OPTIMIZATION OF THE UVA INFUSION CENTER WORKFLOW

UNDERSTANDING RACIAL DISPARITY WITHIN INFUSION SCHEDULING

A Thesis Prospectus
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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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In the past decade, oncology programs across the country have expressed challenges in optimizing infusion center workflow, leading to the formation of the Infusion Efficiency Workgroup by the National Comprehensive Cancer Network in 2015 (Sugalski et al., 2019, p. 458). The University of Virginia (UVA) Health System encompasses four different infusion centers in the Greater Charlottesville area, and these centers serve a majority of residents within central and southern Virginia. Due to increased demand, supply chain considerations due to lasting COVID implications, and continual short staffing, the University of Virginia Cancer Center leadership team desires outside consulting services dedicated towards creating a more strategic plan and efficient use of their main infusion center, the UVA Infusion Center in the Emily Couric Cancer Center. As a healthcare institution, the infusion center aims to serve as many patients as possible while maintaining safe conditions for both the patient and nurse. However, the leadership team and consulting team are concurrently motivated by revenue and profit maximization, as the infusion center serves as one of the top revenue generating entities within the hospital.

The UVA Infusion Center has already made changes to their operations within the past two years, specifically funneling optimal scheduling of appointments through a popular infusion center scheduling software, iQueue. Scheduling is commonly seen as the first leverage point in these optimization problems, but many of these software systems are prone to creating racial healthcare disparities through their algorithms. Thus, in a tightly coupled fashion, this science, technology, and society (STS) paper looks to analyze how current data collection issues, "no-show" data, and other scheduling data can identify how the introduction of these new software affects existing racial disparities. Consequently, these findings can evaluate the social impacts of scheduling software, like the one introduced in the UVA Infusion Center, and if the heightened efficiency comes with a tradeoff of racial equity.

Both the technical and STS portions of this project include a variety of deliverables throughout the process, which ultimately lead to a final deliverable. A portion of these deliverables have already been completed in the first semester. In terms of the STS paper, the Statement of Topics assignment and Annotated Bibliography assignment have already been completed in order to prepare for this Prospectus. This Prospectus will be fully completed and signed off by both advisors by the end of the semester, and the spring semester timeline includes the Sociotechnical Executive Summary and STS Research Paper as the two main deliverables, both due before graduation. Meanwhile, the technical project has focused on project scoping, preliminary analysis, and observations thus far, with an interim report outlining pilot tests for the Cancer Center leadership being the main deliverable due at the end of the semester. Finally, the technical project requires an abstract in February, an Institute of Electrical and Electronics (IEEE) formatted paper for the System Information and Engineering Design Symposium (SEIDS) in April, and a final report for Cancer Center leadership at the end of the spring semester.

OPTIMIZATION OF THE UVA INFUSION CENTER WORKFLOW

The UVA Infusion Center located within the Emily Couric Cancer Center is the largest infusion clinic in the UVA Health System (UVAHS). Of the four main infusion locations offered, the UVA Infusion Center accounts for over 60% of the patient visits within the system. Daniel Kilgore, the Director of Service Line Business Development at UVAHS, and his team initially set the problem as a lack of efficient utilization of the fifty-four infusion chairs within the center, mentioning the center’s economic contribution to the health system as a significant factor. D'Anna et al. (2022) reaffirms this infusion center revenue dominance, citing that infusion centers are the driving revenue factor in the field of rheumatology (p. 1044). Sugalski et al. (2019) claims inefficient operation and long wait times are a driving force in negative satisfaction scores and perception of treatment from a patient perspective, widening the significance of this problem to patients as well as leadership (p. e461). This optimization problem can be measured by maximizing revenue per chair per day from a quantitative business perspective. However, our analysis incorporates the Systems Engineering Initiative for Patient Safety (SEIPS) model proposed by Carayon (2006), which organizes a system into domains of technology, organization, person, tasks, and the environment (p. i50). Thus, patient safety, nurse status, technological improvements, and connected organizations will also factor into holistic scope and overall analysis of the system.

Led by Rupa Valdez, an associate professor in Engineering Systems and the Environment and Public Health Sciences, and aided by the UVAHS duo of Jose Valdez, a Senior Operations Research Scientist and Health Systems Scientist, and Karen Measells, a Senior Operations and Systems Engineer, the capstone team is composed of three fourth year systems engineering students: myself, Anna Bustamante, and Hayden Ratliff. The objective of this project is to first provide a general understanding of the infusion center workflow, as leadership is currently unaware of if and where inefficiencies lie within the process. The work is classified as a quality control and improvement study, and thus does not require Institutional Review Board approval. The workflow of the system, including patient, staff, and information perspectives is mapped in Figure 1 on page 4. Second, we aim to identify key leverage points within the outlined workflow based on data analysis of data from the prior fiscal year and observations conducted within the infusion center. According to Gourdji et al. (2003), wait time and interaction time are two main customer experience variables, so leverage points effectively shorten one of those two areas (p. 46). Our project breaks these two temporal categories into even more granular distinctions to improve desired outcomes. Next, the capstone group plans to pilot test one or two of the most leverageable and actionable solutions in order to collect experimental data on whether the piloted change had an effect on the utilization or underlying revenue creation. According to Valdez et al. (2010), it will be necessary to encourage “workshop participants’ belief in the adequacy of current ISyE knowledge” during this process (p. 832). The pilot test results will be analyzed to judge the effectiveness of the solution, and an actionable plan to test other workflow improvements will be delivered to the infusion center leadership team.

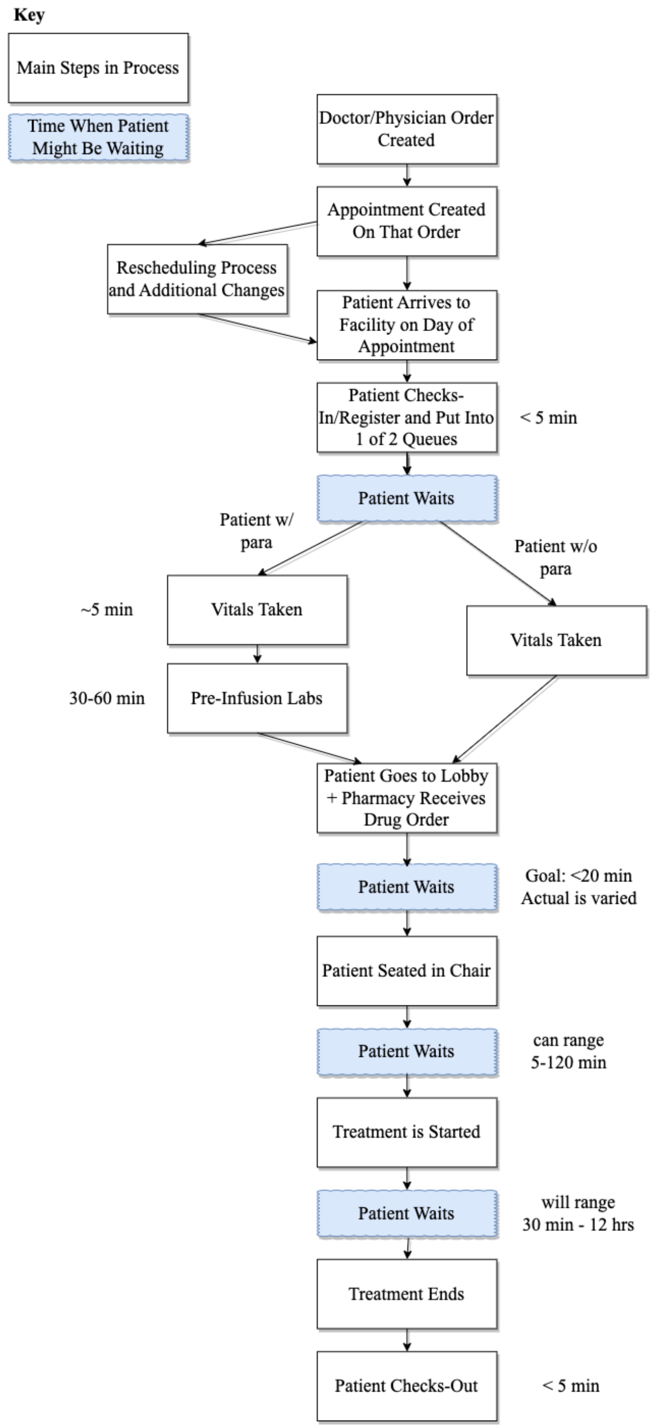

Figure 1: Process map of clinic workflow. The workflow of the patient, clinic staff, and patient information when they enter the clinic for an appointment. Each phase has an estimated or goal time based on the data. (Created by Zavacky (2022) with Diagrams.io)

Ultimately, this process of problem scoping, infusion center observations, follow-up staff interviews, data analysis from the prior fiscal year, and an experimental pilot test and evaluation yields an increase in current utilization towards the theoretical capacity of the infusion center. However, the initial anticipated outcome is a decrease in visit time for a patient, due to a decrease in either wait or interaction time. In the short term, a decrease in visit time will create a decrease in utilization before schedulers are adapted and confident with the resulting faster visits from the tested changes. Additionally, this desired outcome is qualified by the fact that this increase in utilization needs to occur with a stability or increase in revenue and patient safety. This value tradeoff is highlighted by Blackmer et al. (2020), where they significantly improved wait time through changing pharmacy operations, but also increased waste in doing so (p. 1458-1459). This idea of value brings us back to our underlying metric of improving revenue, which should encompass both more patients and less waste. The background research, outlined methods above, and actual outcomes will be published in an IEEE-formatted scholarly paper and presented at the SEIDS conference in April.

UNDERSTANDING RACIAL DISPARITY WITHIN INFUSION SCHEDULING

Optimization within healthcare, including infusion appointments, rely on complex scheduling software and automation practices. In many scenarios, the mathematical models fueling this software can adjust based on lengthy visits and fill unexpected openings at a rapid pace (Issabakhsh et al., 2021, p. 117). These scheduling technologies have been viewed as a “black box”, but recently individuals have begun researching if this software treat all patient identities correctly. Samorani et al. (2021) exposes differing “no show” rates in racial groups as one factor creating bias in the objective function of these scheduling programs, and ultimately creating longer waits and a worse patient experience for the minority racial groups with lower show probabilities (p. 16). As the movement towards these scheduling software increases, especially in regards to infusion centers, it will become important to first understand where these biases can be introduced and to train these algorithms to be resilient against such results. Many current solutions explicitly factor in race in some capacity to counter biases within these models, neglecting the sensitivity of the data collection realm and leaving space within this topic to still offer more research.

Additionally, there are social and legal implications involved with data collection for such software and the bias created by this software, which heighten the significance of such a problem. Prior qualitative assessments exposed racial disparities from human shortcomings, such as improper symptom diagnosis and reporting, for chemotherapy infusions (Robertson-Jones et al., 2018, p. 94). Improved technology will only worsen these issues if fed improperly reported data. Even if the data collected is accurate, the act of collecting data on identity traits can create a negative healthcare environment for both patients and practitioners. In her work, Cruz (2020) concedes that data collection and analysis can theoretically inform local providers about their patient population and specific needs, but also showcases the practice of data collection can worsen the patient experience and add difficulty to the practioner's duties (pp. 5-9). Thus, the benefit of solutions that do not explicitly factor in race or need racial data is evident. From a legal perspective, it is significant to understand these algorithm biases and propose alternative solutions in order to uphold a country or state's safety laws. For example, California's attorney general, Rob Bonta, is currently investigating this issue of scheduling algorithm bias, and Bonta (2022) writes "Government Code section 11135, Health & Safety Code section 1317, Civil Code section 51 et seq., and Business & Professions Code section 17200 et seq., as well as related federal laws" as the main legal areas of importance (p. 1).

In order to better understand and work towards a solution of minimizing racial bias within scheduling algorithms, the problem can be framed through Actor Network Theory (ANT). Actor Network Theory, according to Latour (1984), applies sociology to technology through associations rather than strictly hierarchical social ties (p. 277). In this scenario, there are a wide variety of human actors, ranging from patients to nurses to internal data scientists to external software companies and the leadership within both the healthcare system and algorithm company. However, racial bias can covertly enter the system because non-human actors, including scheduling algorithms and electronic health records, serve as the main communication link between the hospital and external environment. This creates a lack of critical thinking and context within the main negotiation space, as seen below in Figure 2. This project will complete

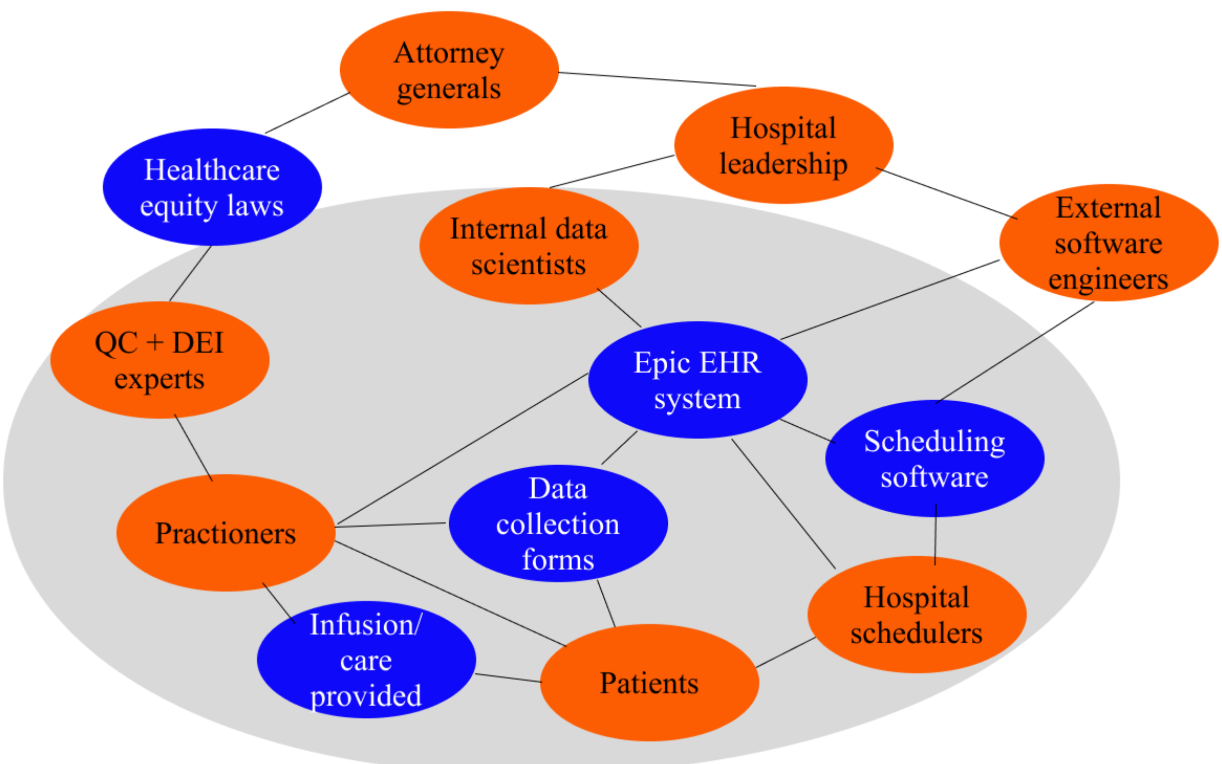

Figure 2: Current system actor-network. This figure depicts the actor-network of the current healthcare system. The orange indicates human actors, the blue indicates non-human factors, and the gray is the local network. The main fault is the global network communicates mainly through a non-human actor with the local network. (Created by Zavacky (2022) with Figma.com)

its anticipated aim of understanding racial bias in scheduling algorithms and recommending better solutions by focusing on the perceived breakdown in the point of passage between the local hospital network and global network in this system. Law and Callon (1988) argued that negotiation space, and ultimately a project, can fail due to an unclear or unreliable communication liaison between a local and global network (p. 292). Thus, this project will include a scholarly article outlining ways to leverage this point of communication, by ensuring that the software company understands the pain of data collection and hospitals understand the mathematics behind the algorithm products, and ultimately change the communication point and resulting behavior of the actor-network, which is shown below in Figure 3. This scholarly article

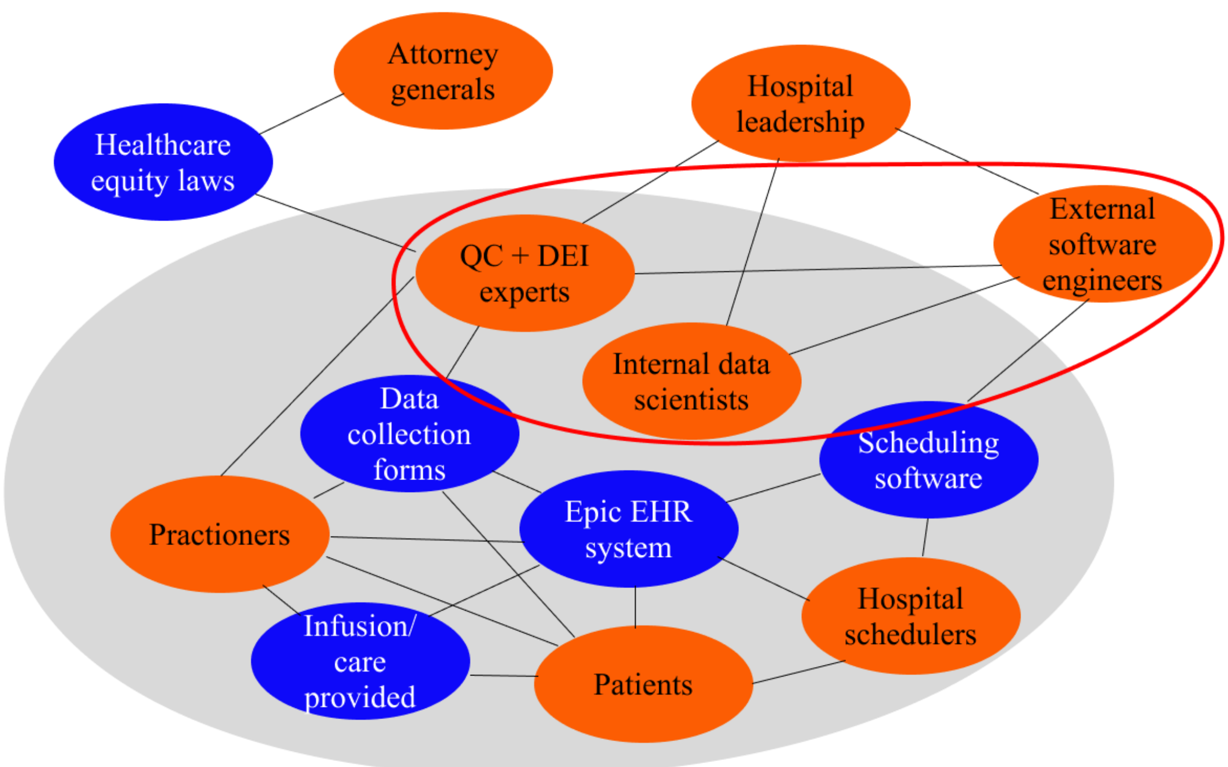

Figure 3: Idealized system actor-network. This figure depicts the actor-network of the ideal healthcare system. The orange indicates human actors, the blue indicates non-human factors, and the gray is the local network. The main change, circled in red, is the global network communicates mainly through knowledgeable human actors to connect to the local network. (Created by Zavacky (2022) with Figma.com)

will first outline the negative patient experiences in infusion centers for minority groups due to bias, describe the way in which bias is introduced in these scheduling tools, and finally propose actionable, alternative outcomes outlined above.

BALANCING EFFICIENCY AND EQUITY IN THE INFUSION PROCESS

In conclusion, optimization of the UVA Infusion Center within the Emily Couric Cancer Center will essentially be a quantitative process spurred by initial qualitative observations. However, maximization of revenue or minimization of wait time requires an objective function measured through data analysis, which will be tested through pilot experiments in the center. This same data and these quantitative conclusions commonly serve as the source for more robust scheduling algorithms and software, such as iQueue offered by LeanTaas, in infusion centers and operating rooms in large hospitals like the UVAHS. These efficiency-driving software can come with unforeseen consequences, such as introducing bias into scheduling and infusion service for minority racial groups. Such bias can be hidden in other variables like the show probability of a patient. Many current solutions to such bias explicitly factor in race, creating residual discomfort and negative experiences within the data collection process.

Thus, it is important to consider the tradeoff between efficiency and equity in leveraging data-driven solutions in infusion environments. While effective in maximizing or minimizing the response metric in an objective function, these tools can fail to see the social and legal implications from achieving this “desired” result. Understanding the tradeoff between efficiency and equity is even more significant in the realm of healthcare. Healthcare, specifically infusions in this case, are pivotal in helping individuals overcome serious, sometimes life-threatening, illnesses. However, negative experiences stemming from bias can act as a large enough deterrent for some patients to pursue these treatments. The goal of serving more of these patients is ethical, but one must be conscious that certain efficiency algorithms may reduce the desirability and access of service for marginalized groups. Thus, proposed and pilot tested technical solutions to improve the UVA Infusion Center will be evaluated for treatment of all subsets of patients, and the Capstone team will be conscious of upholding ethics in the process of meeting the objective function.

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