Developing a Usable Coronavirus Respirator Using a Full-Face Snorkel Mask

Through the coronavirus outbreak, healthcare workers around the world have found that sufficient face covering is essential to mitigate the spread and infection rate of the virus. The respiratory infection SARS-COV2 as a result of a COVID-19 infection mainly spreads through respiratory droplets from person-to-person most commonly produced at one's mouth or nose. Logically, blocking or mitigating the flow of potentially hazardous droplets either in or out of one's nostril and out into their surroundings would likely mitigate the negative impacts of continued transmission and complications of infection. Currently, most Americans use disposable or washable facial coverings to maintain the necessary resulting public hygiene. However, most commercially available and widely used options, such as N95 masks, have their limitations. N95 masks are rated for a limited use of 8 to 12 hours of continuous use. A recent study also tested the public's proficiency in using these strap-on masks, and found that only 13% of participants were able to wear the mask correctly so it was able to effectively prevent the spread of viruses and bacteria. Recently, hospital staff in areas of high COVID-19 infection rates and hospitalization have begun utilizing PAPR (Powered Air-Purifying Respirator) systems that create a closed loop protective environment of respiratory gas exchange around one's face. Some young inventors in southern california set out to create a similar low cost papar system for use by the typical consumer. Ellen Hong and Deven Gupta, students working in Dr. Brian Wong's lab at University of California, Irvine, have developed an affordable PAPR and completed early stage development feasibility.

Hong's and Gupta's design uses a commercially available scuba mask, filter, fan, and tubing in combination with 3D-printed parts to create a cost-effective, reusable ventilator mask. The parts are readily accessible through online manufacturers, to allow for users to easily assemble this mask design at their own residences.

We used a full-face snorkel mask with an airway breathing filter affixed to the snorkel using 3D printed jigs. Tubing was added with a portable fan in order to make breathing easier for the user. These parts were also connected using 3D printed models. A large snorkel mask (WSTOO Full Face Snorkel Mask; WSTOO, Guangdong Province, China) was chosen based on coverage of the entire face and ease with which to connect a filter. The bacterial/viral filter (Westmed Bacterial/Viral Filter 15/22 X 22 mm; Westmed, Inc, Tucson, AZ), tubing (1 1/8" flexible bilge tubing; Home Depot, Atlanta, GA), and portable fan (Rubie's Mini Blower Fan; Rubie's, Richmond Hill, NY) were selected due to ease of acquisition. The jigs were printed with SLS resin-based 3D printer (Formlabs Form 2 3D Printer; Formlabs Inc., MA). The total cost of the mask is $43.

Assembly of the device required detaching the snorkel from the snorkel fitting, and affixing the filter onto the fitting, connected by the 3D printed jig. The snorkel fitting includes two baffles that differentiate the airflow into and out of the snorkel mask, with the filter being attached to the inner ring which filtered the airflow into the mask. One end of the tubing was then attached to the end of the filter, with the other end of the tubing being connected to the end of the portable fan using the other 3D printed jig.

These full face snorkel masks could serve as surrogates for commercial N95 masks. The use of the airway filters from the snorkel masks can also help prevent contamination of anesthesia equipment with bacteria and viruses. The snorkel mask itself is easy to wash and can be reused, although the filters should be replaced after every 24 hours of use according to the manufacturer. Nonetheless, the filter has twice the length of safe usage than an N95 mask (which can only be worn up to 12 hours before it needs to be replaced). The filters are easy to replace, as it only requires the quick detachment of it from the 3D printed jig and fitting a new one back into the system.

Users of this mask have reported on the ease of use of the mask. The snorkel mask was tested on continuous usage without the user feeling discomfort. The results found that the users were able to wear the mask without any problems for 3 hours.

The external fan added to the mask was used to produce sufficient positive pressure as the user is wearing the mask to create a comfortable environment with sufficient ventilation. The fan itself is compact and lightweight, enabling portable use.

The limitations of this device stem from sound and wearability. The portable fan creates a significant noise when running at a speed necessary for adequate airflow. The snorkel mask design might be bulky or unconventional for some users, but its full-face coverage allows for better protection from bacteria and viruses.

Development of these masks is not limited to the specific snorkel mask used in this project. A different commercially available snorkel mask could be used by modifying the 3D-printed model in order to accommodate their differences, but the remaining assembly would stay the same.

Please see below for the links to the .stl files for the 3D printed jigs.

Questions?
Please reach out to the inventors: Ms. Ellen Hong (insert email) & Mr. Deven Gupta (guptadk@uci.edu)

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