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Editorial

Publications About COVID-19 Research by the BME Community

Almost 3 years have passed since the Coronavirus Disease 2019 (COVID-19) pandemic began. Members of the biomedical engineering (BME) community stepped up to the plate during these uncertain times where collaboration and innovation were necessary to support overall public health. The significant need to understand and mitigate COVID-19 disease progression motivated interdisciplinary partnerships that led to the development of critical technologies and strategies aimed to reduce infections across the globe. ABME is proud of the way the BME community came together and aims to highlight and reflect on the influential works that contributed to the fight against COVID-19.

At the beginning of the pandemic, shelter-in-place orders were issued where individuals were directed to stay at home to slow the spread of infection. In the United States, these orders lasted from March 1, 2020 to May 31, 2020. These requirements forced institutions to restructure curriculum from in-person learning to online platforms overnight. Instructors were left with the daunting task of maintaining classroom engagement through a computer screen, which can prove particularly difficult in hands-on design, laboratory, and innovation focused courses. Nevertheless, BME faculty rose to the occasion and created a collection of virtual brainstorming documents where faculty from around the world could contribute ways to overcome these obstacles and facilitate online teaching in creative ways.[3] Outcomes of this study have since led to increased discussions on effective online educational platforms as well as the development of successful online BME-based laboratory curricula.[8,11] Pandemic restrictions also motivated many BME departments throughout the United States to consider the removal of graduate record examinations (GRE) requirements for graduate studies and promoted data collection to study potential institutional biases in graduate admissions.[10] Further evidence has since emerged to underscore the positive impact surrounding the removal of GRE requirements to improve diversity, equity, and inclusion in BME.[1,17]

Despite social distancing efforts, rates of COVID-19 infections increased drastically and demonstrated the need for innovative early mitigation strategies to reduce aerosol transmission. These strategies needed to be easy to implement and cost-effective. The Patient Particle Containment Chamber (PPCC) was developed by Maloney et al. for physicians to monitor infected patients with reduced risk of aerosol transmission. The PPCC was found to be 99% effective and consisted of a PVC pipe frame covered in a shower liner with 3D printed sleeve portals for patient access.[14] Additionally, Moreno et al. designed, simulated, and built UVC radiation filtration devices capable of deactivating pathogens with greater than 99% accuracy. These devices were designed to be cost-efficient and low-maintenance and demonstrated reduced bioaerosol contamination using passive flow control.[16]

After the centers for disease control and prevention (CDC) recommended the use of face coverings by all individuals in public spaces, increased demand for personal protective equipment (PPE) and worldwide shortages due to delays in the supply chain left frontline healthcare workers at increased risk of infection. Early on, numerous designs and prototypes for cloth face masks were tested to determine the best hospital-approved cloth mask design. The final designs were shared with the BME community as a way for local volunteers to easily make effective PPE for frontline workers and combat the shortage.[7] PPE shortages persisted and there remained a significant need for large volumes of protective equipment to mitigate the risk of infection as community members returned to work. Interdisciplinary teams of volunteers got together to design and manufacture AJFlex Face shields, consisting of a plastic protective shield attached to a 3D printed headband using strut supports, where 33,000 face shields were delivered to over 100 organizations.[23] Throughout COVID-19, 3D printing from non-traditional manufacturers also aided the efforts to increase production of nasopharyngeal swabs, mask connectors for CPAP and BiPAP devices, and N95 masks. The design process for creating 3D printed reusable N95 masks was published to communicate constraints necessary to achieve 95% filtration of particulates less than 0.3 μm.[22] Multiple experiments have been performed to further address the difficulties associated with quality control of 3D printing medical devices and improve future iterations.[9,19]

With mitigation strategies in place, clinicians and researchers were interested in identifying the best ways

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to monitor and treat COVID-19 patients in order to avoid acute respiratory failure and its associated rapid decline. Rubano et al. found two-wavelength pulse oximetry to be an unreliable measure of arterial oxygen content in COVID-19 patients and motivated hospitals to use alternate methods for determining oxygen saturation and avoid acute hypoxemic respiratory failure in high-risk patients.[20] Computational approaches also utilized experimental data from infected patients to model the spread of virus-laden aerosols through the airways and lungs as well as the fluid dynamics through the airways. Outcomes of these models suggested the use of targeting therapies to slow primary ground-glass opacity (GGO) lesion growth and control airflow patterns and also encouraged the use of active airway humidification and expectorant drugs as treatment for airway management.[4,6]

COVID-19 diagnostics and measures for detection of disease progression were developed using machine learning algorithms. In a study by Sattar et al., the Novel Coronavirus Cough Database was used to fully automate cough sound processing and evaluate the risk of disease progression.[21] Alternatively, Zouch et al. utilized databases comprised of COVID-19 and non-COVID-19 X-rays and CT images to develop a deep learning (DL)-based method capable of detecting COVID-19 pneumonia with greater than 99% accuracy.[24] Access to the databases utilized in these studies were critical for the development of these methods. Many researchers are continuing discussions related to the potential outcomes of increased data sharing and open access resulting from health emergencies.[13,18]

Lastly, scientists are continuing to investigate improved disease treatment and prevention strategies. The use of cold atmospheric plasma (CAP), a mix of reactive oxygen and nitrogen species known to have advantages in disinfection and wound healing, was proposed as a method for COVID-19 management and prevention. In particular, robot-assisted CAP delivery was suggested to maximize efficiency of CAP for targeted treatment in lung tissue.[5] While improved treatment strategies are necessary, the development of COVID-19 vaccines led to significantly reduced rates of infections, hospitalizations, and deaths.[15] Even as new variants arise, studies have provided evidence of long-term protection against COVID-19 up to 9 months post-vaccination.[12] Nevertheless, many individuals are vaccine hesitant, meaning that they delay or refuse available vaccinations. Alsharawy et al. investigated the complex factors influencing vaccine hesitancy as a function of betrayal aversion where it was found that willingness to become vaccinated was decreased when trust in the government or scientific community was breached.[2] As the pandemic shifts to an endemic, there remains a critical need for improved COVID-19 prevention, treatment, and diagnostic strategies. The BME community has proven its ability to keep moving forward in the face of adversity where we expect to continue addressing difficult topics and researching challenging questions, constantly evolving. ABME thanks you for taking action and working together to keep our communities safe and informed.

CONFLICT OF INTEREST

The authors disclose no conflicts of interest.

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