

Engineering a Resilient Regional Healthcare System

An Analysis of the Effect of Patient-Doctor Communication on Health Outcomes

A Thesis Prospectus

In STS 4500

Presented to

The Faculty of the

School of Engineering and Applied Science

University of Virginia

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Science in Biomedical Engineering

By

Kayla Perkins

October 14, 2021

Technical Team Members: Sophie Fossett, Ketki Morabkar, Emily Pham

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.

ADVISORS

Dr. Sean Ferguson PhD, Department of Engineering and Society

Nathan Edwards, Principle Engineer, The Mitre Corporation

Introduction

Every year, 805,000 Americans have a heart attack. About 12% of these annual heart attacks are fatal¹. Onset of a heart attack begins when a blockage occurs in the coronary artery which limits or stops the blood from reaching the heart. The block is typically caused by cholesterol triggering a clot factor, resulting in fat either forming on the artery walls, or breaking off the walls as plaque and forming a clot². Factors that can cause a greater probability of having a heart attack include: gender, race, household income, age, tobacco and drug use, obesity, and diabetes among others^{2,3}. The heart attack treatment timeline includes lifeline ground and air emergency services to the hospital, surgery with balloon angioplasty, stent placement, or coronary artery bypass, cardiac rehabilitation, then ongoing medications⁴. However, it is also important to consider preventative care, such as eating healthy, early detection of lipid buildup, and post-heart attack care in order to reduce the burden on healthcare facilities. The social determinants of health are relevant to heart attack morbidity because although 12% of all heart attacks are fatal, this percentage is much greater for non-white individuals and individuals that have less education and are impoverished.

When researching the impact of patient demographics on medical outcomes, it became apparent that a lack of human understanding of each other results in the complication of medical care. As a result of this, it is critical to analyze how cultural similarities can empower patients to express their medical needs and differing language and communication techniques can result in a power dynamic that makes receiving proper healthcare more difficult. **My aim is to dissect how the way that a patient communicates during a doctor's visit determines the outcome of their care. I will focus on patient versus clinician demographics and how cultural differences between the groups result in differential treatment and care for patients.**

The STS topic is closely related to the Capstone technical project as the technical project analyzes social determinants of health in a multivariate function to improve heart attack outcomes in the specific region of Indiana. Meanwhile, the STS topic is designed to dissect how culture, language, and communication affect medical outcomes while using the Sociotechnical Systems, Users, and Practices framework. While the technical project uses mathematical operations to engineer a solution, the STS project will analyze scholarly articles written by clinicians and patients to dissect the current situation to be used as insight for the problem and a stepping stone for those who would like to begin to rectify the issue of inequalities in healthcare.

Technical Topic

The team will research heart attacks within the state of Indiana and analyze the delivery resource data within the state. Our objectives are to create a multivariate objective function and then to apply real world constraints to optimize the model. We will then make visualizations that document outcomes to inform and create new public health strategies to allow for more equitable access to cardiac treatments that lower Indiana's morbidity rates associated with heart attacks. While each person on the team will lead a designated portion of the project, these roles are still being determined as we are continuing the preliminary work or researching data sets.

The state of Indiana was chosen for the region to be optimized as it is ranked 32nd out of 50 for the best healthcare by US states⁵ and 38th out of 50 for the heart disease mortality rates⁶ as of 2019. The aim is to dissect the discrepancy between the two rankings and why New Mexico, which is ranked 33rd for the best healthcare, is ranked 26th for mortality rate. By determining why New Mexico with a similar

but slightly worse ranking for overall healthcare treatment is so much more successful with heart attack outcomes when compared to Indiana, Indiana will be able to modify their treatment delivery resources to improve their patient outcomes. Additionally, after creating and analyzing the model, it can be modified and optimized to be applicable to numerous regions in the United States to be used as a national tool in decision making for allocating healthcare resources.

The preliminary function will consider 15 design specifications such as the patient's county's wealth, patient's race, patient's biological gender, patient's education level, patient's household income, treatment availability, and more. If the project's timeline/deadline permits, the team will also use simulations to visualize and validate the efficacy of the multicriteria decision model in informing recommendations on public health delivery strategies. The simulations will be using an online agent based software that can include real world constraints that put pressure on the healthcare delivery system (such as a pandemic) to assess resilience and adaptiveness of the model.

STS Topic

The framework that this topic will be explored under is Hess and Sovocal's Sociotechnical Systems, Users, and Practices⁷. The system that will be explored is the healthcare system that is involved in treating patients including but not limited to: hospitals, primary care physicians, and first responders. In analyzing the system's users, it is important to not just consider the patients, but also the clinicians and others employed by the healthcare system. The reason to consider the employees of the system is that they are critical to the "deployment and operation of the system⁷." The important thing to note within this framework is that when the "connected aspects of human social life that are based on shared understandings and skill⁷" are to be evaluated, the shared understandings are not necessarily factual. For example, both known and subconscious biases are based on what society teaches individuals even though they are typically rooted in ignorance rather than truth. As a result, when the users of the system impact the practices, they are acting on what has been taught to them rather than what is an unequivocal fact. This will form the basis of how different users within the system are treated unequally based on their demographics resulting in varying levels of care.

Regarding race, it has been found that when comparing black and white patients admitted to hospitals for cardiovascular disease, the black patients are 33% more likely to die in the hospital regardless of care quality. Regarding gender, women are less likely to receive cardiac care when complaining of chest pains which puts them at 25% more likely to die in the hospital if cardiac specific care is not provided⁸. This data was collected in 2018 by the American College of Cardiology's Cardiology Magazine with the motive of seeing if discrepancies in patient outcomes had changed since the Institute of Medicine conducted a similar report 17 years prior. The conclusion that can be drawn is that very little has changed regarding making morbidity rates consistent across patient demographics. Regarding overall life expectancy, it has been found that Asian Americans have the highest life expectancy of 84.9 years, then white Americans in rural Northern Plains/Dakotas, then low-income whites in Appalachia and the Mississippi Valley, then western Native Americans, then middle-income blacks, then southern rural blacks, and lastly blacks in poor urban areas with a life expectancy of 71.1 years. It is critical to note that the lowest three groups all identify as black and that race played more of a factor than income, as it could be seen that low-income whites had a higher life expectancy. Additionally, the overall gap of 13.8 years displays a statistically significant gross inequality of life expectancy across these groups⁹. From this data, the practice that must be explored is how communication plays a role in

doctor/patient relationships. Is it racial discrimination, a lack of patients being able to be understood by their physician, cultural differences between the physician and their patient, or a combination of all three that results in differing patient outcomes?

Dr. Warren J. Ferguson is the Director of Academic Programs, Health and Criminal Justice Program as well as a Professor and Vice Chair of the Department of Family Medicine and Community Health at the University of Massachusetts Chan Medical School. His interest in mediating health disparities for vulnerable communities¹⁰ led to him investigating this topic on Culture, Language, and the Doctor-Patient Relationship. What he found was that patients that have less of a command of the English language receive less emotional care from their healthcare providers and do not develop long lasting relationships with them. Those results caused the patients to not receive as much information about their conditions as well as less say in how they are treated when compared to their white counterparts but more so their English speaking counterparts¹¹. Ferguson's exploration shows the importance of fluency in the same languages, however, different vernaculars within the same language must also be analyzed for their impact on medical outcomes. While many people speak the same language, different regions and cultures may adopt vastly different meanings for the same words as well as unspoken connotations associated with certain phrases. As a result, it is critical that doctor's have education on the cultural practices of their patients. Even more so, it is necessary for the career path of a clinician to become more accessible so that physicians of varying backgrounds can connect with their patients on shared experiences. In my thesis, I will continue to explore cultural impacts on the doctor-patient relationship and look into what type of patients are receiving medical care and how to make the field of doctors more closely resemble the backgrounds of their patients.

Next Steps

Technical Topic

1. Continue to collect data sets that fulfill our 15 design specifications.
2. Determine what type of multivariate function will be used.
3. Create 92 functions (for each county in Indiana) as each function will be a sample in our t-test.
 - a. The base function will be the same for each county, however, the data inputted into the variables will be dependent on the county.
4. Run a t-test on the efficiency of our proposed healthcare model (u_A) compared with the efficiency of the existing system (u_B).
5. Run agent based modelling to optimize our function to see how stresses such as a pandemic would affect the model and the time that it takes to return back to normal.

STS Topic

1. Research what underlying factors in medical systems are racist that can result in bias in data. For example, do certain calculations take race into consideration or do not take it into consideration when it should that would improve outcomes for non-white patients?
2. Research the background demographics of physicians and if physicians tend to treat the communities in which they grew up. Also, look into backgrounds of nurses, EMTs, etc. to see if patients are represented in other healthcare interactions.

3. Research how education impacts language and communication styles and if vernacular languages such as AAVE has an impact on communication with physicians such as the article that was read for STS 4500 about the researcher that did not understand the language used in tweets and how that affected how AI classified the nature of the tweets.
4. Research how criteria for medical school admissions has changed over the years and what it currently is to see what barriers to entry there are for physicians and how language is a factor.

References

1. E. J. Benjamin et al., “Heart Disease and Stroke Statistics—2019 Update: A Report From the American Heart Association,” *Circulation*, vol. 139, no. 10, Mar. 2019, doi: 10.1161/CIR.0000000000000659.
2. Mayo Foundation for Medical Education and Research. (2020, June 16). *Heart attack*. Mayo Clinic. Retrieved October 14, 2021, from <https://www.mayoclinic.org/diseases-conditions/heart-attack/symptoms-causes/syc-20373106>.
3. E. S. Ford et al., “Explaining the Decrease in U.S. Deaths from Coronary Disease, 1980–2000,” *N. Engl. J. Med.*, vol. 356, no. 23, pp. 2388–2398, Jun. 2007, doi: 10.1056/NEJMsa053935.
4. “Level One Cardiovascular Emergencies Programs,” IU Health. Retrieved October 14, 2021 from <https://iuhealth.org/find-medical-services/level-one-cardiovascular-emergencies-programs>
5. “Best States for Healthcare | US News Best States.” Retrieved October 14, 2021 from <https://www.usnews.com/news/best-states/rankings/health-care>
6. “Stats of the States - Heart Disease Mortality,” (2021, Feb. 08). Retrieved October 14, 2021 from https://www.cdc.gov/nchs/pressroom/sosmap/heart_disease_mortality/heart_disease.htm
7. Hess, D. J., & Sovacool, B. K. (2020, February 17). Sociotechnical matters: Reviewing and Integrating Science and Technology Studies with energy social science. *Energy Research & Social Science*. Retrieved October 5, 2021, from <https://www.sciencedirect.com/science/article/pii/S2214629620300396?via%3Dihub>. Section 4.4
8. Cover story: One size does not fit all: The role of sex, gender, race and ethnicity in Cardiovascular Medicine. *American College of Cardiology*. (2018, October 19). Retrieved October 5, 2021, from <https://www.acc.org/latest-in-cardiology/articles/2018/10/14/12/42/cover-story-one-size-does-not-fit-all-sex-gender-race-and-ethnicity-in-cardiovascular-medicine>.
9. Havranek, E., Mujahid, M., Barr, D., Blair, I., Cohen, M., Cruz-Flores, S., Davey-Smith, G., Dennison-Himmelfarb, C., Lauer, M., Lockwood, D., Rosal, M., & Yancy, C. (2015, August 3). *Social determinants of risk and outcomes for cardiovascular disease*. *Circulation*. Retrieved October 14, 2021, from <https://www.ahajournals.org/doi/10.1161/cir.0000000000000228>.
10. Warren J. Ferguson. (n.d.). Retrieved November 2, 2021, from <https://commed.umassmed.edu/experts/warren-j-ferguson>.
11. Ferguson, W. J., & Candib, L. M. (2002, May). *Culture, language, and the doctor-patient relationship*. eScholarship@UMassChan. Retrieved November 2, 2021, from https://escholarship.umassmed.edu/fmch_articles/61/?utm_source=escholarship.umassmed.edu%2Ffmch_articles%2F61&utm_medium=PDF&utm_campaign=PDFCoverPages.