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SIMULATION STUDY OF DREYER URGENT CARE FACILITY

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ABSTRACT

The health service center is considering modification of the current doctor schedule to decrease the average time patients spend in the facility. A new schedule, which on average has an extra doctor added for each time slot, has been suggested by the preliminary queueing analysis. It is anticipated that the schedule will improve the system performance but has yet to be verified by a discrete event simulation model. The shifting bottleneck issue has to be considered as well. Increasing the resource capacity of the current bottleneck (believed to be the doctor resource) might trigger a new bottleneck and could possibly worsen the current situation. In this study, the current and proposed doctor schedules are tested on the simulation model created using SIMAN language and simulated on Arena. The output from the simulation just verifies the preliminary queueing analysis that the proposed schedule decreases the average time patients spend in the facility. Sensitivity analysis is performed as well, and the next bottleneck resource is identified.

1 INTRODUCTION

Dreyer Urgent Care Center (Dreyer UCC) is located in Aurora, Illinois. The facility has no emergency room; doctors and nurses that work at the facility take care of patients with a variety of symptoms that are relatively non-emergency. These include but are not limited to earaches, sore throats, stomach problems, broken bones, etc. Treating each of these ailments takes various lengths of time. In addition, the arrival of patients and doctor service times changes randomly. Normally, the patient has to wait for a significant amount of time in various stages before he/she can be treated and depart the system. Currently, the facility faces the problem of high average waiting times for patients at all stages. Dreyer UCC management has observed and suspected that doctors may have the highest average utilization and, therefore, currently represent the bottleneck of the system. It also commented that doctors are not being appropriately assigned. It does not have enough doctors at the facility during some work hours; on the other hand sometimes doctors are unnecessarily assigned. The current doctor schedule is shown in Table 1 with the suggested doctor schedule recommended by a preliminary queueing analysis.

Table 1: Daily Current and Suggested Doctor Schedules

MDs on schedule	Time of day						
	7am	8am	9am	10am	11am	12pm	1pm
Current	2	2	2	2	2	2	3
Proposed	3	4	4	4	3	3	3
MDs on schedule	Time of day						
	2pm	3pm	4pm	5pm	6pm	7pm	8pm
Current	4	3	2	2	2	2	2
Proposed	3	3	3	3	3	3	2

Management at Dreyer UCC believes that increasing the doctor hours (equivalent to increasing the service rate) will reasonably cut down the waiting time for patients at all stages, as well as the overall time in the facility for patients. However, the new schedule has yet to be verified with a discrete event simulation model.

We can look at this service process as a job-shop manufacturing system, where different jobs have to visit different workstations depending on their manufacturing requirements. If we increase the resources of doctor stations (current bottleneck), this will undoubtedly reduce patient waiting time. However, the bottleneck could be shifted to another station that has a minimal number of resources to handle the traffic and could risk increasing the overall flow time. Therefore, when verifying the simulation model, the output results that have to be collected to perform a thorough analysis of the effectiveness of the new schedule are (1) Average time in system and (2) Utilization of each resource.

The first performance measure is for direct comparison between the current and suggested schedules, while the second measure is to determine whether a bottleneck is shifted to other stations.

2 LITERATURE REVIEW

Computer simulation models are increasingly used by large healthcare institutions to meet the challenges of aggressive pricing, tough competition, and rapidly changing guidelines (Alexopoulos et al. 2001). The focus of those models is placed on a range of different issues, such as childhood immunization delivery services (Alexopoulos et al. 2001), or optimizing current health care system capacity (Johnson 1998).

Rossetti et al. (1999) use a computer simulation model to identify inefficiencies and problem areas within the existing ED system in the Emergency Department at the University of Virginia Medical Center. The model challenges the current attending physician staffing schedules and evaluates alternative staffing strategies.

Ramis et al. (2001) built a computer simulation model to evaluate different alternatives of operation of a projected center for ambulatory surgery in a major research hospital in Chile.

Harrell and Heflin (1998) provide a discussion of the healthcare simulation software pack MedModel. This software is specifically designed to be simple to use and tailored to the needs of healthcare managers, engineers, and clinicians.

3 MODEL

The facility operates from 7am to 9pm during weekdays and from 7am to 5pm during weekends. For simulation analysis purposes, it is considered a terminating system. According to Pegden et al. (1995), a terminating system has a fixed starting condition (system returns to this condition after each termination) and has an event defining the natural end of the simulation. A patient flow diagram is shown in Figure 1. The following patient groups were identified: (1) critical patients, (2) appointment patients, (3) walk-in patients that are eligible for FAST TRACK service, and (4) regular walk-in patients. FAST TRACK is a new service offered by Dreyer UCC. It is available for patients who need treatment for a predefined number of minor sicknesses and injuries. These patients will be seen by doctors immediately or will have only minimal waiting time. Their relatively easy diagnosis and treatment (conditions such as ear pain, allergies, sinus problems, sore throats, bladder infections, pink eye, etc.) make patients eligible for FAST TRACK service. In this way, other patients who will take longer for the doctors to assess do not slow down the FAST TRACK subsystem, where patients get in and out of the clinic as fast as possible.

All patients have to register at the reception desk first. All of them except critical patients will be waiting in the waiting room according to the priority that they have been assigned. Critical patients who require immediate attention are allowed to bypass the waiting area and go straight to the nurse screening stage. Priorities to patients are assigned according to the patient types mentioned above (the highest priority = critical patients, the next highest priority = appointment patients, and so on.)

Next, patients will wait for a nurse to call them when an exam room and a doctor are available. The nurse then brings a patient to the exam room and performs initial screening. After that the nurse leaves the patient there to wait for a doctor who will perform the detailed assessment. During the assessment, the doctor determines if the patient has to be tested in the Lab only, sent to the X-ray room only, tested in the Lab and sent to the X-ray room, or does not need any tests and may leave the facility. If the patient goes through the testing, he/she has to return to the same doctor before he/she can be discharged from the facility.

3.1 Assumptions

Due to the complexity of the real system and the fact that some detailed situations are not known, reasonable assumptions are made in order to reflect the real system as much as possible. Assumptions made are as follows:

1. Infinite capacity for reception desk queue and nurse queue. Patients do not leave just because the line is long.
2. If the doctor leaves for the day before his/her patient returns from Lab test and/or X-ray exam, the next available doctor takes over the patient.
3. Routing delays are included in the associated service times.

3.2 Data Collection

The Director of Engineering Services from Dreyer provided historical data for the study. However, Dreyer has never performed a time study at their Aurora facility. Therefore, all data, except the arrival information collected recently, are from a 1995 time study in a similar health service facility.

3.2.1 Patient Arrivals

Comparing arrival information in February and August of 2001, August 13, 2001, shows the busiest day in terms of number of patients treated. The arrival rate for this date is selected for this study. Using Input Analyzer in Arena 5.0, lognormal distribution is identified as the best fit and thus selected to be the distribution of time between patient arrivals.

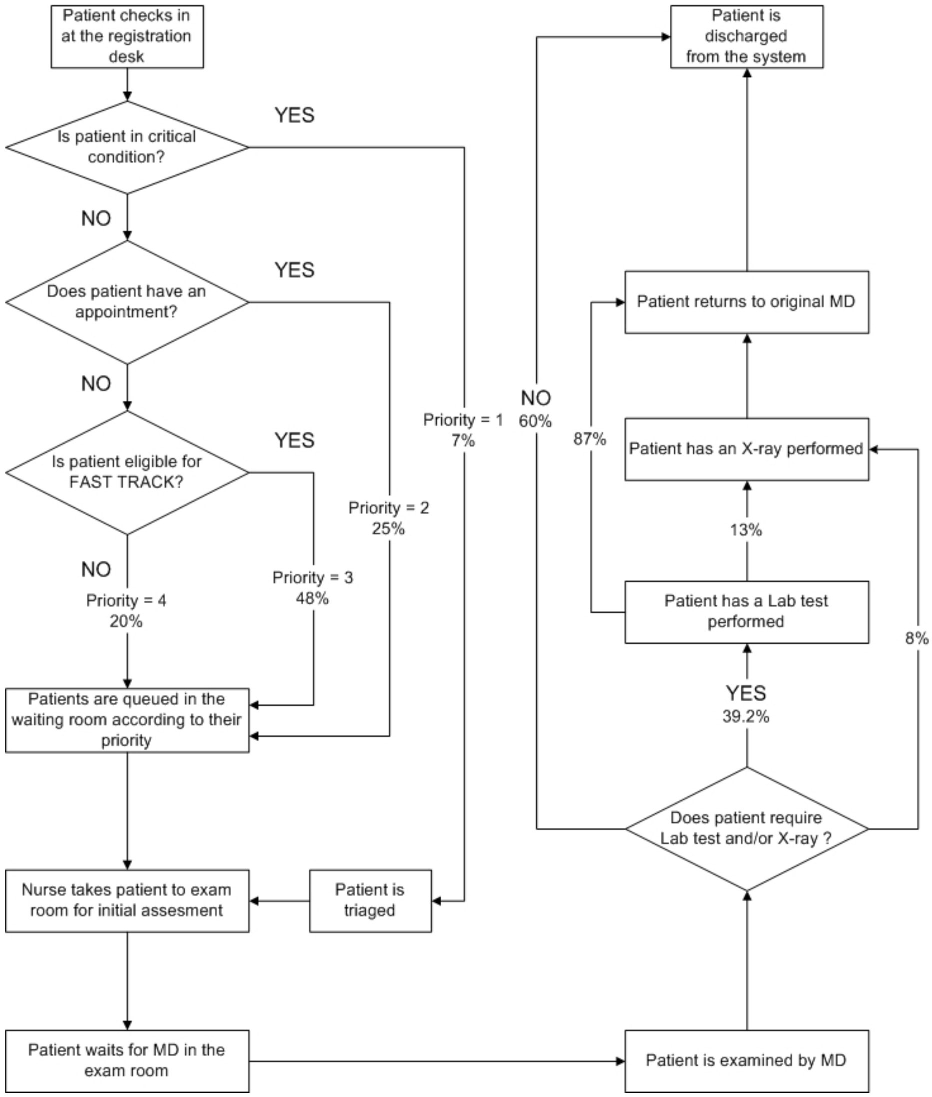

Figure 1: Patient Flow Diagram

3.2.2 Patient Types and Routing Probabilities

Dreyer UCC provided historical patient demographic information that was necessary for simulation modeling. Critical patients constitute 7% of all patients, 25% are appointment patients, 48% are FAST TRACK walk-in patients, and 20% are regular walk-in patients. It has also been determined that historically 39.2% of the patients will go to the Lab test only, 0.8% will go to the X-ray room only, and the remaining 60% will not need either of them and will be discharged from the system.

Also 13% of those patients that go to the Lab test first will go to the X-ray room as well, while the other 87% will bypass the X-ray room and return to the same doctor before they are discharged from the facility.

3.2.3 Service Delays

As already mentioned above service delays for preliminary study are derived from time studies performed at a similar health service facility. Due to the Central Limit Theorem (Pegden *et al*, 1995; Ross, 1997), an assumption is made that normal distribution is more appropriate for all service time distributions. After analyzing the provided data, the following delay times (all in minutes) are identified:

- Patient registration: NORM (3.45, 1.97)*
- Nurse primary screening: NORM (3.4, 1.1)
- Medical Doctor thorough examination: NORM (15.9, 7.6)
- Lab test: NORM (13.67, 13.3)

- X-ray room: NORM (20.7, 12.5)
- Doctor post-testing examination: NORM (7.58, 4.2)

*NORM ([mean], [standard deviation])

4 ANALYSIS OF RESULTS

The simulation model is created using SIMAN simulation language and is run on Arena 5.0. The system is modeled with 5 stations, which are Registration, Nurse, Exam room, Doctor, and X-ray Room. Patients depending whether they need a Lab test and/or X-ray may revisit the Doctor station. Output results from the simulation included total patient time in the system and utilization of all resources.

Twenty replicates were run on Arena to obtain the statistic results. Figure 2 shows the 95% Confidence Intervals (CI) for the average total patient time in the system for two scenarios. The study shows that the suggested schedule, with one or two extra doctors added each hour, does statistically outperform the current schedule. The 95% CI graphs show no overlapping between two schedules. Thus it gives us more confidence that the suggested schedule is better than the current schedule. The suggested schedule not only improves the average time in system by 18% (from 44 to 36.1 minute), but it also has a tighter interval, which implies more accurate predictions of the time in the system.

Figure 3 shows the utilization comparison for all stations between the current and the suggested schedules. The suggested schedule reduces the utilization of doctors significantly. As expected, this increases the traffic of the downstream station, in this case, the X-ray room, by about 2%. However, the bottleneck of the suggested schedule is still at the Doctor station.

5 SENSITIVITY ANALYSIS

As mentioned before, some sensitivity study was performed and the issue of the bottleneck shifting to another workstation was considered. For that purpose seven different schedules have been developed (Figure 4) that have even more MDs on duty than the proposed schedule suggests. After running our simulation model for the different schedule we have identified the two most utilized stations: Doctor and Exam room. The statistical output was collected and the utilization for these stations is shown on the right side in Figure 4.

Schedule	Mean	Std Dev	Half Width	95% CI
Original	44	10.1	4.74	[39.26, 48.74]
Proposed	36.1	4.94	2.31	[33.79, 38.41]

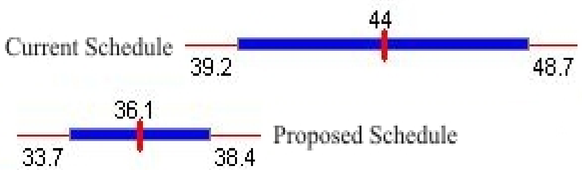

Figure 2: 95% Confidence Intervals for Time in System

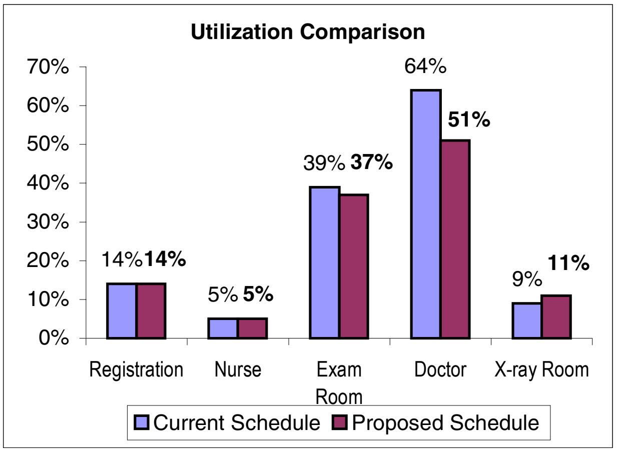

Figure 3: Comparing Utilization of each Resource in the System for two schedules

The sensitivity study showed that implementing Case 5 schedule (6 MDs from 7am to 4pm and 3 MDs from 4pm to 9pm), the bottleneck shifts to another station, in this case the Exam room. In other words, if the system has a working doctor schedule according to Case 5 then in terms of time in the system, the system performance would not improve even if management increased the number of MDs on duty.

6 CONCLUSIONS AND FUTURE WORK

We have built a discrete event simulation model of Dreyer Urgent Care Center to compare two doctor schedules. One is the current schedule, and the other is the suggested schedule from a preliminary queueing analysis. The performance measures of interest are the average time in system of patients and the utilizations of all stations in the system. The output results from the current schedule suggest that the Doctor station is the bottleneck. Increasing the bottleneck capacity according to the suggested schedule will reduce patient time in system. The suggested schedule obviously does not trigger any other station to become a new bottleneck; this fact is reinforced from an 18% reduction in the average time a patient spent in the system when the suggested schedule was simulated.

Our simulation model is rather generic at this stage. We only considered the busiest day in our model. Further comparison should use various congested days in the simulation study. In addition, time study at the current fac-

MDs on schedule	Time of day														Utilization	
	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	MD	Exam room
Case 1	4	4	4	4	3	3	3	3	3	3	3	3	3	2	51%	34%
Case 2	4	4	4	4	4	4	4	4	3	3	3	3	3	2	47%	39%
Case 3	3	4	4	4	4	3	3	3	3	3	3	3	3	2	51%	37%
Case 4	3	4	4	4	4	4	4	4	4	3	3	3	3	2	45%	34%
Case 5	6	6	6	6	6	6	6	6	6	3	3	3	3	3	32%	35%
Case 6	6	6	6	6	6	6	6	6	6	4	4	4	4	4	29%	33%
Case 7	6	8	8	8	8	8	8	8	8	6	6	6	6	4	25%	37%

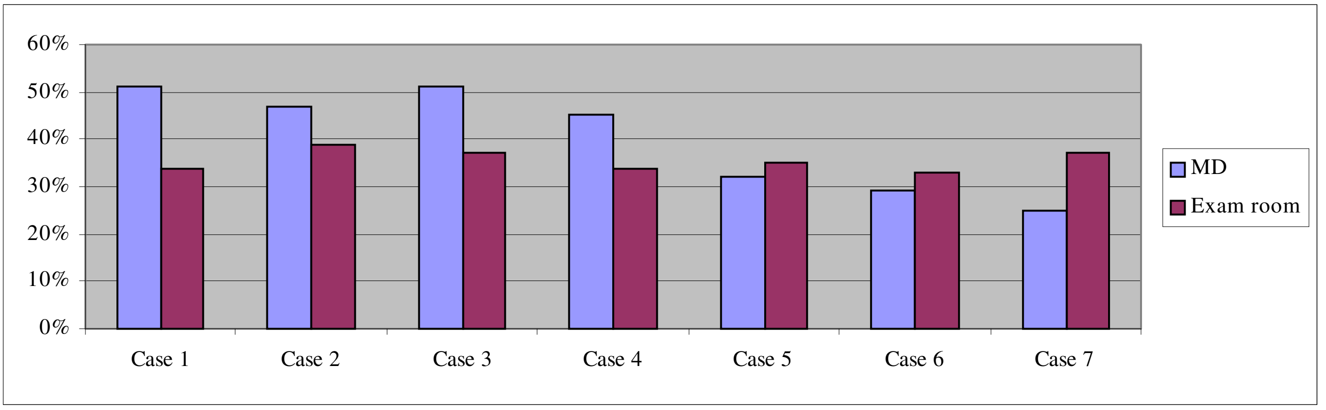

Figure 4: Schedules for Different Cases and the Utilization of the Bottleneck Stations

ility is recommended in order to obtain more accurate results. Another possible future work is to use the data obtained from this simulation model to perform cost and further sensitivity analysis.

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