NON-INVASIVE MEASUREMENT OF BILIRUBIN TO BE INCLUSIVE FOR ALL SKIN-TONES

OPTICAL IMAGING: EXPLAINING RACIAL DISPARITIES SEEN IN COVID DEATHS AND TREATMENT

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SOCIOTECHNICAL SYNTHESIS

We live in a world where the quality of healthcare a patient receives is dependent on the color of their skin. Medical devices fail to account for melanin content in the skin, the chromophore responsible for skin-pigment, resulting in the inaccurate measurement of bilirubin in dark-skinned infants with jaundice, a highly prevalent and dangerous disease if not monitored effectively. The technical component aims to remedy this dissonance in the quality of healthcare received by ethnic groups by developing a computational and physical model that coalesce to provide a proof concept of measuring serum bilirubin non-invasively, with no contingency on skin-tone. Biases in pulse oximeters result in a 3.2-fold increased likelihood that dark-skinned patients are not diagnosed for hypoxia and thus do not receive supplemental oxygen that they would otherwise need. These disparities in medical treatment illustrate the importance of creating skin-tone inclusive designs and investigating the design of medical devices through the lens of Pacey's triangle. Tightly coupled, the STS component will examine how skin melanin content can change medical outcomes pertaining to pulse oximeter administration and the Technical will cover the ground work in addressing effective bilirubin measurement.

Monitors tend to overestimate bilirubin concentration in infants with high melanin content due to an overlap in the frequency of absorption of bilirubin and melanin. Because melanin governs skin-tone and is a potent light absorber, this chromophore decreases the amount of light that can be used diagnostically, preventing deeper penetration of image devices. Overestimation of bilirubin levels leads to the infant undergoing phototherapy to treat jaundice for longer than necessary durations which has many negative side effects, including depleting essential nutrients, disrupting the thermochemical environment, and needlessly separating the infant from its mother. The criteria for success of our project is based on the overarching

improvements it aims to achieve over current technologies. Most importantly, this involved utilizing timed photobleaching in order to create a decay curve for individual patients with specific concentrations of melanin.

The team has developed a computational framework in MATLAB that can be adapted in order to determine the optimal photoisomerization wavelength using extinction coefficients and quantum yield of bilirubin and melanin using existing literature. Accomplished deliverables include establishing a procedure to dissolve melanin and bilirubin, which are typically non-aqueous, in an aqueous solution at physiological pH. This allowed us to photo isomerized bilirubin using blue light and tracked the changes in absorbance at regular time intervals which provided us with information regarding the decay rate of bilirubin. The last deliverable was designing a physical model that suggests bilirubin concentration can be estimated in a mixture of chromophores.

There is a similar medical device bias with pulse oximeters. Applying Pacey's triangle to optical imaging, the socio-technical intricacies of this healthcare practice start becoming significantly important. The STS component will examine optical imaging through the lens of Pacey’s Triangle and address the question: what are the challenges in addressing a universally biased clinical measurement device? It is proposed in this thesis that granting societal and ethical considerations a more integral role in the design process allows an enhanced prioritization of both risk-benefit analysis and transparency at each design step.

Importantly, the Technical group has been exposed to many of the challenges associated with ground work and researching methods in attempting to establish an unbiased alternative to bilirubin measurement; our experience and relevant anecdotes transfer over smoothly to the STS analysis. Additionally, revisiting the unintended consequences posed throughout the

development and implementation is imperative to the sociotechnical narrative of a project and its subsequent success. The literature also showed some striking opinions about the relevancy of empathy and ethics in engineering education, highlighting a need to grant ethical and moral considerations more central to the medical device design process.

Understanding that a technology encompasses more than its functional design involves breaking down a project's narrative. This substantive approach to dismantling the technical apparatus is simple in concept, but has rich applications for tracing power, politics, and mythos in these technologies.

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