

Thesis Portfolio

Novel Bilirubin Quantification Method: Computational and *In Vitro* Validation

(Technical Report)

Universal Design: Comparative Costs for Implementation

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Neonatal jaundice presents a common challenge in newborn care due to elevated bilirubin levels. Phototherapy, a standard treatment, uses blue light to photoconvert bilirubin into a more water-soluble isomer, lumirubin, facilitating its excretion. However, existing transcutaneous bilirubinometers often overestimate bilirubin levels in infants with darker skin tones, potentially leading to unnecessary phototherapy treatments and adverse side effects that create racial healthcare disparities. To address this, a novel non-invasive method utilizing bilirubin photoconversion has been proposed and tested by the previous Capstone team. This method measures bilirubin concentrations by assessing the exponential decay of absorbance during blue light exposure. For the technical report, a comprehensive study integrating experimental and computational approaches was conducted to validate this method's efficacy in a more complex and physiologically relevant system.

Experimental models, including *in vitro* flow dialysis and computational partial differential equation (PDE) models, were employed to mimic bilirubin diffusion and photoconversion. The *in vitro* model confirmed diffusion and photoconversion mechanisms, while the analytical PDE model successfully exhibited diffusion out of the control volume and accurately approximated experimental outcomes. This coupled approach aids the understanding of bilirubin transport from hydrophobic to hydrophilic environments within the body.

Results showed moderate to good correlation between experimental and theoretical data, with diffusion-reaction experiments exhibiting the highest predictive capacity. Challenges and limitations included the physiological accuracy of the experimental setup and literature gaps in the characterization of bilirubin and lumirubin transport *in vivo*. Future directions include implementing a system of PDE equations that integrates bilirubin and lumirubin, incorporating

additional factors such as albumin and skin chromophores into the *in vitro* experiments for enhanced physiological representation, and additional validation of the predictive capacity of the analytical model. Overall, this research offers a promising approach for non-invasive bilirubin measurement, potentially mitigating racial biases in neonatal jaundice diagnosis and treatment.

For the STS research, the paper explores the concept of universal design and its critiques in the context of comparative costs. It details the principles of universal design and how they are applied to spaces that shape society. It specifically investigates the accessibility enhancements made on sidewalks and crosswalks after the passage of the Americans with Disabilities Act in 1990 as a case study on the costs of universal design as a barrier for adoption. The conclusion of this case study is that there are greater costs for implementing accessible technology in sidewalks and this has historically prevented adoption of these technologies by municipalities because the cost of these upgrades falls on them. I explored various counter arguments for the idea and practicality of universal design. These included arguments based on resources, impracticality, and a progressive critique that argues the concept of universal design gives the notion that disability has been eradicated and prejudices do not still affect the disabled.

The STS research was inspired by the technical project in that the investigation of a more accurate method of bilirubin measurement for darker skin tones aims to address a racial healthcare disparity. Universal design as a concept looks to eliminate inequality by providing every person with the same maximally good experience. This would theoretically erase disparities like that in bilirubin measurement and across healthcare and society as a whole. While universal design has great ambitions in solving problems of society, there are arguments against its realistic effectiveness and interaction with how society currently functions.