A Technical Analysis of the UVA Primary Care Unit

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Tyson Wittmann

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Technical Project Team Members: Eric Nour, Emily Riggleman, Aditi Jain, Harshal Patel

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

Signature Tyson Wittmann Date 10/30/2022

Tyson Wittmann

Introduction

Hospital systems across the United States have revolutionized their operation methods due to the Coronavirus pandemic. Transforming the hospital systems for this dangerous and highly transmissible disease has been a problem that systems engineers who aim to maximize the number of people a hospital can see while limiting coronavirus exposure have had to address. However, as more people have been vaccinated and more people have natural immunity, the overall lethality of the virus has been reduced. As a result of these developments, hospital systems will have to readjust to a new normal of operations in a post-pandemic world. While this transition poses some logistical challenges, it also presents a unique opportunity to redesign hospital systems like those at the University of Virginia primary care facility to reduce patient wait times and ensure patients receive the care they need.

The current situation at the University of Virginia's primary care facility looks grim. Nurses feel overworked as their appointments start stacking up, patients are left waiting, and their stress levels are rising. Situations like this in the past few years across the United States have led to increasing rates of nurse attrition (Haddad, Annamaraju, Toney-Butler; 2022). This rising rate of nurse attrition combined with the aforementioned difficulty transitioning back into pre-pandemic operations has hospital margins down 37% relative to their pre-pandemic levels, and more than half of all hospitals in the United States are projected to lose money in 2022 (Kaufman-Hall, 2022). Another factor that has been increasing costs for hospitals is the increase in the number of travel nurses. While a regular nurse normally costs around $1,400 a week, travel nurses are paid anywhere from $5,000-10,000 a week (Yang, 2022). Since some hospitals have trouble finding nurses with the rising attrition rates, they resort to hiring part-time travel nurses who cost more but can be brought in on an ad-hoc basis to fill a hole left by nursing staff

shortages. All of these compounding factors combined with the fact that hospitals in more rural areas had been closing at an alarming rate pre-pandemic means that the healthcare industry faces many challenges (Kaufman, 2022). One of the best ways to alleviate all of these compounding problems facing United States hospital systems is to reduce the load on nurses through a more streamlined process. This new process hopefully reduces the reliance on hiring travel nurses, allowing hospitals to return to profitability and remain open in this transition period.

Improving the University of Virginia's Primary Care Facility Operations

While there has not been peer-reviewed literature on the UVA primary care system, there has been research done on hospital queuing systems models at other universities. These other studies will help Emily Riggleman, Harshal Patel, Aditi Jain, and I anticipate outcomes from our experimentation and ensure our final results are consistent with the other peer-reviewed literature in the field of hospital queueing model data analysis and redesign of hospital systems. In a similar study of a hospital system in Gainsville, Florida, a team of researchers at the University of Florida analyzed the queuing system of their local hospital system. Their hospital queueing system was modeled as shown in figure 1 and had three different, independent arrival rates of λ_d, λ_f, and λ_a where λ is in units of the number of people arriving per minute.

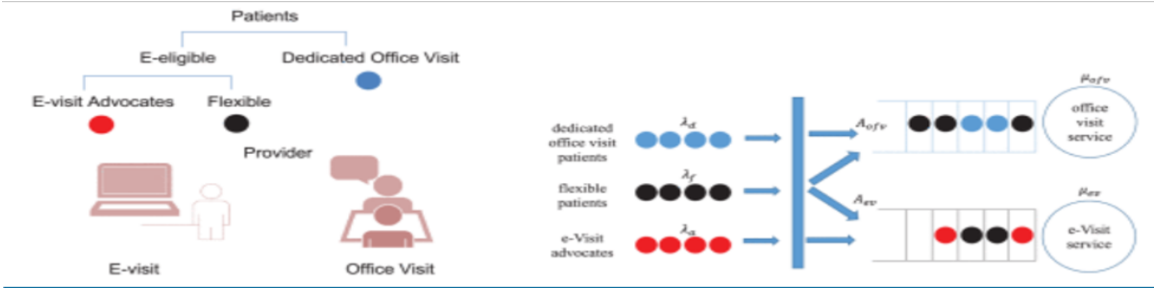

Figure 1. University of Florida Hospital Queueing Model

The three patients arrive at different rates, but each of the rates is modeled with the same distribution and underlying assumptions. These assumptions are that the arrivals are independent of each other (meaning the arrival of one patient does not affect the arrival of another), no patients arrive simultaneously, and that the probability of a patient arriving over one given interval versus the next is the same regardless of previous arrivals (Prakash, Zhong; 2022). These assumptions simplify the mathematical models, making the calculations for expected long-run behavior more simple. This research shows that these assumptions are valid for hospital systems, and they can be used to simplify our calculations and help make the mathematical predictions for results and recommendations more precise. These more precise recommendations should the UVA primary care facility make better, more informed decisions.

In addition to addressing the problem of how to build precise and usable mathematical models, the UVA primary care facility also faces the problem of data inconsistent and uninterpretable data that reduces the credibility of potential recommendations. The patient timing data is currently a black box. The company that the University of Virginia uses to compile the patient timing data does not disclose how it complies the important variables like appointment time, time the patient is roomed, and time the visit ends. As a result, our team had to go in and make in-person observations of the times the nurse gets the patient, the nurse enters the room, the nurse leaves the room, and the patient leaves the room. We would then use this observational data to assess the validity of the black box data which the company provides to the primary care facility. After comparing the observational to the data that the University has provided, the group can determine which variables are similar to the observed values. For example, after the first round of observations done in late September and early October, it has been determined that, on average, the time that the black box system says the nurse enters the room with the patient is two

and a half minutes earlier than the in-person, observational data determined. This two-and-a-half difference is not significant enough to warrant throwing out the data, and the system data can simply be adjusted to better match the in-person observations. Since the electronic patient process tracking system can take measurements for every visit, it provides a dataset an order of magnitude times larger than using strictly the observational data the group collected in person. This ability to determine the precise problem with the data that was previously a black box will then lead to better recommendations to fix the backups the facility currently faces with its queuing process during peak visiting hours.

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