Thesis Project Portfolio

Designing an Agent-based Model of Placental Development During Gestation

(Technical Report)

Obstetric and Gynecological Health Disparities between Black and White Cis Women in the United States

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

Racial disparities in healthcare in the United States are vast and perpetuated by a history of systemic misrepresentation of, and a society that devalues, non-white people. Obstetrics and gynecology (OB/GYN) — the areas of medicine pertaining to prenatal, pregnancy, and postpartum care, and women's reproductive health — are particularly steeped with a sexist and racist history, and women, especially women of color, still feel these effects today. My technical research focuses on building a computational model that will eventually be able to take a pregnant person's personal health background and ethnoracial-biological trends to predict a patient-specific approach to pregnancy treatments and vaccination, thus maximizing health benefits to the baby. My sociotechnical research investigates the history of obstetrics and gynecology in America to explore how and why there are enduring disparities in OB/GYN healthcare as experienced by white versus Black women. The motivation for both projects is to demystify and bring awareness to the way race impacts biological processes and health outcomes, exacerbated by the gender-specific nature of OB/GYN.

During pregnancy, the placenta develops in the uterus to provide the fetus with oxygen, nutrients, and immunity. Proper development of the placenta is crucial to neonatal health, specifically because transplacental antibody transfer from pregnant person to fetus confers it with early life immune protection. This process has been leveraged to provide neonates with pathogen-specific immunity via vaccination of the pregnant person. However, little is known regarding the mechanisms of transplacental antibody transfer and how it is dynamically regulated throughout gestation, or how it is affected by the pregnant person's health (i.e. chronic stress, diabetes, etc). A recent quantitative mechanistic model, designed to uncover determinants of this process, is able to calculate the concentration of antibody in the neonate given the time of

vaccination of the pregnant person, but it is limited by its inability to account for the placenta's spatial heterogeneity over the course of its development. Here, I used another modeling system to fill in the gap — agent-based models (ABMs) use a set of autonomous, decision-making individuals called agents that interact, act, and react to each other and the environment under the governance of a set of rules. This first version of the model depicts angiogenesis of fetal vasculature at the placental interface, and we used quantitative immunohistochemical images of term patient placenta samples to fit the model to human data. Eventually, the model will uncover how the changes in placental shape and constitution over time affect transplacental antibody transfer, allowing for integration with the quantitative mechanistic model to provide a more complete and accurate model for predicting patient-specific approaches to pregnancy treatments and vaccines.

Health outcomes are impacted by a variety of factors rarely considered in traditional Western medical practices. Interestingly, a person's zip code is a strong determinant of their health outcomes because it holds implications about race, socioeconomic status, and environmental factors. In the United States' racist, sexist legacy, Black people and women especially have been exploited. Black women's bodies were used to advance scientific understanding of the female reproductive system, but Black women who came after do not reap the benefits of that knowledge. Using Langdon Winner's theory of political technology, I discuss how Black bodies have been historically used as technology by controlling which spaces they are allowed into, shaped by and itself shaping political climate in the United States, the repercussions of which are still felt by Black women today.

The extent to which a person's lived experiences influence their biological functions was incredible to observe. My technical project, for which I built a model that simulates the growth

of placental vasculature through 40 weeks of gestation, brought to my attention the sheer quantity of variables that goes into physiological development, in terms of chemicals, nutrients, and such. Black women often have completely different levels of hormones, nutrient absorption, and other factors than even a white woman of similar socioeconomic background, likely because of unique systemic stresses that Black women face. Consequently, a Black woman is biologically predisposed to improper placental development and related issues, which leads to health complications for both mother and child. My thesis describes the history of systemic difficulties Black women face in even receiving quality OB/GYN care. This disparity in OB/GYN care is a comorbidity of the observed biological differences — they exist in a feedback loop, one exacerbating the other, and it all comes together to highlight the dire necessity of dismantling social and scientific systems that perpetuate the disease of anti-Blackness.