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threat with ongoing community transmission in the USA. Sharing conflicting information and largely politicising the pandemic has led to greater loss of trust in science and life-saving public health measures with constant undermining of public health professionals.

Finally, training and hands-on experience are critical. During the 2014–16 Ebola outbreak in west Africa, academic (medical and public health) institutions across the world contributed faculty and staff to aid the response. This global assistance was crucial to ending the outbreak and provided unparalleled real-world and hands-on experience to thousands of health professionals who would subsequently use those skills to lead future responses at home and abroad. Although case studies and simulated exercises are helpful didactic tools in preparedness and response, they do not reliably mimic the on-the-ground complexity of response activities during a disease outbreak. Compared with their counterparts across the globe, the academic institutions and public health schools in the USA were more restrictive and less likely to send faculty and staff, often for logistic or legal reasons. This situation meant that the USA had fewer front-line providers with real-life experience in a rapidly changing disease outbreak. Had more Ebola-experienced providers been on the front lines during the early stages of the COVID-19 pandemic, we would have responded better, faster, and more efficiently.

We declare no competing interests.

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For the **Gender and COVID-19 Agenda-setting Initiative** see www.ghhbuzzboard.org

Sex-disaggregated data in COVID-19 vaccine trials

As the first wave of COVID-19 vaccines enter the market, and global immunisation programmes are implemented, the time is right to remind researchers and regulatory agencies of the critical importance of including biological sex as a variable in trial data analysis and reporting.[1] The phase 3 Oxford–AstraZeneca trial interim report indicates more participation from women, which the investigators attribute to a recruitment focus on health-care workers,[2] but they have not yet reported or discussed how biological sex could influence the data. Future reporting of sex-disaggregated data and a discussion of how sex factors influence the trial outcomes would benefit regulatory and public decision making and the design of mass vaccination programmes.

Why is biological sex relevant, and sex-disaggregated analysis important? A growing body of research highlights the influence of biological sex in clinically relevant health outcomes, including sex-specific differences in immunity, pharmacology, and vaccines outcomes (side-effects and efficacy).[3] In vaccine studies, cisgender females tend to develop higher antibody response and, relatedly, higher efficacy and more side-effects, suggesting the need for sex-differentiated dosing regimens.[3,4] Previous influenza vaccine research suggests that women can produce the same immunological response to half-dose vaccine as men do to full dose.[5] According to research findings in preprint,[6] sex-based differences in innate and adaptive immunity in SARS-CoV-2 infections are probable contributors to the increased risk of intensive care unit admission and overall mortality in men, and increased reports of long-COVID symptoms in women. These hypotheses and evidence on the sex determinants of immune responses could also be present in COVID-19 vaccine-induced immunity and adverse outcomes.

Taking a cue from the remarkable achievements in vaccine innovation and research during the COVID-19 pandemic, we have an opportunity to course-correct the integration of biological sex as a core variable in study design, analysis, and reporting. Sex factors, including sex-disaggregated analysis and reporting, are still neglected across the continuum of medicines research and regulation.[7] This is also the case in COVID-19 trial data reporting. According to an evaluation in preprint[8] of nearly 2500 COVID-19-related studies, less than 5% of investigators had pre-planned for sex-disaggregated data analysis in their studies. We note and applaud those vaccine trial reports that did include sex-disaggregated primary outcomes data.[9,10] A further mention of sex-disaggregated adverse events and secondary outcomes in future reports would be beneficial. This would collectively set an analysis and reporting benchmark not just for the many COVID-19 candidate vaccines in the research pipeline, but also for all future pharmaceuticals, biologics, and other medical interventions.

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Clinician engineers—the time is now

I read with great interest the Perspective by Roger Kneebone and Claudia Schlegel,[1] and I agree about the pigeon-holed approach to medical education.[1] COVID-19 has shown clinicians and engineers working side by side to ensure health-care worker safety via personal protective equipment and the management of patients through ventilators.

Engineering platforms are used to diagnose and treat patients. Clinicians use the endoscope, the CT scan, dialysis machines, cardiac stents, etc, yet have little understanding about how these devices are made or work.

The Clinician Engineer Hub is a global network aimed at bridging the gap between medicine and engineering. The hub offers workshops, research opportunities, and industry-based opportunities for medical students, and early career doctors to ensure they are given the chance to gain knowledge and skills in engineering. Students within the network are empowered to serve as leaders. To date, we have held summer and winter schools, multiple webinars, a 3-day conference, and offered collaborations with researchers in laboratories or through industry internships. Webinars have included topics such as biomechanics, optics, coding, and aerospace engineering. Our conference featuring academic experts globally and industry members—from Google Health, Microsoft, and Amazon Web Services as well as WHO—gained considerable interest (20 million impressions via Twitter).

Later this year, we will be holding a virtual hackathon—ClinHacks—aimed at innovative engineering solutions to health care.

As Kneebone and Schlegel highlight, medical education is typically funnel based and I fully endorse the need for "funnel perforation".[1]

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Long-haul COVID: heed the lessons from other infection-triggered illnesses

According to the Johns Hopkins Coronavirus Resource Center, more than 115 million people worldwide have been infected with SARS-CoV-2 during the COVID-19 pandemic, with extensive implications for morbidity and mortality. Description of long-term effects of COVID-19 are appearing in the medical literature; the first large cohort study[1] with 6-months' follow-up has been published, and more data are sure to follow. A small number of studies point not only to persistent imaging and testing abnormalities across several organ systems in the postacute period, but to a high frequency of patient-reported symptoms such as fatigue, insomnia, anxiety and depression, autonomic disturbances, cognitive difficulties, pain, and others. The presence of patient support groups, and the rapid expansion of clinics to manage or treat these symptoms, validate further their existence and impact.

Although the frequency, severity, and potentially the etiology of persistent symptoms can vary, sequelae after COVID-19 appears poised to join the range of other postinfectious syndromes described in the field of infectious diseases.[2] These often share a common symptom phenotype, which might also meet case definitions for myalgic encephalomyelitis/chronic fatigue syndrome, fibromyalgia, or post-treatment Lyme disease. We hope that researchers and clinicians will draw on these other conditions as they continue to advance scientific understanding of so-called long-haul or persistent COVID-19. We would also argue that there are important lessons to learn and pitfalls to avoid; our specific area of clinical care and research (post-treatment Lyme disease) has remained a fiercely contentious condition for more than 30 years.[3]

To quantify severity and measure improvements are inherently easier in objective abnormalities than in patient-reported symptoms. Furthermore, a scientific knowledge gap surrounds the cause of persistent symptoms after acute infections, such as fatigue. Both factors contribute to the risk of dismissing patient-reported complaints, particularly those that

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