Thesis Project Portfolio

Pulse Waveform Analysis Instrument for Cardiovascular Heart Disease Assessment

(Technical Report)

Investigation of Racial Bias in Modern Pulse Oximeters During the COVID-19 Pandemic

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

My technical work and my STS research are connected through a commonly used medical device: the pulse oximeter. Pulse oximeters have two main capabilities, and my technical project and research paper each focus on one. Pulse oximeters are popularly used to monitor the oxygen saturation of a patient's blood. My STS research paper explores these oxygen saturation measurements and the subsequent diagnostic capabilities of pulse oximeters in diverse patient populations. As a lesser known feature, pulse oximeters can also measure the blood volume changes in peripheral circulation using a technique called photoplethysmography (PPG). My technical project contains a pulse oximeter component that uses these blood volume change waveforms collected from PPG methods to develop a heart disease risk assessment. While my technical project and my research paper focus on two different diagnostic capabilities, they both originate from the same pulse oximeter device.

My technical project focuses on the development of a pulse waveform analysis instrument for cardiovascular heart disease assessment. My capstone team worked to improve upon a prototype of a device that non-invasively and accurately measures pulse waveform velocity and calculates a patient's risk of death from cardiovascular heart disease. Our ultimate goal is to make the device accessible, cost-effective, and easy to use for individuals who may not possess an engineering or medical background. In addition to the device development, we conducted a patient study at the cardiovascular wing of UVA Health to collect data using our instrument. We hope to verify the accuracy and precision of the collected pulse waveforms and the resulting predicted risk measurements in order to work towards preventing premature deaths from cardiovascular disease.

My STS research paper investigates the link between the racial bias embedded in pulse oximeters and the differential COVID-19 treatments based on race. Drawing on the concept of technological politics, my argument is that pulse oximeters used in hospitals during the COVID-19 pandemic performed social and political work by privileging patients with lighter skin tones and marginalizing patients with darker skin tones. My paper explores pulse oximetry's historical and modern neglect of racial and ethnic minorities and the missed diagnoses, treatment eligibility, and adverse outcomes for different races during the COVID-19 pandemic. The goal of my research is to highlight the role medical devices such as pulse oximeters play in the exacerbation of racial inequalities in order to work towards eliminating racial biases in healthcare.

Working on both my technical project and my STS research paper simultaneously has been very illuminating and added great value to both projects. The research I conducted for my STS paper helped me understand how popular medical devices such as the pulse oximeter can actually perform political work through the racial biases embedded in it and how important it is to integrate equitable design principles into device development. As my technical work involved developing a device with a pulse oximeter component, it was crucial to understand the politics pulse oximeters possessed to ensure the developed device would not follow the same racial biases. Additionally, collecting patient data and observing healthcare in action at the UVA hospital for my technical project helped me to understand pulse oximeter technology's role in medicine for my research paper. In conclusion, the intersection between my research and technical work has brought insights and actions to improve both projects in terms of engineering and societal impacts.