Researchers develop low-cost method to decontaminate personal protective equipment

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Widely available materials found in hardware stores, like those shown here, can be combined with ultraviolet lights found in shuttered research labs to enable low-cost decontamination of personal protective equipment, UD researchers say. Credit: University of Delaware

As the weather turns cooler and people move activities indoors, the number of new coronavirus (COVID-19) cases being reported in the United States is rising. This mirrors COVID-19 activity already seen in Europe and elsewhere across the globe.

Meanwhile, supply-chain problems are likely to cause limited supplies of filtering facepiece respirators, such as N95 masks. Yet strategies to decontaminate personal protective equipment, or PPE, remain unresolved in many hospitals with limited resources, both in the United States and abroad.

University of Delaware researchers, led by biomedical engineer Jason Gleghorn, have devised a system for decontaminating N95 masks using off-the-shelf materials available at any hardware store combined with ultraviolet type C (UV-C) lights found in shuttered research laboratories.

The UD-developed method offers comparable decontamination to more expensive methods at an affordable cost of about $50 in materials.

"We focused on frugal science—how do you decontaminate PPE in a very simple way that is easily scalable for high throughput so that any health care facility can use it globally," said Gleghorn, an associate professor of biomedical engineering at UD.

A simple solution

The project was inspired earlier this year by Rachel Gilbert, a doctoral candidate in the Gleghorn lab, after she learned that friends in the medical field were repeatedly donning the same N95 mask day after day.

"This is more widely known today, of course, thanks to media publicity around this issue, but it got me thinking," said Gilbert.

She knew that UV-C light was routinely used for sterilization of various materials and equipment found in research labs. She wondered if this technique could be repurposed to decontaminate specialized masks, specifically for front line workers, in a low-cost, scalable way.

Ultraviolet germicidal irradiation (UVGI) has been validated as an effective method to decontaminate masks between use. UVGI systems are routinely used to decontaminate work environments and surgical suites, equipment and ambulances, but not all healthcare facilities have access to this expensive commercial sterilization equipment. That said, many UV-C bulbs are sitting idle in biosafety cabinets in university labs and research facilities that may be empty due to restrictions arising from the pandemic.

"Being able to provide something that can be on-site, as opposed to other methods that require surgical-suite UV systems costing tens of thousands of dollars or shipping masks out for decontamination and relying on them coming back in a timely manner, was important," added Gilbert.

When she discussed the idea with Gleghorn, a former firefighter and critical care medic, he immediately agreed. Gilbert called the effort a "huge, collaborative team effort" with many lab members collectively reading the literature, figuring out a solution and then going to the hardware store and creating the setup in the peak of the pandemic in April, all while working from home.

It only took a few weeks to solve the problem and put the system together, but securing peer-review took longer.

"Peer-review is an important part of the process. And while we wish it could move faster, there is a reason that innovations are rigorously examined in the scientific community," said Gleghorn. "We need to make sure the science is sound and the methods we develop are safe for people."

Using basic resources

Now, more about how the method works.

Lay two N95 masks side-by-side and it is impossible to tell which mask, if either, is contaminated with the novel coronavirus SARS-CoV-2 that causes the disease COVID-19. It's not like dirt, which you can see.

The UD research team created a sloped surface to help align masks situated along the edge of the system toward the light source for more uniform decontamination across the surface. Credit: University of Delaware

The system the research team constructed modifies common fluorescent light fixtures to hold and power the specialized UVGI light bulbs. That, in addition to specific light placement arrangements and tin foil covered

cardboard for reflectors, creates multiple decontamination arrangements people can make. To confirm the UV-C lights were effective, the researchers did copious mathematical calculations and modeling to make sure the intensity of UV radiation that the repurposed lights emit was correct and the N95 masks received the correct UV exposure to decontaminate the masks.

The team developed freely downloadable build instructions in simple, easy-to-understand language with a lot of pictures and made them freely available on the Gleghorn lab website. The directions emphasize UV safety and focus on use in healthcare because of the need for specialized equipment, like a UV-C intensity meter. They also include precautions to measure UV-C intensity to ensure confidence the system is delivering the correct degree of UV intensity for enough time to decontaminate.

The detailed setup instructions include granular information, too, such as how far apart to space the masks for maximum effectiveness. This is critical because placing them too close together can create shadows that prevent comprehensive UV-C decontamination.

It is important to note that this is not an at-home device.

"You need proper personal protective equipment to work with UV light, which can disrupt DNA and pose safety concerns," said Gilbert.

This disruptive feature, however, is exactly what makes the UV-C light useful for decontaminating PPE.

"The UV light causes the virus DNA to break up and become ineffective," explained Gleghorn.

"So, the virus—that little spiky thing you've seen by now—might still stick to you, but the genetic material inside will be fragmented and will

not have the correct machinery to replicate."

The research team enlisted Kim Bothi, former global engineering director and now executive director of UD's Center for Hybrid, Active, and Responsive Materials, to help think through ways to scale the project. She, too, has firefighting and emergency medical technician experience, not to mention expertise in integrating new ideas across a global spectrum.

Bothi used her global expertise and relationships to recruit volunteers across the world to translate the build instructions into multiple languages with regional-specific information. So far, the directions have been translated in French, Spanish, Portuguese, Russian and German. To-date, the build plans have been accessed over 1,060 times from users in 52 countries.

She also is working on a policy brief to share the research team's method with Delaware's congressional delegation. Additionally, Bothi is passing information along to colleagues working with the Kenya Medical Research Institute and in other nongovernmental organizations across the world.

"Like any other technology or innovation, our off-the-shelf decontamination method will only have impact if people are aware of it," she said.

The researchers concede that mask re-use is not ideal, but they also recognize that not all hospitals or other patient care facilities are equipped with enough PPE to meet demand in a crisis, so first responders may be required to reuse masks in emergency situations.

This includes doctors, nurses and emergency response personnel, but also extends to staff behind-the-scenes who may be cleaning,

disinfecting or preparing spaces for patient care. Beyond hospitals, PPE is worn in residential facilities and rural clinics around the globe that may have limited access to resources.

In a perfect world, Bothi would like to see academic and research institutions working hand-in-hand with hospital systems to collaboratively put these off-the-shelf systems in place where they are needed.

Kenya, for example, is a country in sub-Saharan Africa that has a fairly robust system for healthcare. Yet, the country is still facing incredible shortages of PPE just like here in the United States.

"The bigger benefit will be translating this to other areas of the world, where they don't have the resources," said Gleghorn.

The team published their method in a paper in the journal *Global Health: Science and Practice*.

More information: Rachel M. Gilbert et al. Mask Reuse in the COVID-19 Pandemic: Creating an Inexpensive and Scalable Ultraviolet System for Filtering Facepiece Respirator Decontamination, *Global Health: Science and Practice* (2020). DOI: 10.9745/GHSP-D-20-00218

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