

“Everyone Gets a Mask!” Team Project

Technical Specifications: Functional Requirements & Recommended Features of Fabrics and Mask Designs

Last updated: April 15, 2020

Note: The on-line version of this document at www.webility.md/masks has active hyperlinks for web access. Other project resource files are also there. Send comments to masks@webility.md.

PLEASE read this document and follow the recommendations to be sure your masks are of good quality. In order to be effective at protecting wearers and bystanders, the masks you make must meet certain requirements which are laid out below.

A lot of information is posted on the web about making masks; some of it is inaccurate and not carefully thought through. Poor quality materials or designs result in masks that give poor protection!

Our companion document “Instructions for Mask Makers” contains links to the specific patterns and sewing instructions for the mask designs we recommend. We encourage you to read all the project documents before finalizing your plans.

The sections of this document cover the following topics:

- A. Mask Designs / Patterns: Summarizes the types of masks to be made.
- B. Materials to Buy or Obtain: Summary of items needed for construction. Yardage estimates.
- C. Recommended Fabrics for Homemade Cloth Masks - Rectangular or Fitted Style: Summary of fabric types that are best suited for cloth masks.
- D. Recommended Fabric for Covers for N-95 Masks: Fabric types best for N95 mask covers.
- E. How to Evaluate Suitability of Fabric – Must Confirm Weave Is Tight Enough: **VERY IMPORANT!!** Easy-to-perform test that clearly indicates whether a fabric will adequately filter particles from the air. Several example images so you can be confident in your choice.
- F. List of Fabrics Not Recommended As Protective Layers, With Reasons: **VERY IMPORTANT!!** This is a long list of fabrics and materials that others have suggested or used, each one with the reasons why it is not well suited for this use.
- G. Notions to Supply: Items needed in addition to fabric.
- H. Equipment Needed By Mask Maker: Tools that each mask maker should have.
- I. Resources for Fabric & Notions Buyers: Links to a few sources of fabrics and notions.
- J. Selected References Re: Choice of Fabrics / Materials: Web links to articles with important information about fabric choices,

Asterisks (*) in the text indicate that a reference in section J applies.

A. MASK DESIGNS / PATTERNS:

There are many different mask designs circulating on the web now. Many of them are very similar. We have found several designs that should be reliable for you to use to create high quality masks, but others may also be suitable.

Everyone Gets a Mask! Project recommends making just three different designs / patterns. See our companion document “Instructions for Mask Makers” at www.webility.md/masks for links to the specific patterns and sewing instructions for these items.

- Two options for face masks.
 - #1 Rectangular pleated mask – easier to make, but less tightly fitting than option #2.
[as per websites of Dr. Streicher, Allina, and Deaconess with ties]
 - #2 Fitted center seam mask – better for flatter faces, smaller noses and chins.
[as per websites of Olson, CraftPassion, UnityPoint Health Avera, and Blue Cross]Both can be made to wear with either short ear loops or longer behind-the-head ties.
Both are made of two layers of fabric. This enables very secure attachment of the loops or ties, but slightly increases breathing effort required.
- One pattern for covers for N95 respirator masks.
 - These are made of two layers of fabric [as per website of Phoebe Putney Memorial Hospital]

B. MATERIALS TO BUY OR OBTAIN:

Most of this document concerns the fabrics used to make masks, but there are other items you will need to buy or have on hand to make them. All of these things are discussed in detail as follows:

- (1) Fabric – Sections C through F
- (2) Notions and supplies – Section G
- (3) Tools and equipment – Section H.

General points about procuring adequate amounts of appropriate fabric:

- **Selecting fabric:** See sections C, D, E and F below for **recommended** and **not recommended** types of fabric. Some internet postings recommend material that is ill-suited for protective face mask! A simple test is described for you to be certain your fabric is suitable.
 - Recommended: buy different-looking fabrics for each of the two layers in each mask to aid recognition of correct positioning by users.
- **Yardage:** The total amount of fabric needed will depend on desired number of finished masks, pattern dimensions, and width of fabric. Very rough approximation of yardage required – you should calculate your own:
 - 100 double layer face masks from 10 yards of fabric - 5 yards of patterned fabric PLUS 5 yards of solid color – one for each side of the mask.
 - 2 covers for N95 respirators per ½ yard.

- Consider shrinkage when calculating yardage: All fabrics must be pre-washed in hot water BEFORE masks/covers are made. This assures shrinkage is complete and sizing chemicals have been removed before cutting and sewing.
- **Calculating total number of masks to be made:** Unless otherwise specified by the organization or person requesting masks:
 - Assume 3 masks per person for institutions that launder daily (1 to wear, 1 as a spare, 1 in laundry).
 - Assume 3 to 8 masks per person for people who will launder them only once per week.

C. RECOMMENDED FABRICS FOR HOMEMADE CLOTH MASKS - RECTANGULAR OR FITTED STYLE:

The specifications for recommended fabrics below were developed after considering and weighing all of the following performance requirements for a high quality homemade cloth face mask:

- (a) ability to filter virus-laden respiratory particles out of the air
- (b) breathability (minimizing additional effort)
- (c) tolerability (comfort, avoiding irritation or allergy)
- (d) durability (strong enough to put on and off many times, wear for long durations)
- (e) washability (endure chlorine bleach and high temperature water/dryer)
- (f) availability and cost.

Fabric specifications:

- Must be high quality fabric in new or in very good condition (not old worn, or thin). **See list of fabrics not recommended below in section F.**
- May be patterned or solid color. Recommend using patterned fabric for outside layer (seen by others) and plain for the inside layer.
- Best options:
 - Tightly woven 100% cotton fabric, preferable new. Recommended by CDC.
 - Look for fabric labelled as quilting cotton, broadcloth, poplin, shirting, percale
 - Most of these fabrics will be densely woven
 - Tightly woven 100% cotton sheets or pillowcases*
 - Look for 300 -500 thread count
 - Lower thread count will be too porous; higher thread count reduces breathability
 - Tightly knit 100% cotton jersey T-shirts*.
 - Look for fabric labelled as jersey knit
 - Caution: Low quality or novelty T-shirt fabric may be too lightweight and loosely-knit.
- See practical test for evaluating suitability of fabrics below.

D. RECOMMENDED FABRIC FOR COVERS FOR N-95 MASKS:

Covers are designed for use on top of N95 respirators. They can be laundered or replaced more easily than respirators and keep the respirators from getting soiled, prolonging their useable life.

Since they serve as a pre-filter for particles, the functional requirements are similar to those of face masks (see above). In addition, however, water repellency is also required. N-95 respirators (and covers) will often be used by healthcare and emergency services workers in situations where liquid splashes and exposures to bodily fluids are possible. Recommended fabrics include:

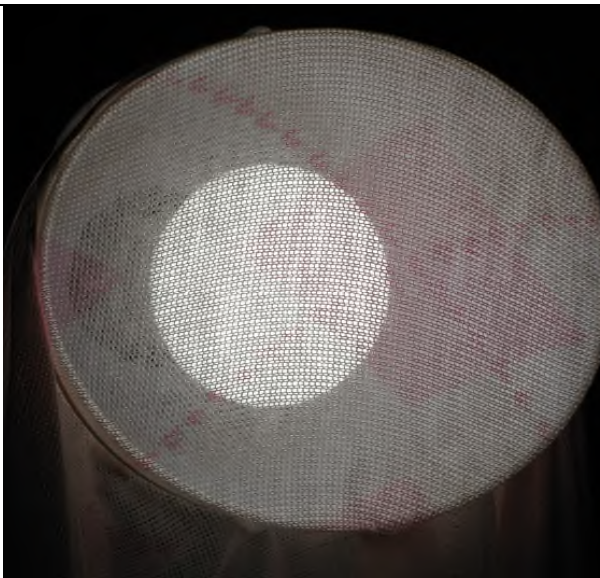

- Operating room surgical drapes - unused
- Breathable water repellent fabric
- Halyard 600 sterilization wrap plastic fabric: **IMPORTANT NOTE: Recommended ONLY for one-time use as disposable covers unless it will be autoclaved.** Fabric cannot be wetted, bleached, washed, dried, ironed or written on. Punctures made during fabrication reduce filtration capability. May be sterilized in an oven at 165 degrees Fahrenheit for 30 minutes, but modern home ovens do not allow that setting. See University of Florida website (www.anest.ufl.edu/clinical-divisions/mask-alternative/mask-dos-and-donts/) and Halyardhealth.com website (www.halyardhealth.com/covid-19/diy-masks.aspx).

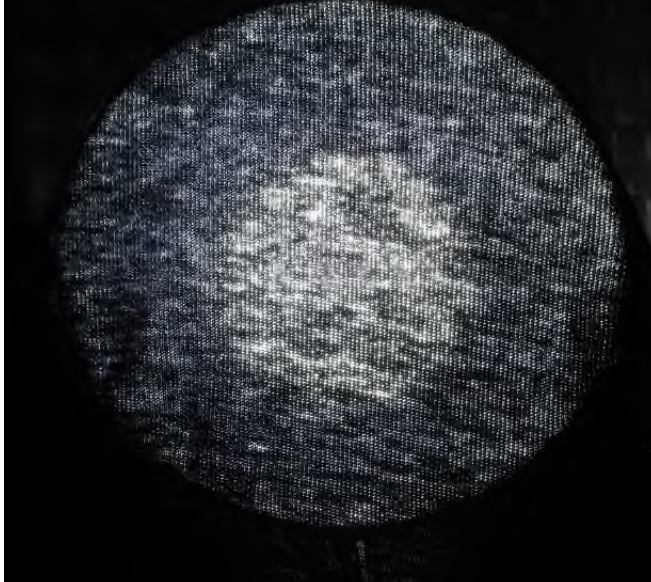
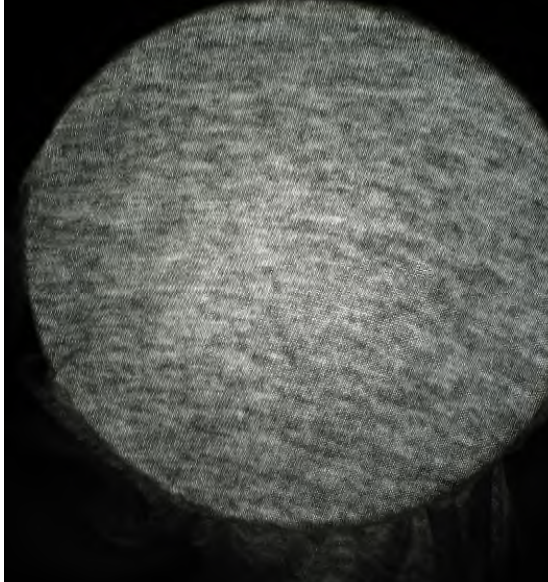

E. HOW TO EVALUATE SUITABILITY OF FABRIC – MUST CONFIRM WEAVE IS TIGHT ENOUGH:

A quick and practical test to see if fabric is tightly woven enough to filter out smaller particles is to stretch and hold a piece of it a few inches away from a light bulb or flashlight while in a dark room. You can tell from how much light passes through whether the fabric is a good choice. (We used a setup with a table lamp and include photographs below to illustrate the different results you might observe. The results are very clear!)

- If you see very little or no light, it is not breathable enough, such as a vacuum cleaner bag.
- If you can clearly see the outline of the bulb, the weave is too open or the fabric is too thin.
- If the center is brighter than the edges, but there is no clear bulb, and the whole area around the bulb is lit up -- it is OK but not best.
- If there is evenly diffused light throughout the whole area (in our test set-up, the area inside the lamp shade) and no hint of the bulb itself -- it is very tightly woven. **THIS IS THE BEST.**

See sample photographs below. Each fabric was stretched over the surrounding shade of the lamp shown in Photo #1.

<p>Photo #1 – OUR TEST LAMP SET-UP Metal shade and 9.9 watt /1100 lumen LED bulb (75 watt incandescent)</p>	<p>Photo #2 RECOMMENDED FABRIC Quilting fabric – tightly knit 100% cotton</p>
<p>Fabric was pulled taut onto metal rim of shade in a dark room (other room lighting turned off)</p>	<p>Light is very diffused – some central brightness</p>
	
<p>Photo #3 NOT RECOMMENDED Lightweight loosely-woven knit</p>	<p>Photo #4 – RECOMMENDED FABRIC Tightly-woven sheet/pillowcase – 100% cotton</p>
<p>Bulb is obvious; lots of light/air comes through weave</p>	<p>Light is diffused – center is slightly brighter</p>
	

<p>Photo #5 – NOT RECOMMENDED Looser-knit 100% cotton jersey</p>	<p>Photo #6 – RECOMMENDED FABRIC Tightly-knit 100% cotton jersey</p>
<p>Bulb outline is clear</p>	<p>Light is diffused; some central brightness</p>
	
<p>Photo # 7 NOT RECOMMENDED AS FILTER LAYER Interfacing (Pellon 835R) – sew-in style; close-up</p>	
<p>Note irregular size of openings; some quite large</p>	
	

F. LIST OF FABRICS NOT RECOMMENDED AS PROTECTIVE LAYERS, WITH REASONS:

NOTE #1 : As an analogy, insects can always find and get through the largest hole in a window screen. Fabric that has ANY large holes will not be effective blocking smaller particles.

NOTE #2: See charts comparing many fabrics / materials in Section J REFERENCES below

The following fabrics are not well suited for regular and sustained use as face masks—for various reasons briefly noted below — even though some internet postings recommend them.

- “Tea towels” otherwise known as kitchen towels. Filter well but require a significant amount of work to breathe through. Not suitable for anyone who is older or has any kind of lung problem.
- Cotton **blend** sheeting/pillowcases. Significantly less breathable than all cotton.
- Non-woven interfacing. Holes are uneven in size; respiratory particles will easily go through the large ones. Certain types can be used internally to stiffen a mask, but fusible interfacing versions are not durable - cannot tolerate bleach / hot water / high temperature drying / frequent laundering.
- Halyard 600 sterilization wrap plastic fabric. Fabric cannot be wetted, bleached, washed, dried, ironed or written on. Punctures made during fabrication seriously reduce filtration capability. Although it can be sterilized for reuse in an oven at 165 degrees Fahrenheit for 30 minutes, modern home ovens do not allow that setting. EXCEPTION: May be suitable for use by healthcare workers in facilities that can autoclave these masks. See University of Florida website (www.anest.ufl.edu/clinical-divisions/mask-alternative/mask-dos-and-donts/) and Halyardhealth.com website (www.halyardhealth.com/covid-19/diy-masks.aspx).
- Cotton flannel. Weave too open, retains moisture, slow to dry.
- Linen. Usually a more open weave, retains moisture.
- Silk. Not durable; requires delicate handling / dry cleaning, retains moisture, expensive.
- Rayon. Not durable; requires hand washing / dry cleaning, retains moisture.
- Synthetic fabrics such as nylon or polyester. Not as soft, breathability varies, may get hot.
- Wool. Itchy, allergies, less durable.
- Vacuum cleaner bags. Not durable for repeated washing; low breathability.
- Automotive oil filters: Filter out 95% of 40 micron particles, but only 10-15% of 10 micron particles – common size for respiratory particles.
- Coffee filters. Uneven and large pore sizes (15-100 microns) are too big to stop many respiratory particles, and definitely not very tiny aerosol particles.
<https://coffeadastra.com/2019/08/04/an-in-depth-analysis-of-coffee-filters-2/>
- Tea bags (fabric bags to put loose tea in). Again, large pore sizes (some up to 1 mm).
- Paper towels. Fragile; low particle capture; cannot withstand repeated washing.
- Facial Tissues, e.g. Kleenex. Fragile, low capture of particles, cannot tolerate repeated washing.
- Waxed cotton to stiffen area at bridge of nose. High temperature wash / dryer will remove wax.

- “Antimicrobial” fabrics:
 - Fabric with incorporated silver/ copper/ zinc threads or coatings applied in the final finishing of the fabric. Metal threads increase fragility*. Many hospitals are requesting fabrics without metal.
 - Bamboo. Little noticeable antimicrobial properties remain in manufactured fabric*, heavy, expensive.

G. NOTIONS TO SUPPLY:

In addition to fabric itself, the following notions and supplies will be required.

1. **Materials for mask fasteners** (ear loops or ties) as per mask pattern being made:
 - Behind-the-head ties: 1/2” bias tape/ twill tape / smooth cloth ribbon
 - Yardage: Assume 2 yards per mask (makes four 15-18” ties)
 - Ear loops: 1/4- 3/8” elastic or, if not available, 1/2” bias tape / smooth cloth ribbon
 - Yardage: Assume 1 yard per mask (four 9.5” elastics)
 - May not be available – shortages in many places
 - Due to possible latex allergies, recommend masks with ties instead of ear loops.
 - Caution: Ear loops may irritate skin behind ear

2. **Cardboard pattern** for cutting multiple lengths of fabric ties or elastics
 - Example: for 9.5” long elastics, you will loop elastic around a 4.25” wide piece of cardboard 10-15 times and then make a single cut to create 10-15 elastic pieces that are 9.5” long

3. **Malleable material to conform the mask to the bridge of nose area** – improves tightness of seal if pattern calls for it and user requests it.
 - Must consider comfort for long wear as well as durability and washability.
 - Recommended: 12 , 14, 16, or 18 gauge aluminum wire, available in 5 yard spools at craft stores, hardware stores, and on-line.
 - Assume: 5” per nosepiece, 6 per yard
 - Must use needlenose pliers to create loop at each end to avoid injury from poking by sharp ends. See image below:
 - Sewing the wire in risks hitting it with needle, bending or breaking it. Options: wrap wire in fabric and pin before sewing, or create a tunnel / pocket at top of mask and slip wire in later. Then sew ends shut.

- Acceptable: Wired ribbon (Dr. Streicher’s pattern) - Yardage: Assume: 4” per nosepiece – Cut 16” and fold four times per mask. (Bend about ¼” of end back and crimp to avoid injury due to sharp ends.)
 - Some hospitals are putting their own nosepieces on the masks.
 - Not recommended: Pipe cleaners and grocery bag fasteners; not durable enough, will not hold shape.
- 4. Non-woven interfacing (stiffening material)** to keep fitted mask design away from face (**Important note** - this will not add protection!! and should not be thought of as filter – see list of fabrics not recommended below).
- Recommended but optional:
 - For use in fitted center-seam masks design – this option may help keep mask away from wearer’s face.
 - Sew-in types of Pellon: 910 Featherweight, 930 Mid-weight, 880F Sof-Shape, 950F Shir-Tailor, 830 Easy Pattern, 380 Soft-N-Stay, 810 Tru-Grid
 - Not recommended: Fusible interfacing – fragile; no high temp washer or dryer
- 5. Sewing machine thread**
- Must be high quality / durable. Putting mask on tightly and taking it off will stress the place where ties / ear loops are attached.
- 6. Waterproof permanent markers** (E.g. Sharpie) to indicate “Inside” and “Top” or “Nose” of masks.
- 7. Bags to gather and transport finished masks** – preferably paper to allow masks to dry completely

H. EQUIPMENT NEEDED BY MASK MAKERS:

- Sewing machine
- Fabric scissors
- Thimbles
- Pins or clips
- Needle nose pliers for bending wire ends (if used in bridge-of-nose area)

I. PROCUREMENT RESOURCES FOR FABRIC & NOTIONS BUYERS:

You may find organizations willing to donate usable fabric or notions. If not, the best places to buy fabric by the yard and notions will be brick & mortar craft stores, sewing stores, or on-line sources.

Online examples include:

Amazon: 100% Cotton and Broadcloth: https://www.amazon.com/Cotton-Fabric/s?k=Cotton+Fabric&rh=n%3A2617941011%2Cp_n_material_browse%3A378535011&dc&qid=1585791214&rnid=316495011&ref=sr_nr_p_n_material_browse_2

Amazon 100% cotton quilting Fabric: <https://www.amazon.com/slp/cotton-quilting-fabric/5ogwobn8k9k842k>

Etsy: 100% Cotton quilting fabric:
<https://www.etsy.com/search?q=100%25%20cotton%20quilting%20fabric>

JoAnn's fabrics and many others have 100% cotton fabrics, in store or online

<https://www.joann.com>

Curbside pickup may be available; fabrics can be shipped. For information these issues and hours, etc: <https://www.joann.com/joanns-letter-to-customers-from-ceo/>

* J. SELECTED REFERENCES RE: CHOICE OF FABRICS / MATERIALS:

GENERAL: Homemade face masks and coronavirus: What to know about CDC guidelines and N95 <https://www.cnet.com/how-to/homemade-face-masks-and-coronavirus-what-to-know-about-cdc-guidelines-and-n95/>

INTERFACING: Durability, laundering
https://vtechworks.lib.vt.edu/bitstream/handle/10919/55972/VCE346_136.pdf?sequence=1
<https://www.fabricana.com/blog-item/interfacing-101-part-two>
https://media.rainpos.com/220/recommended_interfacing.pdf

SIDE-BY-SIDE COMPARISON OF VARIOUS FABRICS

The source of the data displayed in the graphic charts immediately below is this paper:

Davies AD, Kafatos G, et al. *Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?* Disaster Medicine and Public Health Preparedness, August 2013

DOI: 10.1017/dmp.2013.43 (free access to full article – see p 414)

https://www.cambridge.org/core/services/aop-cambridge-core/content/view/0921A05A69A9419C862FA2F35F819D55/S1935789313000438a.pdf/testing_the_efficacy_of_homemade_masks_would_they_protect_in_an_influenza_pandemic.pdf

Researchers' Pick for Best-Performing Homemade Mask Material from Cambridge University

<https://smartairfilters.com/en/blog/best-materials-make-diy-face-mask-virus/>

Based on both particle capture and breathability, the researchers concluded that cotton t-shirts and pillowcases are the best choices for DIY masks.

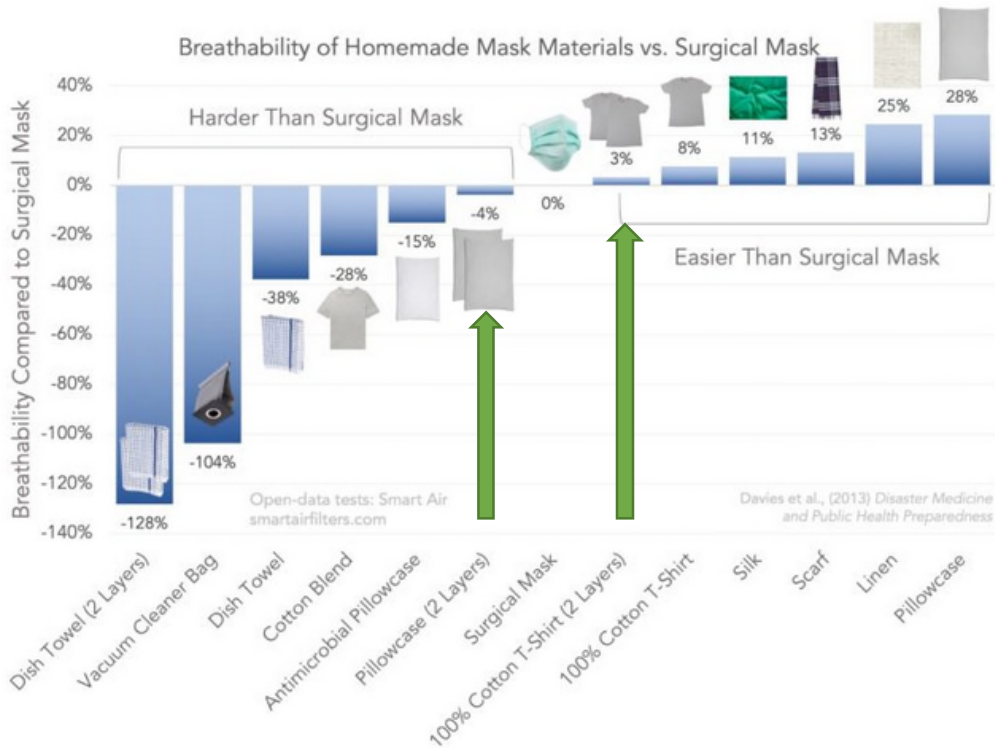
1. These materials filtered out at least half of the 0.2-micron test particles, which are similar in size to aerosolized coronavirus particles.

- These two types of fabrics are also as easy to breathe through as surgical masks, which is essential if they must be worn for a prolonged period, even a whole day.

Chart 1:

Breathability of various fabrics compared to surgical masks

NOTE : Green arrows point to our recommended fabrics



Source: <https://smartairfilters.com/en/blog/best-materials-make-diy-face-mask-virus/?rel=1>

The following two charts show the comparative effectiveness of various fabrics against particles that are the size of small respiratory droplets (10 microns), and particles that are the size of aerosolized particles (0.2 microns) – which is roughly the size of the COVID19 virus itself.

Note: * Green arrows point to the fabrics recommended in this project.

However, charts show data for a single layer; we recommend two.

**Chart 2:
Effectiveness of various fabrics at filtering particles
the size of small respiratory droplets**

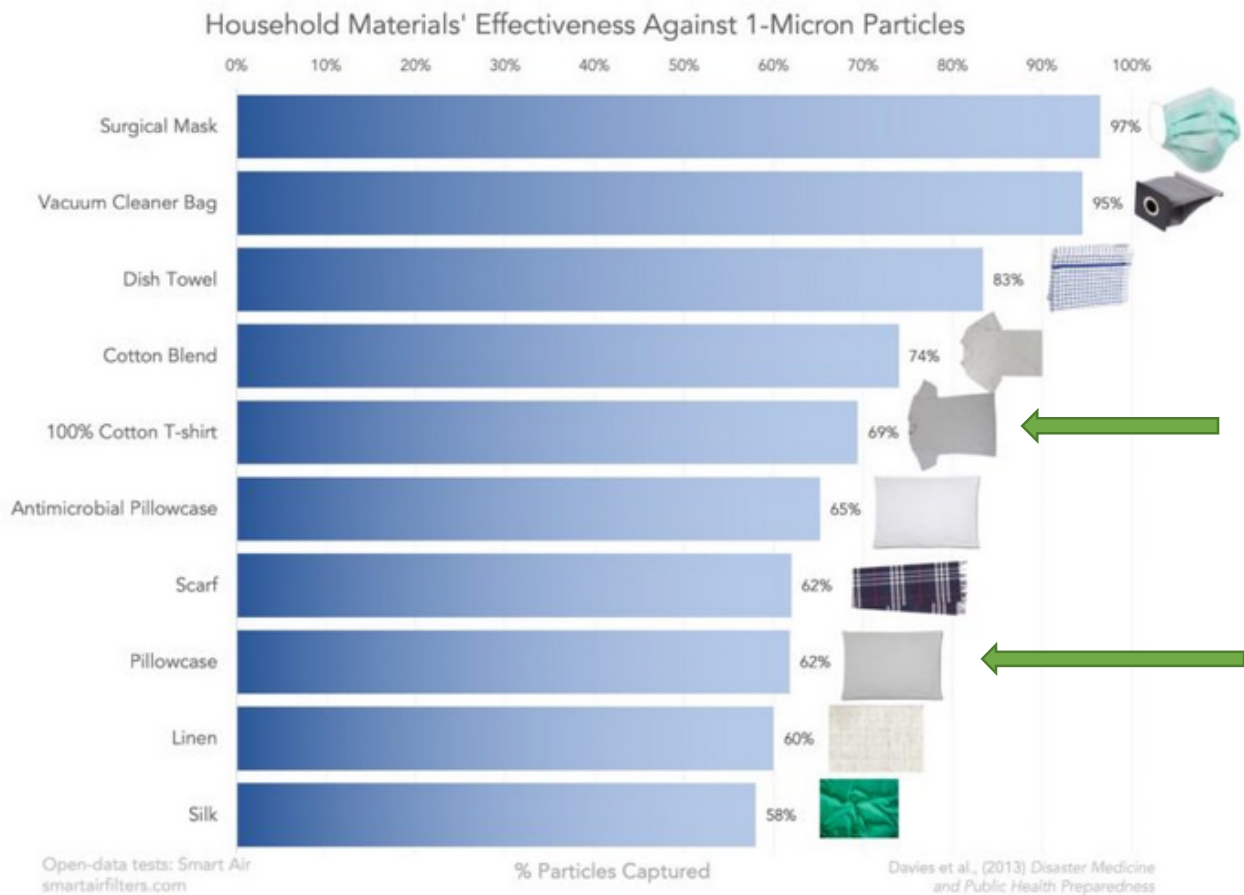
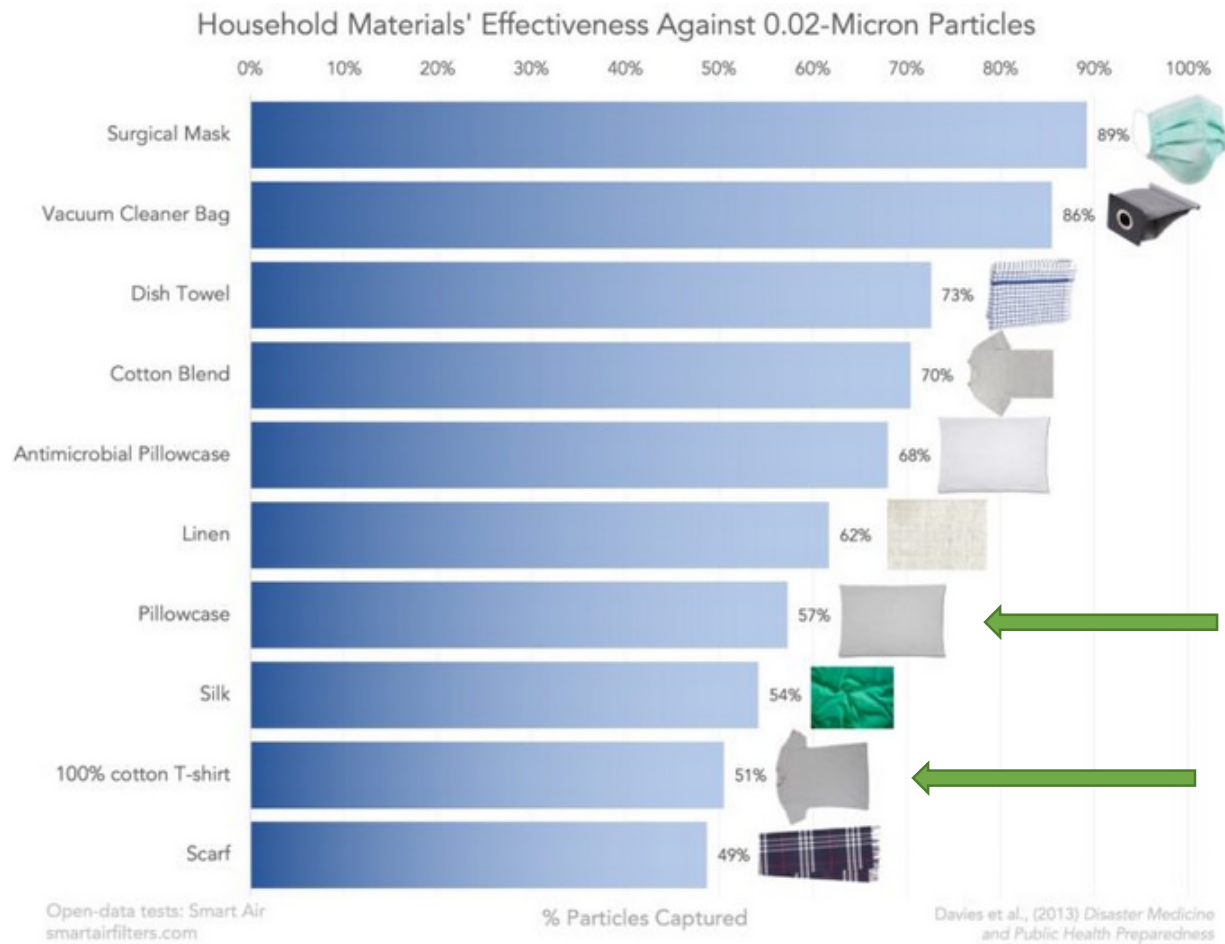


Chart 3:
Effectiveness of various fabrics at filtering particles
roughly the size of a single aerosolized virus



Source: <https://smartairfilters.com/en/blog/best-materials-make-diy-face-mask-virus/>

Paper Towels:

<https://smartairfilters.com/en/blog/paper-towel-effective-against-viruses-diy-mask/?rel=1>

Metallic Fabrics:

https://digitalcommons.uri.edu/cgi/viewcontent.cgi?article=1005&context=tmd_major_papers

Bamboo Fabrics:

https://www.researchgate.net/publication/242506934_An_Assessment_of_the_Validity_of_Claims_for_Bamboo_Fibers