



DIY Respirator

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The general public needs better masks. There are three main problems to address to create what is technically called improvised PPE (i.e., Personal Protective Equipment): 1) we need to acknowledge current and future supply chain crises, 2) we need a proper fit to protect us from aerosol particles, and 3) we need standardized filters that are quantifiable in terms of efficacy.

Ramping up manufacturing of masks to meet a sudden demand—like a global pandemic—is near impossible. Customers want the best masks but, in a crisis, most cannot have them or, for the poor, buy them. We cannot think mask manufacturers will save us and stockpiling always comes short. We need to be able to make our own respiratory devices with supplies readily available in stores that remain open during lockdowns (e.g., grocery stores, pharmacies, and hardware stores).

We need the proper fit afforded by respirators, as both the fit and the quality of the filter are essential to generate a better mask. Social distancing is not enough when airborne transmission is at play. Virus-laden aerosol particles can remain suspended in the air for hours. People emitting virus particles move on, but their unseen airborne particles can remain. With a better fit, respiratory devices can filter both inhalations and exhalations, thus better protecting the mask wearer and the community. A good fit increases the quantity of air filtered and, in effect, the amount of virus particles a mask can intercept.

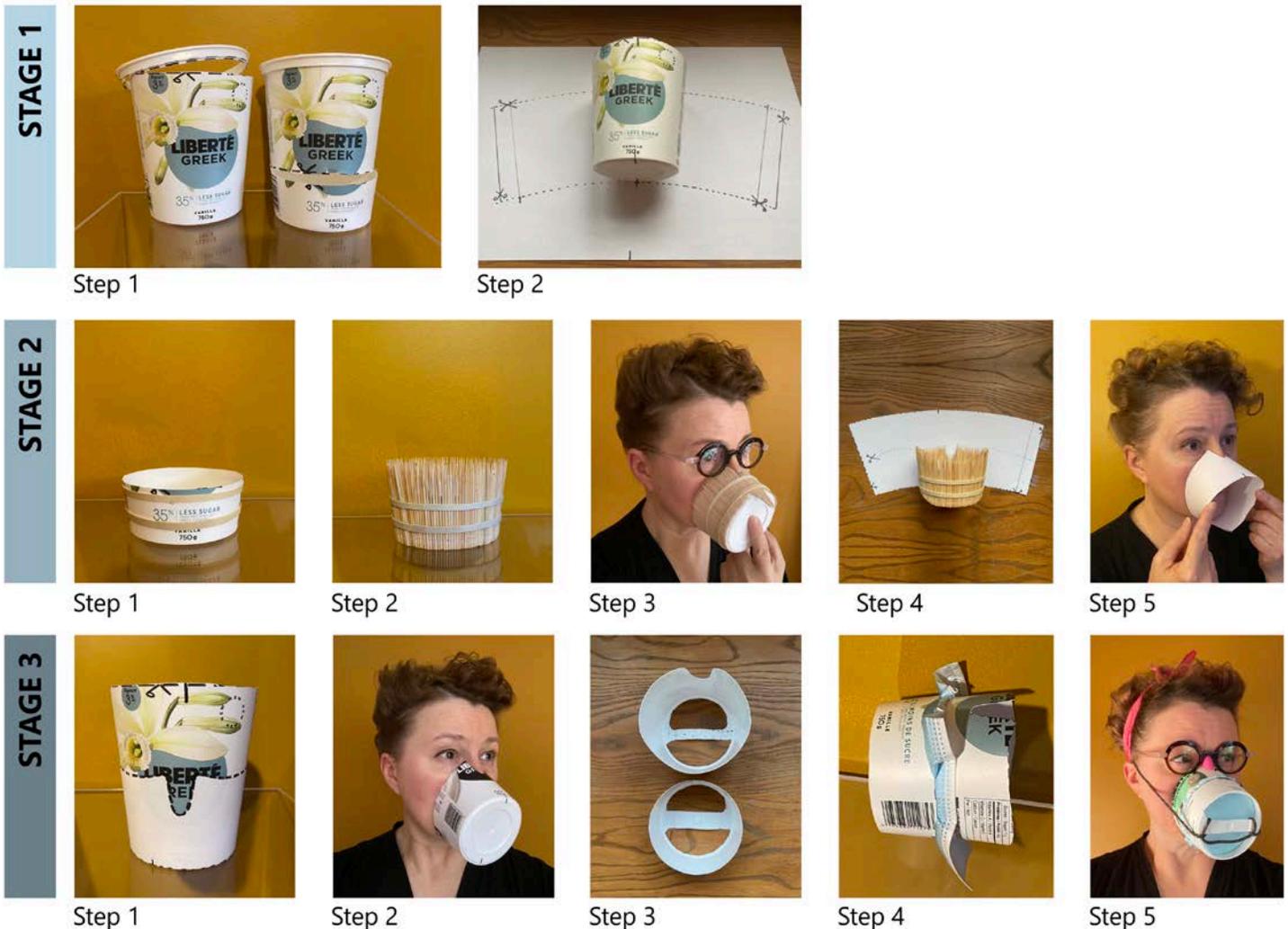
People need to know how effective homemade and commercially purchased respiratory devices are. When it comes to filter choices, non-woven materials are preferable. They range from tested, regulated and recognizable, like medical masks, to readily available but not tested, like paper or microfiber cleaning cloths. The “Do-It-Yourself” (DIY) respirator uses of a new medical mask as a removable filter because its efficacy is quantifiable but they are not always available. As a result, there is a need for tests on readily available, standardized, brand-named, non-woven textiles available in stores that remain open during lockdowns. Ultimately, people need to be able to find the non-woven textiles tested and quantified by scientists: only then can they make important, evidence-based PPE decisions.

The proposed DIY respirator is one solution to these problems. It is made of two identical upcycled plastic containers, a shoelace, and a removable filter that can adjust to supply shortages or when new scientific tests and discoveries arise. The custom-fit reduces fogging in eyewear, which can rest directly on the nose. Plastic yogurt containers selected for five reasons: 1) their truncated-cone shape can be stacked; 2) the diameter of the opening can cover the nose and mouth of an adult’s face; 3) their pliability (supple enough to be cut with scissors yet sturdy enough to retain their shape after sanitizing and reuse); 4) the cost (as low as a few dollars per container); and 5) the availability of the product in grocery stores. Containers of similar proportions but with a smaller diameter could be tested for smaller faces. There are twelve steps to create this custom-fitted DIY respirator. Its strengths and limitations are described afterwards.

MATERIALS NEEDED FOR THE DIY RESPIRATOR

- 1) paper (Tabloid/B size/11" x 17" works best but you can also tape paper together);
- 2) writing instrument such as a fine-tipped permanent ink pen, an ink pen, or a pencil;
- 3) scissors;
- 4) measuring tape or ruler;
- 5) two identical plastic yogurt containers that hold 750 g (3 cups): container #1 will have the custom face seal and container #2 will secure the filter in place over it;
- 6) 2 rubber elastics large enough to circle the base of the container (wide ones work best);
- 7) toothpicks (about 150);
- 8) adhesive tape;
- 9) a filter (e.g., a medical mask or other non-woven materials, discussed later); and
- 10) 1 shoelace, 123 cm (48") long to secure the respirator to the head (alternatively a fabric strip, a string, or a flat 0.6 cm (1/4") wide sewing elastic could do).

Once you gather these supplies, you can begin the three stages of fabrication illustrated below.



STAGES OF FABRICATION

In **Stage 1**, both containers are cut and a pattern is created of container #1.

- **Step 1:** cut off the bent rim of container #1 and the upper wall portion of container #2 so that it is 4 cm (1 ½ ") tall.
- **Step 2:** with paper, pen, and scissors, create a paper pattern of the wall of container #1.
To do so: a) measure the rim's circumference with a tape measure or string and divide in two; b) mark these two reference points on the container's rim (inside and outside the wall) and carry them to the bottom section (wall and base); c) place one reference point on the middle of a large sheet of paper at the top, place a rim reference point on container #1 there, then mark the base reference point from container #1 on the paper; d) with a pen, trace the rim and base as you roll the container on the paper to the left and then the right until you reach the other halfway reference point; e) connect the rim and base halfway points on the paper and add another line 2 cm (3/4") parallel to it: cut along this last line after transferring all your reference points on the other sides of the pattern lines. Once the approximate paper pattern is done, place it on the container and cut out extra paper to obtain a perfectly fitted pattern.

In **Stage 2**, a customized pattern of the wearer's face-mask seal is created.

- **Step 1:** place two elastics on the wall of container #2: one close to the rim and the other about 1.3 cm (½") below the first elastic.
- **Step 2:** insert as many toothpicks as you can, pointy end towards the top, under both elastics.
- **Step 3:** if you wear eyeglasses and/or goggles, put them on. Push down 10 toothpicks so the pointy edges are at the rim of the container and place this opening over the bridge of your nose where the toothpicks will be able to go in below your eyeglasses/sunglasses. Carefully push the toothpicks until they reach your face all around the container. Press slightly (but very carefully!) around the orbit of the eyes: a good fit there will reduce fogging in lenses.
- **Step 4:** with a fine-tip pen, transfer the customized rim of (toothpick-covered) container #2 to your first paper pattern. To do so, line up the base of the container #2 at the halfway point at the base of your paper pattern. Roll the container left then right to line up the container's base and its matching line in the pattern even if the toothpicks get in the way. As you roll, trace the customized rim's edge as near as possible to the tip of the toothpicks.
- **Step 5:** cut the pattern along the new customized rim and tape the pattern back into a cone. Place it on your face to make sure it fits, especially near the eyes. Adjust if need be.

In **Stage 3**, the customized pattern is transferred to container #1 and the respirator is finished.

- **Step 1:** insert container #1 into your customized paper pattern, transfer the rim line, and cut directly below this line. **Step 2:** test the seal by placing container #1 on your face. Difficulty breathing indicates a good seal/fit. This self-test is critical and an exceptional feature of the DIY respirator. Recut the rim for a better seal or attenuate sharp edges if necessary.
- **Step 3:** remove toothpicks and elastics from container #2 and cut out two semi-circles from the bottom of both containers but leave a 1.3 cm (½") strip of plastic attached to the left and right sides. If leaving a strip is hard, just leave tabs on the bottom of container #2 where you can anchor the shoelace with slipknots.
- **Step 4:** place a filter smoothly over the base of container #1 and place container #2 over it tightly. Cut out the excess filter around the rim of container #2.
- **Step 5:** anchor the shoelace to the horizontal strip at the bottom of container #2. Place a thin, almond-shaped silicone nose protector for increased wearing comfort (optional). Place the respirator over it, and tie the shoelace behind your head.

STRENGTHS AND LIMITATIONS

The DIY respirator is not perfect but the fit is individualized. A device made entirely from a silicone container would be more comfortable but a thin piece of silicone sheet—used for baking or craft—can go over the nose and makes it quite adequate for occasional repeated use.

Strengths

Custom Fit

- The DIY respirator’s greatest strength is the custom fit it provides for a variety of faces: this allows for a good face-mask seal and increases wearing comfort.
- In the testing stage, before the bottom of container #1 is cut, individuals can verify the face-mask seal by trying to inhale: the more difficult, the better the seal.
- The seal provides increased protection while limiting eyewear fogging.
- The seal, combined with the use of a high efficiency filter, enables the device to fall in the (uncertified) respirator category.

Easy to Make

- Made of materials readily available in stores that remain open during lockdowns.
- No need for special skills or equipment, like sewing machines.

More Sustainable

- The two upcycled-plastic containers and the shoelace are easily sanitized for reuse.
- The design distances the filter from the nose and mouth. This keeps filtering materials dryer, which improves efficacy and extends the filter’s lifespan.

Improved Design

- The filtering material does not touch the face: this can decrease skin reactions.
- There is no pulling or tugging on the filtering material(s) from ties that could lead to tearing. This lesser tension can broaden the range of materials used as filters that would otherwise be considered too delicate to be made into masks by themselves, such as paper towels

Limitations

Not Meant for All-day Use

- The pressure from the container’s rim onto the face is less comfortable than a cloth mask in terms of all-day use. When worn for occasional repeated use, facial marks created by the rim dissipate rather quickly. If used for an extended period of time, the rim may leave longer-lasting marks or scars.
- The sharpness of the plastic container’s edges can cause discomfort over time. This may be alleviated for the nose area with the use of the thin, almond-shaped silicone nose protector.
- The tight seal means that small amounts of condensation will create droplets on the wall of the DIY respirator. To address this, a small piece of tissue can be placed between respirator and face at the chin.

Social Acceptability

- While designers and dress researchers could investigate a mask wearer’s need to be socially acceptable/invisible to the detriment of their health, improved PPE options that look odd should still be presented to the general public to offer solutions with greater efficacy that address individual needs.

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