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Biophotonics for pandemic control: Large-area infection monitoring and microbial inactivation of COVID-19

Due to the rapid transmission of COVID-19 through direct routes (droplet inhalation, cough, and sneeze) and contact routes (contact with nasal, oral, and eye mucous membranes), the World Health Organization (WHO) issued guidance on infection prevention and control (IPC) strategies [1]. However, complying with the IPC strategies is not sufficient to contain the coronavirus spread, especially in the context of the global shortage of personal protective equipment (PPE), physicians, negative pressure rooms, and hospital beds. With this in mind, biophotonic techniques for microbial inactivation as well as COVID-19 infection identification and monitoring in large areas can help to control the pandemic. This letter aims to encourage research and investment on the development of these techniques by proposing highlighting practical implementation aspects and the most suitable applications in the pandemic context.

In order to control the virus spreading and ensure the safety of healthcare workers, it is essential to develop ultraviolet (UV) light-based innovations for extension of the lifetime of PPE (e.g. N95/SN95 respirators) [2], disinfection of environmental surfaces of rooms or objects, and microbial inactivation on food or biological tissues. These innovations are based on UV germicidal irradiation (UVGI), which typically uses UV-C irradiation including the 254 nm wavelength for respirator decontamination. On the other hand, UV-C may affect the electrostatic charges in polypropylene material and compromise N95 respirator integrity. In this case, UV-B may be a potential alternative for UVGI, as narrow-band UV-B phototherapy devices can be found at dermatology offices and academic departments using them mostly for psoriasis treatment.

Current UV technology cannot be used by every institution [3]. Hospitals have major space issues due to the pandemic, which prevents them to purchase additional UV equipment. The social distancing measures also decrease the space available at transportation facilities as well as critical industries (e.g. food and pharmaceutical) supplying continuous resources during the pandemic. In addition, UVGI protocols are not well established neither for inactivation of SARS-CoV-2 (virus causing the COVID-19) nor for safe reuse of PPE. With this in mind, novel UV equipment should be sufficiently portable for crowded places. The equipment should also contain sufficiently powerful UV-light emitting diodes (UV-LEDs) to eradicate the virus in various settings. Developed protocols should be developed for user safety and total microbial inactivation. In terms of large scale production, the existing UV-LED industry and device manufacturers may benefit from designing standard equipment.

While the production of the necessary amount of UV equipment is not met, short-term measures may use optical technology to evaluate places requiring decontamination/disinfection resources. This technology includes infrared imaging (IRI), which can be used to monitor body temperature and identify potential fever cases in large areas [4]. Since the identification accuracy depends on limiting the local temperature variation, IRI is most suitable for acclimatized rooms on the entrance of buildings or isolation areas in hospitals. With further studies and privacy policies, IRI can be extended to applications such as identifying infected individuals at open environments and reporting the risk of infection of neighbors. In this case, alerts can be created upon face recognition by security systems. Another possible approach was previously discussed by Carvalho and Nogueira [5], where COVID-19 detection and study of its molecular origin can also be potentially performed by probing coronavirus biomarkers using vibrational spectroscopy. In this case, direct analysis of biofluid samples and cell cultures allows fast screening at crowded places. Practical implementation depends on determining the protocol and instrument specifications for reproducible virus detection. Worldwide technology adoption relies on large scale production of Fourier-transform infrared spectroscopy and Raman spectroscopy equipment to be distributed at the screening sites. Other alternatives comprise manufacturing disposable lab-on-a-chip devices, which can be transported and stored at healthcare facilities. These devices require minimal amount of sample and no operational costs. Highly specific biofluid and breath analysis could be performed by incorporating the lab-on-a-chip devices in respirators/masks. Even though breath analysis may require additional studies to determine which volatile organic compounds (VOCs) are associated to COVID-19 infection, it may also indicate the necessary UV light dosimetry for decontaminating respirators and their safe reuse.

By using large-area infection screening and monitoring, it may be possible to estimate the regional need for UVGI equipment and adjust its supply accordingly. Based on this, biophotonic and optical technologies can play a significant role in the control and management of the COVID-19 pandemic. Overcoming the limitations placed by the pandemic as well as ensuring the global health and safety depends on the collaboration among researchers, industry and medical institutions. More than ever, opportunities for collaboration should be fostered for further advancement of the technology and the humanity itself.

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Declaration of Competing Interest

No conflicts of interest to declare.

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