



Reduce, Reuse, Recycle: Navigating Mask Shortages in a Pandemic

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Back in March, when the CDC suggested that health care workers could use a *bandana* as a makeshift mask for protection against SARS-CoV2, many scoured the shelves of home maintenance stores for personal protective equipment (PPE). “Those who cannot remember the past are condemned to repeat it,” said Spanish philosopher George Santayana in 1905 (*The Life of Reason: The Phases of Human Progress*. 2011). I could not remember much from the 2003 SARS outbreak, the 2009 H1N1 influenza pandemic, or the 2014 Ebola outbreak, as I was in college, an intern, and starting private practice during those times. A prescient article in 2015 shared how after the influenza pandemic, the Veterans Health Administration stockpiled reusable respirators in case of N95 shortages (*Am J Infect Control* 2015;43:629-34). A colleague from social media, Dr. Lauren Jones, had purchased her own respirator after being handed a paper gown and a mask to examine patients with possible Ebola. I spent two days playing email/text/phone tag with her industry contact, becoming a middle distributor with strangers wiring me several hundred dollars to secure Wuhan-style PPE. Armed with my backup PPE, I set out on a mission to explore options to preserve N95 masks, working through how to reduce, reuse, and recycle.

Reduce:

- 1. Cancel quantitative fit tests.** This preserved N95 masks because the test requires punching a hole in the mask, rendering it useless.
- 2. Stagger case starts.** Surgery case-loads plummeted when U.S. Surgeon General Jerome Adams, MD, FASA, urged cancellation of elective surgeries on March 14. The reduced case-load allowed for staggered case starts with one individual wearing an N95 mask performing all the intubations and extubations.
- 3. Allocate masks.** Some groups controlled inventory by giving members a set number of N95 masks to use.
- 4. Distribute sparingly.** Some physician specialties were forced to lobby for the necessity of masks in their procedures.

- 5. Track inventory.** In my institution, after noticing that masks were being used at two to four times the expected rate, I created an inventory management system and diverted supply chain N95 mask dispensation through the OR pharmacy. The accountability ensured that masks were distributed per local policy and tracked size availability.

Reuse:

As recommendations changed from N95 masks being “single use” to “extended use/limited reuse” to “whatever-you-have-available-to-you use,” websites like www.n95decon.org discussed reuse. The following is a descriptive, not prescriptive list:

- 1. Air-Dry:** I emailed Dr. Peter Tsai, the inventor of the N95 mask filtration material, on March 23 to confirm a social media posting I had seen on a method for reuse: the paper bag rotation (*J Emerg Med* 2020;58:817-20). Masks would be rotated daily with each mask stored in a paper bag for a few days to dry, killing viral particles prior to reuse. Silica beads can speed up the drying process. I began to practice this technique several months before the CDC endorsed it.
- 2. Sun-Dry:** Ultraviolet germicidal irradiation has been studied to inactivate viruses on surfaces and N95 respirators (*Ann Occup Hyg* 2009;53:815-27; *J Occup Environ Hyg* 2015;12:509-17; *Am J Infect Control* 2018;46:e49-55; *J Occup Environ Hyg* 2007;4:400-5; *Pathog Immun* 2020;5:52-67). Some physicians purchased UV sterilizers used for nail salons. I purchased several UV CPAP cleaners that later demonstrated efficacy against coronavirus (*Pathog Immun* 2020;5:52-67). Nebraska Medicine developed a UV decontamination protocol (asamonitor.pub/354TkcQ).
- 3. Bake:** Experiments have been done with dry or moist heat using convection ovens, microwave ovens, rice cookers, and autoclaves. Complications include filter degradation and melting the respirator near metal components, compromising fit (*J Emerg Med* 2020;58:817-20; *Ann Occup Hyg* 2009;53:815-27; asamonitor.pub/32m-

WKWm; *PLoS One* 2017;12:e0186217; *CMAJ* 2020;192:E1189-97; *ACS Nano* 2020;14:6348-56).

- 4. Soak:** Experiments have been done soaking masks in ethanol, isopropanol, hydrogen peroxide, or bleach, with concerns for degradation in filter performance, skin irritation, and chlorine off-gassing (*Ann Occup Hyg* 2009;53:815-27; asamonitor.pub/32mWKWm; *PLoS One* 2017;12:e01862170).
- 5. Steam:** Microwave-generated steam can be used to disinfect masks (*Ann Occup Hyg* 2009;53:815-27). One study found that avian coronavirus was inactivated after five minutes of steam (*J Med Virol* April 2020). However, it may cause filter and fit degradation (asamonitor.pub/32mWKWm).
- 6. Vaporize:**
 - a. Ethylene oxide:** Sterilizers have been trialed with concerns for off-gassing since ethylene oxide is a respiratory carcinogen (*Ann Occup Hyg* 2009;53:815-27; asamonitor.pub/32mWKWm).
 - b. Ozone:** A more “green” disinfectant than ethylene oxide, ozone has demonstrated virucidal activity and in one study did not damage the filter material or the electrostatic charge. However, the elastic straps, headband, and noseform were not tested, and a re-design of the N95 mask using magnets or fabric straps would be necessary for reuse. It is also concerning for toxic byproducts or damage to the lungs (asamonitor.pub/32mWKWm; *JoSaM* 2020;2:1-23; *JoSaM* 2020;2:1-28).
 - c. Hydrogen peroxide:** Duke University has used hydrogen peroxide vapor (or gas plasma) (*ABSA* 2020;25:67-70), but cellulose-based products like cotton can absorb the hydrogen peroxide and decrease the vapor concentration during sterilization (*Ann Occup Hyg* 2009;53:815-27).
- 7. Boil:** Masks can be boiled and then air-dried with minimal loss of electrostatic charge (*J Emerg Med* 2020;58:817-20).
- 8. Wash:** Soap and water or alcohol washes can erase the electrostatic charge and decrease the filtration efficiency by 10 times (*J Emerg Med* 2020;58:817-200).



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- 9. Radiate:** Using gamma irradiation likely discharges the electrostatic charge, decreasing filtration efficiency despite passing a qualitative fit-test (*JAMA Netw Open* 2020;3:e209961).

Recycle:

The University of Florida created an innovative mask out of medical-grade Halyard H600 fabric, the same material used to wrap sterile gowns, towels, instrument sets, and procedure trays. These sterilization wraps have microbial barrier protection, and the masks passed a qualitative fit test by sweet or bitter taste on several volunteers (asamonitor.pub/316E7xr). It may function better than a surgical mask but should not replace an N95. Sonia Mehta, MD, and colleagues engineered the mask and enlisted community sewists to recycle Halyard fabric and make masks. She shared how it started with an idea that burst into full-fledged production, producing approximately 5,000 masks in three weeks (*Am J Med Qual* September 2020).

After surviving the first wave of the COVID-19 pandemic as a young, impressionable physician, I look back on events with a sense of empowerment. Through social media platforms and online research, I connected with physicians across the world and assessed global information in real-time. As I navigated mask shortages during the pandemic, I bypassed the bandana recommendation, purchased my own PPE, and even mailed PPE to desperate physicians across the country. I sought out ways to reduce, reuse, and recycle N95 masks. Crisis sparks innovative opportunity, including the opportunity for young physicians to lead from the middle. We can bring fresh ideas to the table, capitalize on our social media resources, and collaborate with colleagues across the world to solve problems, because that’s what physician anesthesiologists do. ■