Ultraviolet germicidal irradiation: possible method for respirator disinfection to facilitate reuse during COVID-19 pandemic

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Abbreviations used: FFRs = filtering facepiece respirators; UVGI = Ultraviolet germicidal irradiation; UVC = Ultraviolet C; DNA = deoxyribonucleic acid.

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ABL and SN are sub-investigators for Biofrontera. DO is an investigator for Biofrontera. HWL is an investigator for LITE study which is funded by PCORI, and home phototherapy machines are provided by Daavlin, and has participated as a speaker in general educational session for Ra Medical System. JMG is PI of the LITE study, which is funded by PCORI, and home phototherapy machines are provided by Daavlin. IK and APM have no relevant conflicts of interest to report. IHH is an investigator for LITE study which is funded by PCORI, and home phototherapy machines are provided by Daavlin.

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To the Editor:

The ability to disinfect and reuse disposable N95 filtering facepiece respirators (FFRs) is urgently needed during the current COVID-19 pandemic as supplies are running low in hospitals throughout the United States and abroad. Ultraviolet germicidal irradiation (UVGI) is one possible method for respirator disinfection to facilitate the reuse of dwindling supplies. Dermatology offices often use narrow band ultraviolet B (UVB) to treat skin diseases. If necessary, we propose a possible repurposing of phototherapy devices, including these UVB units, to serve as a platform for ultraviolet C (UVC) germicidal disinfection.

UVGI is a disinfection method that uses UVC radiation to inactivate microorganisms by causing deoxyribonucleic acid damage (DNA) and preventing replication. Previous studies have shown that UVC can inactivate coronaviruses including severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV).[1] One study of H1N1 influenza A contaminated respirators found significant reductions (≥3 log reduction) in viable influenza under substantial artificial soiling conditions after being treated for 60-70 seconds at an irradiance of 17 mW/cm^2, resulting in a UVGI dose of ~1 J/cm^2 measured at 254 nm.[2] The efficacy of this dose has been verified in additional studies and higher doses (up to 2 J/cm^2) have been shown to provide diminished benefit after 1 J/cm^2.[3, 4] It is recommended to treat used masks, but not visibly soiled, in order to allow the 3 log reduction, reported in the literature, to be sufficient to achieve safe re-use levels.[5]

It is important to note that the time to deliver 1 J/cm^2 is dependent on the irradiance; hence, it can be longer or shorter depending on the delivery device's capabilities. In a prototype model that has been developed (Fig 1), this dose can be delivered in 1 min 40 sec at an irradiance

of 10 mW/cm^2. The distance from the lamp to the top of the table in Figure 1 is approximately 14cm.

However, UV radiation does degrade polymers which presents the possibility that UVGI exposure, while decontaminating, may also reduce the efficacy of the respirator and decrease protection to workers. Lindsley et al exposed 4 different models of N95 FFRs to UVGI doses of 120-950 J/cm^2. Results of the study showed that UVGI exposure led to a small increase in particle penetration (up to 1.25%) and had little effect on the flow resistance. However, at higher UVGI doses, the strength of the layers of the respirator material was substantially reduced (in some cases, > 90%), but this significantly varied among the different models. UVGI had less of an effect on the respirator straps; a dose of a dose of 2360 J/cm^2 reduced the breaking strength of the straps by 20–51%.[6] It should be noted that the dosages used in the study above are 100-1000x higher than those shown to disinfect H1N1 influenza A contaminated respirators. Therefore, considering that many of our healthcare providers are using substitutes for N95 FFRs that offer very limited degree of protection, using UVGI and repurposing phototherapy devices could be the best practical solution at this time.

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Figure 1. Image of prototype being developed by Daavlin. The field of irradiation is approximately 15 inches x 45 inches, and depending on the manufacturer of the mask, this would allow for the treatment of ~18-27 masks (2 minutes per side). With UV light on a) and UV light off b)

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