STUDENT HEALTH CENTER LEAN ANALYSIS PROJECT

GROUP #5

OSCARBERMUDEZ

MARTHA BONILLA

DIEGO ESCARE

THERESA GARCIA

TABLE OF CONTENTS

INTRODUCTION AND BACKGROUND

Located on LSU's campus, The Student Health Center (SHC) provides a place for LSU students and staff and local citizens to receive health related services. At the SHC, the following services are available:

1. Allergy, Immunization, and Travel Medicine
2. Diagnostic Imaging
3. Laboratory
4. Pharmacy
5. Physical Rehabilitation
6. Primary Medical Care
7. Specialty Services
8. Women's Health

The current system asks that patients call ahead to schedule an appointment, but walk-ins are also welcome. Once an appointment has been made, the patient is asked to check in and then proceeds to sit in the wait-room area until a nurse or doctor is available to see them. Some patients have waited up to half an hour to see a nurse only to be sent back out to wait for a doctor.

MANAGEMENT OBJECTIVES

Through this project, we hope to accomplish the following lean management objectives:

a. Decrease average time in system per entity (Flow time)
b. Decrease average number of students in queue.
c. Increase resource utilization in the system.

PROBLEM DESCRIPTION

The objective of this project is to analyze and evaluate the SHC in order to determine a more efficient way of assigning resources in order to reduce queue and wait room times. In order to do this, we will be using Arena simulation software to assist in modeling the system and the following information that will be collected:

- Arrival rate
- Queue times at check-in, appointment desk, pharmacy, and billing counters
- Customer processing times in doctors and nurse offices

Project Scope

This project will study the Primary Medical Care area of the SHC (this includes the Nurse Practitioner, Triage Nurse, and general doctors that attend patients who come with a previous appointment and, under special circumstances, those who come without one), and the Pharmacy and Cashier, as it is normal for a doctor to prescribe medicine to the patient he/she attends. The rest of the SHC areas previously mentioned on the Introduction and Background Section will be excluded from the project scope.

Simplifying Assumptions

- Random arrivals
- Random service times
- Infinite calling population
- Finite number of servers
- Simulations are from 8am-12pm
- No schedules for resources since only a four hour period was considered, assumed resources were always there
- If a patient receives a prescription, they fill their prescription immediately after the appointment at the Pharmacy located in the SHC
- The service distribution of each member of the staff working in the same station is identical.
- The service distribution of each member of the staff remains constant during the day (the service rate doesn't "slow down" through the day).

PERFORMANCE METRICS

In order to assess and evaluate the current system and develop a new and improved alternative, we noted the following:

- Flow time of patients
- Wait time of patients
- Average number of students in queue.

By taking into consideration the aforementioned information, the newly created system reduces queuing and wait room times. Patient throughput has been increased, which in turn allows the SHC to process a greater amount of patients in the same amount of time.

CONCEPTUAL MODEL OF THE EXISTING SYSTEM

Model Description

The flow of a patient in the system depends on whether or not they have scheduled an appointment prior to their arrival at the SHC. Appointments are booked to either see a doctor or a nurse. If a patient has an appointment, the normal flow through the system is as follows:

1. Arrive and check in.
2. Wait to be called by the Doctor/Nurse.
3. Receive examination and prescription.
4. Proceed to the Pharmacy and order medication(s).

5. Go to the Cashier and pay for the medication(s).
6. Leave system*****.

If a student doesn't have an appointment, the normal flow through the system is as follows:

1. Arrive and consult at the Front Desk.
2. If the patient is very sick, he is put in the queue to see the Triage Nurse. Otherwise, patient is sent to the Appointment Desk to schedule an appointment and then leaves the system.
3. Once the Triage nurse has taken the patient's vital signs, the patient is sent to see the On-Call doctor. If the nurse in the triage station determines that the patient is not too sick, the patient is sent to the Appointment Desk to schedule an appointment and then leaves the system.
4. The doctor examines the patient, and gives him/her a prescription.
5. The patient then goes to the pharmacy, and orders their medication(s).
6. Then patient goes to the cashier to pay for their medication(s).
7. Leave system*****.

*****As a matter of fact, the student can remain in the Health center, and visit other areas like the appointment desk, but these are out of the scope of this project.

There are several decision blocks in the existing model system. All of them are "By Chance" decision blocks. The way we are determining the probabilities associated with "True" or "False" are as follows:

- **"Appointment?" Block:** In our observations of arrival times, we have taken notes on whether the patient has an appointment or not. With this, a proportion can be calculated between the arrivals with an appointment, and the ones who don't.
- **"Nurse or Doctor?" Block:** Ms. Julie Hupperich, the director of the SHC, provided the group with a document that lists the number of appointments each clinician had each day for a 5-day period. With this information, it is possible to calculate the probability.
- **"Seeing the Doctor?" Block:** This data was collected from the Triage Nurse office, as the nurse that works here is who decides if the patient is good to go, or must see the On-call Doctor.

Also, the model possesses Route and Station blocks. These represent the walking distance between the locations where the services are offered (attention by nurse, doctor, pharmacist, cashier and triage office). The time it takes from place to place is to be measured with stopwatches. Next are the SHC areas with their respective Station Blocks:

Location	Block
Check-In	Station1
Pharmacy	Station2
Cashier	Station3
On-call doctor	Station4
Hall 1 (Nurses' offices)	None**
Hall 2 (Doctor offices)	None**

TABLE 1: SHC LOCATIONS AND CORRESPONDING STATIONS

And now, the Route blocks and their respective destinations:

Block	Destination
Route 1	Station 1
Route 2	Station 2
Route 3	Station 2
Route 4	Station 2
Route 6	Station 2
Route 7	Station 2
Route 8	Station 4

TABLE 2: ROUTE BLOCKS AND CORRESPONDING STATIONS

DATA COLLECTION

The following data will be needed:

Existing System Data:

- Arrival time of each patient that enters the center. Will be manually written down in tables. With this, we can calculate inter arrival times and make an estimation of the arrival rate of students.
- Number of appointments in the day. This will be asked at the center, since their database keeps this information.
- Time a patient enters a station, and time a patient leaves a station. This data will be collected with tables, where the exact hour, minute and second of an event (arrival or departure) occurs. This data will be used to calculate service times, and with it, we can estimate service rate distribution.
- Number of nurses, doctors, and people working in other stations (front-desk, billing counter, pharmacy, etc.). This will be asked at the front desk.

Validation Data:

- Count number of patients in the waiting area. These patients are waiting to be attended by a nurse or a doctor, thus, it's the sum of the Nurse and the Doctor station queues.

- Current rate of service is in fact a result of having a 15-minute based appointment system. Thanks to this, it's possible to know the maximum number of appointments to be scheduled into one day, and thus, the approximate number of persons that will be attended on the day. We can use this number, and add it to the Triage Number out to see if the numbers match. If they do, the model is valid.

Alternatives for Improvement

Several alternatives are proposed to increase the efficiency of the Student Health Center. Currently in the LSU SHC, the stations that patients must go to check-in, receive treatment, pick-up and pay for medications are very spread out. This leads to excessive travel times, which increases patient flow time. In order to decrease patient flow time, we have proposed several facility design changes. Presently, the SHC has separate locations for their pharmacy and cashier stations. Since all students that visit the pharmacy must also visit the cashier station, we decided to merge the two stations, thus creating a one stop shop for patients where they can pick up their prescription and pay for it at the same place.

Another improvement that we believe would benefit the SHC dealt with the location of the Medical Records within the health center, and in turn, led to the idea of the new location for the merged pharmacy and cashier station. The medical records take up a large amount of space in a highly trafficked area, the main entrance area. The problem with this is that these medical records, once stored, are accessed very rarely. Also, the SHC is transitioning over to having their medical records system in computers. Our alternative proposal is to move these records to the current cashier location, and merge the cashier and pharmacy stations into the medical records location. This would reduce flow time of entities not only because of the merge, but also because the new pharmacy and cashier location would be right next to the main doctor and nurses offices, which is where the bulk of patients going to this newly merged station will be coming from.

Another alternative we propose to this system is to reduce the space and resources assigned to the check-in desk. The check in desk has two student workers manning the check-in desk. Recently, the SHC implemented a change in the check-in process. This change requires that all patients check in on computers. Prior to the implementation of the computer system, student workers would manually check in all patients at the front desk. The computer check-in was fully integrated into the SHC in August of 2011, but there are still student workers sitting at the front desk that sit idle for most of the day because their job responsibilities have not been modified. The two main jobs of employees working at the front desk, prior to this change, were to check in patients and also give them parking passes. With their main job now obsolete, this leaves wasted time and resources at the check in desk. Our solution is to relieve one of the 2 workers of their duties to more fully utilize the other worker. With less space needed for the check-in desk, we propose to merge the appointment desk with the check in desk (at the check in desk location). A wall will be put up to now separate the newly created pharmacy and cashier station and the appointment/check in desk. The appointment desk will now be used as a new doctor's office.

It was also noted at the SHC that doctors attend patients faster than nurses, and therefore a longer queue builds up at the nurse's station leading to increased wait and flow times. To decrease the queue build-up and patient wait and flow times, we propose to have more appointments scheduled with doctors than nurses.

In order to test the effectiveness of the aforementioned alternatives against the existing system, we grouped them into three categories. Alternative 1 included all proposed layout changes. To implement this into the arena model, we calculated the new route times between the proposed station locations and deleted the Route/Station between the Pharmacy and Cashier (since they have been merged together). The second alternative included the increased appointment allocation to doctors, and the third alternative included the first two alternatives combined and also eliminating one of the student workers at the check-in desk.

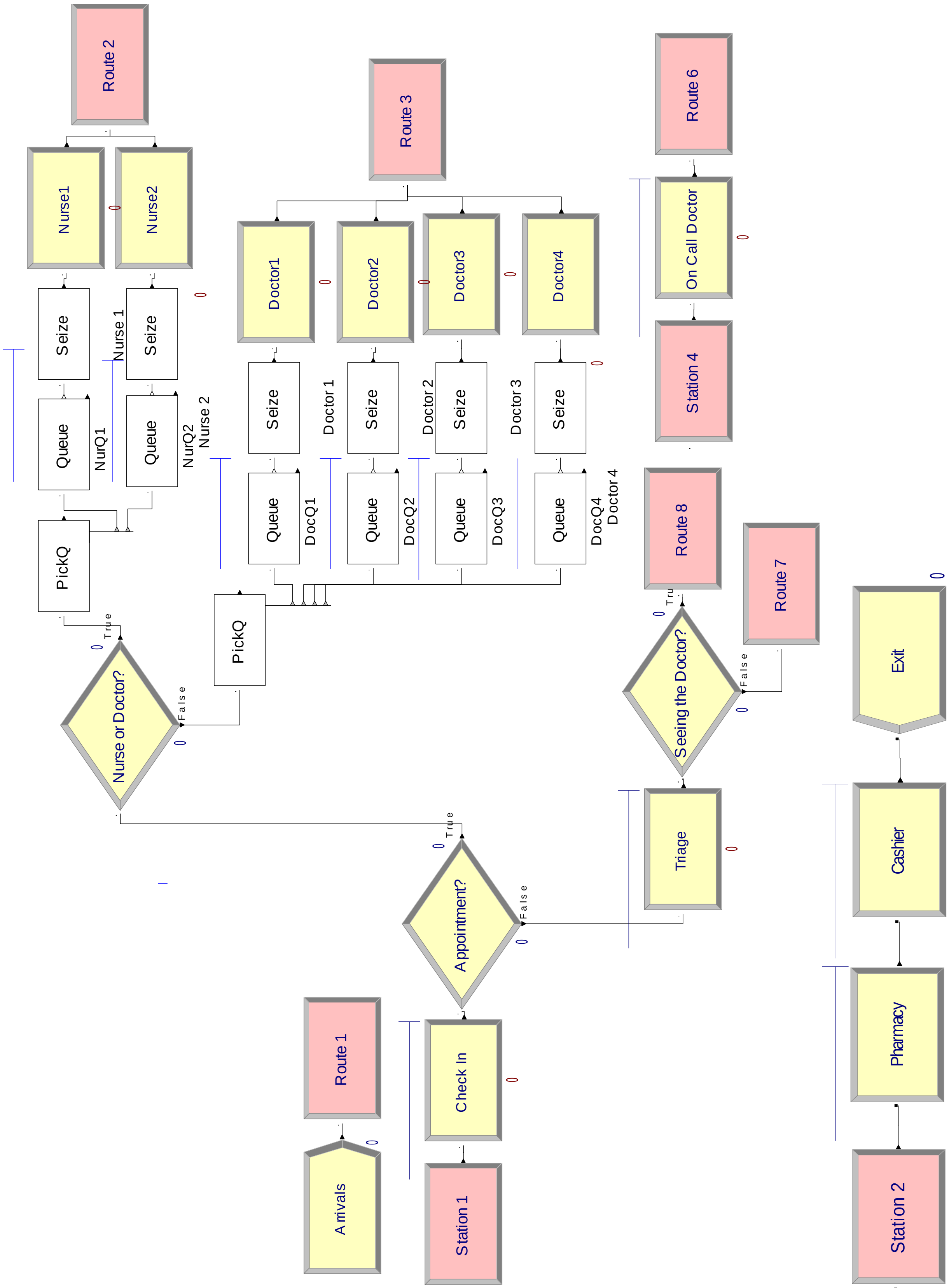


FIGURE 1: ALTERNATIVE 1 AND 3 MODEL SYSTEMS

PROJECT PLAN

We plan to continue our team efforts by splitting the work load and collaborating with our efforts.

Oscar Bermudez will discuss replication and run length strategies used in our simulation testing. This will be completed by Wednesday, November 30, 2011.

Diego Escare will analyze and summarize statistical results for each alternative (mean, confidence intervals for all performance measures of interest). This will be completed by Friday, December 2, 2011.

Theresa Garcia will be responsible for summarizing the results of the statistical comparison of alternatives. She will also discuss conclusions and recommendations of the SHC study. Her summary will be due on Monday, December 5, 2011.

Cecilia Bonilla will point out the challenges that our team ran into and what we learned from these challenges. Her summary will also be due on Monday, December 5, 2011.

The entire group will meet on Wednesday, December 7, 2011 to compile, review and edit and the final paper will be turned in on Friday, December 9, 2011.

INPUT ANALYSIS

In order to collect all necessary data for the project, the team visited the Student Health Center ten times in a one week period. The processes observed were arrivals and service times at each relevant station. Each team member was assigned a specific day and hour to get data for a particular station. The stations observed were the entrance (arrivals), front desk, nurse's station, doctor's station, pharmacy and cashier station. The process of gathering data was done using stopwatches and specific tables for the data to be recorded specially designed for each station. Once the data was collected, it was typed and saved into a text file so it could be opened using input analyzer.

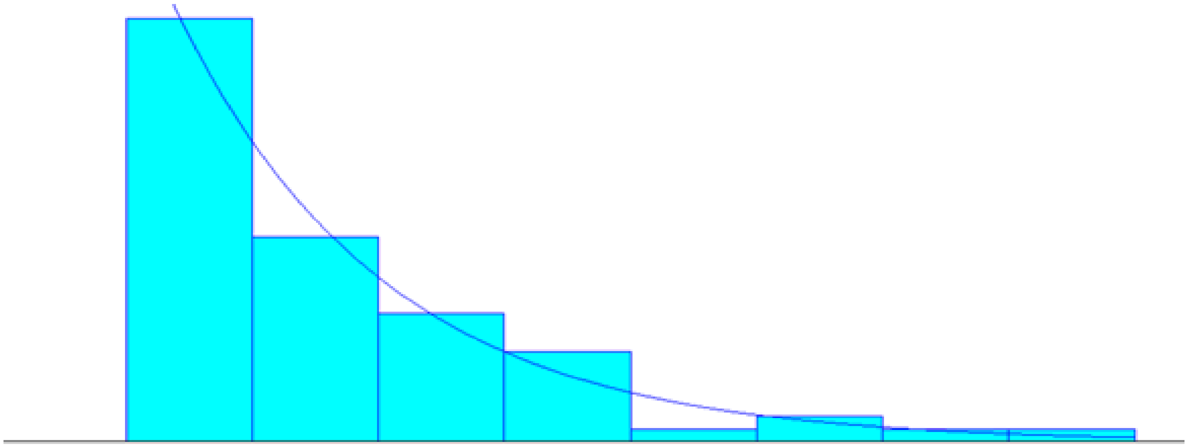
Input Analyzer was used to evaluate the data collected for each station in the SHC. It was also used to determine which distribution best fit the data sets (Using Fit ALL option). The Input Analyzer presented graphs with several statistical data for each station. With all the information given by the program, and by getting the best p value for each data set, the team can continue to add this data to the model for the health center.

Process Blocks

Using a significance level of $\alpha=0.05$, the results of the Goodness-of-fit test results for each process block are as follows:

- Figure 3 Inter-Arrival Times: With a Chi-Square p value > .75 and using 71 observations, the inter-arrival time was best fit to an Exponential Distribution, with a β=2.28 minutes.
- Figure 4 Check In Service Times: With a Chi square test p-value of 0.42 and a KS Test p value > .15 and using 32 observations, the service time distribution that will e used for the model is an Exponential Distribution, with β=0.288 minutes.
- Figure 5 Cashier Service Times: With a Chi-square Test P-value of 0.315 and KS Test p value > .15 and using 34 observations, the Cashier service time was best fitted as an Exponential Distribution, with a β=1.67 minutes. .
- Figure 6 Pharmacy Service Times: With a Chi-Square p-value of 0.47 and a KS p value >0.15, the Hypothesis was not rejected, meaning that we will use the following expression for the Pharmacy Service Time: 1 + 17 * BETA(1.54, 2.49) minutes.
- Figure 7 Triage Service Times: with a Chi-square p value >0.15, and using 12 observations, Exponential Distribution was the best fit to our data, with a β= 2.06 minutes.
- Figure 8 Nurses Service Times: There is no Chi-square since we have insufficient data points. Using 11 observations, the Nurse service time was best fit to Gamma Distribution, with α =1.15, and β=12.5 minutes. Also, the service time considers a constant time of 2 minutes.
- Figure 9 Doctors Service Times: There is no chi-square since we do not have enough data to analyze the information. Using 5 observations, the Doctor service time was best fit to a Lognormal Distribution, with μ=2.25 and α= 2.17minutes. Also, the service time considers a constant time of 4 minutes.

Input Analysis Histograms



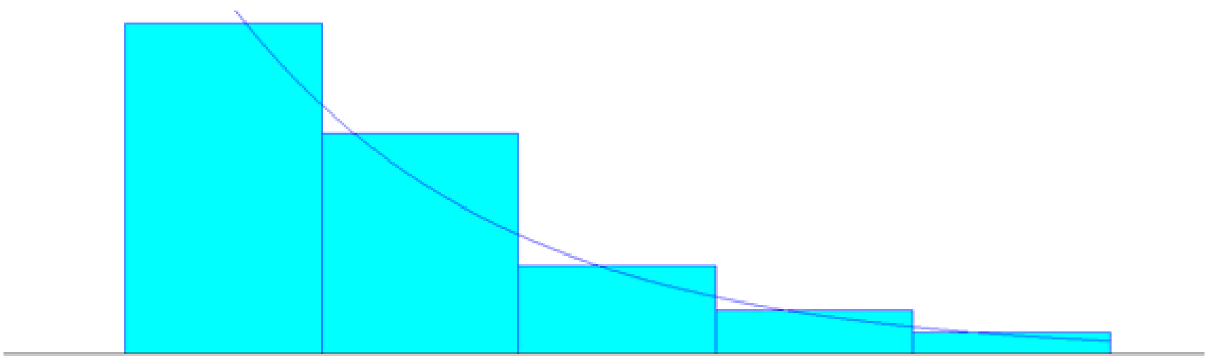
```
        Distribution Summary

Distribution:   Exponential
Expression:     EXPO(2.28)
Square Error:   0.002075

Chi Square Test
  Number of intervals   = 4
  Degrees of freedom    = 2
  Test Statistic        = 0.259
  Corresponding p-value > 0.75

Kolmogorov-Smirnov Test
  Test Statistic        = 0.0731
  Corresponding p-value > 0.15
```

FIGURE 2: HISTOGRAM OF INTER-ARRIVAL TIMES



```
        Distribution Summary

Distribution:   Exponential
Expression:     EXPO(0.434)
Square Error:   0.006799

Chi Square Test
  Number of intervals   = 3
  Degrees of freedom    = 1
  Test Statistic        = 0.733
  Corresponding p-value = 0.42

Kolmogorov-Smirnov Test
  Test Statistic        = 0.168
  Corresponding p-value > 0.15

        Data Summary

Number of Data Points   = 32
Min Data Value          = 0.02
Max Data Value          = 1.45
Sample Mean             = 0.434
Sample Std Dev          = 0.331

        Histogram Summary

Histogram Range         = 0 to 1.6
Number of Intervals     = 5
```

FIGURE 3: HISTOGRAM OF CHECK IN SERVICE TIMES

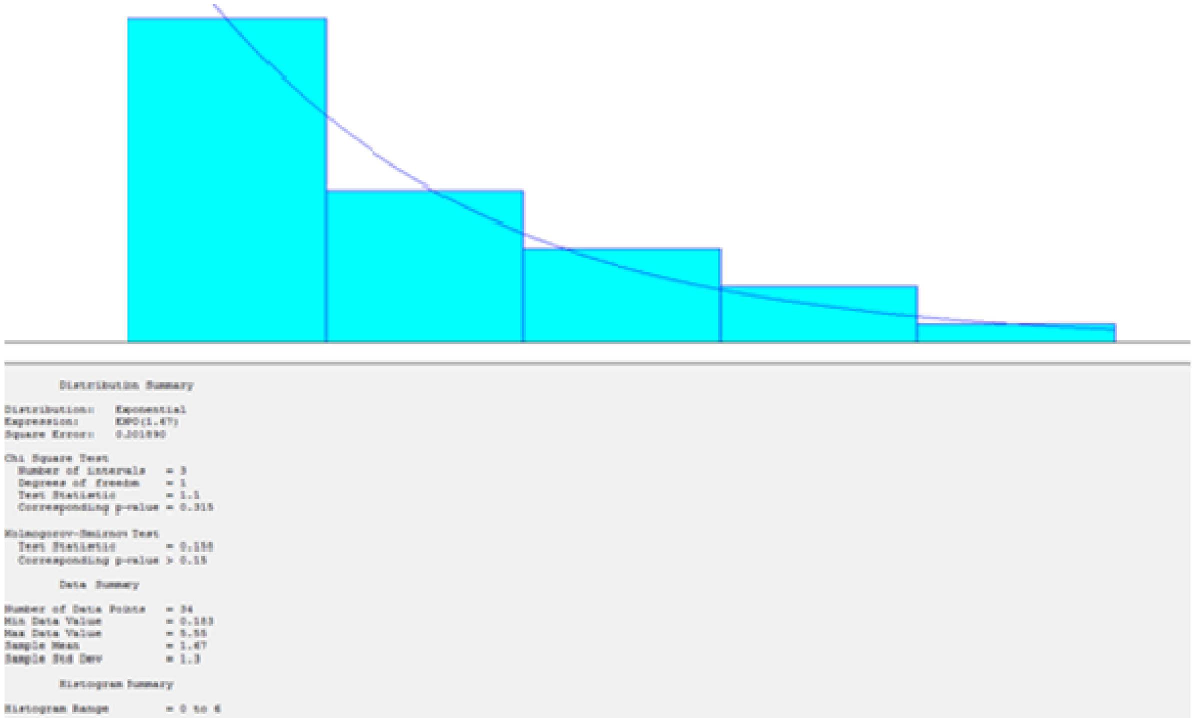


FIGURE 4: HISTOGRAM OF CASHIER SERVICE TIMES

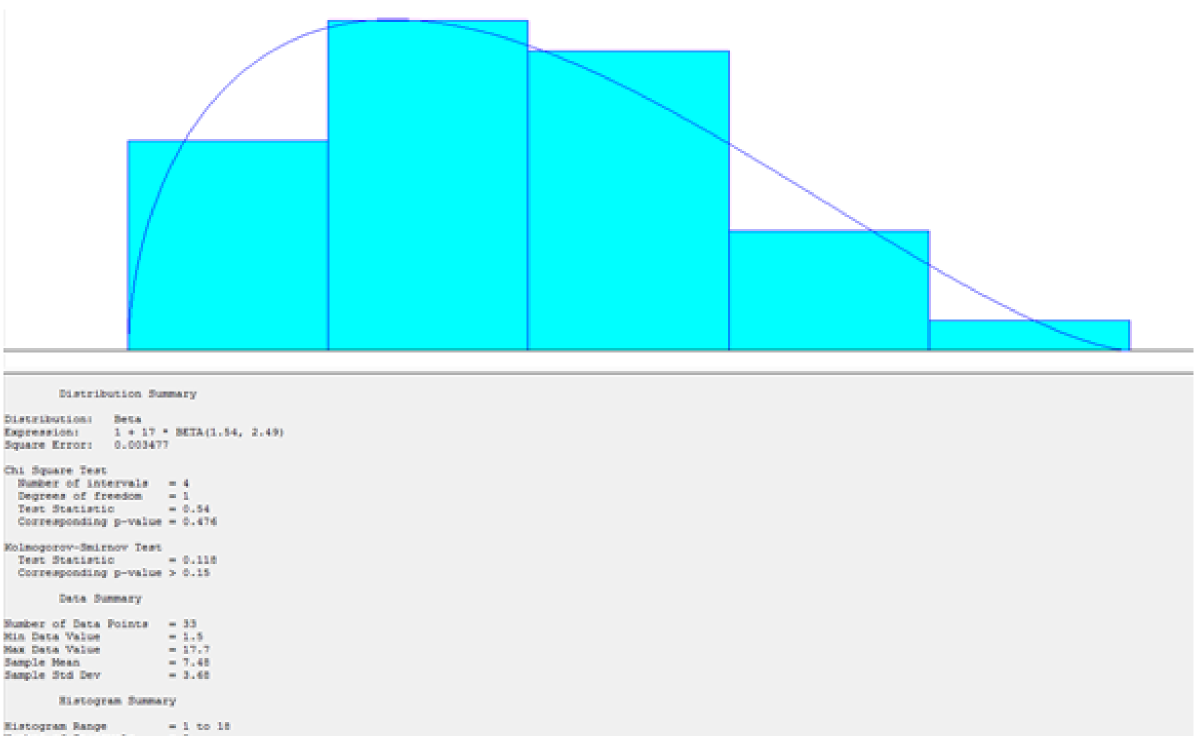


FIGURE 5: HISTOGRAM OF PHARMACY SERVICE TIMES

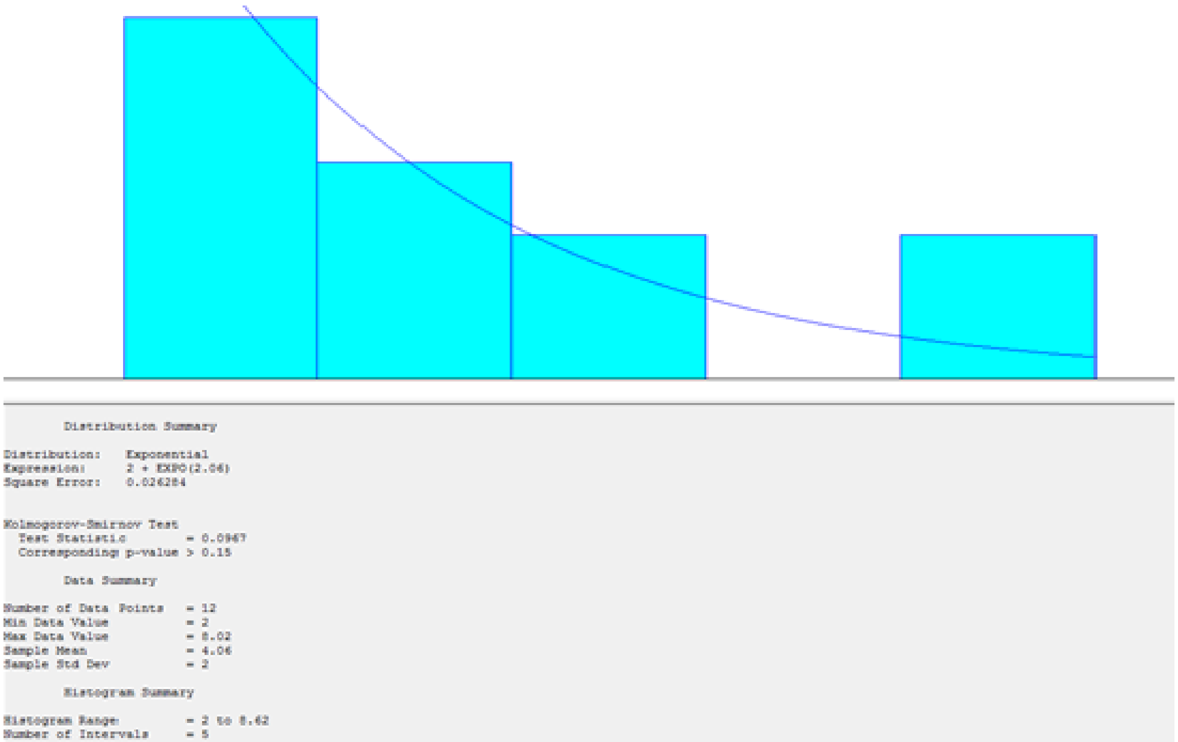


FIGURE 6: HISTOGRAM OF TRIAGE SERVICE TIMES

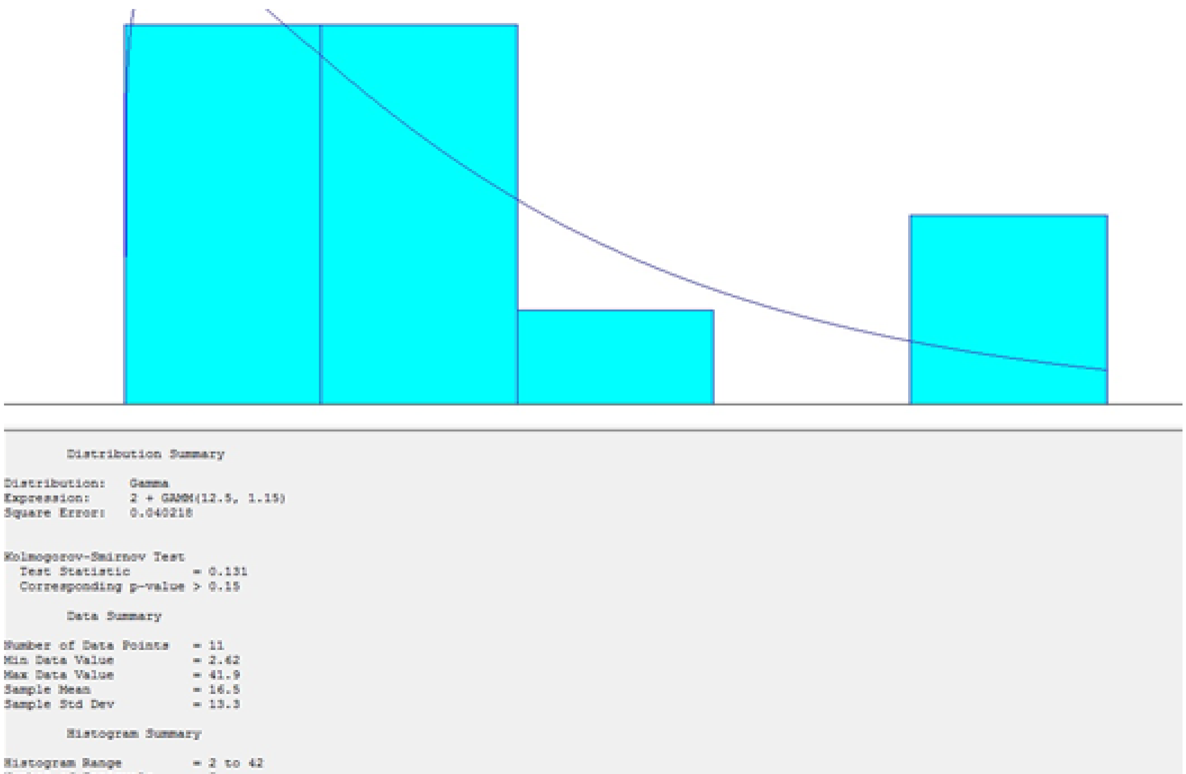


FIGURE 7: HISTOGRAM OF NURSES SERVICE TIMES

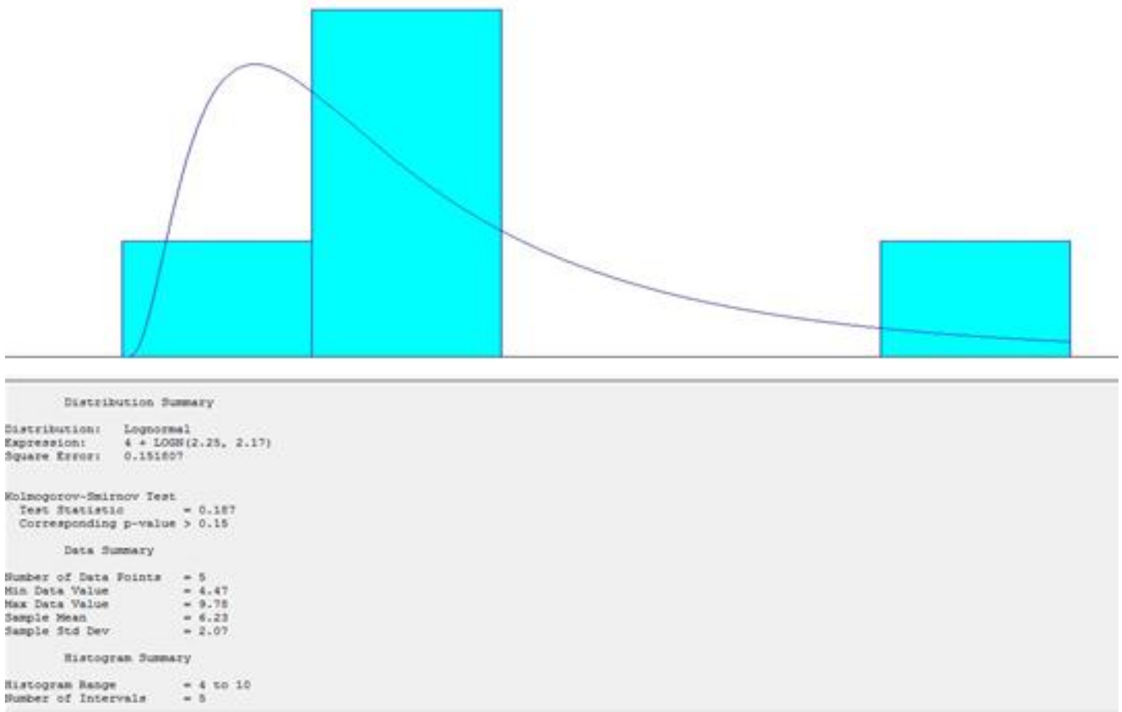


FIGURE 8: HISTOGRAM OF DOCTORS SERVICE TIMES

Decision Blocks

- Appointments?: By chance. Percentage calculated with data measured at the front desk during the first weeks. People would say if they had an appointment or not, this data was recorded, and the estimation of the proportion of people that arrive with an appointment was 70.45%. This number was used as the block's chance.
- Nurse or Doctor?: By chance. Calculated by documenting the number of appointments per day during a given week for nurses and doctors. The results showed that 27.52% of scheduled appointments are for nurses, while the remaining 72.48% of appointments are to see doctors.
- Seeing a doctor?: Based on questions made to nurses in the Health Center, around 75% of walk in patients that see the Triage Nurse go to see the on-call doctor. Data was also taken and on a specific day, 87 patients were attended by the Triage nurse and 57 of the patients attended by the triage were then directed to the on-call doctor. Therefore 65.52% of patients that go to the Triage then go to see the doctor. We will be using 70%, the average of these two numbers, as the percentage of walk in patients that see a doctor after a visit to the triage.

Route & Station Blocks

Using a stopwatch, the time to walk from one station to the other was measured (twice). The transport time will be considered constant, and it will be the average of the 1st and 2nd observation for each distance:

Existing Model	Transport Times Between Existing Stations (seconds)		
Distance	1st Measure	2nd Measure	Average
Entrance – Check In	9.75	9.16	9.455
Hall 1(Nurses) - Pharmacy	41.98	41.46	41.72
Hall 2 (Doctors) - Pharmacy	58.39	55.96	57.175
Pharmacy - Cashier	13.33	14.43	13.88
Triage – On call doctor	9.08	7.81	8.445

TABLE 3: TRANSPORT TIMES BETWEEN EXISTING STATIONS

Alternative Model	Transport Times Between Stations in Alternative Locations (seconds)		
Distance	1st Measure	2nd Measure	Average
Entrance – Check In	4.74	4.24	4.49
Hall 1 – Pharmacy	19.44	18.4	18.92
Hall 2 – Pharmacy	12.95	13.63	13.29
Triage – On call doctor	22.67	21.93	22.3
Pharmacy – Cashier	-	-	

TABLE 4: TRANSPORT TIMES BETWEEN STATIONS IN ALTERNATIVE LOCATIONS

Existing Model Validation

In order to ensure that our Arena simulation was giving us an accurate representation of the real system, we compared confidence intervals of the flow and wait times between the arena output data and the hard data that we collected. The calculated confidence intervals can be referenced in Table 3. Since both the arena output and hard data confidence intervals overlap for wait times and flow times, it can be concluded that the arena simulation produces an accurate representation of the real system.

Arena Output		Hard Data	
Wait Time	Flow Time	Wait Time	Flow Time
(5.39, 7.51)	(24.27, 26.75)	(5.84, 8.73)	(22.38, 24.86)

TABLE 5: CONFIDENCE INTERVAL COMPARISONS FOR MODEL VALIDATION

We also performed another validation calculation. Currently the Student Health Center is working with 15 minutes appointments instead of 10 because they are implementing the self-check in. As a result, each doctor has 25 appointments each day. There are 6 doctors working daily and 100 walk in come daily from the triage, meaning that 25 appointments * 6 doctors + 100 walk in from the triage will give a total of 250 patients. In our existing modeling the results were 221 patients, so it can be concluded that it is similar to the real life model.

OUTPUT ANALYSIS

To test if there is any statistical significance among the alternatives and the existing model, several aspects were tested between them: flow time, wait times, and instantaneous utilization of the resources.

A confidence interval was made for each, creating a total of 9 Confidence Intervals per alternative. Even though there are just 2 nurses and 4 doctors, there is only one C.I for the Nurses, and one for the Doctors (Why this average was made will be explained further).

The reason behind making an average C.I for doctors and nurses is that into the model, the PickQ block had the Random (RAN) selection rule, and the utilization for each nurse/doctor was subject to the RNG. It was common to see a nurse get a really high utilization in expense of the other during a replication, while in other replications the same nurse would get a low utilization, in benefit of the other one (same is true for the doctors). So since both nurses share the same input (coming from the same decision block) and have the same distribution, an average was possible.

If we go back to queuing theory, the definition for Instantaneous Utilization is given by the following equation:

$$\rho = \frac{\lambda}{\mu}$$

If we assume that the input that arrives at the Nurses is denoted by λ, we can state that:

$$\lambda = \lambda_1 + \lambda_2$$

Where λ_1 is the effective arrival rate for Nurse 1, and λ_2 is the effective arrival rate for Nurse 2. As we said, both of them have the same service distribution, and thus the same mean. If we average their Utilizations:

$$\frac{\rho_1 + \rho_2}{2} = \frac{1}{2} * \left(\frac{\lambda_1}{\mu} + \frac{\lambda_2}{\mu}\right) = \frac{\lambda}{\mu * 2}$$

This final result equals the formula for queuing theory Utilization, when multiple stations with the same service distribution work in parallel. This analysis can be done for the doctors, getting the same results. Thus, the Utilization will be averaged replication per replication (meaning that our confidence intervals will still be made out of 30 I.I.D data points).

All of the following Confidence Intervals were calculated using the T-Paired Test method, subtracting the result of the Alternative to the Base Model's results.

RESULTS

In order to compare our alternatives and conclude which alternatives produced a significant improvement we performed paired t-tests between each alternative and the existing base model.

BASE MODEL-ALTERNATIVE 1

Flow time

Confidence Interval	
Lower Bound	Upper Bound
-0.4770	2.8819

Conclusion: C.I. on flow time does not yield sufficient statistical evidence to state that Alternative 1 actually reduces the Flow time.

Wait Times

Confidence Interval	
Lower Bound	Upper Bound
-1.1191	1.8339

Conclusion: C.I. on wait time does not yield sufficient statistical evidence to state that Alternative 1 actually reduces the waiting times of patients.

Check-In Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0059	0.0029

Conclusion: C.I does not yield sufficient statistical evidence to state that Alternative 1 actually increases Check-In Utilization.

Nurses Utilization

Confidence Interval	
Lower Bound	Upper Bound
0.0252	0.1617

Conclusions: C.I indicates that there is statistical evidence that Alternative 1 reduces the Nurses Average Utilization.

Doctors Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0294	0.0282

Conclusions: C.I indicates that there is no statistically significant change in doctors utilization.

Pharmacy Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0596	0.0136

Conclusions: C.I indicates that there is no statistically significant change in the pharmacy utilization.

Cashier Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0542	0.0066

Conclusions: C.I indicates that there is no statistically significant change in the cashier utilization.

Triage Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0844	0.0236

Conclusions: C.I indicates that there is no statistically significant change in the triage utilization.

On-Call Doctor Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0618	0.0535

Conclusions: C.I indicates that there is no statistically significant change in the on-call doctor utilization.

BASE MODEL- ALTERNATIVE 2

Flow time

Confidence Interval	
Lower Bound	Upper Bound
0.5075	3.6855

Conclusions: C.I indicates that there is statistically relevant evidence that Alternative 2 effectively decreases flowtime.

Wait Time

Confidence Interval	
Lower Bound	Upper Bound
0.3638	2.9173

Conclusions: C.I indicates that there is statistically relevant evidence that Alternative 2 decreases wait times.

Check-In Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0705	-0.0538

Conclusions: C.I indicates that there is statistically relevant evidence that Alternative 2 effectively increases Check-In Utilization.

Nurses Utilization

Confidence Interval	
Lower Bound	Upper Bound
0.0763	0.2173

Conclusions: C.I indicates that there is statistically relevant evidence that Alternative 2 decreases Nurses average Utilization (which is normal, since we are reducing the workload on them).

Doctors Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0631	0.0021

Conclusions: C.I indicates that there is no evidence that Alternative 2 does not increase doctors average utilization.

Pharmacy Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0483	0.0309

Conclusions: C.I indicates that there is no statistically relevant evidence that Alternative 2 effectively increases Pharmacy Utilization.

Cashier Utilization:

Confidence Interval	
Lower Bound	Upper Bound
0.0809	0.1207

Conclusions: C.I indicates that there is statistically relevant evidence that Alternative 2 reduces Check-In Utilization.

Triage Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0910	0.0125

Conclusions: C.I indicates that there is statistically relevant evidence that Alternative 2 affects Triage Utilization.

On-Call Doctor Utilizations

Confidence Interval	
Lower Bound	Upper Bound
-0.0866	0.0446

Conclusions: C.I. indicates that there is statistically relevant evidence that Alternative 2 affects Check-In Utilization.

BASE MODEL- ALTERNATIVE 3

Flow time

Confidence Interval	
Lower Bound	Upper Bound
0.8540	3.9540

Conclusions: C.I. indicates that there is statistically relevant evidence that Alternative 3 effectively reduces flow time.

Wait Time

Confidence Interval	
Lower Bound	Upper Bound
-0.1284	2.2061

Conclusions: C.I. indicates that there is no statistically relevant evidence that Alternative 3 effectively reduces waiting time.

Check-In Utilizations

Confidence Interval	
Lower Bound	Upper Bound
-0.0686	-0.0577

Conclusions: C.I. indicates that there is statistically relevant evidence that indicates that Alternative 3 reduces Check In utilization.

Nurses Utilization

Confidence Interval	
Lower Bound	Upper Bound
0.1525	0.3040

Conclusions: C.I. indicates that there is statistically relevant evidence that Alternative 3 reduces Nurses Utilization.

Doctors Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0490	0.0026

Conclusions: C.I. indicates that there is no statistically relevant evidence that Alternative 3 affects Doctors Utilization.

Pharmacy Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0512	0.0245

Conclusions: C.I. indicates that there is no statistically relevant evidence that Alternative 3 affects Pharmacy Utilization.

Cashier Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0249	0.0344

Conclusions: C.I. indicates that there is no statistically relevant evidence that Alternative 3 affects Cashier Utilization.

Triage Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0907	0.0255

Conclusions: C.I. indicates that there is no statistically relevant evidence that Alternative 3 affects Triage Utilization.

On-Call Doctor Utilization

Confidence Interval	
Lower Bound	Upper Bound
-0.0917	0.0300

Conclusions: C.I. indicates that there is no statistically relevant evidence that Alternative 3 affects On-Call Doctor Utilization.

CONCLUSION

The paired t tests showed that Alternative 1 produced the least significant results. The confidence intervals for the flow time, wait time and resource utilizations in Alternative 1 all contained 0 within the intervals. Only the confidence interval for the Nurse's utilization did not contain 0 but it yielded a positive interval meaning that the base alternative had a higher utilization than the alternative. We therefore concluded that the proposed layout changes are not justified for the sake of decreasing flow and wait times and increasing resource utilization.

Interpreting the results of the paired t tests for Alternative 2 showed that both flow and wait times were decreased. Because the alternative was subtracted from existing base model and the confidence intervals both had positive ranges, the base model had larger times. Because smaller numbers are preferred for flow and wait times, alternative 2 is preferred. The only resource utilizations that produced significant results were the check-in, nurse and cashier resources. Only the check-in confidence interval yielded a negative interval, and as previously explained, this means that Alternative 2's resource utilization was higher than the base model but both nurse and cashier resource utilization for the alternative was lower.

Alternative 3 yielded smaller flow times but wait times did not yield significant results. The only resource utilizations that produced significant results were the check-in and nurse resources. Only check-ins increased the resource utilization as the result yielded a negative confidence interval meaning that the alternative had higher check-in resource utilizations than the base models.

Of the three Alternatives, Alternative 2 was selected as the best Lean Alternative for The Student Health Center as its results most fully accomplished our management objectives of decreasing flow and wait times, and increasing resource utilization.

CHALLENGES

We encountered several challenges throughout the course of this project. The first, and most difficult, challenge we encountered dealt with data collection. In order to collect data at the student health center, we had to speak with the manager in order to receive permission to collect data. We were discouraged from going anywhere other than the waiting room which made it difficult to watch for doctor and nurse utilizations as we had to stand at the end of the hallway to take down data. It was also very difficult for one person to note service times for more than one doctor or nurse at a time. Receiving greater clearance within the SHC and having one data collector for every resource would have been a tremendous help to record more accurate data. Other difficulties that our group encountered were finding times when all group members could meet and coming up with lean alternatives that would not that would yield positive results in regards to our management objectives. From these challenges, we learned that data collection requires patience and is more difficult than it seems, people are very busy and that alternatives of which you are certain will produce the wanted results sometimes don't, and therefore model simulation is an extremely valuable tool in making decisions. Testing out an alternative model to see if it produces the wanted results before spending a dime on implementing it is very beneficial.