Issues Relating to the Use of Cloth Masks in the Covid-19 Pandemic
A Summary of the Evidence

Introduction
Face masks are part of a composite group of effective prevention measures that include safe physical distancing, hand hygiene, wide-scale testing and responsible behaviour change. There are many false messages on mask-use circulating on social media that need to be debunked. This is an attempt to summarise the data on COVD-19 prevention with a focus on the use of cloth masks. I have used reviews that collated currently available evidence and research (see references) – they contain evidence from a number of studies, systematic reviews and meta-analysis. I have generally avoided any opinions that are not evidence based. **Important points from current evidence are given at the start of each section.** Clear, consistent policy recommendations and advice for public are necessary on cloth mask use.

An important point from The Royal Society & the British Academy (July 2020):
"A repeated concern raised by some is that there are few randomised control trials (RCTs) with conclusive results examining the effectiveness of face masks conducted in community settings. As we discussed .... RCTs are challenging for evaluating face masks in a public setting given both the ethical and practical considerations. This echoes experts in the field who have urgently called for the implementation of face masks and coverings for the general public. We note that there have also been no clinical trials for …. social distancing and quarantine, yet these measures have been widely adopted and are considered as effective."

Covid-19 Transmission
Aerosol (airborne) transmission is important, especially indoors, enclosed environments.
Asymptomatic transmission is an important driver of transmission.

1. "Current evidence suggests that COVID-19 spreads between people through direct, indirect (through contaminated objects or surfaces), or close contact with infected people via mouth and nose secretions. These include saliva, respiratory secretions or secretion droplets released from the mouth or nose of an infected person. These infectious droplets can infect others via their mouth, nose or eyes." (WHO 2020)
2. "Aerosol transmission, particularly in these indoor locations where there are crowded and inadequately ventilated spaces where infected persons spend long periods of time with others, cannot be ruled out." (WHO 2020)
3. "Studies … have demonstrated beyond any reasonable doubt that viruses are released during exhalation, talking, and coughing in microdroplets small enough to remain aloft in air and pose a risk of exposure at distances beyond 1 to 2 m from an infected individual. For example, at typical indoor air velocities, a 5 μm droplet will travel tens of meters, much greater than the scale of a typical room, while settling from a height of 1.5 m to the floor. Several retrospective studies conducted after the SARS-CoV-1 epidemic demonstrated that airborne transmission was the most likely mechanism explaining the spatial pattern of infections." (Morawska & Milton 2020, co-signed by 239 scientists and engineers)
4. One recent study looking at aerosol and surface contamination observed in quarantine and isolation care detected viral contamination among all air and surface samples (virus culture). (Santarpia et al 2020)
5. "Transmission of Covid-19 from asymptomatic or presymptomatic people allows community and institutional spread. These people, who are contagious, feel well and therefore may expose others. Multiple studies have shown that respiratory tract viral loads are highest for a few days preceding symptom onset and a few days afterwards. New evidence from epidemiological and modelling studies continues to lend strong support for the role of asymptomatic and presymptomatic transmission. Concurrently, there are new rigorous longitudinal data showing that the majority of SARS-CoV-2 infected individuals (up to ~ 90%) remain asymptomatic throughout infection as well as multiple new studies that add further support to asymptomatic transmission of SARS-CoV-2 being a substantial driver of transmission, including through aerosols and superspreader events." (Edelstein & Ramakrishnan 2020)

N-95 and 3-Ply Surgical Masks

Use of Medical or surgical face masks might result in a large reduction in virus infection.
N95 respirators might be associated with a larger reduction in risk compared with surgical or similar masks.

Note that the majority of existing studies are conducted in health care settings and focus on protection of the mask wearer as opposed to wearing a mask for the protection of others.

1. The findings of a systematic review and meta-analysis based on 39 studies showed that "face mask use could result in a large reduction in risk of infection (aOR 0·15, 95% CI 0·07-0·34), with stronger associations with N95 or similar respirators compared with disposable surgical masks or similar (e.g. reusable cotton masks)". (Chu et al 2020) The authors concluded that the use of both N95 respirators and surgical masks (including similar reusable cloth masks) were associated with large reductions in virus transmission.
2. Another meta-analysis (Bartoszko et al 2020) found that medical masks provided similar protection to N95 respirators in protecting against viral respiratory infections in healthcare settings: "Low certainty evidence suggests that medical masks and N95 respirators offer similar protection against viral respiratory infection including coronavirus in healthcare workers during non–aerosol-generating care."

Do Cloth Masks Work?
Do they Protect Others? Do they Protect the User?
Does the Type of Cloth and Number of Layers Matter?

Cloth masks (non-medical masks) with multiple layers and hybrid constructions appear effective (e.g. combining cotton and silk or flannel provide over 95% filtration) in both transmission and protection.
An outermost layer made of hydrophobic material, like polypropylene, polyester, or their blends can limit external contamination to the user.
An improper fit of any mask can result in a significant decrease in the filtration efficiency.
Cloth mask effect size may be in the range of 50%.

Note that many studies are done in the laboratory setting.

1. The filtration ability of cloth masks in a review of 19 studies found that the filtration effectiveness was generally lower than medical masks and respirators. (Chughtai et al 2013, Chughtai et al 2020)
2. Filtration effectiveness of cloth masks varies widely according to the thread count, number of layers, type of fabric, and water resistance. (Rengasamy et al 2010, Chughtai et al 2013, Davies et al 2013, Konda et al 2020, Chughtai et al 2020).
3. However all home-made masks from household materials show some ability to block bacterial and viral aerosols although less than that of medical masks (van der Sande et al 2008, Davies et al 2013).
4. "Overall combinations of various commonly available fabrics used in cloth masks can potentially provide significant protection against the transmission of aerosol particles. Filtration efficiencies for various fabrics when a single layer was used ranged from 5 to 80% and 5 to 95% for particle sizes of <300 nm and >300 nm, respectively. However the efficiencies improved when multiple layers were used and when using a specific combination of different fabrics. Filtration efficiencies of the hybrids (such as cotton−silk, cotton−chiffon, cotton−flannel) was >80% (for particles <300 nm) and >90% (for particles >300 nm). Cotton, the most widely used material for cloth masks performs better at higher weave densities (i.e., thread count) and can make a significant difference in filtration efficiencies." (Konda et al 2020, Chughtai et al 2020, Amanda et al 2020, Chu et al 2020)
5. "Studies also imply that gaps (as caused by an improper fit of the mask) can result in over a 60% decrease in the filtration efficiency, implying the need for future cloth mask design studies to take into account issues of "fit" and leakage, while allowing the exhaled air to vent efficiently." (Konda et al 2020)
6. Filtration effectiveness of wet masks is reportedly lower than that of dry masks. (Chughtai et al 2013)
7. A number of visualisation studies have recently been done to show the effect of cloth masks on obstructing respiratory jets (Viola et al 2020, Verma et al 2020, Bahl et al 2020, Dbouka 2020). "We found that all face covers without an outlet valve reduce the front flow through jet by more than 90%" Surgical and hand-made masks, and face shields, generate several leakage jets…" (Viola et al 2020) "Well-fitted homemade masks with multiple layers of quilting fabric, and off-the-

shelf cone style masks, proved to be the most effective in reducing droplet dispersal. These masks were able to curtail the speed and range of the respiratory jets significantly, albeit with some leakage through the mask material and from small gaps along the edges." (Verma et al 2020)

8. WHO (June 2020) cloth mask guidelines include: "When physical distancing (standing one metre or more away) is not possible, wearing a fabric mask is an important measure to protect others." "A minimum of three layers is required for non-medical masks, depending on the fabric used. The ideal combination of material for non-medical masks should include an innermost layer of a hydrophilic material (e.g. cotton or cotton blends); an outermost layer made of hydrophobic material (e.g., polypropylene, polyester, or their blends) and a middle hydrophobic layer of synthetic non-woven material such as polyproplylene or a cotton layer which may enhance filtration or retain droplets. It is preferable not to select elastic material for making masks. Fabric cloths (e.g., nylon blends and 100% polyester) when folded into two layers, provides 2-5 times increased filtration efficiency compared to a single layer of the same cloth, and filtration efficiency increases 2-7 times if it is folded into 4 layers. With more tightly woven materials, as number of layers increases, the breathability may be reduced. Mask shapes include flat-fold or duckbill and are designed to fit closely over the nose, cheeks and chin of the wearer."

The time has come to provide some guidelines on commercial cloth mask manufacture. Exmaple" Non-medical mask standards developed by French Standardization Association (AFNOR Group). Minimum performance in terms of filtration (minimum 70% solid particle filtration or droplet filtration) and breathability (maximum pressure difference of 0.6 mbar/cm2 or maximum inhalation resistance of 2.4 mbar and maximum exhalation resistance of 3 mbar).

Who Should Not Use Cloth Masks?
When/Where Should Cloth Masks be Worn?

Based on WHO (June 2020) Recommendations:

Cloth masks are <u>not</u> recommended for:

1. Healthcare professionals (especially when working in the health sector).
2. People aged ≥60 years.
3. People with underlying comorbidities or chronic illnesses (e.g. cardiovascular disease, diabetes mellitus, chronic lung disease, cancer, cerebrovascular disease, immunosuppression).
4. Persons with any symptoms suggestive of COVID-19.

These are higher risk individuals and should use medical masks.

Situations where the <u>general public are encouraged</u> to use cloth/non-medical masks in the face of known or suspected Covid-19 community transmission:

1. General population in public settings, such as grocery stores, at work, social gatherings, mass gatherings, closed settings, including schools, churches, mosques, etc.
2. Specific working conditions which places the employee in close contact or potential close contact with others e.g., social workers, cashiers, servers.
3. General public on transportation (e.g., on a bus, plane, trains).
4. People living in cramped conditions, and specific settings such as refugee camps, camp-like settings, slums.

The Royal Society & the British Academy (July 2020): has summarised the international policies on face mask requirements and recommendations countries (as of 15th June 2020). 77 out of 120 (64%) countries have recommended use of facemasks everywhere in public or a universal usage.

Misuse, Availability, Access, Fake masks and Risk of Re-use of 3-Ply Surgical Masks
There are no large studies on these areas with respect to 3-Ply Surgical Masks.
Anecdotal data suggest that:

1. Masks with unprotected exhaust valve filtration do not protect others and should not be used.
2. Fake 3-ply surgical masks do exist.
3. Misuse of surgical masks may be wide spread (especially pulling down to the chin or hand contamination) (See one small local study, Amar 2020).
4. A segment of the population may not be able to afford their use in a disposable manner and resort to reusing them.

"Evidence on the impact of extended use and re-use of surgical masks and respirators (with or without reprocessing) is very limited. Such practises should only be considered in situations of critical shortage." (Toomey et al 2020)

There are significant **environmental dangers of using single-use face masks**. A comprehensive review by UCL Plastic Waste Innovation Hub (Mark Miodownik) has looked at the environmental impact of single-use and various reusable face masks and showed that the use of reusable masks significantly reduces. "66,000 tonnes of contaminated plastic waste and 57,000 tonnes of plastic packaging would be generated if every one in the UK used just one disposable surgical mask each day for a year". They conclude that single-use plastic masks would result in "ten times more climate change impact than using reusable masks". "Masks often contain plastics such as polypropylene". "With a lifespan of 450 years, these masks are an ecological timebomb given their lasting environmental consequences for our planet" (Éric Pauget).

Face Shields for High Risk Individuals & those Unable to Wear Masks

Face shields are useful for individuals unable to wear masks, as adjunct in high risk situations as well as part of eye protection from droplet spread. "Face shields are personal protective equipment for protection of the facial area and associated mucous membranes (eyes, nose, mouth) from splashes, sprays, and spatter of body fluids. Face shields are generally not used alone, but in conjunction with other protective equipment and are therefore classified as adjunctive personal protective equipment. …. little research is available regarding their efficacy." (Roberge 2016)

"During testing of an influenza-laden cough aerosol with a volume median diameter (VMD) of 8.5 μm, wearing a face shield reduced the inhalational exposure of the worker by 96% in the period immediately after a cough. The face shield also reduced the surface contamination of a respirator by 97%. When a smaller cough aerosol was used (VMD = 3.4 μm), the face shield was less effective, blocking only 68% of the cough and 76% of the surface contamination. … face shields provide a useful adjunct to respiratory protection for workers caring for patients with respiratory infections. However, they cannot be used as a substitute for respiratory protection when it is needed." (Lindsley 2014)

"One recent study measured air (with an optical technique), coming from breathing and coughs found shields highly effective (more than masks) at stopping direct frontward emission, although most of the air was sent downward, and smaller amounts to the sides and upward (leak from seams and joints)". Therefore, shields would be unsuitable to prevent transmission to people lower than the wearer…. However, leakage jets were also seen with masks, including downward and to the back and sides." (Edelstein & Ramakrishnan 2020, Viola et al 2020)

Masks of the Future - Other Mask Types

New mask types are rapidly being developed. Of note are:

1. Gill Mask – a reusable 'N95-like-respirator' (mask), made of silicone, with a good face fit and that reduces face mask waste (see: https://www.gillmask.com/). The gill mask does increase breathing effort.
2. LEAF Mask – a reusable, transparent, 'N99-like-respirator' (mask) with HEPA filters, made of silicone with UV-C sterilizing, and has a N95 exhaust value filtration. Breathing is very easy. The LEAF mask is quite expensive and requires replaceable HEPA and carbon filters (see: https://www.indiegogo.com/projects/leaf-mask-world-s-first-fda-uv-c-n99-clear-mask/x/23972640?utm_source=sailthru&utm_medium=email&utm_campaign=bck-07222020update&utm_term=#/).

I believe the mask of the future should be a custom printed silicon full-face mask (N95-like) that is designed to fit individual faces - laser face scanning with 3D printing and a replaceable HEPA/Carbon filter (inlet & exhaust filters).

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