

Engineering Better Medicine for Public Health Crises and the Future

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When my brother told me he had been diagnosed with COVID-19, I was scared. My memory immediately jumped to visions of his childhood struggles with asthma, which he described as having an ever-tightening chain around his chest. I thought of intubated COVID-19 patients at so many hospitals across the nation, and all of the patients who did not leave the hospitals alive. As we now know, African-American men like my brother are several times more likely to die from COVID-19 than someone who is white [1].

In my home state of Georgia, for example, 80 percent of all patients hospitalized due to COVID-19 in March 2020 were Black people. Nationally through June, American Indians, Native Alaskans, and Black people have had a hospitalization rate that is five times more than whites. For Hispanic people it is four times higher [2]. The compounding factors of increased rates of comorbidities, reduced access to care, limited resources inclusive of health guidance information, and even trust in mainstream medicine no doubt make these populations more vulnerable to a raging viral illness.

Thus, this pandemic has dramatically revealed a deeply rooted national challenge in delivering equitable health care for all Americans. Indeed, while our nation fights the pandemic, it must simultaneously work on addressing systemic inequities and the social marginalization of minority communities that is making the pandemic worse for everyone.

The battle with COVID-19 is on several fronts, involving not just the novel virus but also inadequacies in the nation's medical system, the disproportionate impact on communities of color, and the devastated economy and educational institutions. All of these are intertwined. To prevail, our nation needs to follow the science that leads to practical solutions. The advice and guidance of seasoned medical and public health professionals are obviously essential. But another, per-

haps less obvious, group that is key to tackling these complex challenges is engineers.

In your unconscious mind, you know that already. The modern world is built by and runs on the ingenuity of engineers—from the systems that meet modern energy needs to your smartphone to, well, your whole way of life.

The engineering “to-do” list to combat COVID-19 and assist in safely opening society is long. It includes the expedited design and distribution of rapid point-of-care and at-home diagnostic tests, predictive analytics that indicate infection before symptoms are evident, efficient contact tracing systems, effective anti-viral and immunomodulatory drugs, and highly effective vaccines with simple - even self-administered - delivery systems. Engineers are critical to further enhance telemedicine functionality for the long term, develop communication systems for personalized health prompts and connections to local services, create predictive models of disease spread, and determine the effectiveness of emerging efforts against the virus.

This work will help keep all of us and our economy healthy. If designed with purposeful intention, it could also provide approaches to help redress socially-based inequities. But we must keep social issues at the forefront of our minds. The history of biotechnology development has been fraught with a lack of diversity in technical teams, contributing to the creation of algorithms and products that increase and exacerbate racial and gender disparities rather than solve them. Technological innovations have often been made inaccessible to underserved populations due to cost, practice norms, and technical barriers [3]. Solutions that benefit only the wealthy, a given racial group, or those with high health literacy do not help all of us. Responsive innovations should be designed with accessibility, ease of use, and social application in mind.

They should also be engineered to help infuse greater cultural humility among health care providers, thus facilitating better outcomes for those with demonstrably greater needs. For example, a simple automated procedure checklist tailored for each situation might help standardize approaches and equilibrate the quality of the outcomes [4].

I envision a deeper integration of clinicians and engineers to meet these challenges. More specifically, the potent strategies that are native to engineering are profoundly relevant to our goals of achieving health care equity. And better outcomes across all zip codes, would be a significant step to a better world. Engineers can design to boundary conditions to ensure that clinical solutions are effective, inclusive, and widely available. The nation's diverse audiences should be targeted in the design process to further enhance applicability and utility across demographics. Newly fashioned solutions could come from a convergence of skills in engineering, medicine and the social sciences to go beyond current levels of effectiveness.

As the engineering community has done in so many other critical moments in history, it can step in as practical problem solvers to help meet pandemic and derivative challenges. For example, the NIH's recent RADx initiative encourages the medical and engineering communities to develop innovative technologies for COVID-19 testing in high volumes [5]. And the National Academy of Engineering has launched a multi-generational, multi-disciplinary COVID-19 Call for Engineering Action [6] that notes "COVID-19 separates us physically", but "also compels us to work together." Indeed, we need young dreamers and seasoned experts alike to brainstorm and implement creative solutions to this unprecedented crisis and those to come. The need for clinicians and engineers to blend their expertise and create integrated solutions that benefit everyone has never been more demonstrably evident.

Our rush to respond to a particularly thorny virus comes amid a period of remarkable global social awareness that has made long-standing social inequities more apparent. We now have an opportunity to take on the interwoven roots of racial and ethnic disparities that have allowed the pandemic to take hold so strongly among our most neglected communities.

This confluence of challenges compels us to support and encourage a new generation that blends the skills of physicians and engineers—"physicianeers"—to create real change-makers. The COVID-19 Call for Engineering Action is a great start with expansive potential through the convergence of these disciplines. Perhaps

a transformative development from such integrated expertise in this innovation incubator will immediately help save lives in our current crisis. But it could also inspire an emerging talent to pursue a career that merges engineering, medicine, and related disciplines to make our global community healthier, more equitable and more harmonious in ways that we cannot yet even imagine.

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Dr. Pettigrew reports having three patents pending: for a method and system of sterilization of medical garments, a reusable N95 mask, and an ENT isolation helmet.

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