Thesis Project Portfolio

Design Optimization of Emergency-Use Ventilator to Improve Assembly Time

(Technical Report)

COVID-19 and Non-Communicable Disease: Where Does It Matter Most?

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

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My technical project is with a company and their emergency-use ventilator, the VM-2000, to make it more user-friendly and optimize the assembly process in an emergency setting. The motivation for this ties back to the COVID-19 pandemic causing massive ventilator and ventilator personnel shortages. Administering invasive ventilation requires a certain level of expertise and for more intensive care needs, an entire team dedicated to a patient's ventilation care. During the pandemic when this was not possible due to shortages in nearly every facet of the medical system, there was a heightened need for more ventilators that were easily accessible and usable. This is connected to my STS research, which seeks to look at the lack of research dedicated to the spillover effects COVID-19 had on non-communicable (NCD) patients, by both examining and seeking to address weaknesses in the medical system infrastructure, namely in the form of resource shortages that impacted patient care. My work with the VM-2000 is one way of addressing the ventilator and personnel shortage by working to improve accessibility and remove training barriers for use. My STS project calls attention to the lack of research on NCD patients and how the presence of such research could be used to better formulate emergency guidelines, shape rationing protocols, and overall help form a more equitable infrastructure.

For the technical project, my team worked with the company, Ventis Medical, to improve the usability and efficiency of the VM-2000 based on design considerations deemed most important in a survey of emergency responders. This project used Fusion 360 to design a 3D-printed manifold and tubing clamp, integrated a wired button to enable more convenient administration of ventilation, and determined a more suitable tubing length. Multiple manifold and clamp prototypes were then fabricated, and an optimal, shorter tubing length was determined after researching standards of care. UVA students were recruited to assemble the original VM-2000 and the VM-2000 with the finalized modifications. Participants were timed and asked to

evaluate the usability and efficiency of the original and modified devices after performing each assembly. A reduction in average assembly time was achieved with the modified device. Based on post-survey responses, participants perceived the modified assembly to be more user-friendly and efficient than the original.

In the context of the STS project, resource and personnel shortages in hospitals during COVID-19 led to the development of utilitarian rationing protocols that disproportionately affected patients with NCDs. Resources and medical personnel typically associated with care for NCDs were also shifted to COVID-19 efforts causing gaps in care, screenings, and prevention for this patient group. This spillover effect has been established on a national and international scale with numerous published studies, surveys, and articles detailing as such. However, despite there being evidence of NCDs being represented differently in different states and thus representing different medical system needs, no research has been or is currently being conducted on the spillover effects of COVID-19 on NCD patients on the state/local/regional level. This presents an obstacle for seeking to deal with the aftermath of COVID-19 on this patient community as the full effects have not yet been examined at the level of attention it requires. Therefore, by first identifying the lack of regional research, examining the implications this has on NCD patient care, and establishing the unique care needs of different states; I called upon medical research centers, local governments, and groups/entities capable of supporting/conducting/collecting research and data in this area to do so.

By working on these projects simultaneously, I gained valuable insight looking at different technologies from different perspectives. For my technical project, I took a more hands-on approach that called upon many of my hard skills as an engineer in designing and prototyping different models. However, for my STS project, I was able to take essentially a bird's eye view

of the problem and its broader impacts on society as a whole. Also, my technical project focused more on how the caregiver would use the technology and so for all intents and purposes, the technology was designed for how they would use it. On the other hand, my STS research focuses on how certain technologies and infrastructures have failed NCD patients and how we might begin to address that. I learned that it is not simply the technologies that affect patient care, but it is how these technologies are distributed, maintained, and accounted for in a larger system before they even reach the patient that must also be considered. By conducting projects on what seemed to be two ends of a spectrum of engineering and technology implementation in general, I was able to take note of and appreciate how interweaved the lessons I have learned are and how they have helped me become a better engineer as a whole.