Thesis Project Portfolio

Advancing Skin-Tone Inclusive Bilirubin Assessment: Refinement and Design of a Non-Invasive Measurement Device

(Technical project)

Lack of Regulation of Minority Data Inclusion in FDA Clinical Trials

(STS project)

An Undergraduate Thesis

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Sociotechnical Synthesis

My STS research paper, and the topic explored, were constructed from the motivation of my Capstone project. My Capstone project sought to address an inequity in healthcare: creating a non-invasive measurement device for bilirubin, also known as bilirubinometers, in infants that is skin-tone inclusive. Currently, non-invasive bilirubinometers are only effective on light-skinned patients, causing an overprescription for phototherapy treatment. My STS research paper considered what political factors led to the allowance of biased medical products to be brought to market, specifically why there are no strict regulations on the inclusion of minority data in clinical trials. The STS research paper addressed the broader implications of the lack of inclusion of minority data in clinical trials, while my Capstone project related to one specific device that was produced from a lack of regulatory power concerning demographic data. Holistically, both projects informed the other with the Capstone project supplementing technical evidence of a larger, more systematic issue that my STS research paper addressed.

Neonatal (newborn) jaundice, resulting from the accumulation of yellowish pigment, bilirubin, presents substantial health risks to both term and preterm infants in their first week of life. Approximately 50% of term and 80% of preterm infants develop jaundice during this critical period (Woodgate & Jardine, 2015). To manage this condition, up to 10% of term neonates and 25% of preterm neonates require phototherapy, which employs blue light to reduce bilirubin levels in the blood by converting it into the easily excretable lumirubin (Queensland Clinical Guidelines, 2022). The spectroscopy employed to non-invasively measure bilirubin levels overestimates the amount of total serum bilirubin (TSB) levels in dark-skinned neonates. Overprescription of phototherapy can lead to a plethora of short-term and long-term side effects for dark-skinned neonates. Our project sought to create a physical and computationally coupled

model that accurately described the physiological mechanisms for bilirubin transport in adipose tissue and photoconversion of bilirubin to lumirubin. The physical model employed a flow dialysis unit that mimicked the transport of bilirubin through adipose tissue into the bloodstream. Simultaneously, blue light was incorporated into the experiment to portray the photoconversion of bilirubin to lumirubin during phototherapy. The computational model solved a diffusion-reaction partial differential equation to compare predicted concentration values and the experimentally obtained values. Our model offered some predictive power, but a more thorough experimental set-up and inclusion of unaccounted for parameters would enhance the predictive power substantially.

My STS research paper developed a policy analysis on the lack of regulation of inclusion of minority data in clinical trials under the jurisdiction of the Food and Drug Administration (FDA). As of now, the FDA still does not offer strict enforcement mechanisms for the inclusion of minority data in any clinical trials. Winner's *Do Artifacts Have Politics?* framework was employed to understand the distribution of power between the FDA and medical manufacturers, and how this propagates into biased medical products (Winner, 1980). Three pieces of legislation were considered in this paper: the Prescription Drug User Fee Act (PDUFA) of 1992, the National Institute of Health (NIH) Revitalization Act of 1993, and the FDA Safety & Innovation Act of 2012. With the framework, it was found that there was considerable economic and political incentive to continue recommending the inclusion of minority data without offering any legal regulatory power. While the FDA still offers virtually unenforceable metrics for minority data inclusion, the submittal requirements are so broad that manufacturers can easily omit minority data with sufficient reason. This sufficient reason is entirely subjective to the reviewer and can be easily bypassed.

Through working on both my Capstone and STS research paper, I was able to explore the intersectionality of biomedical sciences and racial bias. My Capstone project signified a much deeper problem than inadequate technology: there was an unmistakable racial bias apparent in the design. This caused me to question the diversification efforts of the FDA, the governing body of medial devices, drugs, and biologics in the United States. From there, I was able to develop my STS research question, as I realized this was not an isolated issue and that many medical devices, drugs, and products contain similar racial biases. Both projects informed the other, allowed for me to understand the inner workings of bringing medical products to the marketplace, and informed me of the current diversification efforts of clinical trials in the United States. I am extremely grateful that my projects were closely tied to one another, as this granted me the opportunity to explore both simultaneously and in great detail. The research I conducted this year was invaluable and demonstrated that there is still work to be done to make the American healthcare system equitable.

References

Queensland Clinical Guidelines. (2022). Neonatal Jaundice. *Queensland Clinical Guidelines, 9*(22), 3-31. http://www.health.qld.gov.au/qcg

Winner, L. (1980). Do Artifacts Have Politics? *Daedalus*, 109(1), 121-136. http://www.jstor.org/stable/20024652

Woodgate, P., & Jardine, L. A. (2015). Neonatal jaundice: Phototherapy. *BMJ Clinical Evidence*, 0319.