Thesis Project Portfolio

Analysis Methods on Imaging Endothelial Adaptation Under Flow

(Technical Report)

Gender, Race, & Socioeconomic Status: The Role of Intersectionality in Clinical Research

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Ramneek Kaur

Spring, 2025

Department of Biomedical Engineering

Table of Contents

Sociotechnical Synthesis

Clinical research is a formative part of understanding disease manifestation and progression, allowing for proper treatment for patients. However, the representation of women as patients in research is still severely lacking, with one study by Bierer et al. (2022) finding that women comprised less than half of the participants in oncology clinical trials, and Black and/or Hispanic patients comprised only 8-11%. This underrepresentation results in inadequate knowledge of how diseases and treatments impact different groups, building upon the inequities of the healthcare system. The technical project, focused on the disease of cerebral cavernous malformations (CCM), relates to the problem of underrepresentation concerning the earlier stages of clinical research. CCM is a disease that impacts various ethnic groups differently in terms of prevalence and types of gene mutations, making the diversity of human-derived cell lines crucial for understanding all forms of CCM. My STS paper looked deeper into the barriers in the clinical research process specific to women across racial, ethnic, and socioeconomic status, and how they prevent their participation in research.

CCM is a disease that impacts 1 in 500 people, where the blood-brain barrier loses its regular function, resulting in an increased risk of toxic substances entering the brain tissue (Zafar et al., 2019). My technical project focused on understanding the mechanisms behind the disease, specifically the role of the KRIT-1 protein, by improving the analysis of cell adaptation to fluid flow through automated methods of image analysis. This was done by running parallel plate flow chamber experiments on bovine aortic endothelial cells and imaging them to analyze how they adapted to flow over 24 hours. Through these experiments, we were able to improve and automate an image analysis method focused on calculating orientation angles and elongation ratio of the individual cells. While our project was at the stage of using animal-derived cells,

utilizing human-derived cell lines is common later on in the process, which is where representation of patients in clinical trials comes into play with future iterations of the project.

The STS research focused on analyzing the internal and external barriers women face when it comes to participating in trials based on their different social identities, to understand factors resulting in women's underrepresentation. Using the intersectionality framework as the analysis method, it was found that the exclusion criteria of contraception usage were prevalent when looking into reasons why women of all groups were underrepresented in clinical research, as the requirements were targeted towards female patients and assumed their personal life choices. Time was found to be an important personal deterrent limiting women from participating in these trials, due to the time constraints women face from taking on a larger brunt of household responsibilities. As the identities of these patients intersected, the impact of these barriers severely increased. This analysis allowed for a better understanding of how social identities shape women's experiences with clinical trials, with the barriers specific to the identities of gender, race/ethnicity, and socioeconomic status.

From the technical project, different image analysis methods were evaluated to determine the most accurate way of analyzing cell orientation and shape changes before and after flow. To continue understanding the formation of CCM, future research focused on knocking down the KRIT-1 protein and performing permeability assessments using transendothelial electrical resistance will be beneficial in determining the exact role of the protein in this disease. With the STS research, exclusion criteria regarding contraception usage and language requirements, and personal deterrents, like mistrust and lack of time, were determined to play a big role in the underrepresentation of women in clinical research. Understanding these factors can help mitigate these barriers for women of all backgrounds and improve their clinical trial participation. By

properly evaluating exclusion criteria to find any hidden biases against certain groups, making trials more accessible on the basis of time and money, and taking initiatives to build a trusting relationship between the patient and medical professionals, the healthcare field will be able to take a step forward towards a more equitable system.

I would like to thank the professors who have supported and guided me throughout this thesis, including Caitlyn Wylie and Brian Helmke. I would also like to thank my capstone teammate for always being committed and determined throughout our technical project, as well as the undergraduate students who supported us through the training portion of our project. Lastly, I would like to thank my peers, friends, and family for their continuous support and encouragement throughout my time here at the University of Virginia.