IE 324: Simulation

Term Project

Spring 2023

You are 3 freshman industrial engineers hired to analyze an emergency department (ED) of a hospital system and make recommendations to improve the operations and service cost and quality. Before your meeting, you have the plan of ED. According to this plan, there are 4 critical care rooms. Furthermore, walking distance seems negligible between doctor & nurse rest room, treatment rooms, observation room, and critical care rooms. After your meeting, you decided to gather information about the system. One of you visits ED, the other collects data from the IT desk, and the last one visits the manager.

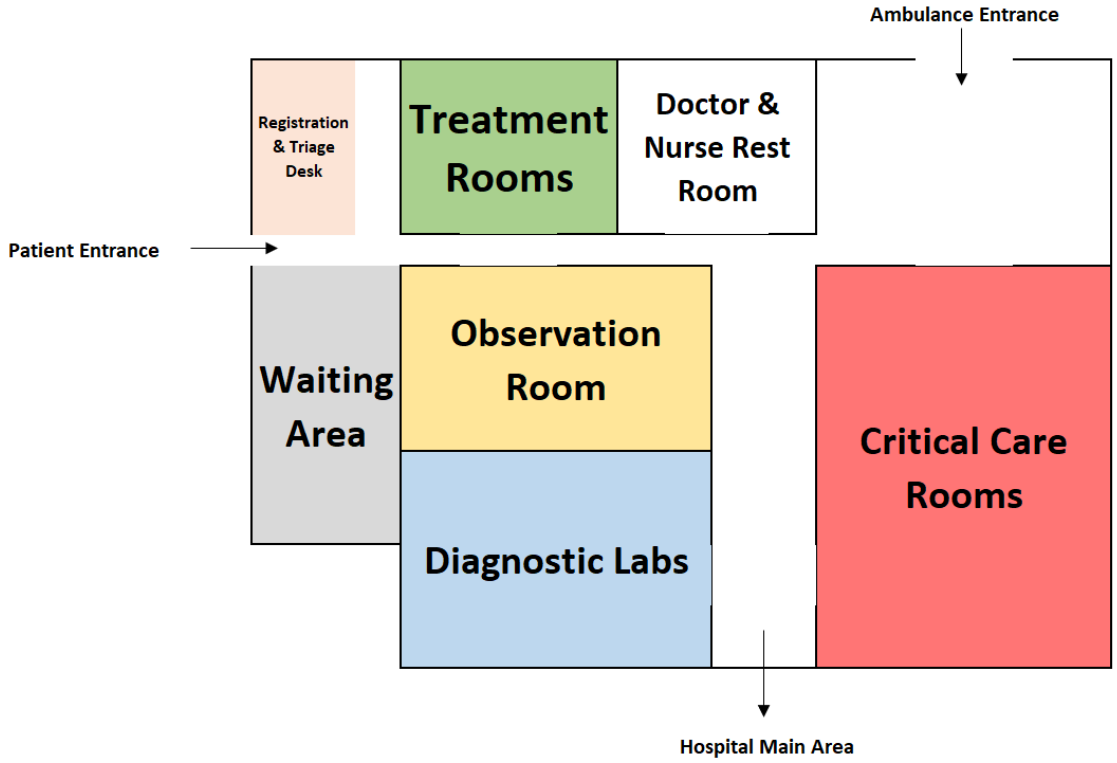

Figure 1: Emergency Department Plan

The following conversation is recorded by one of you after your visit to ED and interview with the head nurse of ED.

You: " Do you have the priority ranking for the patients?"

Head Nurse: " Of course, we use a triage system that sorts patients to 3 different labels depending on the severity of the patient's condition. Starting from the most to least critical labels are red, yellow, and green. As the main purpose of the triage system, we prioritize all our resources on **red then yellow, and finally green** patients."

You: " Can you explain the means of arrival to the system?"

Head Nurse: " Patients arrive at ED by one of two possible ways, either through their own means or with an emergency call. Let me start with the emergency calls. When we receive an emergency call, we first check the availability of an ambulance and critical care rooms (CCR); we can accept it only if both resources are available at the moment of the call. If at least one is not available, we reject the call immediately. Then we send an ambulance without delay. Our ambulance crew conducts necessary interventions on the way here. The ambulance crew may bring one or two patients depending on the events such as traffic accidents. Upon arrival at ED, we immediately carry patients to the critical care room with an assistance of a nurse. These patients are labeled as red. While transferring the patients here, CCRs may get occupied so; in case of the number of available CCRs is insufficient, we transfer the excess patients to the nearest hospital using the same ambulance. "

You: "Can you talk about the procedures you follow for these critical patients?"

Head Nurse: " The first thing is doctors say whether a clinical test is required to decide which treatment will be applied. The patient is carried to the labs by a nurse due to her/his condition. Once the tests are done, the doctor examines the test results and decides whether s/he will perform the treatment or redirects the patient to surgery. But sometimes, the patient is not as critical as initially thought. We switch the label to yellow for those patients and follow the necessary procedures for the patients with yellow label."

You: "How long does the doctor's intervention take?"

Head Nurse: "I cannot tell an exact duration, but I'm sure that doctor examination and treatment take more than 5 minutes together."

You: "To prevent confusion, shall we continue with red patients?"

Head Nurse: " Once the treatment is done, the patient is kept in CCR for a duration to observe vital values. CCRs are well equipped; thus we ,nurses, are responsible for assisting the

doctor during treatment and full attention observation. Finally, the same doctor who treats the patient checks again and admits the patient to the hospital for further treatment such as inpatient care. Further is not in the scope of ED."

You: "So, the patients leave the system. You mentioned two means of arrival; can you also talk about the other one?"

Head Nurse: " Indeed, as I mentioned before, patients can arrive by their own means or by their relatives. We record each patient separately. The patient may come with a complaint or for an injection. If s/he has a complaint that needs diagnosis, we send the patient to the triage desk. A nurse performs the triage tests and assigns either yellow, green or sometimes red. Green and yellow patients must register just after triage. We have a single registration desk. By the way, patients who came for injection are labeled green without visiting the triage desk."

You: " What happens after that?"

Head Nurse: " First of all, if the patient label is red, we immediately check whether we have an available CCR. If yes, then we follow the protocol of red patients. If we don't, we check for the ambulance to transfer the patient. Unfortunately... We must reject the patient if neither a CCR nor an ambulance is available."

You: " What about yellow and green patients?"

Head Nurse: " Unlike red patients, yellow and green patients can wait if the resources are busy. In that case, the patient is sent to the waiting area. Sometimes yellow patients require medical tests similar to red patients. However, they can go to the labs by themselves without assistance. If the doctor is available s/he treats the patient based on the complaints and/or the test results. Then a nurse sets up a bed for the patient in the observation room. During the observation period, yellow patients do not need the full attention of a nurse, and an available nurse visits to discharge the patient after the observation period."

You: " Thanks for the information. I guess, we go over green patients' flow and then we are done."

Head Nurse: " Green patients have much simpler procedures. A green patient waits for an available doctor in the waiting room. Then the doctor examines the patient. Depending on the complaints, the doctor prescribes a medicine. If the patient needs an observation, we perform the same steps as we do for yellow patients. If the medicine includes an injection, the patients return to the waiting room for injection. Injection is done by a nurse in one of the treatment rooms. If neither observation nor injection is prescribed, the patient leaves ED. Anything more you want to

ask?"

You: " Oh! I have almost forgotten. May I get more details about the Labs?"

Head Nurse: " Actually, the Labs are sufficient to satisfy the needs of ED, so we have never observed a patient waiting for a medical test, at least not in ED. Hence you can assume the Labs are always available."

You: " Thank you for all your help. I noted all and I think these are enough for our study."

Head Nurse: " If you need more, you may visit again."

The following files are created by one of you (in zip folder xxxxx) and it contains all data you get from IT. However, you have to analyze the data to obtain meaningful information. Apart from these, patients leave the system if the waiting area is too crowded. Exact data is not accessible; still, according to your analysis of the number of patients registered but left without treatment, you can assume that yellow and green patients leave the system if 10 and 15 patients are already waiting, respectively.

Last but not least, the following notes are taken by one of you during your meeting with the hospital manager. During this meeting, s/he highlighted the importance of service quality many times and stated the following performance targets which are crucial to the hospital's cause.

Performance Targets (Must be satisfied)

- At most 15% of the patients should leave ED due to crowded waiting area.
- The percentage of rejected emergency calls should be below 7.5%.
- The maximum time a red patient waits for doctor's care must be less than 10 minutes.
- The percentage of patients transferred or rejected should be below 15%.
- The number of rejected red patients arriving by their own means must be less than 2.

The manager also mentioned that the target service quality must be reached with efficient usage of resources. Hence, meet the target values using minimum inefficiency. In the direction of this goal, s/he wants you to present two alternative systems.

Systems Requested

- Propose a system with the minimum number of nurses, ambulances, and observation beds.

- Propose a system with x (x will be shared in the second meeting) nurses. However, you must allocate these nurses to services. Except for the head nurse, each nurse can be assigned to either critical patient care or other services. One of the nurses assigned to other services can also be specialized to triage.

Finally, the number of doctors working in ED is 5 and fixed throughout the study.

What you need to do and Submission Details

After your visit to the hospital, you created your road map and set 3 appointments with the manager to present your results.

First Stage (20%): You will present your analysis on data you obtained.

Use the Input Analyzer tool to find the distribution for:

- Interarrival times between a) patients and b) emergency calls
- Ambulance response times a) bringing the patient to ED b) transferring the patient to the nearest hospital
- Triage test, registration, medical test, injection, green patient examination, yellow patient treatment, red patient treatment, patient observation, nurse observation bed set-up and discharge times
- Patient label distribution of a) patients and b) emergency calls
- Emergency call patient group size

Specify the distributions mentioned above and report the parameters. Submit Input Analyzer files and a short report (.pdf) about your analysis. You need to support your decision in your report.
First Meeting Date: 30 April at 23:5

Second Stage (60% model, 5 % animation): You will present your Arena model of the system. Using your own distributions, build your model in Arena simulation with animation (abide by ED plan). Animation part will be graded effort based (considering all the other groups). You are expected to simulate your system for 7 days. While doing all these, **do not forget to use version Arena 14.5**. Submit your simulation model (.doe file) and a report (.pdf) containing the logic of your model and the extra assumptions you made. In this meeting, the manager wants to see a performing system, even if it is not optimized yet. Thus, your model should be able to present the measures needed for the third stage.
Second Meeting Date: 21 May at 23:59

Third Stage (15%): You will present your final results and propose a decision.
Using OptQuest or Output Analyzer determine the optimal number of nurses (for system 1) and the allocation of nurses (for system 2), ambulances, and observation beds for cost minimization with your existing model. Submit an OptQuest and/or Process Analyzer file, and a detailed report (.pdf) containing the logic of your model, and optimization details. You need to specify why and how you have done your optimization.
Third Meeting Date: 4 June at 23.59

Note that, the manager is a busy person and you are hired to provide decision support. S/he cares about your report. The report you presented at each meeting must be self-explanatory.