Size-dependent filtration efficiencies of face masks and respirators for removing SARS-CoV-2–laden aerosols

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To the Editor—A recent article by Liu et al[1] reports that severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was detected in the air in hospital areas occupied by inpatients, medical staff, and the public. Their study reported the size distribution of SARS-CoV-2–laden aerosols, which makes it possible to evaluate the filtration efficiencies required for face masks and respirators. The use of face masks and respirators has been recommended for protecting healthcare workers and the general public during the COVID-19 pandemic because SARS-CoV-2 is widely distributed in the air of Wuhan hospitals[2,3] and the virus can remain viable in aerosols for several hours.[4] However, the size-dependent filtration efficiencies of face masks and respirators for removing SARS-CoV-2–laden aerosols have not yet been reported.

The study by Liu et al[1] reported that SARS-CoV-2 occurs most commonly in aerosols in the submicron (0.25–1.0 μm) and supermicron (>2.5 μm) ranges. We reviewed the measured filtration efficiencies of different masks and respirators reported by Konda et al[5] and compared them to sizes of SARS-CoV-2–laden aerosols (Fig. 1). The N95 respirator and surgical mask show a high filtration efficiency of >60% for aerosols in the submicron range and almost 100% for aerosols in the supermicron range. The filtration efficiency of cloth masks is much lower (<50%). Therefore, for healthcare workers facing a high risk of opportunistic airborne infection, an N95 respirator or surgical mask is sufficient to defend against SARS-CoV-2. For people at low risk of infection, a homemade cloth face mask is a suitable alternative if there are shortages of face masks and respirators, provided that the correct fabrics are used.[5] Importantly, any leakage from the edges of the face mask may result in a significant decrease in filtration efficiency,[6] so face masks must fit correctly to be effective.

With the spread of the COVID-19 pandemic, numerous findings have shown the protective effect of wearing face masks,[7] which increases public recognition of the need for them. Considering the limited supplies of face masks, the rational use different types of face masks or respirators depending on the pandemic severity and context of use has been advised.[8] In the meantime, the size-dependent filtration efficiencies for SARS-CoV-2–laden aerosols reported here can be used to inform policies on the use of face masks.

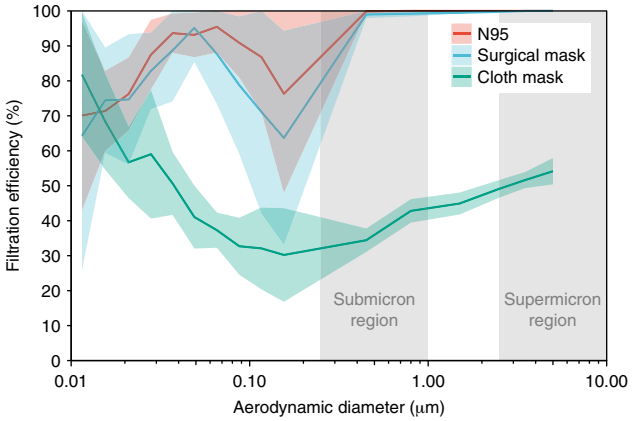

Fig. 1. Filtration efficiencies of an N95 respirator, a surgical mask, and a cloth mask. The filtration efficiencies are combined from Konda et al.[5] The cloth mask is made of double-layered quilter's cotton with a thread-count of 80 threads per inch, which is often used in do-it-yourself masks. The flow rate was 1.2 cubic feet per minute (CFM), which represents human respiration rates at rest. The graph lines represent the mean values, and the shaded areas represent the standard error of 7 experiments.

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Conflict of interest. All authors report no conflicts of interest relevant to this article.

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Effect of vaporized hydrogen peroxide reprocessing on N95 respirators

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To the Editor—The high demand for personal protective equipment (PPE) during the coronavirus disease 2019 (COVID-19) pandemic has required reprocessing and reuse of N95 respirators to mitigate shortages. Data on the impacts of reprocessing and reuse on the physical integrity and continued performance of these PPE are sparse.

Our facility uses vaporized hydrogen peroxide (VHP) according to the Duke method as a strategy to reprocess respirators for reuse.[1] We conducted repeated quantitative fit testing of N95 respirators (model 3M 1870+, 3M, Maplewood, MN) by measuring the amount of leakage into the facepiece. We sought to better understand the impact of VHP reprocessing on reuse and extended reuse of respirators as well as the effect on the tight fit of the respirator in 2 experiments.

In our first experiment, 5 masks that were reprocessed with VHP were compared to 5 masks that were not treated with VHP. Quantitative fit testing was conducted using TSI PortaCount according to the Occupational Safety and Health Administration (OSHA) quantitative fit testing protocol. Safety staff conducted repeat use and fit tests in 10 cycles as follows: (1) Inspect the respirator. (2) Adjust and don the respirator. (3) Perform a quantitative respirator fit test. (4) Doff the respirator. And (5) flatten the respirator. Any observable failures and fit-test failures were documented after each cycle (Table 1). We found no fit-testing failure among the respirators treated with VHP, while the 5 control respirators had 4 total fit-test failures. Notably, 3 failures occurred after the ninth cycle of donning and doffing the respirators.

In our second experiment, to better understand the impact of VHP reprocessing on reuse and extended use (defined as repeat half-day use, or 4-hour shifts), we tested the same type of respirators (3M 1870) according to the following procedure: (1) The respirator was used for 4 hours. (2) The respirator was reprocessed with VHP. (3) The respirator was used for an additional 4 hours. (4) The respirator was reprocessed with VHP. And (5) a quantitative fit test was performed on the respirator. Respirators used in this experiment had already been used in hospital service by a single user for a clinical purpose. The duration of use was unknown.

All 5 respirators successfully passed the quantitative fit testing. The results from both experiments suggested that reprocessing with VHP allows for reuse and extended use of respirators. Our study has several limitations. These results might not be generalizable to other contexts. The quality and integrity of respirator used may differ by brand and style. Variability in the results may have resulted from the use of quantitative versus qualitative fit-testing techniques, which may be more prone to error due to the subjective nature of the test. Our evaluations were based on conclusions from quantitative testing.[2,3] Finally, fit-testing expertise among the staff who volunteered to run the experiment varied; however, we expect our data to be reliable because the same staff performed multiple tests. Finally, we were not able to capture the duration of clinical use of the respirators in the hospital prior to the start of our second experiment, and we were unable to define the overall "use" in the project given this limitation.

Limited evidence is available regarding the use of VHP with extended reuse of N95 respirators.[4,5] Similar to other studies, we found no detrimental effect of VHP processing on the ability of N95 respirators to pass fit testing. Our results suggest that VHP does not affect limited reuse and extended use of 3M-1870 respirators in the context of maintenance fit testing with repeated donning and doffing.

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