Creating a fully functional 3D computational model of the female pelvic region for pelvic organ prolapse simulation

Biases in gender equality in healthcare with an emphasis on research disparities

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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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Introduction

"Pelvic organ prolapse (POP) occurs when one or more of the pelvic organs (vagina, bladder, uterus, urethra, rectum) drop from their position, causing a bulge in the vagina" (*Pelvic Organ Prolapse - Symptoms and Causes*, n.d.). The risk of pelvic organ prolapse (POP) rises as pelvic tissues weaken and muscles stretch due to factors such as aging, menopausal status, and vaginal birth, all of which contribute to the likelihood of its occurrence (*Pelvic Organ Prolapse - Symptoms and Causes*, n.d.). POP causes symptoms such as urinary and fecal incontinence, vaginal spotting, dyspareunia, and abdominal and back pain (*Pelvic Organ Prolapse*, n.d.). Current treatments include pessaries, surgery, and physical therapy, however, these do not have high success rates and recurrence regularly occurs. Unfortunately, these treatments do not fix and strengthen the muscle, they simply fix the bulge. It affects almost 50% of the female population, causing a big issue in female healthcare (Carroll et al., 2022). Recent research studies have shown that some places in the world only have an average of 21.3% of women who seek healthcare after POP diagnoses (Siyoum et al., 2023). This is a concerningly low number for a disease that affects a major function of a woman's body.

Gender biases in healthcare will be examined with an emphasis on research funding disparities. Throughout history, gender has affected every aspect of healthcare. From being the chosen subject for unethical medical testing to suddenly not being allowed into clinical trials due to childbearing abilities, many different influences have impacted the research done in and out of the medical field. This lack of research has caused a multitude of problems, including how, when, and for how much people are treated. It has also affected what diseases researchers study, who is included, and which researchers are funded. This paper will dive into these reasons further to

examine how these biases came to be.

Technical Project Proposal

My technical project involves creating a 3D computational model of a female pelvis, to simulate pelvic organ prolapse. The three main goals for the technical project are building a model of closer-to-normal female anatomy of the pelvic region, validating the finite element simulations using normal material properties, and running simulations with modified materials thought to be associated with pelvic organ prolapse. Building a model as close to normal as possible female anatomy of the pelvic region is the project's biggest and most important challenge. This technical project has been passed down through different groups for a few years, with no significant breakthroughs. The biggest challenge has been finding a modeling system that builds the organs correctly without muscle surface contacts. Currently, the agreed-upon software is ANSYS. Once appropriate software has been found, it is even harder to find available datasets to use for simulations. Most datasets are privately owned or are not usable for this type of research. These datasets are needed for replication in the modeling software.

To test the viability of the model, muscle simulations, such as elastic modulus and tensile strength, using normal material properties will be conducted. Next is testing the contacts between the element surfaces, ensuring they do not fuse during the simulations. Finite element analysis will also be used to test the model. Lastly, simulations with modified material properties that are thought to be associated with pelvic organ prolapse will be conducted, looking at the muscle strengths and elastic modulus. Testing the 3D model with these properties will allow researchers to observe how the POP properties affect the model, the outcomes of the simulation, if the model

is working as designed, and what new treatments could be created based on these known conditions.

This project will be done in a two-part semester solo project, fulfilling the requirements of BME4063 and BME4064 Biomedical Engineering Capstone Design 1 and 2. My focus for the first semester will consist of model creation, with the second semester focused on model simulations.

STS Project Proposal

Gender inequalities exist in every aspect of healthcare, heavily affecting patient care. This dates all the way back to the beginning of civilization and is still a prominent issue in the current world. These biases modify all parts of women's healthcare, influencing everything from the type of treatments offered, insurance costs, pain management and anesthetics offered, wait times in the hospital, dependability to get diagnosed properly, and research funding for gender-specific and non-gender-specific conditions (*Women's Health Research Lacks Funding – These Charts Show How*, n.d.; United States, 2001). This project will focus more on the overall healthcare biases with a focus on research funding. The Social Construct of Technology theory, or SCOT, will be used to identify the origins of healthcare disparities and map out branches such as healthcare, funding, and history.

The National Institute of Health (NIH) supplies hospitals, universities, and companies with billions of dollars every year for all types of medical research. In 1990, the Office of Research on Women's Health (ORWH) was created in an effort to combat the disparities observed yearly in the NIH funding statistics (Douthard et al., 2022). The ORWH had three major goals:

"to strengthen, develop, and increase research into diseases, disorders, and conditions that are unique to, more prevalent among, or more serious in women, or for which there are different risk factors for women than for men; to ensure that women are appropriately represented in biomedical and biobehavioral research studies, especially clinical trials, that are supported by the NIH; and to direct initiatives to increase the number of women in biomedical careers" (Douthard et al., 2022). As much as these seemed like realistic goals, the NIH still has a huge gap to fill. In 2023, the work of Arthur Mirin was published in an article by Nature, detailing that the gap was still very prevalent (*Women's Health Research Lacks Funding – These Charts Show How*, n.d.). This study had a few conclusions. First, studies were not funded based on disease burden, meaning many of the diseases that affect women the most were lower on the payment chart, despite being on the higher side of burden disease. Second, following the same trend, lethality to funding is skewed, with gynecological cancers being one of the most underfunded cancers yet one of the biggest killers (*Women's Reproductive Cancers Are Among The Most Deadly And Most Neglected. How Do We Fix This?*, n.d.). Third, clinical trial participation was examined as a factor for funding. Women were underrepresented in trials where women's burden was higher, yet overrepresented in other trials. This dates back to when clinical trials were created, as women were not originally allowed to participate due to the potential to harm childbearing abilities (Rothenberg, 1996). Finally, non-gender-specific diseases had less research on gender-specific symptoms which is a huge problem because most diseases, like cardiovascular disease, affect every organ in the body (*Women's Health Research Lacks Funding – These Charts Show How*, n.d.). Without women-specific research on diseases, standard treatments will be made based on non-gender-specific symptoms. This could cause women-specific symptoms to not be recognized

as a way to identify the disease, causing patient diagnosis to be missed and patients left without effective treatment.

On the other side of the healthcare research field, there are biases towards who gets awarded research grants. A study was conducted over a span of 25 years, 1995 - 2020, investigating 2,078 surgeon-scientists (Nguyen et al., 2023). They found that despite an increase of women in the surgeon-scientist field, funding was still underprovided for women. Women were also 25% less likely to be appointed as a super primary investigator, the person in charge of a research project (Nguyen et al., 2023). This lack of scientific leadership exemplifies the need for a change in the research field.

Established as a surgical specialty in 1889, the field of gynecology has evolved over several decades and has added to the amount of gender inequality experienced today in healthcare. Dr. James Marion Sims is known as "the father of modern gynecology" however, he contributed to the many unethical medical practices patients have experienced (*The 'Father of Modern Gynecology' Performed Shocking Experiments on Enslaved Women*, 2018). He surgically practiced on non-consenting women, without the use of anesthetic, which helped form the idea that women don't need as much pain medication as men, even though these women went through excruciating pain in as many as 32 surgeries (*History of Modern Gynecology*, n.d.). This lack of pain belief is still experienced today, as an intrauterine device (IUD) insertion, a popular form of birth control, does not require the use of anesthesia or pain medication, even though the cervix is pierced during the procedure. Pain bias goes even further during birth, causing higher maternal death rates and lower pain medication doses for the mothers. Birth is already a scary and sometimes life-threatening event, thus adding these extra factors simply leads to additional stress on the mother and child. The book titled *The Pain Gap: How Sexism in Healthcare Kills Women*

explains these experiences firsthand, discussing how the author had unexplained, invasive, medical treatments pre and post-birth and experienced condescending, comments and conditions from her doctors who she is meant to trust while staying in the hospital (Hossain, 2021). Women also have longer wait times in the waiting rooms, highlighting the biased idea that women can wait longer due to their higher pain tolerance (*Women Wait Longer for Hospital Emergency Room Care than Men, Study Finds - UPI.Com*, n.d.). Doctors also usually do not believe women when they have medical problems, resulting in a diagnosis of hysteria and anxiety. This causes women to make multiple medical trips and years of self advocating before finally getting a correct diagnosis, delaying treatment and dissuading any patient-doctor trust. This affects research by skewing the amount of patients affected by diseases. Research affecting smaller populations will be more likely to not be pursued, causing a negative cycle of effects.

This causes higher pricing for medications, medical insurance, treatments, and hospital stays. In a study conducted by the Agency for Healthcare Research and Quality, researchers concluded women pay more in almost all healthcare categories (United States, 2001). In comparison to men, women were more likely to have healthcare expenses, with a difference of $57 billion between the two groups. Additionally, women had a higher out-of-pocket cost compared to their counterparts. Ambulatory care and medication costs were consistently higher for women as well. The researchers also discovered an interesting statistic that women aged 18 - 29 were the least likely to have a primary care provider (United States, 2001). Another big issue in healthcare inequalities is the amount of gender-specific doctors. Doctors who specialize in gynecology will have greater knowledge to help patients compared to a standard practitioner. For example, in 2020, there were only 1,178 actively practicing gynecological oncologists in the United States (*Geographic Disparities in Potential Accessibility to Gynecologic Oncologists in*

the United States From 2001 to 2020, n.d.). Care cannot be offered at a high enough standard if there are not enough doctors available to provide this level of care.

Conclusion

Many issues regarding healthcare imbalances, including research based on one's gender, have existed for centuries and still have yet to be fixed. I believe that many different factors, including the government, gender standards, and healthcare standards, are to blame for this imbalance of research and gender healthcare biases. For this project, I will use SCOT, to analyze how everything fits together (figure 1). In SCOT gender inequality will be at the center, with branches such as healthcare, funding, and history used. These biases are not unfounded, so I will use this theory to help trace back the origins of women's healthcare, specifically trying to find the reasoning behind a lack of research funding for gender-specific research in the field of women's health. Hopefully, these key ideas can be identified and used to help unbias the medical world.

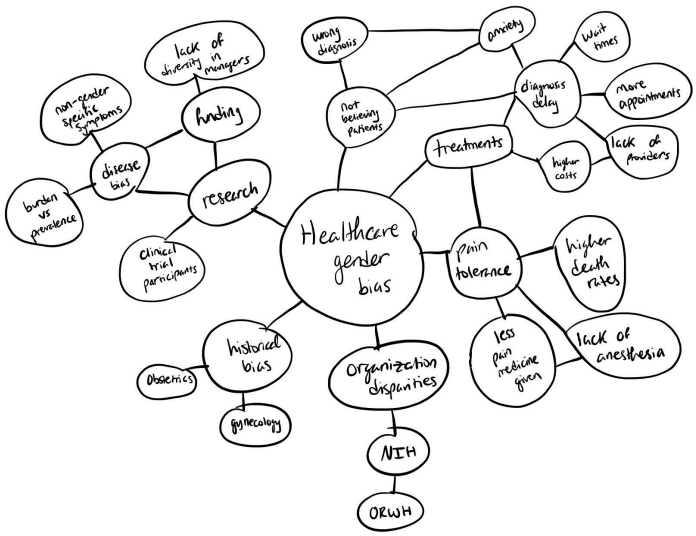

Figure 1: This is a SCOT map analyzing the branches of healthcare gender bias to determine the causes of unequal treatment in the medical field

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