Undergraduate Thesis Prospectus

Understanding Pelvic Organ Prolapse: A Comprehensive, Biofidelic Computational Model of the Pelvic Floor

(technical research project in Biomedical Engineering)

Combating Maternal Mortality in the United States

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.
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General Research Problem

How can healthcare be more accessible in the United States?

The United States is a leader in medical advancements. From top-tier healthcare facilities to cutting edge technology, many have claimed the United States has the best healthcare system in the world. However, these cutting-edge treatments and facilities are expensive and racially biased. High-tech healthcare is inaccessible to 28 million Americans, or 13.9 percent of the population. African Americans and Latinos are much less likely to have such access than others (Cha & Cohen, 2022). Healthcare inequities in the U.S. leave millions with insufficient access (Riley, 2012). Healthcare providers, emergency responders, and health advocates strive to improve healthcare access in the communities they represent.

Understanding Pelvic Organ Prolapse: A Model for Customized Medicine

How can pessaries be redesigned to better treat symptoms of pelvic organ prolapse?

Pelvic organ prolapse (POP) is the protrusion of the bladder, vagina, uterus, or rectum caused by the weakening of the vaginal wall and/or connective tissue. POP afflicts 50% of women over the age of 50, a statistic that will affect over 20 million women by 2030 (Aytan et al, 2014; Jones, 2010). POP interferes with daily life due to painful symptoms: sexual dysfunction, pelvic pressure, vaginal bulge, and urinary and bowel dysfunction (Raju & Linder, 2021). Nonsurgical treatment of POP includes pessaries, a broad range of medical devices that mechanically support the pelvic floor. However, pessaries are often ineffective in relieving symptoms of rectal prolapse (rectocele).

Currently, there are few computational models of the female pelvic floor and none model rectocele appropriately, which correlates to the limited understanding of the disease and

consequently ineffective treatments. Such treatments include pessaries, which often fall out or require multiple follow-up visits in a medical office. This prompts patient noncompliance due to inaccessibility, and results in worsening POP. The goal of this capstone project is to develop a computational model of the pelvic floor to better represent the female anatomy and physiology. This computational model will inform the design of a physical model to simulate rectocele and be used to test pessary prototypes to nonsurgically treat symptoms of rectocele.

High quality images of real female pelvic floors, in the form of magnetic resonance images (MRI), will be imported into Fusion 360 computer aided design (CAD) to design the computational model. Finite element analysis (FEA) will be used to study pressure gradients caused by muscle and tissue weakening, to model POP. This model will be converted into a 3-dimensional (3D) printable mold. Silicone will be cast in the molds to develop the physical model, as silicone has mechanical properties, like elasticity, comparable to human tissue. Pessary prototypes will be designed in Fusion 360 CAD and 3D printable. Prototypes will be tested in the computational and physical models. Ultimately, the capstone project will have three end deliverables. One, a computational model that accurately displays the pelvic floor and is capable of modeling pressure gradients representing POP. Two, a physical model, which can be physically handled to comprehend POP and test pessary prototypes. Three, a functional pessary prototype, focused on treating rectocele. The success of this capstone project will lay the foundation for progress towards customized medicine when treating POP.

This biomedical engineering capstone project is advised by William Guilford of the biomedical engineering department, as part of the biomedical engineering capstone class. The project group members are Liza Harold and Mary-Jean Rowson.

Combating Maternal Mortality in the United States

In the U.S., how are advocacies and health professionals striving to diminish maternal mortality among pregnant women of color?

In 2020, the maternal mortality rate for Black women was 55.3 deaths per 100,000 births, a statistically significant 2.9 times higher than that of White women (Hoyert, 2022). The leading causes of maternal mortality include cardiomyopathy, pulmonary embolism, and hypertension. Over 60% of these maternal deaths are preventable (Robeznieks, 2021). Black maternal mortality is due to systemic racism integrated in US healthcare, rooted in slavery. Black female enslaved laborers were used as machines to reproduce the maximum number of enslaved laborers. Experiments were repeated and nonconsensual. Gynecology was created from experiments on Black female enslaved laborers, conducted without anesthesia (Taylor, 2020).

Post-emancipation, structural and implicit racism against Black Americans perpetuates the gap between White and Black maternal mortality. Legislation and public policy affect the environment of healthcare delivery, making healthcare more inaccessible for low-income Americans (Taylor, 2020). Implicit bias negatively affects physician-patient interaction: condescending tone, less diagnostic work, and recommending different treatments based on assumptions of compliance with treatment regimens (Hall et al, 2015). Concerns of Black women are dismissed or not taken seriously. Social determinants, like income and education level, are not positively correlated with better Black maternal outcomes, but are with White maternal outcomes (Taylor, 2020). Flanders-Stepans (2000) found that racial disparities are institutional and suggests actions to be taken by advocacy and government groups. Since the 1970s, such groups have been working towards addressing this system of racism, with an end goal of improving preventable prognoses of pregnant Black females.

Participants include advocacies. The Kaiser Family Foundation (KFF) keeps patients informed about the health policies that shape women's access to care. They remain up-to-date on legislation changes, like the proposal to repeal the Affordable Care Act, and how it "would likely lead to disproportionate coverage losses among people of color" (Artiga, 2020). KFF compiles resources and information about Black maternal mortality. They found that the COVID-19 pandemic disproportionality affected the Black community, and proposed equitable pandemic response as a key to "supporting progress in advancing" maternal health. They call on legislators to take action and initiate progress towards equitable healthcare (Pham et al., 2020).

Another group is Sista Midwife Productions (SMP), a birth advocacy in New Orleans. They provide education and training for communities that work with women of color to eliminate perinatal disparities and "increase the number of community birth workers across Louisiana" (SMP, 2022). Midwives and doulas train to recognize life-threatening symptoms in Black patients, which are often overlooked in hospital settings, and ensure their patients get the attention and treatment they need. SMP provides a platform for Black women to share their birth story and "be a part of the movement to save Black mothers," encouraging discussion of "the good, the celebratory, the traumatic, the painful, and everything in between" (SMP, 2022).

Health professionals, such as those of the Blavatnik Family Women's Health Research Institute, conduct research to find ways to improve maternal healthcare for women of color. Glazer and Balbierz et al (2021) conducted a study on perinatal care experiences in the NICU and found that Black women reported poorer provider communication and responsiveness (Glazer et al., 2021). Betancourt et al. (2003) define the field of "cultural competence" as an area physicians can use to address racial health disparities. The health professional community acknowledges the systemic and implicit racism against Black patients and the difficult task of

addressing it. They work towards equity by conducting self-reflective research to find specific areas for improvement.

Research on efforts to promote equity in other realms of public life can shed light on such efforts in healthcare. Nellis et al. (2008) discuss strategies for combating racial disparity in law enforcement. These same strategies can be translated to combating healthcare disparities. Felicia Ellis, a Black mother, compared "A Black woman having a baby" to "a Black man at a traffic stop" (Eiselt & Lee, 2022). Black pregnant females and their partners have learned they are their own advocates. Ellis says she must "really pay attention to what's going on every step of the way," to avoid being dismissed by medical professionals (Eiselt & Lee, 2022). This unofficial social group of advocates are related to Black women who died from pregnancy-related complications – friends, family, spouses, and children left in the aftermath. They utilize strategic visibility techniques to increase awareness about the Black maternal mortality crisis. Marches, interviews, artwork, and a documentary (Aftershock), advance their agenda of combatting systemic racism and improving the outcomes of Black pregnant females.

In response, the US government's Office of Minority Health and Health Equity (OMHHE), of the Center for Disease Control and Prevention, strives to eliminate health disparities, including the high maternal mortality rate of Black women. One initiative is an annual Black Maternal Health Week, that focuses every "April 11-17 to bring attention and action in improving Black maternal health" (OMHHE, 2022). Part of their agenda is to "develop and implement strategies to address and reduce the impact of gender discrimination and gendered racism…" (OMHHE, 2022). The office conducts public health research, surveillance, and implementation efforts to advance their agenda and address community concerns at the legislative level.

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