Thesis Project Portfolio

Computational Flow Dynamics for Pediatric Congenital Heart Disease

(Technical Report)

Disproportional Effect of Congenital Heart Disease on People of Low Socioeconomic Status

(STS Research Paper)

An Undergraduate Thesis

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

University of Virginia • Charlottesville, Virginia

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Spring, 2024

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April 19, 2024

Introduction

My STS and Technical research projects are both in the area of Congenital Heart Disease (CHD). CHD is an abnormality in the heart that develops before birth and affects around 1% of all live born births worldwide. My technical project involves using computational flow dynamics on patient CT scans to model blood flow to each part of the lungs, while my STS project takes a holistic view on Congenital Heart Disease and explores the reasons why people of a low socioeconomic status are more likely to be diagnosed with CHD.

Technical Project

Congenital heart disease (CHD) poses significant challenges in pediatric cardiology, requiring precise diagnosis and treatment strategies. Given the variability and uncertainty in treatment plans between congenital heart disease patients, it is imperative that pediatric cardiologists use every tool at their disposal to create more accurate diagnoses and treatment plans. In response, my project aimed to take an element of this subjectivity away by creating a process that can take in a CT angiogram scan, create a 3-dimensional model out of it, and quantify blood flow to each section of the lungs. The output of this program is the same output of performing a nuclear lung perfusion scan, but only requires the patient needing a single CT scan which is done as standard practice anyways. In a nuclear lung perfusion scan radioactive contrast is injected intravenously, and a gamma camera is used to take scans at multiple angles. Doctors are able to see the percentage of blood perfusion to each part of the lung based on this scan, and often use it before and after catheterization procedures. Although my technical project did not

get to a level of accuracy where it could replace this scan in the clinic, future steps will allow cardiologists to get quick blood flow data before, after, and even during catheterization procedures, ultimately reducing patient cost and improving clinical outcomes.

STS Project

The STS portion of my project aimed to explore the disparities seen with congenital heart disease disproportionately affecting individuals who are part of a lower socioeconomic status. Through a thorough literature review I first proved that this disparity seen with low-income families being more predisposed to CHD does in fact exist. Given that CHD is a genetic disease, I then determined that a major epigenetic factor that can lead to a higher risk of CHD overtime is environmental pollutants. Lastly, I determined that low-income families are consistently being exposed to more environmental pollution than the rest of the population. Given this established research on the topic, my paper took this a step further by analyzing the reasons why these low-income families are being forced to live in areas that are far more exposed to harmful environmental pollutants and why the same is not happening for higher-income families. Through the use of historical analysis and policy research, I used a variety of primary and secondary sources to understand government zoning laws in urban contexts and why these areas are highly polluted. I also analyzed my research from the perspective of Langdon Winner's "Do Artefacts Have Politics?" framework. I explored government housing historically being built on cheap and undesirable land, historical exclusionary zoning laws, and policy on superfund sites. The analysis revealed stark realities for some families in America such as deliberately placed housing complexes in polluted industrial areas to zoning practices that confine them to undesirable neighborhoods, it's clear that systemic neglect and exploitation persist. The proximity of housing projects to superfund sites highlights the health risks faced by residents,

and the lack of legislative action leaves communities vulnerable and unprotected. I recommended that the ultimate way to start fixing these systemic problems is by implementing legislation for government housing locations and the effective cleanup of superfund sites.

Reflection

Doing both projects simultaneously gave me a unique perspective on each project as the year progressed. For example, when doing the technical project and reflecting on the outcomes that project could produce in the future, I knew this would ultimately benefit the patient with more accurate and cost efficient care. When thinking about the disparity with CHD diagnosis and low-income families, my technical project could potentially help this population with more affordable and accessible CHD care due to reducing patient costs by eliminating nuclear lung perfusion scans. By performing my technical project I also became very familiar with the nature of Congenital Heart Disease, and in my STS project it was fascinating to see the effect of epigenetic factors on CHD prevalence and dig deeper into the background of the disease itself. In today's world, it is imperative that researchers, especially in the medical field, are aware of the biases and social trends present in the topics being researched. This leads to more thoughtful and applicable research questions, as well as more impactful results that will ultimately move the world forward together. In my case, doing both projects simultaneously led to a more holistic understanding of the issues presented.