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Usher Network for COVID-19 Evidence Reviews

Review: Are homemade facemasks effective at reducing transmission of covid-19 in community settings?

Date: 19 April 2020 Version: 004-01

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Title: Are homemade facemasks effective at reducing transmission of covid-19 in community settings?

Date of review: 19 April 2020.

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Background and Aims

As governments around the world turn their attention to strategies for coming out of the lockdown, one approach being explored is the use of facemasks to reduce person-to-person transmission in community settings as levels of self-isolation are reduced.

The CDC recommendation that people should wear facemasks in public settings where other social distancing measures are difficult to maintain (e.g. when visiting supermarkets) is based on the fact that a significant proportion of individuals with, and able to transmit, coronavirus are asymptomatic or pre-symptomatic. Thus it is based on the precautionary principle that facemasks *may* reduce transmission of covid-19 in community settings. There is no clear RCT evidence that this is the case.

Any move to recommend widespread use of facemasks by the general public risks disrupting the already fragile supply of medical and surgical facemasks to frontline healthcare workers, whose needs must be prioritised. This has led CDC to recommend that the general public use homemade, cloth facemasks. They have launched a website with detailed instructions of how homemade facemasks can be easily made at home using commonly available materials.

The purpose of this review is to assess the evidence of effectiveness of homemade or improvised facemasks. Specifically, it will address the following questions:

- Do homemade or improvised facemasks prevent the transmission of respiratory viruses?
- What materials work (what are the virus filtration properties of different materials)?
- What design(s) of mask work (in terms of fit and comfort)?
- Can these masks be safely washed and reused?

This study will not look at behavioural aspects of facemask use, beyond issues related to fit and comfort. Those issues are explored elsewhere.

For a useful background website describing the different types of commercially available masks and respirators and their standards, see: Sampol C (2020) Surgical Masks, Respirators, Barrier Masks: Which Masks Actually Protect Against Coronavirus?

Methods

Inclusion and Exclusion Criteria:

This study will include:

- studies which focus on the general population in any non-clinical setting where it is difficult to maintain social distancing
- studies in clinical settings will be included only if they compare cloth with surgical masks
- studies which focus on the effectiveness and reusability of homemade or improvised cloth facemasks compared with medical/surgical masks or with no mask at preventing the transmission of respiratory viruses;
- studies which report on the use of homemade or improvised cloth facemasks with or without handwashing and/or eye protection;
- studies which focus on the virus filtration properties of different materials used in the construction of homemade cloth masks;

- studies which focus on the comfort or breathability of different materials used in the construction of homemade cloth masks for preventing the transmission of respiratory viruses;
- studies which focus on the ability of different designs/shapes of facemasks to achieve a close fit to prevent transmission of respiratory viruses;
- any study design providing data on the effectiveness, virus filtration, reusability or design of homemade or improvised cloth facemasks to prevent the transmission of respiratory viruses will be included.

This review will exclude articles that:

- do not include data on the effectiveness homemade or improvised cloth facemasks at preventing the transmission of respiratory viruses (or proxy);
- do not include an outcome measure of or equivalent to respiratory illness (laboratory confirmed, clinically confirmed, self-reported, hospital admission, deaths, absence from work/school, or penetration of material by virus-sized or droplet-sized particles);
- report on the effectiveness of commercially manufactured masks that are not designed for clinical settings (e.g. masks purchased in DIY shops);
- are exclusively conducted in clinical settings (except where evaluating cloth vs other materials);
- studies not published in English;
- studies that focus on filtration properties of materials without reference to homemade cloth facemasks;
- studies that focus on the filtration properties of materials not commonly available in households.

Literature search: The literature search was designed and executed with the involvement of an Information Specialist (MD). We adopted a four-pronged approach:

- We reviewed the primary studies from three recent systematic reviews (Jefferson et al (2020), Brainard et al (2020), Xiao et al (2020));
- We screened the reference lists of two key papers (Davies et al (2013; Ma et al (2020));
- We performed forward citation tracking for the above two papers
- We repeated a search strategy by created by Ovid (WoltersKluwer 2020) on Medline
- We created a new search strategy for CINAHL (see below
- We created a new search strategy for MedRxiv (see below)
- We created a new search strategy for Web of Science (see below)

CINAHL – searched 17th April 2020 by NA - 206 Results

"(facemask* OR "face mask*" OR mask* OR veil*) AND (self-made OR "self made" OR "home made" OR homemade OR improvise* OR at-home OR re-purpose* OR "re purpose*") AND ("virus*" OR "viral" OR respiratory OR infection* OR outbreak* OR transmission* OR influenza OR "coronavirus*" OR COVID* OR "COVID-19" OR "severe acute respiratory syndrome" OR SARS* OR MERS*) Language: English AND Apply equivalent subjects on 2020-04-17 01:21 PM".

medRxiv – searched 17 April 2020 by MD - 70 results

for abstract or title "facemask facemasks mask masks covering veil" (match any words) and full text or abstract or title "household home-made improvised self-made" (match whole any)

Web of Science – searched 17 April 2020 by NA - 142 Results

(self-made OR "self made" OR "home made" OR homemade OR improvise* OR at-home OR re-purpose* OR "re purpose*") AND (facemask* OR "face mask*" OR mask* OR veil*) AND ("virus*" OR "viral" OR viroid* OR respiratory OR infection* OR outbreak* OR transmission* OR influenza OR "coronavirus*" OR COVID* OR "COVID-19" OR "severe acute respiratory syndrome" OR SARS* OR MERS*)

Medline (Ovid) searched 17 April 2020 run by MD - 33 results

Search source: Developed by expert searchers at Ovid in April 2020, available from: https://tools.ovid.com/coronavirus/

1. disease outbreaks/ or epidemics/ or pandemics/ or disease transmission, infectious/ or exp equipment contamination/ or equipment reuse/ or exp hygiene/ or exp Infection Control/ or exp coronavirus/
2. ((disease$ adj2 outbreak$) or epidemic$ or pandemic$ or pandemie* or influenza or SARS or MERS or flu or tuberculosis or zika or ebola or covid19 or "covid-19" or "SARS-CoV-2" or "2019-nCov" or coronavirus* or corona-virus* or nCov or SARS-CoV* or SARSCov2 or ncov*).mp.
3. middle east respiratory syndrome coronavirus/ or sars virus/ or exp Tuberculosis/ or influenza, Human/ or exp respiratory tract infections/
4. or/1-3
5. ((cloth$ or DIY or "do it yourself" or t-shirt$ or homemade or home-made or bandana$ or scarf$ or neckscarf$ or kerchief$ or napkin$ or bracup$ or bra-cup$ or 3D or "3-D" or cotton$ or muslin$ or gauze$ or "cheese cloth" or towel$ or fabric$ or tight$ woven or tight$ weav$) adj2 (facemask$ or face-mask$ or mask$)).mp.
6. (((home adj1 made) or homemaker$ or household$ or "house hold$") adj1 mask$).mp.
7. ("16752475" or "26980847" or "25903751" or "18612429" or "32203710" or "23968983" or "25903751" or "19702582" or "20584862").ui.
8. or/5-7
9. (((cloth$ or DIY or "do it yourself" or t-shirt$ or homemade or home-made or bandana$ or scarf$ or neckscarf$ or kerchief$ or napkin$ or bracup$ or bra-cup$ or 3D or "3-D" or cotton$ or muslin$ or gauze$ or "cheese cloth" or towel$ or fabric$ or tight$ woven or tight$ weav$) adj (facemask$1 or face-mask$1 or mask$1)) and (develop$ adj1 countr$)).mp.
10. ("16752475" or "26980847" or "25903751" or "18612429" or "32203710" or "23968983" or "25903751" or "19702582" or "20584862").ui.
11. "20390479".ui.
12. (4 and 8) or 7 or 9
13. 12 not 11

Title and Abstract Screen: Titles and abstracts were each screened by one reviewer (RM, AN, MD). A second reviewer then screened all excluded abstracts. Where there was a conflict, the abstract was included in full text screening.

Full Text Screen: The included full text articles were each screened by one reviewer (RM, MD). A second reviewer then screened all excluded full texts (RM, MD). Conflicts were resolved by discussion.

Data Extraction: Data extraction for each article was conducted by a single reviewer (RM). Data extraction was limited to a minimal set of required data items.

Risk of Bias Assessment: We used the following validated risk of bias tools to assess study quality for epidemiological studies: CASP and Joanna Briggs Institute checklists. For non-epidemiological studies, articles were assessed for rigour but without using a standardised tool. Risk of bias and evidence certainty for each article was assessed by a single reviewer (RM). Risk of bias ratings were limited to the most important outcomes.

Data Synthesis: Data were synthesized narratively. Because of the heterogeneity of the evidence, a meta-analysis was not appropriate. Using the GRADE system (Guyatt et al, 2008) a single reviewer (RM) graded the certainty of the evidence.

Results

After removal of duplicates, a total of 549 results was found from the database searching. We excluded 461 records by screening titles and abstracts and a further 77 at the full text screen stage, leaving 11 articles for inclusion in the final review. Reasons for exclusion were: article did not contain relevant data, article was not about facemasks/homemade facemasks, article was in Chinese, could not find article. See PRISMA diagram below for full details.

The key findings from this rapid review were:

Evidence:

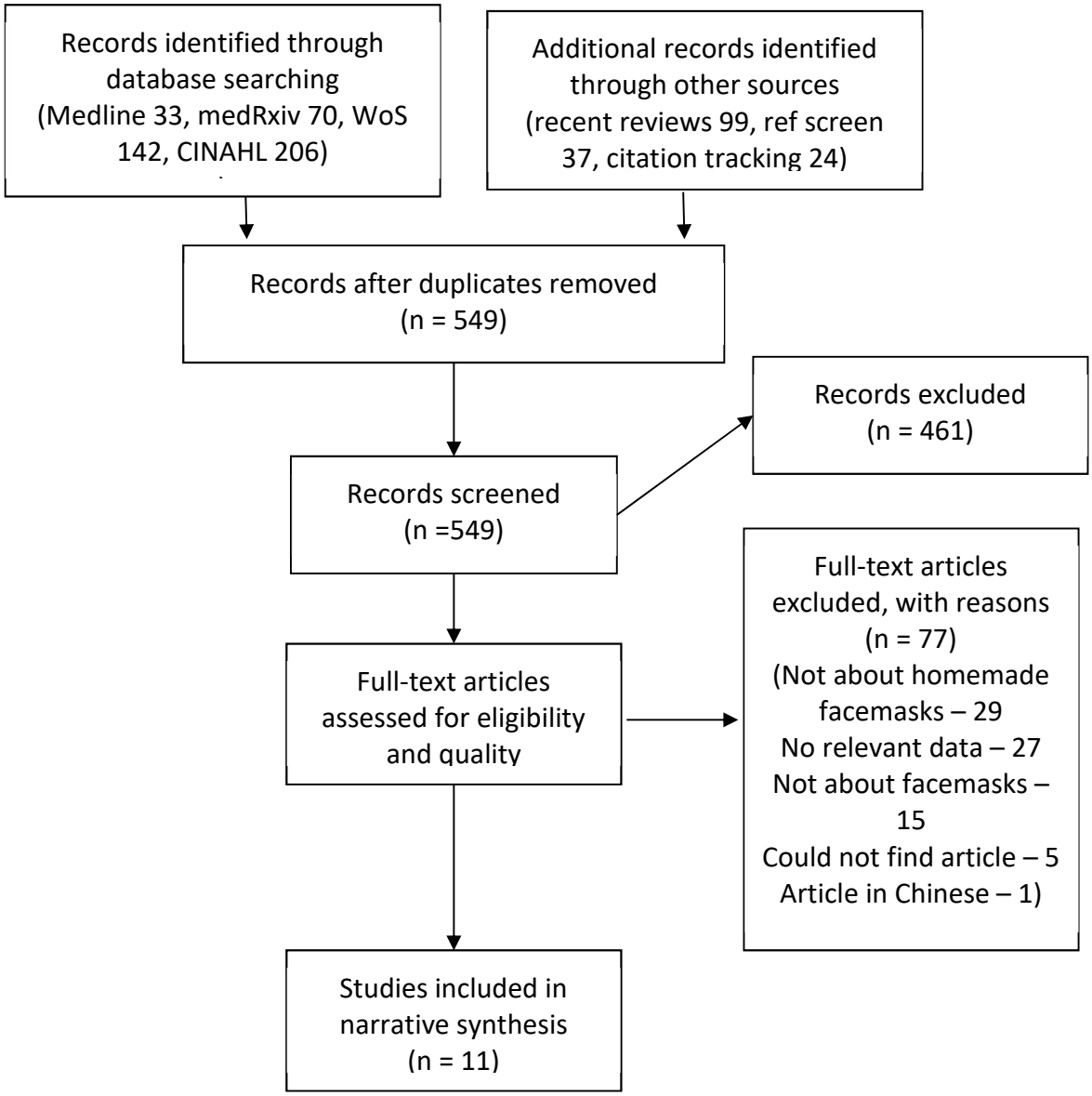
- The quality of the evidence available was **very low**.
- Homemade masks are **not effective at filtering respiratory aerosols**. Van der Sande et al (2008) compared the effectiveness of different masks at filtering respiratory aerosols from the outside to the inside of the mask. FFP respirators, which provide a minimum of 94% filtration, were found to be 25 times more effective than surgical masks, which were in turn about twice as protective as homemade masks.
- Homemade masks **may have potential to reduce transmission through droplets**. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.
- Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. T-shirt or jersey material combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence about suitable materials focuses only on filtration properties tested in laboratories and not on comfort and breathability tested in human subjects.

- Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
- If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.
- Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Policy implications:

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission. However, we found no research evidence quantifying this.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers. Again, we found no evidence quantifying the likely impacts.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.
- It is vital to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

Prisma flow diagram of publications screening and appraisal



Summary of results

A total of 549 unique articles were identified through the search strategies. After screening all titles and abstracts, 88 articles remained. After full text screening, eleven articles met the inclusion criteria and are included in this review:

- Bae et al (2020) Effectiveness of Surgical and Cotton Masks in Blocking SARS-CoV-2: A Controlled Comparison in 4 Patients
- Choudhry et al (2006) Hajj-associated acute respiratory infection among hajjis from Riyadh.
- Dato et al (2006) Simple respiratory mask
- Davies et al (2013) Testing the efficacy of homemade masks: would they protect in an influenza pandemic?
- Hashim et al (2016) The prevalence and preventive measures of the respiratory illness among Malaysian pilgrims in 2013 Hajj season
- Ma et al (2020) Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2
- MacIntyre et al (2015) A cluster randomised trial of cloth masks compared with medical masks in healthcare workers
- Neupane et al (2019) Optical microscopic study of surface morphology and filtering efficiency of face masks
- Rengasamy et al (2010) Simple respiratory protection--evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles.
- Rodriguez-Palacios et al (2020) Textile Masks and Surface Covers - A 'Universal Droplet Reduction Model' Against Respiratory Pandemics
- van der Sande et al (2008) Professional and home-made face masks reduce exposure to respiratory infections among the general population

The overall quality of the evidence is **very low**. There are no studies evaluating homemade facemasks in real life conditions. We found three studies evaluating the effectiveness of homemade masks under laboratory conditions using human subjects (Davies et al, 2013; van der Sande et al, 2008; Dato et al, 2006); however only one of these (Dato et al, 2006) specified mask design. We found five studies evaluating commonly available household materials for their effectiveness at virus filtration; however only one of these (Davies et al, 2013) also tested the breathability of the materials and their overall suitability for use in a homemade mask. We found only one study which investigated the impact of repeated laundering on the effectiveness of cloth masks (Neupane et al, 2019).

Sub-question 1: Do homemade or improvised facemasks prevent the transmission of respiratory viruses? Answer:

- Homemade masks may reduce the number of microorganisms expelled when coughing or sneezing but not as effectively as surgical masks. Surgical masks are more effective than homemade masks at filtering aerosolised virus particles, but even surgical masks are only marginally effective.
- Homemade masks may have potential to reduce transmission through droplets. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- It is also important to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

Sub-question 2: What materials work (what are the virus filtration properties of different materials)? Answer:

Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. A double layer of T-shirt material or pillowcase, combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence about suitable materials focuses only on filtration properties and not on comfort and breathability. Mask comfort and breathability are essential, as people will not wear uncomfortable masks or masks which make it harder to breathe.

Sub-question 3: What design(s) of mask work (in terms of fit and comfort)? Answer:

Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.

Sub-question 4: Can homemade masks be safely washed and reused? Answer:

Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Detailed results by study sub-question and type of study

The results of this review are organised and presented by reporting evidence relating to each of the four sub-questions, broken down by study type. This is summarised in table 1.

Table 1: Summary of the types of evidence available to address each sub-question

Sub-question	Types and numbers of studies (n.b. the same study may contribute to more than one of the sub-questions)
Do homemade or improvised facemasks prevent the transmission of respiratory viruses?	Studies testing homemade masks under laboratory conditions using human subjects (n = 3)
What materials work (what are the virus filtration properties of different materials)?	• Laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects (n = 5) • Studies comparing cloth masks with surgical masks in healthcare settings (n = 2)
What design(s) of mask work (in terms of fit and comfort)?	• Studies evaluating homemade mask designs (n = 3) • Studies evaluating improvised (as opposed to homemade) masks (n = 2)
Can homemade masks be safely washed and reused?	Laboratory experiment (n = 1)

Studies testing homemade masks under laboratory conditions using human subjects

Three studies (Davies et al, 2013; van der Sande et al, 2008, Dato et al, 2006) tested homemade masks under laboratory conditions using human subjects. All three specified the material used to make the mask but only one (Dato et al, 2006) specified the precise mask design. All three used commercial fit tests to test the effectiveness of the masks at preventing the transmission of particles. None tested the mask under real world conditions. Results are summarised in table 2.

Davies et al (2013) tested a range of household materials under controlled experimental conditions for their virus filtration properties and breathability and compared the results with surgical masks. They concluded that a double layer of cotton T-shirt material achieved the optimum combination of filtration and breathability. They then tested this mask for fit and comfort using human volunteers. There is a good lay summary of this study.

Van der Sande (2008) tested the fit and virus filtration of a homemade mask made from teatowel material under laboratory conditions, using human subjects. They tested the performance of the mask for both short (minutes) and long term (three hours) periods. They tested for both outward and inward transmission. They did not clearly specify mask design and they did not test the mask under real world conditions. The study is available here.

Dato et al (2006) used a commercial fit test to evaluate several prototype homemade mask designs. The researchers report a detailed specification for the best performing design (see figure 2). They fit tested two different sizes of this design, made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. This was compared wit an N95 mask.

Table 2: Summary of the evidence on the effectiveness of homemade masks from studies testing homemade masks under laboratory conditions using human subjects

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Davies et al, 2013	Mask made from 2 layers of cotton T-shirt material. Volunteers made masks at home using sewing machine to a specification provided by the researchers (not published)	Surgical mask	• Homemade masks reduce the number of microorganisms expelled when coughing but not as effectively as surgical masks, particularly at low particle sizes. The authors conclude that an improvised face mask should be viewed as the last possible alternative if a supply of commercial face masks is not available. • The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken. • Any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene. • If a mask does not fit well around the nose and mouth it will be of no benefit. • Mask comfort is essential, as people will not wear uncomfortable masks. • Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.	**Strengths of this study**: it looked at all aspects of mask effectiveness: virus filtration properties of different materials, breathability of different materials, design capable of being made at home by volunteers, fit of the mask and comfort of the mask. It used objective measures to assess parameters. It tested masks on real people, doing breathing exercises to simulate real life conditions. It used a virus smaller than corona virus to test the materials. **Limitations of this study**: the authors did not make the mask design available for evaluation. Washability and performance of the mask after being worn for longer periods are not assessed.
Van der Sande et al, 2008	Homemade mask made from teatowel material. Design not provided	Surgical and FFP2 (European equivalent of N95) masks	• Although masks provided protection against transmission for both children and adults, homemade masks provided much less protection than surgical or FFP2 masks and this difference was strongly statistically significant.	**Strengths of this study**: This study was performed under carefully controlled conditions using standard protocols and human subjects. **Limitations**: There was a small number of participants. Because it

			• Findings were similar for both short term and long term use. • Surgical masks provided about twice as much protection as home made masks, the difference a bit more marked among adults. • FFP2 masks provided adults with about 50 times as much protection as home made masks, and 25 times as much protection as surgical masks. • The increase in protection for children was less marked, about 10 times as much protection by FFP2 versus home-made masks and 6 times as much protection as surgical masks. • The homemade mask provided only marginal outward protection (i.e protection of the external environment from particles generated by the mask user). Interestingly, this study found that inward protection (i.e. protection of the mask user) was considerably higher than outward protection for all mask types.	was conducted under experimental conditions, it may not reflect behavioural and other parameters in the real world. Mask design was not specified.
Dato et al, 2006	Two different sizes of homemade mask made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and	N95	• The smaller mask achieved a fit factor of 67 (compared with 100 for an N95 respirator). The larger mask achieved fit factors between 13 and 17.	**Strengths of this study**: It provided a detailed design specification and specification of materials. It evaluated more than one size of mask. It used validated, objective methods to assess fit. **Limitations**: it did not assess breathability. It did not directly measure respiratory virus. It was a very small study (3 subjects).

	nose. See figure 2 for specification			

Laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects

Five studies tested commonly available household materials for their virus filtration properties under controlled laboratory conditions (Davies et al, 2013; Ma et al, 2020; Rengasamy et al, 2010; Rodrigues-Palacios et al, 2020; Neupane et al, 2019). Results are summarised in table 3.

Davies et al (2013) compared the virus filtration properties and breathability of a range of common household materials (cotton t-shirt, scarf, teatowel, pillowcase, antimicrobial pillowcase, vacuum cleaner bag, cotton mix, linen, silk) with surgical masks. This was the only laboratory study that assessed breathability as well as virus filtration. They did this by measuring the pressure drop across the different materials when air was blown at them.

Ma et al (2020) tested the virus filtration properties of a homemade mask made of 1 layer of polyester and 4 layers of kitchen paper under laboratory conditions, using aerosolised low pathogenic avian influenza A virus. They compared the results with a medical mask and an N95 mask.

Rengasamy et al (2010) assessed the filtration performance of a range of household materials (T-shirts, towels, scarves, and cloth masks) by subjecting them to dispersed aerosols of nano-size particles the size of viruses (20-1000 nm). This was repeated at different velocities to simulate breathing and coughing. They compared the results with an N95 mask.

Rodriguez-Palacios et al (2020) assessed household textiles (T-shirt material, pillow case, woven cotton cloth, sport jersey material) to quantify their potential to prevent transmission via droplet, as opposed to aerosol. They compared the fabrics with no barrier, a medical mask and surgical cloth material.

Neupane et al (2019) evaluated the effectiveness of commercially produced cloth masks at filtering particulate matter (PM - i.e. much bigger particle size than viruses). Although this study is not about homemade, masks is included because it evaluates relevant materials (cloth masks). Although it is about the filtration of PM rather than viruses, it is included because if cloth masks are shown to be ineffective at filtering much larger particles, they will certainly be ineffective for virus filtration.

Table 3: Summary of the evidence on suitable materials for homemade masks (sub-question 2) from laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects

Study	Materials tested	Comparator	Key Findings	Strengths and Limitations
Davies et al, 2013	cotton t-shirt, scarf, teatowel, pillowcase, antimicrobial pillowcase, vacuum cleaner bag, cotton mix, linen, silk	Surgical mask	• All the materials tested showed some capability to filter microbial aerosols of similar particle size to SARS-CoV-2. • Filtration efficiency for MS2 (particle size 5 x smaller than corona virus) was: surgical mask 90%, vacuum cleaner bag 86%, teatowel 72%, cottonmix 70%, antimicrobial pillow case 69%, linen 62%, pillowcase 57%, silk 54%, cotton t-shirt 51% and scarf 49%. • Doubling the layers increased the filtration efficiency slightly for the t-shirt and pillow case and significantly for the teatowel. • Although the vacuum cleaner bag had the best virus filtration properties, its thickness, stiffness and poor breathability make it unsuitable for a face mask. • Similarly, although the double layered tea towel had a high filtration efficiency it had poor breathability. • The authors concluded that a double layer of T-shirt material was the optimum choice for a homemade mask because it combined filtration, breathability, comfort and fit. The slightly stretchy quality of a double layer of T-shirt material compared to the other materials tested was considered likely to provide a better fit.	See above.
Ma et al, 2020	homemade mask made of 1 layer of polyester and 4 layers of kitchen paper	Medical mask, N95 mask	• The homemade mask made from 1 layer of polyester and 4 layers of kitchen paper prevented 95% of virus penetration, compared with over 99.9% for the N95 mask and 97% for the medical mask. • The authors stress the importance of incorporating kitchen paper in the mask. • They suggest it may be effective in blocking the virus because of its multiple layers, nonwoven structure, and virus-absorbing properties.	**Strengths of this study**: it used objective measures to assess virus filtration properties of different materials under carefully controlled conditions, using avian influenza virus in the

			• They also suggest that effectiveness will likely be reduced if fewer layers of kitchen paper are used and that other types of homemade masks, especially those made of cloth alone, may be unable to block the virus and thus confer no protection against the virus. • An advantage of this style of mask is that the kitchen paper can be changed frequently. • The authors conclude that whilst homemade masks have limited potential to prevent transmission at the individual level, when multiplied up to the population level they have the potential for significant impact, particularly if used in conjunction with hand hygiene.	experiment. It repeated measurements to bolster robustness of results. **Limitations**: it did not assess how the masks might work in the real world (breathability, comfort, closeness of fit) and did not address mask design (shape).
Rengasamy et al, 2010	T-shirts, towels, scarves, and cloth masks	N95 mask	• The penetration levels of all the fabric materials tested were much higher than the penetrations for the N95 mask (in other words, virus easily penetrated all the fabric materials). • The different household materials had 40 – 90% instantaneous penetration compared with 0.12 % for the N95 mask. • The authors concluded that common fabric materials may provide only marginal protection against nanoparticles including those in the size ranges of virus-containing particles in exhaled breath.	**Strengths of this study**: It was performed under controlled experimental conditions using standard protocols. **Limitations**: The study only tested a few types of fabric and only measured penetration – it did not assess face seal leakage, which is a critical component of respiratory protection. It also did not assess the effect of laundering the materials (none of the materials had been

				worn or laundered), which could affect filtration performance.
Rodrigues-Palacios et al, 2020	t-shirt material, pillow case, woven cotton cloth, sport jersey material	no barrier, a medical mask and surgical cloth material	• All textiles reduced the number of droplets reaching surfaces, restricting their dispersion to <30cm, when used as single layers. • When used as double-layers, textiles were as effective as medical mask/surgical-cloth materials, reducing droplet dispersion to <10cm. • T-shirt and sport jersey material were the most effective. • The authors conclude that homemade masks made from household materials could have potential to reduce environmental contamination and the risk of transmitting or acquiring infectious respiratory pathogens, including COVID-19.	**Strengths of this study**: It evaluated different fabrics under controlled laboratory conditions. **Limitations**: This study investigates droplet spread only – it does not evaluate aerosol transmission. It is a laboratory study, which does not evaluate real life use of homemade masks.
Neupane et al, 2019	20 different types of cloth facemasks purchased from markets in Kathmandu, Nepal	7 different brands of surgical mask	• Filtering efficiency of cloth masks for ambient PM 10 was poorer than in surgical masks because of the presence of larger sized pores. • Stretching the CM surface alters the pore size and potentially decreases the filtering efficiency. • The authors conclude that cloth masks are not effective, and that effectiveness deteriorates if the mask is stretched.	**Strengths of this study**: It was conducted under controlled experimental conditions. **Limitations**: This study is about particulate matter (i.e. much bigger particle sizes than viruses). However, demonstrating the limitations of cloth face masks even with bigger

				particle size underlines the limitations for virus filtering.

Studies comparing cloth masks with surgical masks in healthcare settings

Two studies evaluated the effectiveness of manufactured cloth masks compared to surgical masks in hospital settings. Although these studies are not about homemade masks and are relevant to a clinical, as opposed to community setting, they are included because they focus on relevant materials (cloth) and provide a direct comparison with surgical masks. Results are summarised in table 4.

Bae et al (2020) evaluated the effectiveness of surgical and cotton masks in filtering SARS–CoV-2 in a hospital-based study involving 4 covid-19 patients. They compared (manufactured) reusable cotton masks with surgical masks.

MacIntyre et al (2015) conducted a cluster randomised controlled trial to compare the efficacy of cloth masks (locally manufactured, two layer) with surgical masks in 1607 healthcare workers in 14 secondary/tertiary hospitals in Hanoi, Vietnam.

Table 4: Summary of the evidence on suitable materials for homemade masks (sub-question 2) from studies comparing cloth masks with surgical masks in healthcare settings

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Bae et al, 2020	Commercially produced cotton mask	Surgical mask	• Neither surgical nor cotton masks effectively filtered SARS–CoV-2 during coughs by infected patients. • This study found greater contamination on the outer than the inner mask surfaces. This observation supports the importance of hand hygiene after touching the outer surface of masks. • The authors conclude that both surgical and cotton masks are ineffective in preventing the dissemination of SARS–CoV-2 from the coughs of patients with COVID-19 to the environment and external mask surface.	**Strengths of this study**: It was conducted under controlled conditions with COVID-19 patients. **Limitations**: It was a very small study (4 patients), data were incomplete and it is not about homemade masks.
MacIntyre et al, 2015	Cloth masks	Medical masks	• The rates of all infection outcomes were highest in the cloth mask arm, with the rate of influenza-like illness statistically significantly higher in the cloth mask arm (relative risk (RR)=13.00, 95% CI 1.69 to 100.07) compared with the medical mask arm. • Rates of laboratory confirmed respiratory virus infection were also higher in the cloth mask arm than in the medical mask arm, but the difference was not significant.	**Strengths of this study**: This was a large, well-conducted cluster RCT. **Limitations**: Researchers did not objectively measure compliance with hand hygiene. This is not directly relevant to the current question because it is not about homemade masks and it was conducted in a hospital, not a community setting.

Studies evaluating mask designs

Despite a plethora of homemade mask designs proliferating on the internet in recent weeks, unfortunately there are no studies which systematically evaluate and compare different homemade mask designs. The US Centers for Disease Control and Prevention website provides patterns for creating masks, categorised into those that require sewing and those that do not; however there is no evidence that these designs have been tested. Most of the designs described are modelled on surgical masks but other designs are also proposed – for example the design tested by Dato et al (2006) – see figure 2.

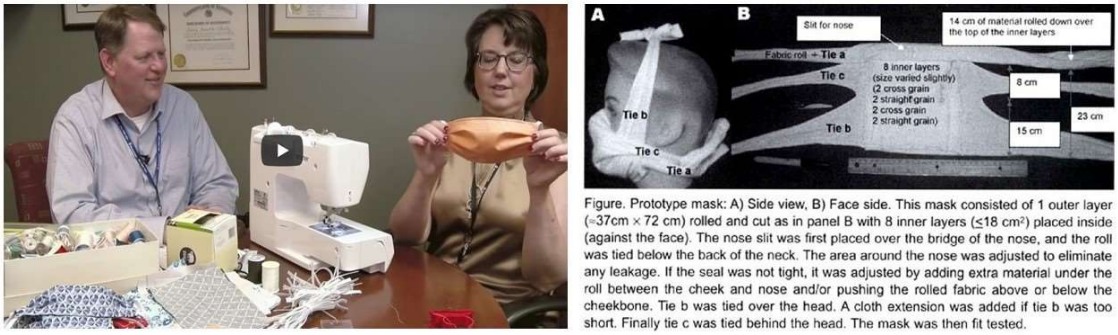


Figure. Prototype mask: A) Side view, B) Face side. This mask consisted of 1 outer layer (≈37cm × 72 cm) rolled and cut as in panel B with 8 inner layers (≤18 cm²) placed inside (against the face). The nose slit was first placed over the bridge of the nose, and the roll was tied below the back of the neck. The area around the nose was adjusted to eliminate any leakage. If the seal was not tight, it was adjusted by adding extra material under the roll between the cheek and nose and/or pushing the rolled fabric above or below the cheekbone. Tie b was tied over the head. A cloth extension was added if tie b was too short. Finally tie c was tied behind the head. The mask was then fit tested.

Figure 2: Two alternative homemade mask designs. The one on the left is based on surgical mask design and requires sewing (source: Deaconess. *https://www.deaconess.com/How-to-make-a-Face-Mask). The one on the right does not require sewing (source: Dato et al, 2006).*

Key dimensions in mask design, apart from the filtration properties of the materials used, which we explored in the previous section, are:

- How well the mask fits – it is essential to have a good seal between the mask and the face to prevent leakage and contamination, otherwise the mask will be ineffective;
- How easy it is to breathe when wearing the mask – as described above, the mask with the most effective filtration properties will not be the optimum design if it is difficult for users to breathe whilst wearing it;
- How comfortable the mask is – people will not wear masks that are uncomfortable.

We found three studies which evaluated at least one of these parameters. Two of these are described above (Davies et al, 2013 and van der Sande et al, 2008). The third is a study by Dato et al (2006)

Davies et al assessed how well their T-shirt material masks fit using a commercial fit test system. The fit factor of a mask is defined as the ratio of the concentration of microscopic particles outside the respirator with the concentration of particles that have leaked into the respirator. Volunteers were instructed to fit their surgical and homemade face masks with no help or guidance from the operator. The fit test was then conducted with volunteers performing a series of exercises. Davies et al also investigated mask comfort by asking volunteers to rate this.

Van der Sande et al (2008) conducted a similar fit test, evaluating their homemade mask made out of teatowel material for both short term (minutes) and long term (3 hours) use.

Dato et al (2006) also used a commercial fit test to evaluate several prototype homemade mask designs. The researchers report a detailed specification for the best performing design (see figure

2). They fit tested two different sizes of this design, made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. This was compared with an N95 mask.

Table 5: Summary of the evidence on mask design (sub-question 3) from studies evaluating mask fit, breathability and comfort

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Davies et al, 2013	Mask made from 2 layers of cotton T-shirt material. Volunteers made masks at home using sewing machine to a specification provided by the researchers (not published)	Surgical mask	• The homemade mask performed significantly poorer on the fit test compared with the surgical mask. • 20/21 participants reported that their t-shirt face mask was comfortable; however, each participant kept their mask on for only a short time (15 min), and with long-term wear, comfort might decrease.	See above.
Van der Sande et al, 2008	Homemade mask made from teatowel material. Design not provided	Surgical and FFP2 (European equivalent of N95) masks	• Although masks provided protection against transmission for both children and adults, homemade masks provided much less protection than surgical or FFP2 masks and this difference was strongly statistically significant. • Findings were similar for both short term and long term use. • Surgical masks provided about twice as much protection as home made masks, the difference a bit more marked among adults. • FFP2 masks provided adults with about 50 times as much protection as home made masks, and 25 times as much protection as surgical masks. • The increase in protection for children was less marked, about 10 times as much protection by FFP2 versus home-made	See above

			masks and 6 times as much protection as surgical masks.	
Dato et al, 2006	Two different sizes of homemade mask made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. See figure 2 for specification	N95	• The smaller mask achieved a fit factor of 67 (compared with 100 for an N95 respirator). The larger mask achieved fit factors between 13 and 17. • Breathability: The authors did not objectively assess breathability but the filter section of the mask was 8 layers of fabric thick. They wore the mask for an hour and their subjective assessment was that ease of breathing was similar to that for a standard N95 mask. However they caution that people with respiratory compromise of any type should not use this mask.	See above.

Studies evaluating improvised (as opposed to homemade) masks

We found two studies in this category, both of which investigated the association between respiratory illness and using a facecover (hijab/niqab) by female pilgrims attending the Hajj in Saudi Arabia. Both studies were of low quality for the purposes of this review because they did not collect detailed information on the consistency or duration of veil or mask use. Also, both studies were set in a very specific context (the Hajj) which is not generalizable to other contexts.

Choudhry et al (2006) conducted a prospective cohort study to estimate the incidence of acute respiratory infections (ARI) among pilgrims travelling from the capital of Saudi Arabia, Riyadh city to the Hajj. ARI were defined in terms of self-reported symptoms. The study asked about use of a facemask among male hajjis and a facemask or a facecover (hijab/niqab) by female hajjis.

Hashim et al (2016) conducted a cross-sectional study to assess factors associated with respiratory illness during the Hajj among 468 Malaysian adult hajj pilgrims. Participants were asked if they used a wet towel, dry towel, veil, surgical mask or N95 mask to protect against respiratory illness. The outcome measure was self-defined influenza-like illness based on symptoms.

Table 6: Summary of the evidence on improvised, as opposed to homemade masks (sub-question 3)

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Choudhry et al, 2006	facemask (male hajjis), facemask or facecover (hijab/niqab) (female hajjis)	No mask	• Whereas for men there was a statistically significant protective effect from wearing a face mask, there was no evidence of a significant decrease in the incidence of ARI among women related to using a facemask or facecover. • This difference from males may be explained by other customs, for example, women do not cover their face when alone in their tents with other females, and therefore have the same high risk of disease transmission in a closed environment with exposure to droplet infection. • Men, however, were using the facemask as a personal hygiene measure, independent of the place where they were.	**Strengths of this study**: It evaluates facemask/face covering behaviour in real-world settings. **Limitations**: The outcome measure (self-reported symptoms) is subjective. The measurement of facemask/face covering is imprecise ("most of the time, sometimes, never").
Hashim et al, 2016	wet towel, dry towel, veil	Surgical or N95 masks	• The study found no difference in influenza-like illness for those wearing improvised masks or veils compared with surgical or N95 masks.	**Strengths of this study**: It assessed facemask use among real life conditions. **Limitations**: The outcome measure (self-reported symptoms) is subjective. The measurement of facemask/face covering is imprecise – there is no measure of frequency or duration of use.

Studies which evaluated whether homemade masks can be safely washed and reused

We found one study which evaluated this question. It is described above (Neupane et al, 2019). The researchers evaluated the impact on filtration efficiency of repeatedly laundering cloth facemasks.

Table 7: Summary of the evidence on whether cloth masks can be safely washed and reused (sub-question 4)

Study	Materials tested	Test	Key Findings	Strengths and Limitations
Neupane et al, 2019	20 different types of cloth facemasks purchased from markets in Kathmandu, Nepal	To measure the mask efficiency after washing and drying cycles, mask was soaked for 1 h in an aqueous solution of powder detergent. The mask was rinsed multiple times with water so as to get rid of the detergent. The mask was then laid on a flat surface to make sure no stretching of the cloth fibres, and the mask was air dried. Filtering efficiency was measured after each washing and drying cycle.	• Repeatedly washing and drying the mask results in deterioration of the filtering efficiency. • The authors conclude that effectiveness of cloth masks deteriorates with repeated washing and drying.	See above

Discussion

This rapid evidence review found that:

Evidence:

- The quality of the evidence available was **very low**.
- Homemade masks are **not effective at filtering respiratory aerosols**. Van der Sande et al (2008) compared the effectiveness of different masks at filtering respiratory aerosols from the outside to the inside of the mask. FFP respirators, which provide a minimum of 94% filtration, were found to be 25 times more effective than surgical masks, which were in turn about twice as protective as homemade masks.
- Homemade masks **may have potential to reduce transmission through droplets**. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.
- Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. T-shirt or jersey material combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence

about suitable materials focuses only on filtration properties tested in laboratories and not on comfort and breathability tested in human subjects.

- Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
- If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.
- Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Policy implications:

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission. However, we found no research evidence quantifying this.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers. Again, we found no evidence quantifying the likely impacts.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.
- It is vital to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

This study has a number of strengths: because it was completed very rapidly, in less than one week, it includes the most up-to-date evidence. It is based on a robust literature search, which interrogated several research databases, including unpublished articles. It also has several limitations: the quality of the primary evidence is very low. The review process is itself subject to bias because several of the steps (data extraction and quality assessment) were undertaken by a single reviewer (RM). In the light of this, the results of the review should be treated with caution.

Keywords: facemasks, homemade, respiratory viruses, covid-19

Key references:

Bae S.; Kim M.C.; Kim J.Y. et al (2020) Effectiveness of Surgical and Cotton Masks in Blocking SARS-CoV-2: A Controlled Comparison in 4 PatientsAnnals of Internal Medicine6():6

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Hashim S.; Ayub Z.N.; Mohamed Z. et al (2016) The prevalence and preventive measures of the respiratory illness among Malaysian pilgrims in 2013 Hajj seasonJournal of Travel Medicine23(2):tav019

Ma Q.X.; Shan H.; Zhang H.L. et al (2020) Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2Journal of Medical Virology31():31

MacIntyre C.R.; Seale H.; Dung T.C. et al (2015) A cluster randomised trial of cloth masks compared with medical masks in healthcare workersBMJ Open5(4):e006577

Neupane B.B.; Mainali S.; Sharma A. et al (2019) Optical microscopic study of surface morphology and filtering efficiency of face masksPeerJ7():e7142

Rengasamy S.; Eimer B.; Shaffer R.E. (2010) Simple respiratory protection--evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particlesAnnals of Occupational Hygiene54(7):789-98

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van der Sande M.; Teunis P.; Sabel R. (2008) Professional and home-made face masks reduce exposure to respiratory infections among the general populationPLoS ONE [Electronic Resource]3(7):e2618

Background and Aims

As governments around the world turn their attention to strategies for coming out of the lockdown, one approach being explored is the use of facemasks to reduce person-to-person transmission in community settings as levels of self-isolation are reduced.

The CDC recommendation that people should wear facemasks in public settings where other social distancing measures are difficult to maintain (e.g. when visiting supermarkets) is based on the fact that a significant proportion of individuals with, and able to transmit, coronavirus are asymptomatic or pre-symptomatic. Thus it is based on the precautionary principle that facemasks *may* reduce transmission of covid-19 in community settings. There is no clear RCT evidence that this is the case.

Any move to recommend widespread use of facemasks by the general public risks disrupting the already fragile supply of medical and surgical facemasks to frontline healthcare workers, whose needs must be prioritised. This has led CDC to recommend that the general public use homemade, cloth facemasks. They have launched a website with detailed instructions of how homemade facemasks can be easily made at home using commonly available materials.

The purpose of this review is to assess the evidence of effectiveness of homemade or improvised facemasks. Specifically, it will address the following questions:

- Do homemade or improvised facemasks prevent the transmission of respiratory viruses?
- What materials work (what are the virus filtration properties of different materials)?
- What design(s) of mask work (in terms of fit and comfort)?
- Can these masks be safely washed and reused?

This study will not look at behavioural aspects of facemask use, beyond issues related to fit and comfort. Those issues are explored elsewhere.

For a useful background website describing the different types of commercially available masks and respirators and their standards, see: Sampol C (2020) Surgical Masks, Respirators, Barrier Masks: Which Masks Actually Protect Against Coronavirus?

Methods

Inclusion and Exclusion Criteria:

This study will include:

- studies which focus on the general population in any non-clinical setting where it is difficult to maintain social distancing
- studies in clinical settings will be included only if they compare cloth with surgical masks
- studies which focus on the effectiveness and reusability of homemade or improvised cloth facemasks compared with medical/surgical masks or with no mask at preventing the transmission of respiratory viruses;
- studies which report on the use of homemade or improvised cloth facemasks with or without handwashing and/or eye protection;
- studies which focus on the virus filtration properties of different materials used in the construction of homemade cloth masks;

- studies which focus on the comfort or breathability of different materials used in the construction of homemade cloth masks for preventing the transmission of respiratory viruses;
- studies which focus on the ability of different designs/shapes of facemasks to achieve a close fit to prevent transmission of respiratory viruses;
- any study design providing data on the effectiveness, virus filtration, reusability or design of homemade or improvised cloth facemasks to prevent the transmission of respiratory viruses will be included.

This review will exclude articles that:

- do not include data on the effectiveness homemade or improvised cloth facemasks at preventing the transmission of respiratory viruses (or proxy);
- do not include an outcome measure of or equivalent to respiratory illness (laboratory confirmed, clinically confirmed, self-reported, hospital admission, deaths, absence from work/school, or penetration of material by virus-sized or droplet-sized particles);
- report on the effectiveness of commercially manufactured masks that are not designed for clinical settings (e.g. masks purchased in DIY shops);
- are exclusively conducted in clinical settings (except where evaluating cloth vs other materials);
- studies not published in English;
- studies that focus on filtration properties of materials without reference to homemade cloth facemasks;
- studies that focus on the filtration properties of materials not commonly available in households.

Literature search: The literature search was designed and executed with the involvement of an Information Specialist (MD). We adopted a four-pronged approach:

- We reviewed the primary studies from three recent systematic reviews (Jefferson et al (2020), Brainard et al (2020), Xiao et al (2020));
- We screened the reference lists of two key papers (Davies et al (2013; Ma et al (2020));
- We performed forward citation tracking for the above two papers
- We repeated a search strategy by created by Ovid (WoltersKluwer 2020) on Medline
- We created a new search strategy for CINAHL (see below
- We created a new search strategy for MedRxiv (see below)
- We created a new search strategy for Web of Science (see below)

CINAHL – searched 17th April 2020 by NA - 206 Results

"(facemask* OR "face mask*" OR mask* OR veil*) AND (self-made OR "self made" OR "home made" OR homemade OR improvise* OR at-home OR re-purpose* OR "re purpose*") AND ("virus*" OR "viral" OR respiratory OR infection* OR outbreak* OR transmission* OR influenza OR "coronavirus*" OR COVID* OR "COVID-19" OR "severe acute respiratory syndrome" OR SARS* OR MERS*) Language: English AND Apply equivalent subjects on 2020-04-17 01:21 PM".

medRxiv – searched 17 April 2020 by MD - 70 results

for abstract or title "facemask facemasks mask masks covering veil" (match any words) and full text or abstract or title "household home-made improvised self-made" (match whole any)

Web of Science – searched 17 April 2020 by NA - 142 Results

(self-made OR "self made" OR "home made" OR homemade OR improvise* OR at-home OR re-purpose* OR "re purpose*") AND (facemask* OR "face mask*" OR mask* OR veil*) AND ("virus*" OR "viral" OR viroid* OR respiratory OR infection* OR outbreak* OR transmission* OR influenza OR "coronavirus*" OR COVID* OR "COVID-19" OR "severe acute respiratory syndrome" OR SARS* OR MERS*)

Medline (Ovid) searched 17 April 2020 run by MD - 33 results

Search source: Developed by expert searchers at Ovid in April 2020, available from: https://tools.ovid.com/coronavirus/

14. disease outbreaks/ or epidemics/ or pandemics/ or disease transmission, infectious/ or exp equipment contamination/ or equipment reuse/ or exp hygiene/ or exp Infection Control/ or exp coronavirus/
15. ((disease$ adj2 outbreak$) or epidemic$ or pandemic$ or pandemie* or influenza or SARS or MERS or flu or tuberculosis or zika or ebola or covid19 or "covid-19" or "SARS-CoV-2" or "2019-nCov" or coronavirus* or corona-virus* or nCov or SARS-CoV* or SARSCov2 or ncov*).mp.
16. middle east respiratory syndrome coronavirus/ or sars virus/ or exp Tuberculosis/ or influenza, Human/ or exp respiratory tract infections/
17. or/1-3
18. ((cloth$ or DIY or "do it yourself" or t-shirt$ or homemade or home-made or bandana$ or scarf$ or neckscarf$ or kerchief$ or napkin$ or bracup$ or bra-cup$ or 3D or "3-D" or cotton$ or muslin$ or gauze$ or "cheese cloth" or towel$ or fabric$ or tight$ woven or tight$ weav$) adj2 (facemask$ or face-mask$ or mask$)).mp.
19. (((home adj1 made) or homemaker$ or household$ or "house hold$") adj1 mask$).mp.
20. ("16752475" or "26980847" or "25903751" or "18612429" or "32203710" or "23968983" or "25903751" or "19702582" or "20584862").ui.
21. or/5-7
22. (((cloth$ or DIY or "do it yourself" or t-shirt$ or homemade or home-made or bandana$ or scarf$ or neckscarf$ or kerchief$ or napkin$ or bracup$ or bra-cup$ or 3D or "3-D" or cotton$ or muslin$ or gauze$ or "cheese cloth" or towel$ or fabric$ or tight$ woven or tight$ weav$) adj (facemask$1 or face-mask$1 or mask$1)) and (develop$ adj1 countr$)).mp.
23. ("16752475" or "26980847" or "25903751" or "18612429" or "32203710" or "23968983" or "25903751" or "19702582" or "20584862").ui.
24. "20390479".ui.
25. (4 and 8) or 7 or 9
26. 12 not 11

Title and Abstract Screen: Titles and abstracts were each screened by one reviewer (RM, AN, MD). A second reviewer then screened all excluded abstracts. Where there was a conflict, the abstract was included in full text screening.

Full Text Screen: The included full text articles were each screened by one reviewer (RM, MD). A second reviewer then screened all excluded full texts (RM, MD). Conflicts were resolved by discussion.

Data Extraction: Data extraction for each article was conducted by a single reviewer (RM). Data extraction was limited to a minimal set of required data items.

Risk of Bias Assessment: We used the following validated risk of bias tools to assess study quality for epidemiological studies: CASP and Joanna Briggs Institute checklists. For non-epidemiological studies, articles were assessed for rigour but without using a standardised tool. Risk of bias and evidence certainty for each article was assessed by a single reviewer (RM). Risk of bias ratings were limited to the most important outcomes.

Data Synthesis: Data were synthesized narratively. Because of the heterogeneity of the evidence, a meta-analysis was not appropriate. Using the GRADE system (Guyatt et al, 2008) a single reviewer (RM) graded the certainty of the evidence.

Results

After removal of duplicates, a total of 549 results was found from the database searching. We excluded 461 records by screening titles and abstracts and a further 77 at the full text screen stage, leaving 11 articles for inclusion in the final review. Reasons for exclusion were: article did not contain relevant data, article was not about facemasks/homemade facemasks, article was in Chinese, could not find article. See PRISMA diagram below for full details.

The key findings from this rapid review were:

Evidence:

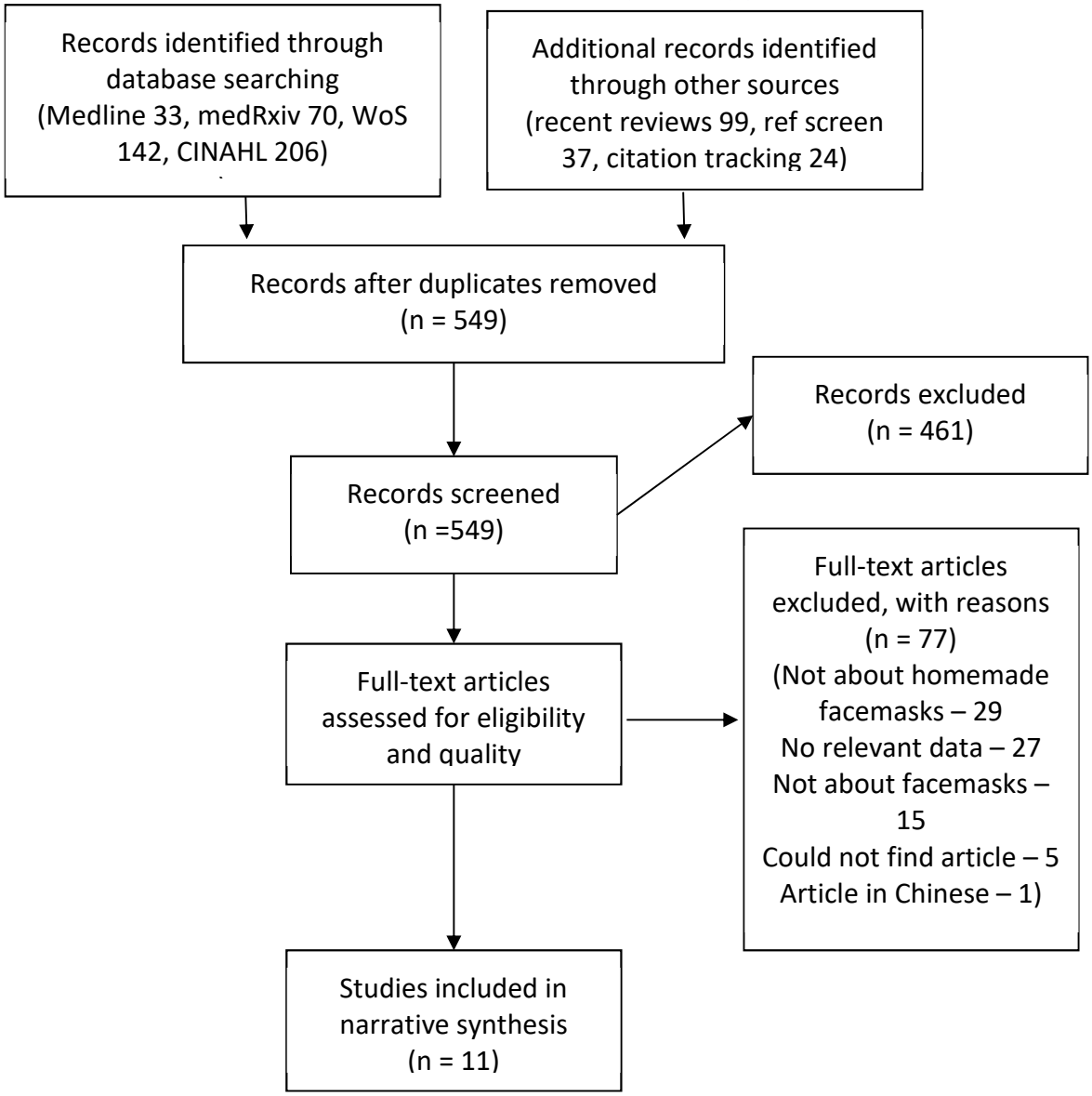
- The quality of the evidence available was **very low**.
- Homemade masks are **not effective at filtering respiratory aerosols**. Van der Sande et al (2008) compared the effectiveness of different masks at filtering respiratory aerosols from the outside to the inside of the mask. FFP respirators, which provide a minimum of 94% filtration, were found to be 25 times more effective than surgical masks, which were in turn about twice as protective as homemade masks.
- Homemade masks **may have potential to reduce transmission through droplets**. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.
- Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. T-shirt or jersey material combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence about suitable materials focuses only on filtration properties tested in laboratories and not on comfort and breathability tested in human subjects.

- Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
- If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.
- Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Policy implications:

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission. However, we found no research evidence quantifying this.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers. Again, we found no evidence quantifying the likely impacts.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.
- It is vital to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

Prisma flow diagram of publications screening and appraisal



Summary of results

A total of 549 unique articles were identified through the search strategies. After screening all titles and abstracts, 88 articles remained. After full text screening, eleven articles met the inclusion criteria and are included in this review:

- Bae et al (2020) Effectiveness of Surgical and Cotton Masks in Blocking SARS-CoV-2: A Controlled Comparison in 4 Patients
- Choudhry et al (2006) Hajj-associated acute respiratory infection among hajjis from Riyadh.
- Dato et al (2006) Simple respiratory mask
- Davies et al (2013) Testing the efficacy of homemade masks: would they protect in an influenza pandemic?
- Hashim et al (2016) The prevalence and preventive measures of the respiratory illness among Malaysian pilgrims in 2013 Hajj season
- Ma et al (2020) Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2
- MacIntyre et al (2015) A cluster randomised trial of cloth masks compared with medical masks in healthcare workers
- Neupane et al (2019) Optical microscopic study of surface morphology and filtering efficiency of face masks
- Rengasamy et al (2010) Simple respiratory protection--evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles.
- Rodriguez-Palacios et al (2020) Textile Masks and Surface Covers - A 'Universal Droplet Reduction Model' Against Respiratory Pandemics
- van der Sande et al (2008) Professional and home-made face masks reduce exposure to respiratory infections among the general population

The overall quality of the evidence is **very low**. There are no studies evaluating homemade facemasks in real life conditions. We found three studies evaluating the effectiveness of homemade masks under laboratory conditions using human subjects (Davies et al, 2013; van der Sande et al, 2008; Dato et al, 2006); however only one of these (Dato et al, 2006) specified mask design. We found five studies evaluating commonly available household materials for their effectiveness at virus filtration; however only one of these (Davies et al, 2013) also tested the breathability of the materials and their overall suitability for use in a homemade mask. We found only one study which investigated the impact of repeated laundering on the effectiveness of cloth masks (Neupane et al, 2019).

Sub-question 1: Do homemade or improvised facemasks prevent the transmission of respiratory viruses? Answer:

- Homemade masks may reduce the number of microorganisms expelled when coughing or sneezing but not as effectively as surgical masks. Surgical masks are more effective than homemade masks at filtering aerosolised virus particles, but even surgical masks are only marginally effective.
- Homemade masks may have potential to reduce transmission through droplets. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- It is also important to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

Sub-question 2: What materials work (what are the virus filtration properties of different materials)? Answer:

Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. A double layer of T-shirt material or pillowcase, combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence about suitable materials focuses only on filtration properties and not on comfort and breathability. Mask comfort and breathability are essential, as people will not wear uncomfortable masks or masks which make it harder to breathe.

Sub-question 3: What design(s) of mask work (in terms of fit and comfort)? Answer:

Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.

Sub-question 4: Can homemade masks be safely washed and reused? Answer:

Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Detailed results by study sub-question and type of study

The results of this review are organised and presented by reporting evidence relating to each of the four sub-questions, broken down by study type. This is summarised in table 1.

Table 1: Summary of the types of evidence available to address each sub-question

Sub-question	Types and numbers of studies (n.b. the same study may contribute to more than one of the sub-questions)
Do homemade or improvised facemasks prevent the transmission of respiratory viruses?	Studies testing homemade masks under laboratory conditions using human subjects (n = 3)
What materials work (what are the virus filtration properties of different materials)?	• Laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects (n = 5) • Studies comparing cloth masks with surgical masks in healthcare settings (n = 2)
What design(s) of mask work (in terms of fit and comfort)?	• Studies evaluating homemade mask designs (n = 3) • Studies evaluating improvised (as opposed to homemade) masks (n = 2)
Can homemade masks be safely washed and reused?	Laboratory experiment (n = 1)

Studies testing homemade masks under laboratory conditions using human subjects

Three studies (Davies et al, 2013; van der Sande et al, 2008, Dato et al, 2006) tested homemade masks under laboratory conditions using human subjects. All three specified the material used to make the mask but only one (Dato et al, 2006) specified the precise mask design. All three used commercial fit tests to test the effectiveness of the masks at preventing the transmission of particles. None tested the mask under real world conditions. Results are summarised in table 2.

Davies et al (2013) tested a range of household materials under controlled experimental conditions for their virus filtration properties and breathability and compared the results with surgical masks. They concluded that a double layer of cotton T-shirt material achieved the optimum combination of filtration and breathability. They then tested this mask for fit and comfort using human volunteers. There is a good lay summary of this study.

Van der Sande (2008) tested the fit and virus filtration of a homemade mask made from teatowel material under laboratory conditions, using human subjects. They tested the performance of the mask for both short (minutes) and long term (three hours) periods. They tested for both outward and inward transmission. They did not clearly specify mask design and they did not test the mask under real world conditions. The study is available here.

Dato et al (2006) used a commercial fit test to evaluate several prototype homemade mask designs. The researchers report a detailed specification for the best performing design (see figure 2). They fit tested two different sizes of this design, made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. This was compared wit an N95 mask.

Table 2: Summary of the evidence on the effectiveness of homemade masks from studies testing homemade masks under laboratory conditions using human subjects

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Davies et al, 2013	Mask made from 2 layers of cotton T-shirt material. Volunteers made masks at home using sewing machine to a specification provided by the researchers (not published)	Surgical mask	• Homemade masks reduce the number of microorganisms expelled when coughing but not as effectively as surgical masks, particularly at low particle sizes. The authors conclude that an improvised face mask should be viewed as the last possible alternative if a supply of commercial face masks is not available. • The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken. • Any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene. • If a mask does not fit well around the nose and mouth it will be of no benefit. • Mask comfort is essential, as people will not wear uncomfortable masks. • Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.	**Strengths of this study**: it looked at all aspects of mask effectiveness: virus filtration properties of different materials, breathability of different materials, design capable of being made at home by volunteers, fit of the mask and comfort of the mask. It used objective measures to assess parameters. It tested masks on real people, doing breathing exercises to simulate real life conditions. It used a virus smaller than corona virus to test the materials. **Limitations of this study**: the authors did not make the mask design available for evaluation. Washability and performance of the mask after being worn for longer periods are not assessed.
Van der Sande et al, 2008	Homemade mask made from teatowel material. Design not provided	Surgical and FFP2 (European equivalent of N95) masks	• Although masks provided protection against transmission for both children and adults, homemade masks provided much less protection than surgical or FFP2 masks and this difference was strongly statistically significant.	**Strengths of this study**: This study was performed under carefully controlled conditions using standard protocols and human subjects. **Limitations**: There was a small number of participants. Because it

			• Findings were similar for both short term and long term use. • Surgical masks provided about twice as much protection as home made masks, the difference a bit more marked among adults. • FFP2 masks provided adults with about 50 times as much protection as home made masks, and 25 times as much protection as surgical masks. • The increase in protection for children was less marked, about 10 times as much protection by FFP2 versus home-made masks and 6 times as much protection as surgical masks. • The homemade mask provided only marginal outward protection (i.e protection of the external environment from particles generated by the mask user). Interestingly, this study found that inward protection (i.e. protection of the mask user) was considerably higher than outward protection for all mask types.	was conducted under experimental conditions, it may not reflect behavioural and other parameters in the real world. Mask design was not specified.
Dato et al, 2006	Two different sizes of homemade mask made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and	N95	• The smaller mask achieved a fit factor of 67 (compared with 100 for an N95 respirator). The larger mask achieved fit factors between 13 and 17.	**Strengths of this study**: It provided a detailed design specification and specification of materials. It evaluated more than one size of mask. It used validated, objective methods to assess fit. **Limitations**: it did not assess breathability. It did not directly measure respiratory virus. It was a very small study (3 subjects).

	nose. See figure 2 for specification			

Laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects

Five studies tested commonly available household materials for their virus filtration properties under controlled laboratory conditions (Davies et al, 2013; Ma et al, 2020; Rengasamy et al, 2010; Rodrigues-Palacios et al, 2020; Neupane et al, 2019). Results are summarised in table 3.

Davies et al (2013) compared the virus filtration properties and breathability of a range of common household materials (cotton t-shirt, scarf, teatowel, pillowcase, antimicrobial pillowcase, vacuum cleaner bag, cotton mix, linen, silk) with surgical masks. This was the only laboratory study that assessed breathability as well as virus filtration. They did this by measuring the pressure drop across the different materials when air was blown at them.

Ma et al (2020) tested the virus filtration properties of a homemade mask made of 1 layer of polyester and 4 layers of kitchen paper under laboratory conditions, using aerosolised low pathogenic avian influenza A virus. They compared the results with a medical mask and an N95 mask.

Rengasamy et al (2010) assessed the filtration performance of a range of household materials (T-shirts, towels, scarves, and cloth masks) by subjecting them to dispersed aerosols of nano-size particles the size of viruses (20-1000 nm). This was repeated at different velocities to simulate breathing and coughing. They compared the results with an N95 mask.

Rodriguez-Palacios et al (2020) assessed household textiles (T-shirt material, pillow case, woven cotton cloth, sport jersey material) to quantify their potential to prevent transmission via droplet, as opposed to aerosol. They compared the fabrics with no barrier, a medical mask and surgical cloth material.

Neupane et al (2019) evaluated the effectiveness of commercially produced cloth masks at filtering particulate matter (PM - i.e. much bigger particle size than viruses). Although this study is not about homemade, masks is included because it evaluates relevant materials (cloth masks). Although it is about the filtration of PM rather than viruses, it is included because if cloth masks are shown to be ineffective at filtering much larger particles, they will certainly be ineffective for virus filtration.

Table 3: Summary of the evidence on suitable materials for homemade masks (sub-question 2) from laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects

Study	Materials tested	Comparator	Key Findings	Strengths and Limitations
Davies et al, 2013	cotton t-shirt, scarf, teatowel, pillowcase, antimicrobial pillowcase, vacuum cleaner bag, cotton mix, linen, silk	Surgical mask	• All the materials tested showed some capability to filter microbial aerosols of similar particle size to SARS-CoV-2. • Filtration efficiency for MS2 (particle size 5 x smaller than corona virus) was: surgical mask 90%, vacuum cleaner bag 86%, teatowel 72%, cottonmix 70%, antimicrobial pillow case 69%, linen 62%, pillowcase 57%, silk 54%, cotton t-shirt 51% and scarf 49%. • Doubling the layers increased the filtration efficiency slightly for the t-shirt and pillow case and significantly for the teatowel. • Although the vacuum cleaner bag had the best virus filtration properties, its thickness, stiffness and poor breathability make it unsuitable for a face mask. • Similarly, although the double layered tea towel had a high filtration efficiency it had poor breathability. • The authors concluded that a double layer of T-shirt material was the optimum choice for a homemade mask because it combined filtration, breathability, comfort and fit. The slightly stretchy quality of a double layer of T-shirt material compared to the other materials tested was considered likely to provide a better fit.	See above.
Ma et al, 2020	homemade mask made of 1 layer of polyester and 4 layers of kitchen paper	Medical mask, N95 mask	• The homemade mask made from 1 layer of polyester and 4 layers of kitchen paper prevented 95% of virus penetration, compared with over 99.9% for the N95 mask and 97% for the medical mask. • The authors stress the importance of incorporating kitchen paper in the mask. • They suggest it may be effective in blocking the virus because of its multiple layers, nonwoven structure, and virus-absorbing properties.	**Strengths of this study**: it used objective measures to assess virus filtration properties of different materials under carefully controlled conditions, using avian influenza virus in the

			• They also suggest that effectiveness will likely be reduced if fewer layers of kitchen paper are used and that other types of homemade masks, especially those made of cloth alone, may be unable to block the virus and thus confer no protection against the virus. • An advantage of this style of mask is that the kitchen paper can be changed frequently. • The authors conclude that whilst homemade masks have limited potential to prevent transmission at the individual level, when multiplied up to the population level they have the potential for significant impact, particularly if used in conjunction with hand hygiene.	experiment. It repeated measurements to bolster robustness of results. **Limitations**: it did not assess how the masks might work in the real world (breathability, comfort, closeness of fit) and did not address mask design (shape).
Rengasamy et al, 2010	T-shirts, towels, scarves, and cloth masks	N95 mask	• The penetration levels of all the fabric materials tested were much higher than the penetrations for the N95 mask (in other words, virus easily penetrated all the fabric materials). • The different household materials had 40 – 90% instantaneous penetration compared with 0.12 % for the N95 mask. • The authors concluded that common fabric materials may provide only marginal protection against nanoparticles including those in the size ranges of virus-containing particles in exhaled breath.	**Strengths of this study**: It was performed under controlled experimental conditions using standard protocols. **Limitations**: The study only tested a few types of fabric and only measured penetration – it did not assess face seal leakage, which is a critical component of respiratory protection. It also did not assess the effect of laundering the materials (none of the materials had been

				worn or laundered), which could affect filtration performance.
Rodrigues-Palacios et al, 2020	t-shirt material, pillow case, woven cotton cloth, sport jersey material	no barrier, a medical mask and surgical cloth material	• All textiles reduced the number of droplets reaching surfaces, restricting their dispersion to <30cm, when used as single layers. • When used as double-layers, textiles were as effective as medical mask/surgical-cloth materials, reducing droplet dispersion to <10cm. • T-shirt and sport jersey material were the most effective. • The authors conclude that homemade masks made from household materials could have potential to reduce environmental contamination and the risk of transmitting or acquiring infectious respiratory pathogens, including COVID-19.	**Strengths of this study**: It evaluated different fabrics under controlled laboratory conditions. **Limitations**: This study investigates droplet spread only – it does not evaluate aerosol transmission. It is a laboratory study, which does not evaluate real life use of homemade masks.
Neupane et al, 2019	20 different types of cloth facemasks purchased from markets in Kathmandu, Nepal	7 different brands of surgical mask	• Filtering efficiency of cloth masks for ambient PM 10 was poorer than in surgical masks because of the presence of larger sized pores. • Stretching the CM surface alters the pore size and potentially decreases the filtering efficiency. • The authors conclude that cloth masks are not effective, and that effectiveness deteriorates if the mask is stretched.	**Strengths of this study**: It was conducted under controlled experimental conditions. **Limitations**: This study is about particulate matter (i.e. much bigger particle sizes than viruses). However, demonstrating the limitations of cloth face masks even with bigger

				particle size underlines the limitations for virus filtering.

Studies comparing cloth masks with surgical masks in healthcare settings

Two studies evaluated the effectiveness of manufactured cloth masks compared to surgical masks in hospital settings. Although these studies are not about homemade masks and are relevant to a clinical, as opposed to community setting, they are included because they focus on relevant materials (cloth) and provide a direct comparison with surgical masks. Results are summarised in table 4.

Bae et al (2020) evaluated the effectiveness of surgical and cotton masks in filtering SARS–CoV-2 in a hospital-based study involving 4 covid-19 patients. They compared (manufactured) reusable cotton masks with surgical masks.

MacIntyre et al (2015) conducted a cluster randomised controlled trial to compare the efficacy of cloth masks (locally manufactured, two layer) with surgical masks in 1607 healthcare workers in 14 secondary/tertiary hospitals in Hanoi, Vietnam.

Table 4: Summary of the evidence on suitable materials for homemade masks (sub-question 2) from studies comparing cloth masks with surgical masks in healthcare settings

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Bae et al, 2020	Commercially produced cotton mask	Surgical mask	• Neither surgical nor cotton masks effectively filtered SARS–CoV-2 during coughs by infected patients. • This study found greater contamination on the outer than the inner mask surfaces. This observation supports the importance of hand hygiene after touching the outer surface of masks. • The authors conclude that both surgical and cotton masks are ineffective in preventing the dissemination of SARS–CoV-2 from the coughs of patients with COVID-19 to the environment and external mask surface.	**Strengths of this study**: It was conducted under controlled conditions with COVID-19 patients. **Limitations**: It was a very small study (4 patients), data were incomplete and it is not about homemade masks.
MacIntyre et al, 2015	Cloth masks	Medical masks	• The rates of all infection outcomes were highest in the cloth mask arm, with the rate of influenza-like illness statistically significantly higher in the cloth mask arm (relative risk (RR)=13.00, 95% CI 1.69 to 100.07) compared with the medical mask arm. • Rates of laboratory confirmed respiratory virus infection were also higher in the cloth mask arm than in the medical mask arm, but the difference was not significant.	**Strengths of this study**: This was a large, well-conducted cluster RCT. **Limitations**: Researchers did not objectively measure compliance with hand hygiene. This is not directly relevant to the current question because it is not about homemade masks and it was conducted in a hospital, not a community setting.

Studies evaluating mask designs

Despite a plethora of homemade mask designs proliferating on the internet in recent weeks, unfortunately there are no studies which systematically evaluate and compare different homemade mask designs. The US Centers for Disease Control and Prevention website provides patterns for creating masks, categorised into those that require sewing and those that do not; however there is no evidence that these designs have been tested. Most of the designs described are modelled on surgical masks but other designs are also proposed – for example the design tested by Dato et al (2006) – see figure 2.

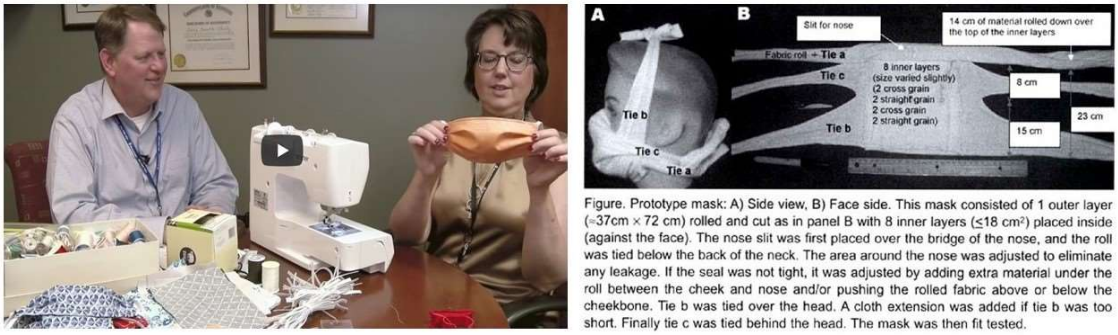


Figure. Prototype mask: A) Side view, B) Face side. This mask consisted of 1 outer layer (≈37cm × 72 cm) rolled and cut as in panel B with 8 inner layers (≤18 cm²) placed inside (against the face). The nose slit was first placed over the bridge of the nose, and the roll was tied below the back of the neck. The area around the nose was adjusted to eliminate any leakage. If the seal was not tight, it was adjusted by adding extra material under the roll between the cheek and nose and/or pushing the rolled fabric above or below the cheekbone. Tie b was tied over the head. A cloth extension was added if tie b was too short. Finally tie c was tied behind the head. The mask was then fit tested.

Figure 2: Two alternative homemade mask designs. The one on the left is based on surgical mask design and requires sewing (source: Deaconess. *https://www.deaconess.com/How-to-make-a-Face-Mask). The one on the right does not require sewing (source: Dato et al, 2006).*

Key dimensions in mask design, apart from the filtration properties of the materials used, which we explored in the previous section, are:

- How well the mask fits – it is essential to have a good seal between the mask and the face to prevent leakage and contamination, otherwise the mask will be ineffective;
- How easy it is to breathe when wearing the mask – as described above, the mask with the most effective filtration properties will not be the optimum design if it is difficult for users to breathe whilst wearing it;
- How comfortable the mask is – people will not wear masks that are uncomfortable.

We found three studies which evaluated at least one of these parameters. Two of these are described above (Davies et al, 2013 and van der Sande et al, 2008). The third is a study by Dato et al (2006)

Davies et al assessed how well their T-shirt material masks fit using a commercial fit test system. The fit factor of a mask is defined as the ratio of the concentration of microscopic particles outside the respirator with the concentration of particles that have leaked into the respirator. Volunteers were instructed to fit their surgical and homemade face masks with no help or guidance from the operator. The fit test was then conducted with volunteers performing a series of exercises. Davies et al also investigated mask comfort by asking volunteers to rate this.

Van der Sande et al (2008) conducted a similar fit test, evaluating their homemade mask made out of teatowel material for both short term (minutes) and long term (3 hours) use.

Dato et al (2006) also used a commercial fit test to evaluate several prototype homemade mask designs. The researchers report a detailed specification for the best performing design (see figure

2). They fit tested two different sizes of this design, made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. This was compared with an N95 mask.

Table 5: Summary of the evidence on mask design (sub-question 3) from studies evaluating mask fit, breathability and comfort

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Davies et al, 2013	Mask made from 2 layers of cotton T-shirt material. Volunteers made masks at home using sewing machine to a specification provided by the researchers (not published)	Surgical mask	• The homemade mask performed significantly poorer on the fit test compared with the surgical mask. • 20/21 participants reported that their t-shirt face mask was comfortable; however, each participant kept their mask on for only a short time (15 min), and with long-term wear, comfort might decrease.	See above.
Van der Sande et al, 2008	Homemade mask made from teatowel material. Design not provided	Surgical and FFP2 (European equivalent of N95) masks	• Although masks provided protection against transmission for both children and adults, homemade masks provided much less protection than surgical or FFP2 masks and this difference was strongly statistically significant. • Findings were similar for both short term and long term use. • Surgical masks provided about twice as much protection as home made masks, the difference a bit more marked among adults. • FFP2 masks provided adults with about 50 times as much protection as home made masks, and 25 times as much protection as surgical masks. • The increase in protection for children was less marked, about 10 times as much protection by FFP2 versus home-made	See above

			masks and 6 times as much protection as surgical masks.	
Dato et al, 2006	Two different sizes of homemade mask made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. See figure 2 for specification	N95	• The smaller mask achieved a fit factor of 67 (compared with 100 for an N95 respirator). The larger mask achieved fit factors between 13 and 17. • Breathability: The authors did not objectively assess breathability but the filter section of the mask was 8 layers of fabric thick. They wore the mask for an hour and their subjective assessment was that ease of breathing was similar to that for a standard N95 mask. However they caution that people with respiratory compromise of any type should not use this mask.	See above.

Studies evaluating improvised (as opposed to homemade) masks

We found two studies in this category, both of which investigated the association between respiratory illness and using a facecover (hijab/niqab) by female pilgrims attending the Hajj in Saudi Arabia. Both studies were of low quality for the purposes of this review because they did not collect detailed information on the consistency or duration of veil or mask use. Also, both studies were set in a very specific context (the Hajj) which is not generalizable to other contexts.

Choudhry et al (2006) conducted a prospective cohort study to estimate the incidence of acute respiratory infections (ARI) among pilgrims travelling from the capital of Saudi Arabia, Riyadh city to the Hajj. ARI were defined in terms of self-reported symptoms. The study asked about use of a facemask among male hajjis and a facemask or a facecover (hijab/niqab) by female hajjis.

Hashim et al (2016) conducted a cross-sectional study to assess factors associated with respiratory illness during the Hajj among 468 Malaysian adult hajj pilgrims. Participants were asked if they used a wet towel, dry towel, veil, surgical mask or N95 mask to protect against respiratory illness. The outcome measure was self-defined influenza-like illness based on symptoms.

Table 6: Summary of the evidence on improvised, as opposed to homemade masks (sub-question 3)

Study	Description of mask	Comparator	Key Findings	Strengths and Limitations
Choudhry et al, 2006	facemask (male hajjis), facemask or facecover (hijab/niqab) (female hajjis)	No mask	• Whereas for men there was a statistically significant protective effect from wearing a face mask, there was no evidence of a significant decrease in the incidence of ARI among women related to using a facemask or facecover. • This difference from males may be explained by other customs, for example, women do not cover their face when alone in their tents with other females, and therefore have the same high risk of disease transmission in a closed environment with exposure to droplet infection. • Men, however, were using the facemask as a personal hygiene measure, independent of the place where they were.	**Strengths of this study**: It evaluates facemask/face covering behaviour in real-world settings. **Limitations**: The outcome measure (self-reported symptoms) is subjective. The measurement of facemask/face covering is imprecise ("most of the time, sometimes, never").
Hashim et al, 2016	wet towel, dry towel, veil	Surgical or N95 masks	• The study found no difference in influenza-like illness for those wearing improvised masks or veils compared with surgical or N95 masks.	**Strengths of this study**: It assessed facemask use among real life conditions. **Limitations**: The outcome measure (self-reported symptoms) is subjective. The measurement of facemask/face covering is imprecise – there is no measure of frequency or duration of use.

Studies which evaluated whether homemade masks can be safely washed and reused

We found one study which evaluated this question. It is described above (Neupane et al, 2019). The researchers evaluated the impact on filtration efficiency of repeatedly laundering cloth facemasks.

Table 7: Summary of the evidence on whether cloth masks can be safely washed and reused (sub-question 4)

Study	Materials tested	Test	Key Findings	Strengths and Limitations
Neupane et al, 2019	20 different types of cloth facemasks purchased from markets in Kathmandu, Nepal	To measure the mask efficiency after washing and drying cycles, mask was soaked for 1 h in an aqueous solution of powder detergent. The mask was rinsed multiple times with water so as to get rid of the detergent. The mask was then laid on a flat surface to make sure no stretching of the cloth fibres, and the mask was air dried. Filtering efficiency was measured after each washing and drying cycle.	• Repeatedly washing and drying the mask results in deterioration of the filtering efficiency. • The authors conclude that effectiveness of cloth masks deteriorates with repeated washing and drying.	See above

Discussion

This rapid evidence review found that:

Evidence:

- The quality of the evidence available was **very low**.
- Homemade masks are **not effective at filtering respiratory aerosols**. Van der Sande et al (2008) compared the effectiveness of different masks at filtering respiratory aerosols from the outside to the inside of the mask. FFP respirators, which provide a minimum of 94% filtration, were found to be 25 times more effective than surgical masks, which were in turn about twice as protective as homemade masks.
- Homemade masks **may have potential to reduce transmission through droplets**. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.
- Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. T-shirt or jersey material combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence

about suitable materials focuses only on filtration properties tested in laboratories and not on comfort and breathability tested in human subjects.

- Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
- If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.
- Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Policy implications:

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission. However, we found no research evidence quantifying this.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers. Again, we found no evidence quantifying the likely impacts.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.
- It is vital to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

This study has a number of strengths: because it was completed very rapidly, in less than one week, it includes the most up-to-date evidence. It is based on a robust literature search, which interrogated several research databases, including unpublished articles. It also has several limitations: the quality of the primary evidence is very low. The review process is itself subject to bias because several of the steps (data extraction and quality assessment) were undertaken by a single reviewer (RM). In the light of this, the results of the review should be treated with caution.

Keywords: facemasks, homemade, respiratory viruses, covid-19

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Background and Aims

As governments around the world turn their attention to strategies for coming out of the lockdown, one approach being explored is the use of facemasks to reduce person-to-person transmission in community settings as levels of self-isolation are reduced.

The CDC recommendation that people should wear facemasks in public settings where other social distancing measures are difficult to maintain (e.g. when visiting supermarkets) is based on the fact that a significant proportion of individuals with, and able to transmit, coronavirus are asymptomatic or pre-symptomatic. Thus it is based on the precautionary principle that facemasks *may* reduce transmission of covid-19 in community settings. There is no clear RCT evidence that this is the case.

Any move to recommend widespread use of facemasks by the general public risks disrupting the already fragile supply of medical and surgical facemasks to frontline healthcare workers, whose needs must be prioritised. This has led CDC to recommend that the general public use homemade, cloth facemasks. They have launched a website with detailed instructions of how homemade facemasks can be easily made at home using commonly available materials. The purpose of this review is to assess the evidence of effectiveness of homemade or improvised facemasks. Specifically, it will address the following questions:

- Do homemade or improvised facemasks prevent the transmission of respiratory viruses?
- What materials work (what are the virus filtration properties of different materials)?
- What design(s) of mask work (in terms of fit and comfort)?
- Can these masks be safely washed and reused?

This study will not look at behavioural aspects of facemask use, beyond issues related to fit and comfort. Those issues are explored elsewhere.

For a useful background website describing the different types of commercially available masks and respirators and their standards, see: Sampol C (2020) Surgical Masks, Respirators, Barrier Masks: Which Masks Actually Protect Against Coronavirus?

Methods

Inclusion and Exclusion Criteria:

This study will include:

- studies which focus on the general population in any non-clinical setting where it is difficult to maintain social distancing
- studies in clinical settings will be included only if they compare cloth with surgical masks
- studies which focus on the effectiveness and reusability of homemade or improvised cloth facemasks compared with medical/surgical masks or with no mask at preventing the transmission of respiratory viruses;
- studies which report on the use of homemade or improvised cloth facemasks with or without handwashing and/or eye protection;
- studies which focus on the virus filtration properties of different materials used in the construction of homemade cloth masks;
- studies which focus on the comfort or breathability of different materials used in the construction of homemade cloth masks for preventing the transmission of respiratory viruses;
- studies which focus on the ability of different designs/shapes of facemasks to achieve a close fit to prevent transmission of respiratory viruses;
- any study design providing data on the effectiveness, virus filtration, reusability or design of homemade or improvised cloth facemasks to prevent the transmission of respiratory viruses will be included.

This review will exclude articles that:

- do not include data on the effectiveness homemade or improvised cloth facemasks at preventing the transmission of respiratory viruses (or proxy);
- do not include an outcome measure of or equivalent to respiratory illness (laboratory confirmed, clinically confirmed, self-reported, hospital admission, deaths, absence from work/school, or penetration of material by virus-sized or droplet-sized particles);
- report on the effectiveness of commercially manufactured masks that are not designed for clinical settings (e.g. masks purchased in DIY shops);
- are exclusively conducted in clinical settings (except where evaluating cloth vs other materials);
- studies not published in English;
- studies that focus on filtration properties of materials without reference to homemade cloth facemasks;
- studies that focus on the filtration properties of materials not commonly available in households.

Literature search: The literature search was designed and executed with the involvement of an Information Specialist (MD). We adopted a four-pronged approach:

- We reviewed the primary studies from three recent systematic reviews (Jefferson et al (2020), Brainard et al (2020), Xiao et al (2020));
- We screened the reference lists of two key papers (Davies et al (2013; Ma et al (2020));
- We performed forward citation tracking for the above two papers
- We repeated a search strategy by created by Ovid (WoltersKluwer 2020) on Medline
- We created a new search strategy for CINAHL (see below

- We created a new search strategy for MedRxiv (see below)
- We created a new search strategy for Web of Science (see below)

CINAHL – searched 17th April 2020 by NA - 206 Results
"(facemask* OR "face mask*" OR mask* OR veil*) AND (self-made OR "self made" OR "home made" OR homemade OR improvise* OR at-home OR re-purpose* OR "re purpose*") AND ("virus*" OR "viral" OR respiratory OR infection* OR outbreak* OR transmission* OR influenza OR "coronavirus*" OR COVID* OR "COVID-19" OR "severe acute respiratory syndrome" OR SARS* OR MERS*) Language: English AND Apply equivalent subjects on 2020-04-17 01:21 PM".

medRxiv – searched 17 April 2020 by MD - 70 results
for abstract or title "facemask facemasks mask masks covering veil" (match any words) and full text or abstract or title "household home-made improvised self-made" (match whole any)

Web of Science – searched 17 April 2020 by NA - 142 Results
(self-made OR "self made" OR "home made" OR homemade OR improvise* OR at-home OR re-purpose* OR "re purpose*") AND (facemask* OR "face mask*" OR mask* OR veil*) AND ("virus*" OR "viral" OR viroid* OR respiratory OR infection* OR outbreak* OR transmission* OR influenza OR "coronavirus*" OR COVID* OR "COVID-19" OR "severe acute respiratory syndrome" OR SARS* OR MERS*)

Medline (Ovid) searched 17 April 2020 run by MD - 33 results
Search source: Developed by expert searchers at Ovid in April 2020, available from: https://tools.ovid.com/coronavirus/

1. disease outbreaks/ or epidemics/ or pandemics/ or disease transmission, infectious/ or exp equipment contamination/ or equipment reuse/ or exp hygiene/ or exp Infection Control/ or exp coronavirus/
2. ((disease$ adj2 outbreak$) or epidemic$ or pandemic$ or pandemie* or influenza or SARS or MERS or flu or tuberculosis or zika or ebola or covid19 or "covid-19" or "SARS-CoV-2" or "2019-nCov" or coronavirus* or corona-virus* or nCov or SARS-CoV* or SARSCov2 or ncov*).mp.
3. middle east respiratory syndrome coronavirus/ or sars virus/ or exp Tuberculosis/ or influenza, Human/ or exp respiratory tract infections/
4. or/1-3
5. ((cloth$ or DIY or "do it yourself" or t-shirt$ or homemade or home-made or bandana$ or scarf$ or neckscarf$ or kerchief$ or napkin$ or bracup$ or bra-cup$ or 3D or "3-D" or cotton$ or muslin$ or gauze$ or "cheese cloth" or towel$ or fabric$ or tight$ woven or tight$ weav$) adj2 (facemask$ or face-mask$ or mask$)).mp.
6. (((home adj1 made) or homemaker$ or household$ or "house hold$") adj1 mask$).mp.
7. ("16752475" or "26980847" or "25903751" or "18612429" or "32203710" or "23968983" or "25903751" or "19702582" or "20584862").ui.
8. or/5-7
9. (((cloth$ or DIY or "do it yourself" or t-shirt$ or homemade or home-made or bandana$ or scarf$ or neckscarf$ or kerchief$ or napkin$ or bracup$ or bra-cup$ or 3D or "3-D" or cotton$ or muslin$ or gauze$ or "cheese cloth" or towel$ or fabric$ or tight$ woven or tight$ weav$) adj (facemask$1 or face-mask$1 or mask$1)) and (develop$ adj1 countr$)).mp.
10. ("16752475" or "26980847" or "25903751" or "18612429" or "32203710" or "23968983" or "25903751" or "19702582" or "20584862").ui.
11. "20390479".ui.
12. (4 and 8) or 7 or 9
13. 12 not 11

Title and Abstract Screen: Titles and abstracts were each screened by one reviewer (RM, AN, MD). A second reviewer then screened all excluded abstracts. Where there was a conflict, the abstract was included in full text screening.

Full Text Screen: The included full text articles were each screened by one reviewer (RM, MD). A second reviewer then screened all excluded full texts (RM, MD). Conflicts were resolved by discussion.

Data Extraction: Data extraction for each article was conducted by a single reviewer (RM). Data extraction was limited to a minimal set of required data items.

Risk of Bias Assessment: We used the following validated risk of bias tools to assess study quality for epidemiological studies: CASP and Joanna Briggs Institute checklists. For non-epidemiological studies, articles were assessed for rigour but without using a standardised tool. Risk of bias and evidence certainty for each article was assessed by a single reviewer (RM). Risk of bias ratings were limited to the most important outcomes.

Data Synthesis: Data were synthesized narratively. Because of the heterogeneity of the evidence, a meta-analysis was not appropriate. Using the GRADE system (Guyatt et al, 2008) a single reviewer (RM) graded the certainty of the evidence.

Results

After removal of duplicates, a total of 549 results was found from the database searching. We excluded 461 records by screening titles and abstracts and a further 77 at the full text screen stage, leaving 11 articles for inclusion in the final review. Reasons for exclusion were: article did not contain relevant data, article was not about facemasks/homemade facemasks, article was in Chinese, could not find article. See PRISMA diagram below for full details.

The key findings from this rapid review were:

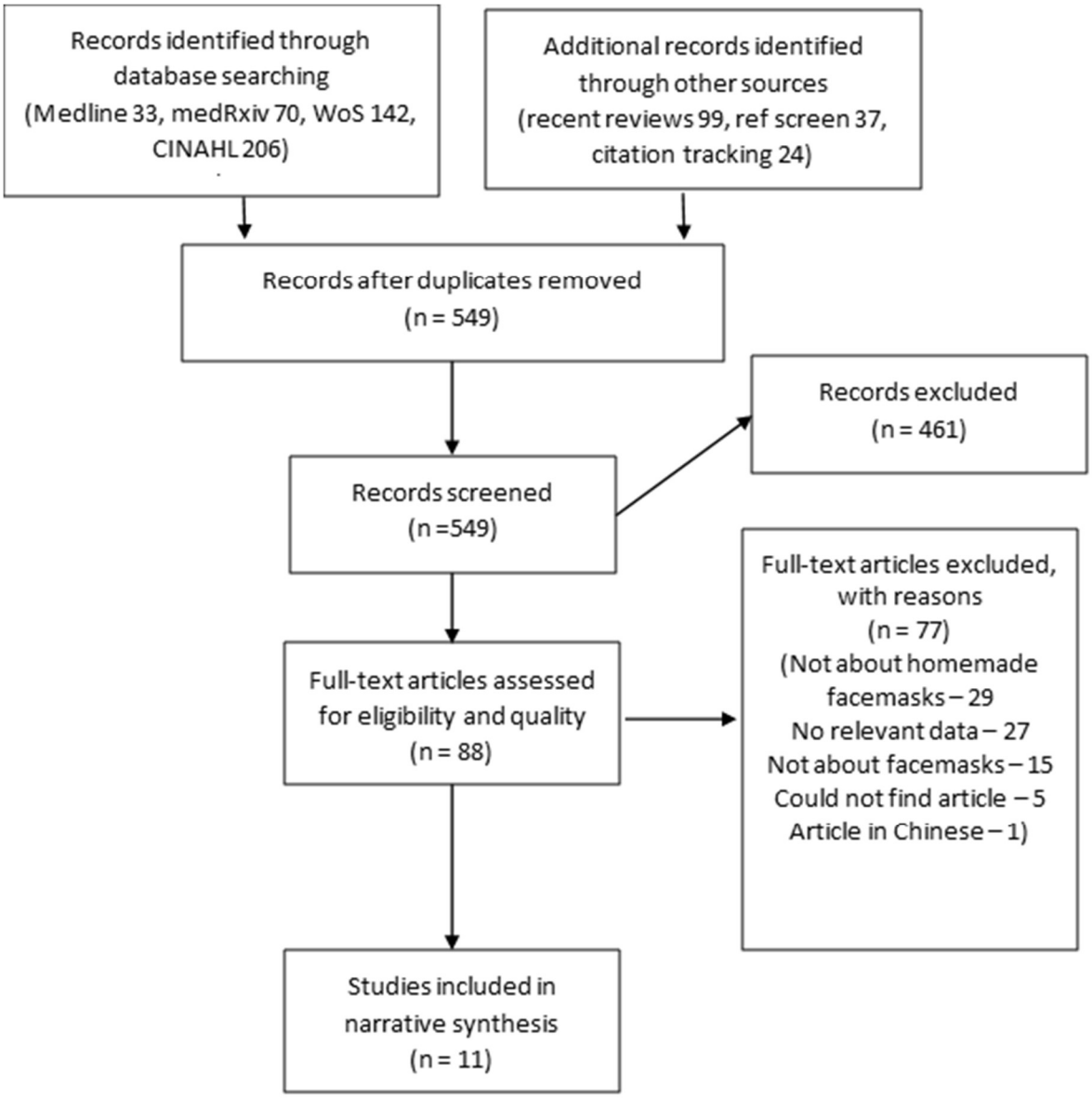
Evidence:

- The quality of the evidence available was **very low**.
- Homemade masks are **not effective at filtering respiratory aerosols**. Van der Sande et al (2008) compared the effectiveness of different masks at filtering respiratory aerosols from the outside to the inside of the mask. FFP respirators, which provide a minimum of 94% filtration, were found to be 25 times more effective than surgical masks, which were in turn about twice as protective as homemade masks.
- Homemade masks **may have potential to reduce transmission through droplets**. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.
- Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. T-shirt or jersey material combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence about suitable materials focuses only on filtration properties tested in laboratories and not on comfort and breathability tested in human subjects.
- Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
- If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.
- Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Policy implications:

- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission. However, we found no research evidence quantifying this.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers. Again, we found no evidence quantifying the likely impacts.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.
- Masks should be changed regularly: a mask that has become damp from use will be less effective than a fresh mask.
- It is vital to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

Prisma flow diagram of publications screening and appraisal



Summary of results

A total of 549 unique articles were identified through the search strategies. After screening all titles and abstracts, 88 articles remained. After full text screening, eleven articles met the inclusion criteria and are included in this review:

- Bae et al (2020) Effectiveness of Surgical and Cotton Masks in Blocking SARS-CoV-2: A Controlled Comparison in 4 Patients
- Choudhry et al (2006) Hajj-associated acute respiratory infection among hajjis from Riyadh.
- Dato et al (2006) Simple respiratory mask
- Davies et al (2013) Testing the efficacy of homemade masks: would they protect in an influenza pandemic?
- Hashim et al (2016) The prevalence and preventive measures of the respiratory illness among Malaysian pilgrims in 2013 Hajj season
- Ma et al (2020) Potential utilities of mask-wearing and instant hand hygiene for fighting SARS-CoV-2
- MacIntyre et al (2015) A cluster randomised trial of cloth masks compared with medical masks in healthcare workers
- Neupane et al (2019) Optical microscopic study of surface morphology and filtering efficiency of face masks
- Rengasamy et al (2010) Simple respiratory protection--evaluation of the filtration performance of cloth masks and common fabric materials against 20-1000 nm size particles.
- Rodriguez-Palacios et al (2020) Textile Masks and Surface Covers - A 'Universal Droplet Reduction Model' Against Respiratory Pandemics
- van der Sande et al (2008) Professional and home-made face masks reduce exposure to respiratory infections among the general population

The overall quality of the evidence is **very low**. There are no studies evaluating homemade facemasks in real life conditions. We found three studies evaluating the effectiveness of homemade masks under laboratory conditions using human subjects (Davies et al, 2013; van der Sande et al, 2008; Dato et al, 2006); however only one of these (Dato et al, 2006) specified mask design. We found five studies evaluating commonly available household materials for their effectiveness at virus filtration; however only one of these (Davies et al, 2013) also tested the breathability of the materials and their overall suitability for use in a homemade mask. We found only one study which investigated the impact of repeated laundering on the effectiveness of cloth masks (Neupane et al, 2019).

Sub-question 1: Do homemade or improvised facemasks prevent the transmission of respiratory viruses? Answer:

- Homemade masks may reduce the number of microorganisms expelled when coughing or sneezing but not as effectively as surgical masks. Surgical masks are more effective than homemade masks at filtering aerosolised virus particles, but even surgical masks are only marginally effective.
- Homemade masks may have potential to reduce transmission through droplets. By reducing the number of droplets reaching surfaces, homemade masks may play a role in reducing the risk of transmitting or acquiring COVID-19 through reducing environmental (surface) contamination.
- Although at the individual level, homemade facemasks may only have a marginal protective effect, when multiplied up to the population level, they may contribute to reducing transmission.
- On the other hand, encouraging the use of facemasks in the general population may have negative consequences such as putting pressure on already fragile supply chains of surgical masks required by healthcare and other frontline health care workers.
- Another potentially serious consequence is that facemasks may give people a false sense of security and encourage behaviour that puts people at increased risk of infection. The

lower protective capabilities of a homemade mask should be emphasized to the public so that unnecessary risks are not taken.

- It is also important to emphasise that any mask will have minimal effect unless used in conjunction with other preventative measures, such as good respiratory etiquette and regular hand hygiene.

Sub-question 2: What materials work (what are the virus filtration properties of different materials)? Answer:

Suitable household materials for making homemade masks must combine filtration properties with breathability. There is a trade-off between filtration and breathability. A double layer of T-shirt material or pillowcase, combined with a non-woven filter, such as kitchen paper, have been proposed as the optimum materials; however evidence is limited. Much of the evidence about suitable materials focuses only on filtration properties and not on comfort and breathability. Mask comfort and breathability are essential, as people will not wear uncomfortable masks or masks which make it harder to breathe.

Sub-question 3: What design(s) of mask work (in terms of fit and comfort)? Answer:

Although there is a proliferation of mask designs available online, no studies have systematically evaluated or compared different designs for filtration, closeness of fit and comfort.
If a mask does not fit well around the nose and mouth it will be of no benefit. Suggestions for improving the fit of homemade masks include the use of pipe-cleaners to ensure a close fit across the bridge of the nose and cheeks.

Sub-question 4: Can homemade masks be safely washed and reused? Answer:

Evidence on the effect of repeatedly washing and homemade masks drying masks suggests that this may reduce mask filtration effectiveness by distorting porousness. This is important because people may be more likely to cut up a less effective old T-shirt than a brand new T-shirt when fashioning a mask at home.

Detailed results by study sub-question and type of study

The results of this review are organised and presented by reporting evidence relating to each of the four sub-questions, broken down by study type. This is summarised in table 1.

Table 1: Summary of the types of evidence available to address each sub-question

Sub-question	Types and numbers of studies (n.b. the same study may contribute to more than one of the sub-questions)
Do homemade or improvised facemasks prevent the transmission of respiratory viruses?	Studies testing homemade masks under laboratory conditions using human subjects (n = 3)
What materials work (what are the virus filtration properties of different materials)?	• Laboratory experiments investigating the filtration properties of commonly-available household materials, not using human subjects (n = 5) • Studies comparing cloth masks with surgical masks in healthcare settings (n = 2)
What design(s) of mask work (in terms of fit and comfort)?	• Studies evaluating homemade mask designs (n = 3) • Studies evaluating improvised (as opposed to homemade) masks (n = 2)
Can homemade masks be safely washed and reused?	Laboratory experiment (n = 1)

Studies testing homemade masks under laboratory conditions using human subjects

Three studies (Davies et al, 2013; van der Sande et al, 2008, Dato et al, 2006) tested homemade masks under laboratory conditions using human subjects. All three specified the material used to make the mask but only one (Dato et al, 2006) specified the precise mask design. All three used commercial fit tests to test the effectiveness of the masks at preventing the transmission of particles. None tested the mask under real world conditions. Results are summarised in table 2.

Davies et al (2013) tested a range of household materials under controlled experimental conditions for their virus filtration properties and breathability and compared the results with surgical masks. They concluded that a double layer of cotton T-shirt material achieved the optimum combination of filtration and breathability. They then tested this mask for fit and comfort using human volunteers. There is a good lay summary of this study.

Van der Sande (2008) tested the fit and virus filtration of a homemade mask made from teatowel material under laboratory conditions, using human subjects. They tested the performance of the mask for both short (minutes) and long term (three hours) periods. They tested for both outward and inward transmission. They did not clearly specify mask design and they did not test the mask under real world conditions. The study is available here.

Dato et al (2006) used a commercial fit test to evaluate several prototype homemade mask designs. The researchers report a detailed specification for the best performing design (see figure 2). They fit tested two different sizes of this design, made from a 100% cotton, preshrunk, heavyweight T-shirt. This mask had 8 layers of fabric across the mouth and nose. This was compared wit an N95 mask.

The UNCOVER network is committed to responding quickly and impartially to requests from policymakers for evidence reviews. This document has therefore been produced in a short timescale and has not been externally peer-reviewed.

Extended abstract:

[brief summary of methods – font size 11]

Link to full review and any relevant updates:

[This will link to a folder for each topic that will include the original review and all updates – if you are unsure where this is, leave this blank and we will insert link – font size 11]

Date completed:

[insert date]

Contact details of lead reviewers:

[font size 11. insert name and email of main reviewer and names of other reviewers. NB please **do not** put mobile numbers here, as this is going on the website – if they need our mobile numbers they can email us!]

Key references:

[insert references with links to articles if available – font size 11 or reduce to 10 if required to fit into 2 pages]