barrier to an infection, if the mask does not fit well around the nose and mouth, or the material freely allows infectious aerosols to pass through it, then it will be of no benefit.

<u>Key factors in DIY face mask construction</u>[2]:

In the 2013 article *Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?*, researchers used fresh and previously unworn materials when testing DIY face masks. In one study cited by the authors, they found a greater breakthrough of bacteriophage MS2 on breathing system filters that had been preconditioned with water vapor. Although the droplet sizes for both viruses and bacteria were the same (MS2 and influenza virus) and affected the filter media in a similar manner, it was suggested that the viruses, after contact with the moisture on the filter, were released from their droplet containment, and driven onward by the flow of gas.[2]

The following is a list of key factors in DIY face mask construction:
- The use of fresh and previously unworn materials.[2]
- Use of ideal materials, which are soft and cotton-based with a bit of stretch, sewn with two layers of material, marked 'inside' and 'outside'.[9]
- Proper fit, to ensure the wearer does not fidget with the mask and touch his/her face. Notably, face masks with looped elastic straps are easier to fit and fit better than face masks that require the user to tie the straps. Variations in face mask fit were identified among individuals tying their own masks.[2]
- Comfort of the materials used to make the mask, and overall comfort of the mask itself, which ensures the wearer can wear it without experiencing significant discomfort for the necessary amount of time.
- Breathability, i.e. whether the mask can accommodate the breathing demands of the wearer. The mask will likely impose at least marginal additional breathing load on the wearer, which could be impracticable for individuals with conditions that already pose breathing difficulties.
- Limited supplies; however, materials used for DIY masks should be more readily available than store-bought masks, and would not need additional resources to provide at large scale.[3]

In the interim, when advising the use of nonmedical masks, the following features related to nonmedical masks should be taken into consideration:

- Numbers of layers of fabric/tissue
- Breathability of material used
- Water repellence/hydrophobic qualities
- Shape of mask
- Fit of mask

- For those who choose to wear a homemade mask, the requirements of cleaning and changing the mask should be highlighted. Most importantly, the lower protective capabilities of a homemade mask should be emphasized so that unnecessary risks are not taken.
- In practice, people will not wear an uncomfortable mask for a long period; even if they do, it is unlikely that they will wear the mask properly. Davies (2013) cited an example from the 2003 SARS outbreak: on a flight from Bangkok, Thailand, to Manchester, England, mask wearers removed their mask to cough, sneeze, and wipe their nose (not necessarily into a handkerchief) and to sort through the communal bread basket.[2]

Mask management:[8]

For any type of face mask (DIY or certified), understanding and employing appropriate use and disposal techniques are essential to ensure they are effective, prevent cross-contamination, and lower risk of transmission. The following information on the correct use of masks is derived from practices in healthcare settings.[8]
- Place the mask carefully on your face, ensuring it covers the mouth and nose, and tie it securely to minimize any gaps between the face and the mask.
- Avoid touching the mask while wearing it.

- Remove the mask using the appropriate technique: do not touch the front of the mask but untie it from behind.
- After removal or whenever a used mask is inadvertently touched, clean hands using an alcohol-based hand rub or warm soap and water.
- Replace masks as soon as they become damp with a new clean, dry mask.
- Do not re-use single-use masks.
- Discard single-use masks after each use and dispose of them immediately upon removal, clean hands using an alcohol-based hand rub or warm soap and water.
- To safely dispose of a N95 respirator or surgical mask place it in a plastic bag and put it in the trash. Wash your hands after handling the used respirator.[11]

<u>Mask care</u>:
- N95 respirator and surgical mask sterilization can be accomplished with hot air at 70°C for 30 minutes, and this process can be repeated approximately 20 times without a noticeable loss in filter efficiency (FE).[5,22]
- N95 respirator and surgical mask sterilization using 125°C steam for three minutes had an unnoticeable effect on FE.[5]
- Surgical mask sterilization using boiling water for three minutes has an unnoticeable effect on FE (do not stir).[5]
- Launder all DIY face masks in hot soapy water and dry completely on high heat.[4]
- Wipes (of any sort), tissues, paper towels, or coffee filters are not ideal for the middle layer of homemade face coverings as aerosolized droplets spread out upon contact with these materials and will penetrate through the material exposing the wearer to the droplets.[5] Also, the additional layer creates challenges in laundering, breathing, and cleaning of the face cover.
- Radiation sources such as gamma rays or UV light are viable options for sterilization; however, it is not recommended because decomposition depends on the radiation and UV intensity as well as the exposure time.[5] However, it is not recommended that the general population use this method as there are other sterilization options available that require less expertise and risk to the user.
- N95 respirator or surgical mask should not be cleaned with soap, water, or alcohol based cleaners as they will degrade the FE.[5]

Refer to attached excel document Face-Mask Comparison Table for a comparison of different types of DIY face masks, respirators, and hospital face masks.

Face-Mask
Comparison Table.xls›

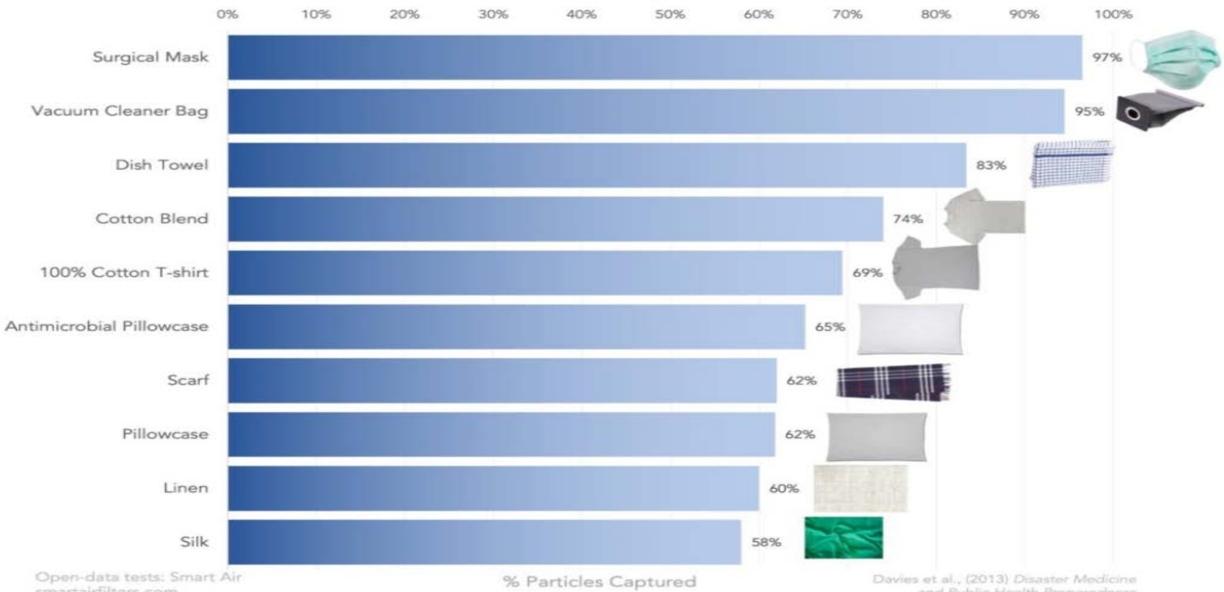
<u>DIY facemasks verses certified surgical masks and respirators filtration efficiencies</u>:

Below, we will discuss results from Davies (2013) research paper *Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?*, which compared a surgical mask to many common household items in order to assess their ability to block bacterial and viral aerosols. Household items discussed in the study included: 100% cotton T-shirt, scarf, dish cloth (aka tea towel), pillowcase, antimicrobial pillowcase, vacuum cleaner bag, cotton mix, linen, and silk. The researchers performed two filtration efficiency tests using two separate microorganisms: *Bacillus atrophaeus* and Bacteriophage MS2.

Bacillus atrophaeus is a rod-shaped spore-forming bacterium (0.95-1.25 µm), and Bacteriophage MS2 (MCIMB10108) a non-enveloped single-stranded RNA coliphage, 23 nm (0.023 µm) in diameter. Both are known to survive the stresses of aerosolization and were chosen to represent influenza virus in the study. These two organisms can also be compared in size to influenza virus, which is pleomorphic and ranges from 60 to 100 nm; *Yersinia pestis*, which is 0.75 µm; *B anthracis*, which is 1 to 1.3 µm; *Francisella tularensis*, which is 0.2 µm; and *Mycobacterium tuberculosis*, which is 0.2 to 0.5 µm.[2] COVID-19 virus ranges from about 60 to 140 nm (0.06-0.14 microns) in diameter, but can also range from 0.5-3 microns when it travels in biological aerosols from coughing and sneezing.[19,20]

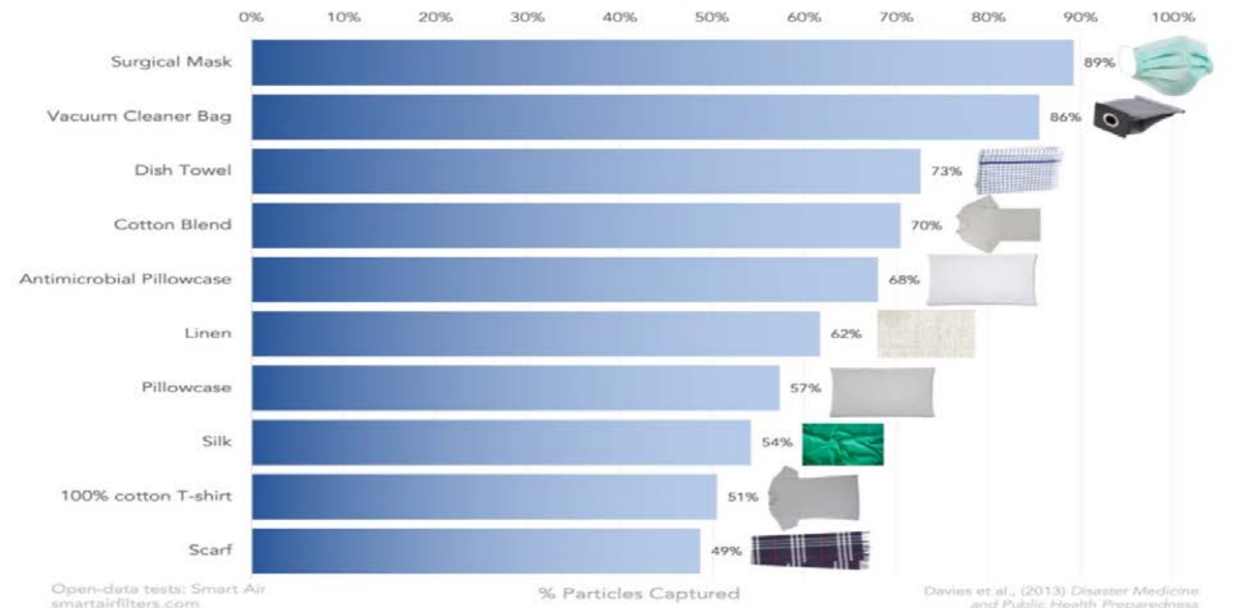
For the first filtration efficiency test, the researchers tested the larger *Bacillus atrophaeus* (0.95-1.25 µm). For results, see Figure 1.

Figure 1. Household Material's Effectiveness against *Bacillus atrophaeus* (0.95-1.25 µm).[11]



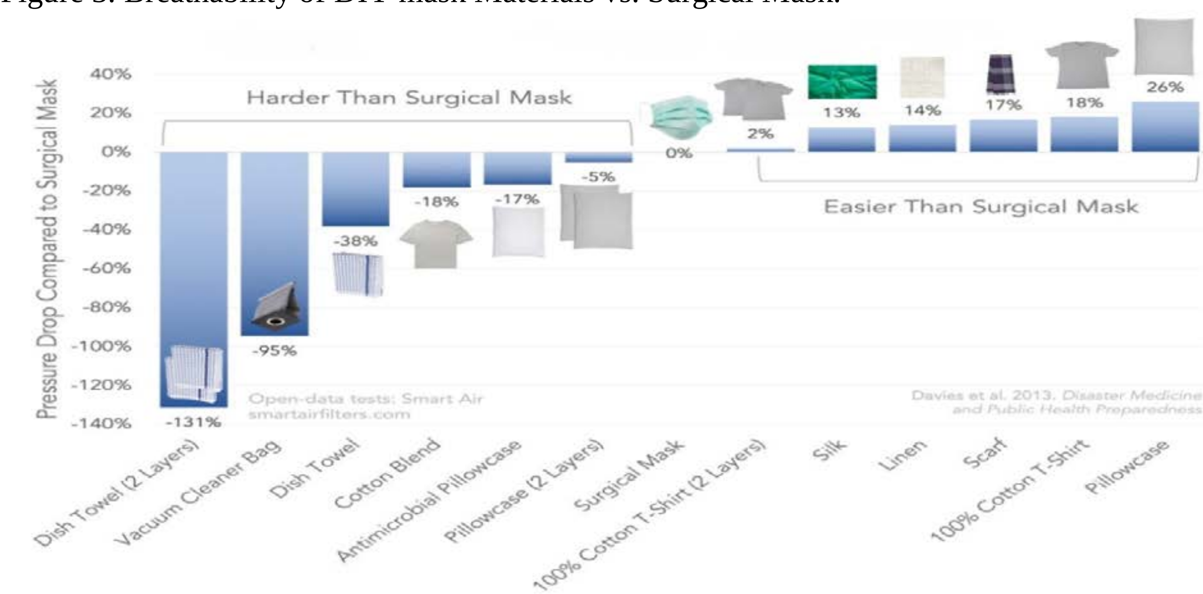
The second filtration efficiency test tested the smaller Bacteriophage MS2 (23 nm, 0.023 µm), which are smaller than the COVID-19 virus. See figure 2, Household Material's Effectiveness against Bacteriophage MS2 (23 nm, 0.023 µm) for results.

Figure 2. Household Material's Effectiveness against Bacteriophage MS2 (23 nm, 0.023 µm).[11]



All of the materials tested showed some capability to block the microbial aerosols at both 1 micron and 0.02 micron. The surgical mask had the highest filtration efficiency, followed by the vacuum cleaner bag, but the bag's stiffness and thickness created a high pressure drop across the material rendering it unsuitable for a face mask. The dish towel (aka tea towel) showed similar characteristics, see Figure 3.

Figure 3. Breathability of DIY mask Materials vs. Surgical Mask.[11]



Based on Figure 3, specifically the items listed in "Easier Than Surgical Mask", the researchers in this study concluded that DIY masks are better than nothing and that a single layer pillowcase and the 100% cotton t-shirt were the most suitable household materials for an improvised (DIY) face mask. The 100% cotton t-shirt, with its slightly stretchy quality, was deemed the most preferable choice for a DIY face mask as it was considered likely to provide a better fit.[2]

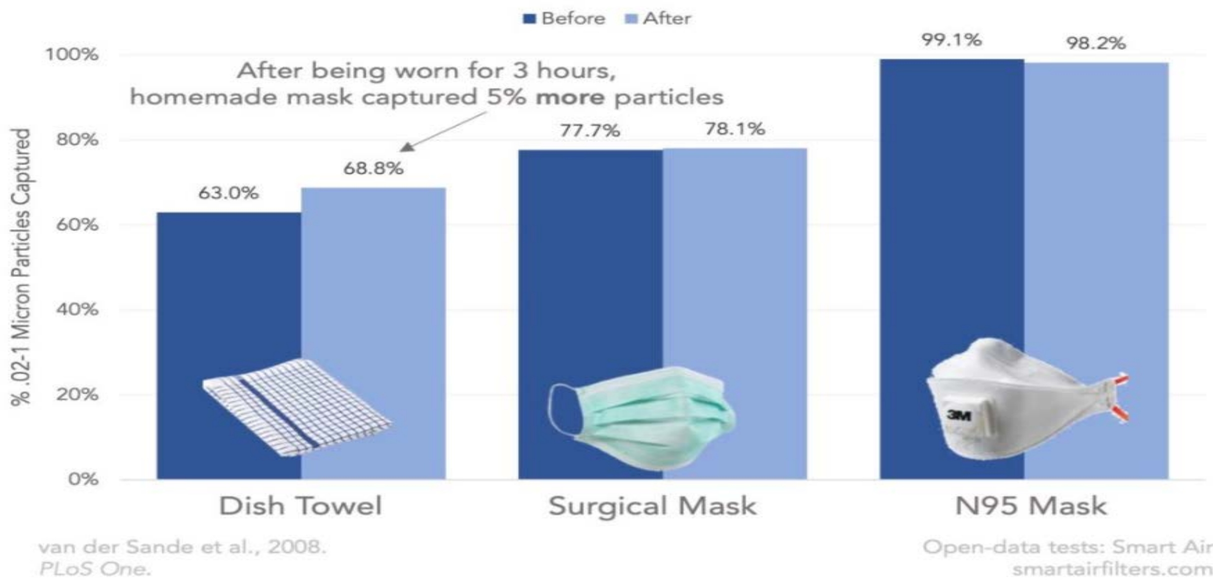
Sande (2008) conducted another DIY vs. certified face mask study titled, *Professional and Home-Made Face Masks Reduce Exposure to Respiratory Infections among the General Population*, investigating the reduction potential of personal respirators (N95 respirator), surgical masks, and DIY face masks, specifically a dish cloth (aka tea towel). Researchers conducted three different experiments: 1) short-term protection (10–15 minutes of wear), 2) long-term protection (3 hours of wear) while performing regular activities, and 3) effectiveness of different types of masks in preventing outgoing transmission by a simulated infectious subject (mechanical head). Inward protection was defined as the effect of mask wearing to protect the wearer from the environment; outward protection was defined as the effect of a mask on protecting the environment from the generation of airborne particles by a patient (or in this case a mechanical head).[3]

For the first experiment, a Portacount® was used to register particles floating in the air with sizes between 0.02 µm and 1 µm, covering most of the size range of infectious respiratory aerosols, see Figure 4.

Figure 4. Short-term Inward Protection Experiment.[12]

Figure 5, shows results from the second experiment.

Figure 5. Long-term Inward Protection Experiment.[12]

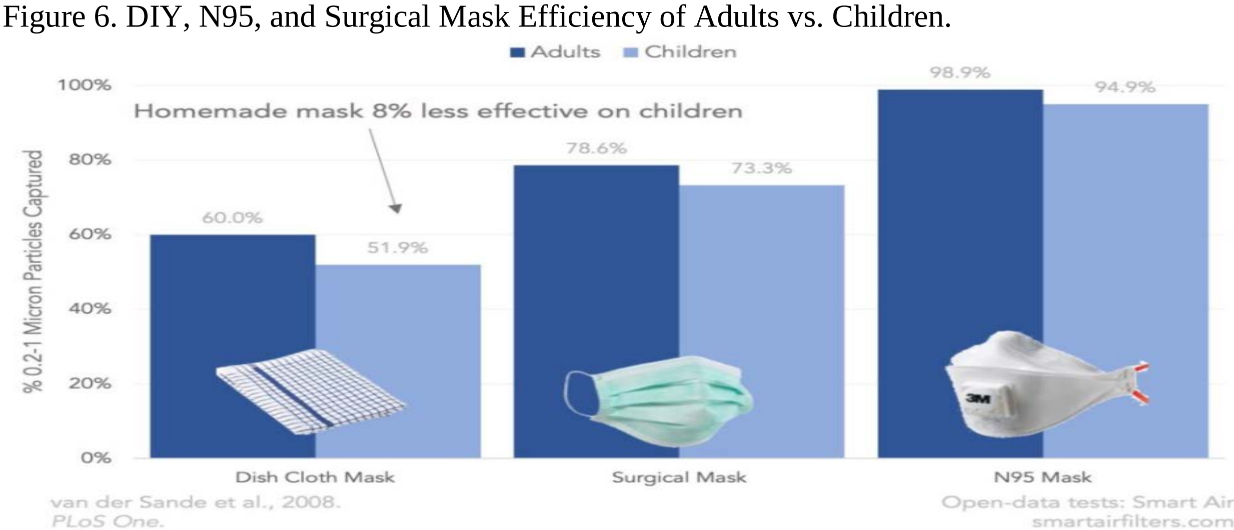


The median protection factors measured over a 3 hour period increased for those wearing homemade masks, decreased for those wearing N95 respirators, and did not show a consistent pattern for those wearing a surgical mask. Overall protection factors calculated per type of mask were stable over time, and did not have a statistically significant change with prolonged wear.[3]

The results of the second experiment also showed that moisture and time had very little impact on effectiveness for any of the masks. The DIY masks actually trapped 5.8% more virus-sized particles after 3 hours, but wearing them for several hours seemed to have little impact on their effectiveness.[3&12]

This study incorporated both children and adults as volunteers. Figure 6 lists the DIY, N95 respirator, and surgical mask efficiencies of the children in the study.

Figure 6. DIY, N95, and Surgical Mask Efficiency of Adults vs. Children.



Eleven children ages 5 to 11 years old were volunteers for this study. Mask effectiveness for children was lower across all mask types.

Researchers noted that the main determinant of the magnitude of protection factors measured by masks was the type of mask, which can be seen as a proxy for potential reduction in infectious disease transmission.[3] The duration of wear and the type of activity did not have a significant impact on exposure reduction.[3]

It is also clear that DIY masks such as tea towels may still confer a significant degree of protection, albeit less strong than surgical masks or N95 respirators.

The authors concluded that DIY masks made with a single layer of cotton clothing or a dish towel (aka tea towel) can remove roughly 40-50% of virus-sized particles, and that face masks not designed for a child's face are less effective.

Sande (2008) and Sohn (2020) postulated that during an influenza pandemic DIY masks could reduce transmission for the general public enough to build some immunity.[9] Given the need for the population to acquire sufficient natural immunity over time, it cannot be excluded that the amount of protection conferred by DIY masks might sufficiently reduce viral exposure to impact on transmission during the early waves, while allowing people enough exposure to start mounting an efficient immune response.[3]

IV. Limitations:

Both the CDC and the WHO emphasize the criticality of prioritizing medical masks and respirators for healthcare workers as they have been shown to be of greater effectiveness (higher protection factor) than DIY face masks. As healthcare workers are highly likely to come in contact with higher concentrations of COVID-19 on a more frequent basis than the general population, it is necessary that they have equipment with a higher protection factor. As previously stated, the vast majority of mask (either single or comparison studies) protective capability tests have concentrated on their use by healthcare workers in a hospital setting and/or in the context of influenza or other respiratory conditions, such as air pollution. The author is unaware of any published studies that have tested DIY face masks efficiency against COVID-19 in a healthy general population setting. Research on the effectiveness of DIY face masks and children is also lacking. The few studies that have incorporated children stress that using adult sized face masks on children should be avoided whenever possible, and highly recommend tailoring DIY face mask for children to their smaller face size during construction.

According to Greenhalgh (2020), "The World Health Organization has produced technical specifications for [face masks], based on simulation exercises using data from past SARS and MERS outbreaks." Currently the WHO and CDC with help from other international and local health/research institutions are working to better understand the effectiveness and efficiency of nonmedical masks. The WHO also strongly encourages countries that issue recommendations for the use of masks in healthy people in the community "to conduct research on this critical topic."

Based on numerous research studies, the WHO and the CDC do not recommend the use of DIY face masks for healthcare providers or individuals who are routinely exposed to infected individuals, except as a last resort. DIY face masks are unlikely to confer much protection against the transmission of small particles like droplet nuclei that can easily penetrate the smaller bronchi, but since the reproduction number of COVID-19 is still unknown a small reduction in transmissibility of the virus may be sufficient for reducing the reproduction number to a value smaller than 1, thus aiding in extinguishing the epidemic.[3] So in an environment where surgical masks and respirators are going to healthcare workers, DIY face masks are better than nothing for the rest of the population.

Our current understanding of the exact size, infectious dose, and concentrations of COVID-19 in aerosols generated during coughing, talking, or sneezing are unknown.[15] Recent research has demonstrated that surgical masks were unable to adequately filter wearer-generated particles measuring 0.9, 2.0, and 3.1 μm in diameter, and prevent particles measuring 0.04 to 0.2 μm from penetrating the mask.[15,17,18] Zhu et al. (2020) discovered that the diameter of COVID-19 varied from about 60 to 140 nm (0.06-0.14 microns). COVID-19 can also range from 0.5-3 microns when traveling in biological aerosols from coughing and sneezing.[20] Given this size, surgical, N95 and DIY cotton masks may not be effective in filtering out this virus.[15,18] Further research (with a larger population and more types of masks) should be conducted in order to generate a confident recommendation on whether or not DIY and certified face masks decrease transmission of the virus from asymptomatic individuals or those with suspected COVID-19 infection who are coughing, talking, breathing hard, or sneezing.[15]

Update as of 3 May 2020 – *In addition to additional mask materials testing, multiphase turbulent gas cloud dynamics and respiratory pathogen emission studies should be further investigated. According to Bourouiba, (2020), these studies should "influence the design and recommended use of surgical and other masks." Presently, surgical masks and N95 respirators can be used both for source control (ie, reducing spread from an infected person) and for protection of the wearer (ie, preventing spread to an unaffected person).[23] The protection efficacy of these masks depends on their ability to filter incoming air from aerosolized droplet nuclei.[23]*

Current masks are only designed for a certain range of environmental and local conditions and a limited duration of usage.[24] Studies have shown that peak exhalation speeds from coughing and sneezing can range anywhere from 33 to 100 feet per second (10-30 m/s), creating a cloud that can span approximately 23 to 27 feet (7-8 m).[23]

Source control and protective masks, as well as other protective equipment, should have the ability to repeatedly withstand exposure from the high-momentum multiphase turbulent gas clouds that may be ejected during a sneeze or a cough.[23] Current surgical and N95 masks have not been tested for these potential characteristics of respiratory emissions making their use during infectious outbreaks subject to scrutiny.[23]

Since COVID-19 has been shown to have multiple routes of transmission, a DIY face mask will not completely eliminate the risk of infection. However, a DIY face mask is preferable to no face mask, provided the wearer remembers that all face masks, no matter how efficient the filtration or how good the seal, will have minimal effect unless they are used in conjunction with other preventative measures, such as isolation of infected individuals, immunization, maintaining healthy eating/fitness standards, cough and respiratory etiquette, and regular hand hygiene.[2,3,8,13]

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