

Improving Patient Wait Times for Oncology Atlanta VA Medical Center

Team 29 VA Process

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**Disclaimer:* This project has been created as a part of a student design project at the Georgia Institute of Technology.

Executive Summary

This report provides an overview of our project at the Oncology Department of the Atlanta Veterans Affairs Medical Center. The main problem was the long wait time cancer patients currently experience, which our project focuses on reducing. The Oncology Department specializes in the diagnosis, treatment, and prevention of cancer for veterans. Three types of patients visit the treatment center: treatment-only patients, physician-only patients, or patients who have both a physician visit and a treatment visit on the same day. From the front desk to the Oncology Treatment Center, treatment-only patients spend 99 minutes versus a target time of 45 minutes, physician only patients spend 70 minutes, and patients scheduled for both spend 146 minutes versus a target time of 75 minutes.

A simulation was created to model the current state of the system. After validation, the simulation model was used to test different scheduling guidelines, Lab alternatives, and expansion opportunities. The model was also used to test different scenarios before implementing our recommendations, which suggest that 40% of Oncology patients use their local CBOC (Community Based Outpatient Clinic) as an alternative location for lab work. The Lab, where all cancer patients must go through before starting their treatment, remains to be a serious bottleneck for patients. The long wait time and process time at the Lab caused significant variability throughout the rest of the flow.

In order to decrease patient wait time and nurse overtime, we took the following steps: we shifted the writing of the return-to-clinic orders from physicians to nurses (with the written approval of the head of the Oncology Department) to reduce the workload on physicians and enhance continuity of care between the nurses and the patients, developed a scheduling tool based on Excel VBA to serve as a visibility tool to efficiently manage the utilization at the Oncology Treatment Center, and proposed scheduling guidelines to enhance the scheduling process of patients by levelling the load of patients throughout the day to reduce variability in the overall utilization of the Oncology Treatment Center.

Finally, an expansion layout to determine the number of treatment chairs/beds in the new space the Oncology Department acquired, was also provided. The design of that layout added to the scheduling tool and guidelines will save 75 minutes in the time spent from checking in to sitting in the treatment chair. The indirect savings added to the savings from the reduction of nurse overtime, including expenses for the expansion amount to \$367,984 a year.

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1. Introduction

1.1. Company Description

The Atlanta Veterans Affairs Medical Center (VAMC) is a designated medical facility serving the healthcare needs of more than 130 thousand enrolled veterans living in 50 counties across Northeast Georgia. The VAMC provides a variety of services from general check-ups to surgeries.

1.2. Client Description

The Oncology Department of the Atlanta VAMC, which is the focus of this project, deals with prevention, diagnosis, and treatment of cancer for over 18 thousand veterans per year. Each day, the Oncology Treatment Center treats 40 to 60 patients on average. The appointment frequency can vary from daily to once every four weeks based on the type of cancer. Currently, 35 different types of treatments with varying durations are administered to the patients. The treatment center is open Monday through Friday from 7:30 AM to 6:30 PM; however, appointments are scheduled only from 7:30 AM till 3:00 PM. The primary problem that the client faces is long patient wait time before treatment. The secondary problem is nurse overtime, as a result of poor scheduling.

1.2.1. Resources

Below are the number of resources at each critical checkpoint in the patient flow.

- Front Desk: 4 receptionists
- Triage: 6 exam rooms
- Physician Resources:
 - 8 Medical doctors
 - 5 Emory fellows
 - 1 Physician assistant
 - 3 Nurse practitioners
 - 1 PharmD
- Oncology Treatment Center:
 - 15 chairs
 - 3 beds
 - 8 nurses

1.2.2. Flow

Figure 1 shows the Oncology patient flow. There are three distinct patient flows, which are based on the three patient types: physician-only patients, treatment-only patients, and patients who have both a physician visit and receive treatment.

All Oncology patients are required to visit the Lab before going to their treatment or physician visit. Lab is where blood is collected, tested, and results are released. Because this area is utilized by all patients and departments in the hospital, 16 thousand blood tests are processed each day. Therefore, the Oncology patients are asked to arrive to Lab one hour before their scheduled appointment to ensure a start of treatment on time.

From the Lab, all patients check in at the Front Desk where they fill out any necessary paperwork and wait in the nearby clinic Waiting Room.

When called, the Oncology patients proceed to Triage, where a nurse checks their vital signs to confirm that they are healthy enough to receive treatment. After Triage, they can either go to the Oncology Treatment Center or to their physician visit. Currently, 52% of patients have only a treatment appointment, 22% have only a physician appointment, and 26% have both a treatment and physician appointment.

Patients who have a physician appointment will proceed to the Physician Waiting Room until called for their appointment, during which physicians review the overall treatment progress and regimen. These appointments must happen within 7 days prior to a patient's scheduled treatment. If the patient has a treatment appointment on the same day, they will go to the Oncology Waiting Room to wait until they are called to begin treatment. Otherwise, patients will proceed to the Front Desk to check-out and schedule their next physician and treatment appointments.

Patients who have a treatment appointment will go to the Oncology Waiting Room until they are called for treatment. Inside the Oncology Treatment Center, patients are assigned to chairs where nurses administer treatments and continuously monitor them until the treatments are complete. Patients are not scheduled for treatments after 3 PM to ensure that they will finish treatment within the clinic operating hours. After treatment, the patient will head to the Front Desk to check-out and schedule their next appointment with a scheduler. The latter receives a return-to-clinic order from the patient's physician, which specifies the following appointment date and time.

From the front desk to the Oncology Treatment Center, treatment-only patients spend 99 minutes versus a target time of 45 minutes, physician-only patients spend 70 minutes versus a target time of 75 minutes, and patients scheduled for both spend 146 minutes versus a target time of 75 minutes.

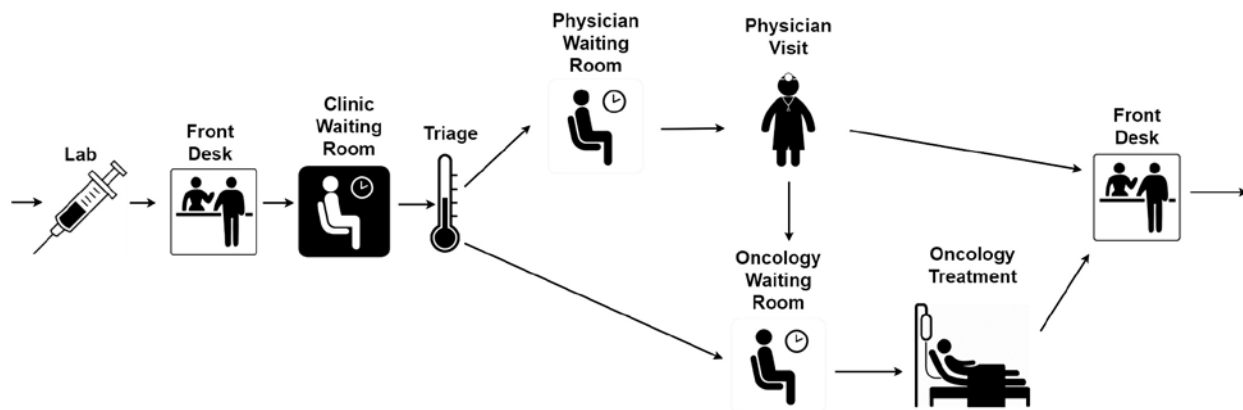


Figure 1. Patient Flow

2. Problem Description

The objective of the project was to analyze the patient flow system through the assessment of the arrival and wait time distribution. Long patient wait times can result in delayed treatment, overburdened working staff, low productivity, and poor patient satisfaction. An efficient patient flow system minimizes unnecessary treatment delays.

Wait time is often the most pervasive cause of patient dissatisfaction in a hospital setting and is the most important area of improvement for the Oncology Department. Multiple factors including increased arrival rate, long processing time, lack of coordination of care, and workload on existing staff, lead to long wait times.

An upstream bottleneck in the system is Lab, which is the first step in the flow and causes great variability throughout the entire system. This leads to an overload of patients due to delays in lab results. High arrival rates in peak hours and unlevelled staffing also result in various bottlenecks throughout the flow.

2.1. Lab

Since patients' lab results must be complete before receiving treatment, the phlebotomists must draw blood and the lab technicians must process lab results in a timely manner. However, time studies for the wait times in the Lab show an average patient wait time of 40 minutes, with a standard deviation of 10 minutes, from arrival to check-in. In addition to the long wait time, the process time for the results takes on average 1 hour and 23 minutes with a standard deviation of 36 minutes. These long wait times cause delays in the treatment center, which significantly affects utilization throughout the day.

2.2. Treatment Scheduling

Currently, patient treatments are scheduled between 7:30 AM and 3:00 PM from Monday to Friday. Appointments are scheduled using the Veterans Information System and Technology Architecture (VistA).

The current scheduling procedure has many opportunities for improvement:

- Physicians are unable to see the Oncology Treatment Center schedule. The lack of visibility causes physicians to write return-to-clinic orders without the knowledge of the number of patients currently scheduled for treatment on a specific day, leading to high fluctuations of patients into the treatment center.
- Schedulers do not follow a standard procedure when inputting the appointments into the VistA scheduling grid. Some schedulers enter the appointments including the treatment duration (scheduling between 30 minutes to 8 hours for the patient's treatment duration) whereas others do not. Therefore, there is no accurate measure of the utilization of the treatment center at any given time.
- Schedulers employ an overbooking policy in order to adhere to VAMC protocol in which every patient receives the appointment requested even if the resulting appointment would cause an overbooking in the VistA system.

Figure 2 shows a sample of the current VistA scheduling grid where the days of the week are in rows, and the times within each day are in columns (in 30-minute interval blocks). The VAMC books patients using a 3, 2, 1, 0, A, B, C system; the alphabet usage of the system can go up to double letters. Currently the schedulers understand the numbering system as:

- 3 - no patient in the system
- 2 - one patient in the system
- 1 - two patients in the system
- 0 - three patients in the system
- A - one overbooked patient

Any letter past "A" means an additional overbooked patient.

TIME DATE	7	8	9	10	11	12	1	2	3							
FR 14	[3]	[C]	[C]	[D]	[D]	[J]	[F]	[J]	[G]	[I]	[D]	[D]	[0]	[A]	[1]	[3]
MO 17	[3]	[0]	[C]	[A]	[0]	[D]	[B]	[E]	[E]	[C]	[0]	[0]	[1]	[2]	[2]	[3]
TU 18	[2]	[B]	[0]	[D]	[D]	[H]	[D]	[D]	[F]	[D]	[D]	[A]	[1]	[1]	[1]	[2] *
WE 19	[3]	[B]	[C]	[F]	[A]	[C]	[A]	[C]	[0]	[D]	[A]	[0]	[0]	[1]	[0]	[1]
TH 20	[3]	[A]	[B]	[A]	[B]	[F]	[B]	[A]	[0]	[1]	[2]	[2]	[2]	[2]	[3]	[3]
FR 21	[3]	[B]	[A]	[C]	[D]	[E]	[C]	[C]	[1]	[0]	[2]	[0]	[1]*	[2]	[2]	[2]
MO 24	[3]	[0]	[1]	[1]	[0]	[A]	[3]	[A]	[0]	[B]	[0]	[0]	[0]	[1]	[2]	[2] *
TU 25	[3]	[0]	[0]	[C]	[E]	[D]	[D]	[0]	[A]	[A]	[0]	[0]	[2]	[2]	[3]	[3]
WE 26	[3]	[A]	[C]	[B]	[E]	[C]	[B]	[E]	[B]	[E]	[0]	[0]	[A]	[A]	[1]	[2] *
TH 27	[3]*	[3]	[0]	[B]	[A]	[C]	[C]	[A]	[2]	[1]	[0]	[2]	[2]	[2]	[3]	[1]
FR 28	[3]	[0]	[1]	[D]	[E]	[B]	[B]	[A]	[C]	[E]	[C]	[C]	[0]	[C]	[0]	[3]
MO 31	[3]	[1]	[2]	[2]	[2]	[B]	[2]	[2]	[1]	[3]	[3]	[2]	[3]	[3]	[3]	[3]
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TU 01	[2]	[2]	[2]	[B]	[1]	[D]	[B]	[D]	[G]	[B]	[0]	[1]	[1]	[0]	[1]	[0]

30 MINUTE APPOINTMENTS (VARIABLE LENGTH)

DATE/TIME:

Figure 2. VistA Scheduling Grid

The treatment center can treat up to 18 patients at once. However, the current VistA system suggests that more than 3 patients scheduled for the same appointment time is considered an overbooking. A true overbooking would have over 18 patients scheduled in the treatment center at the same time. Therefore, schedulers do not have an accurate visualization of the current state of the treatment center when using VistA.

2.3. Physician Constraints

The number of physicians available each day at the Oncology Treatment Center varies because the physicians' schedules are based on the number of exam rooms dedicated to the Oncology Department each day of the week. The allotment of rooms does not change, so the schedule remains consistent from week to week. Changing the number of exam rooms dedicated to the department is out of the scope of the project.

The Oncology physicians include medical students (fellows), medical doctors (MD), nurse practitioners, and physician assistants. The appointment durations depend on the level of education the physician has completed as well the physician's expertise. Table 1 shows the day by day breakdown of available physician appointments with their corresponding durations. Fellows have 30 minute appointment durations because they must consult an MD for treatment recommendations.

Table 1. Physician Appointment Availability

	Number of Physician Appointments					Appointment Durations
	Monday	Tuesday	Wednesday	Thursday	Friday	
NP1	7		9			15 minutes
MD-D	7		9		9	45 minutes
PA1	7		7	9		15 minutes
Ther MD1	7					15 minutes
Phar MD	4	4	4	4	4	30 minutes
Hem NP		9				45 minutes
GI MD		9				15 minutes
MD-K		9				15 minutes
Hem MD1			4			60 minutes
Ther MD2					10	10 minutes
Fellow 6					6	30 minutes
Fellow 7					6	30 minutes
Fellow 1		6				30 minutes
Fellow 3		6				30 minutes
Total	32	43	33	13	35	

Of all the Oncology patients, 26% come to the VAMC specifically for a physician appointment and must return within the next seven days for treatment. However, the physicians prefer patients to return the following day for treatment. On average, 80% of the patients who have a physician visit on Tuesday (when most of the physicians are scheduled) return later in the week for treatment. This increases the number patients receiving treatment during the latter half of the week, creating congestions in the treatment center, which result in longer patient wait times.

Therefore, the issue of unbalanced utilization and availability of resources contributes to longer wait times.

2.4. Nurse Overtime

Nurse overtime is a secondary issue resulting from long patient treatments, which start usually after 12 PM. As a policy, a nurse must stay until the completion of a patient's treatment, which potentially leads to overtime, thus inducing unnecessary costs to the Oncology Department.

3. Data Collection Process

In order to fully analyze the system, data points and timestamps were collected from the hospital records both electronically and manually. The VAMC uses two main applications for electronic health records: VistA and CPRS. The Computerized Patient Record System, or CPRS for short, holds all historical health records for all patients as well as appointment histories. Refer to Table A (in Appendix Section 7.1.) for the breakdown of each type of data and sources.

To gather more information about the patient flow, we performed two time studies in order to find the following two averages: lab waiting time and physician consultation time.

Below are types of data that the team collected for data analysis:

- Lab check-in times
- Patient check-in times
- Triage check-in times
- Physician appointment times
- Treatment appointments and duration of treatment
- Overtime of nurses in treatment center
- Nurse shift schedule

4. Data Analysis

4.1. Data Inconsistencies

When comparing the times between checkpoints, some patient data were out of order. Some timestamps showed that the patients started their treatment before they left Triage. There were less than 15 such occurrences, and those points were removed from our data. These contradicting times may come from human error when entering written records into the computer for analysis. Furthermore, Triage timestamps are entered in as a note in the patient's electronic health record, and the treatment start time is a manual record.

4.2. Lab

Figure 3 shows a chart of the percentage of patients who, on a typical day¹, wait over an hour for lab results. On average, 60% of patients experience delayed treatment times due to the long wait for lab results. These delays can also lead to nurse overtime.

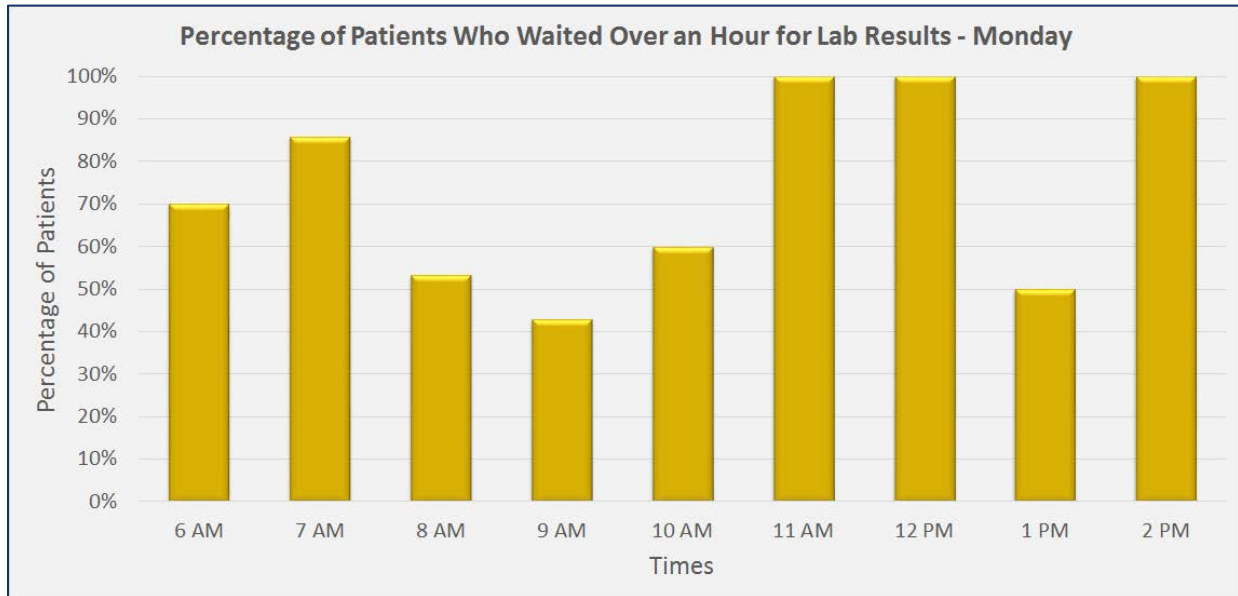


Figure 3. Lab Delays

The VAMC has Community Based Outpatient Clinics (CBOCs), which can be utilized to reduce wait time in the Lab. These facilities can provide lab work for patients. Currently, there are 13 CBOCs that feed directly into the Atlanta VAMC. Approximately 80% of Oncology patients live within a 20 mile radius of a CBOC. The population density diagram can be seen in Figure 4. In the diagram, the red circles indicate the CBOC locations, and the blue sections show the patient densities as specified in the key at the top right hand corner of the diagram.

On average, CBOC patients will spend 15 minutes driving each way, 30 minutes driving in total, and they must wait on average of 10 minutes at any given CBOC before having their blood drawn. Lab results taken at a CBOC the day before a patient's appointment will be ready the next business day, and the couriers drop off the vials at the Atlanta VAMC between 10:45 AM - 11:45 AM and 3:45 PM - 4:45 PM. Going to a CBOC will cost the patient at most 10 minutes extra. We assume that a patient who goes to CBOC is driving 15 minutes (10 miles) back and forth, which equates to a total of 30 minutes. Once they arrive at the CBOC, these patients will have to wait an average of 10 minutes prior to getting their blood collected. Therefore, the total time one takes at the CBOC is assumed to be 40 minutes. Comparing those 40 minutes with the main VAMC process time, we found that if a patient was to get lab at the VAMC they would wait 30 minutes after completing Triage to receive blood results. This 30 minutes equates to using

¹ All days of the week have similar results.

the lower end of the estimate for lab process time which is 47 minutes minus the check in process time (5 minutes) and Triage process/wait times (4 and 8 minutes respectively). Therefore, the patients who go to CBOC compared to patients who go to VAMC will have to spend an extra 10 minutes. Note that the wait time at the main VA Lab, which is 40 minutes with a standard deviation of 10 minutes, has not been taken into account when computing the time saved.

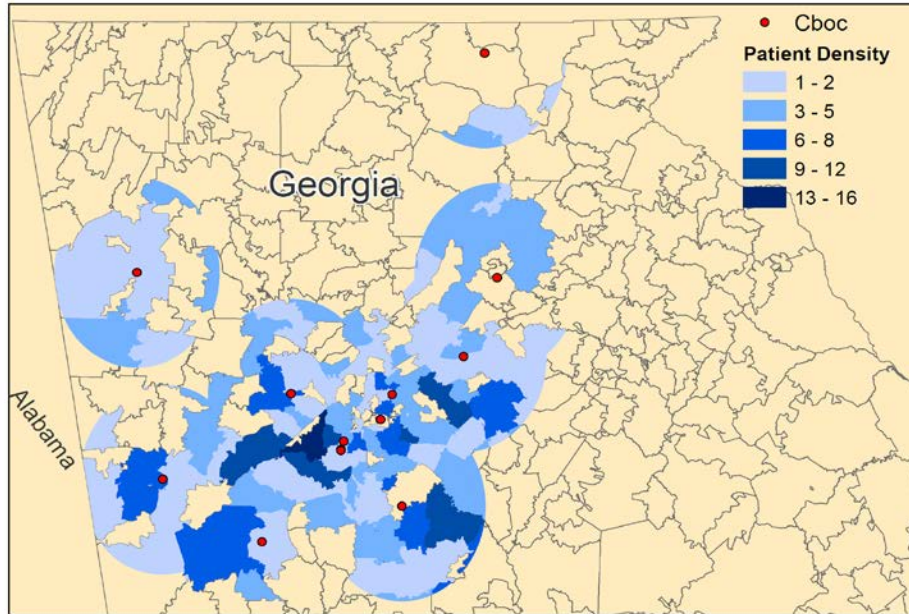


Figure 4. CBOC Patient Densities

4.3. Treatment

To validate the given treatment durations from the Oncology Treatment Center, the in and out times from the nurse assignment sheets were collected for each type of treatment. We created box and whisker plots for each treatment and compared the true treatment time to the expected treatment time. Box and whisker plots would show the distribution of treatment duration times in comparison to the median duration time. The box width shows that 50% of the collected treatment durations fall within the box area. Figure 5 shows a boxplot of the FolFox/Foliri treatment duration times². By adding 30 minutes to the estimated bounds, depicted by the dashed lines, the recommended treatment durations will accurately represent the historical data.

For the true treatment time, we added an extra 30 minutes to all treatment estimated durations because patients must be administered pre-medications (this excludes the Port-Flush Treatment because it does not require pre-medication). After validating the treatment durations provided by the Oncology Department with box and whisker plots, we were able to confidently use these times in our analysis.

² For other treatment duration boxplots, see Appendix Section 7.4. We were only able to analyze these treatments because they had a sample size of at least 32 points.

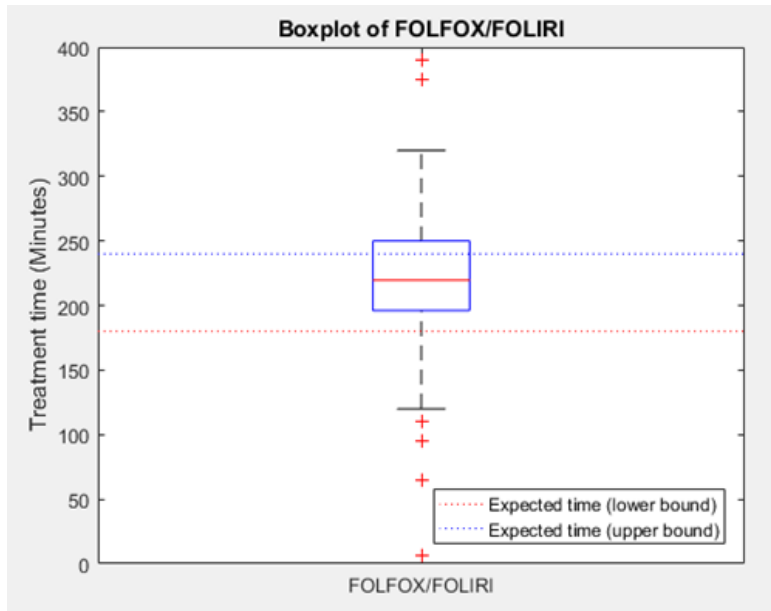


Figure 5. FolFox/Foliri Boxplot of Treatment Duration
**This represent a sample size of 132 patients.*

4.4. Nurse Overtime

Currently, there are 6-7 nurses that work at the Oncology Treatment Center each day and one charge nurse who comes in early to assign nurses to patients and stays late to assist any patients whose treatments go past the Oncology Treatment Center’s operating hours. The total nurse overtime amounts to roughly 1,830 hours from 63 weeks’ worth of data³, in which 4 nurses account work 77% of the total overtime hours. The charge nurse accounts for 33% of the overtime hours. Figure 6 shows the breakdown of the nurse overtime.

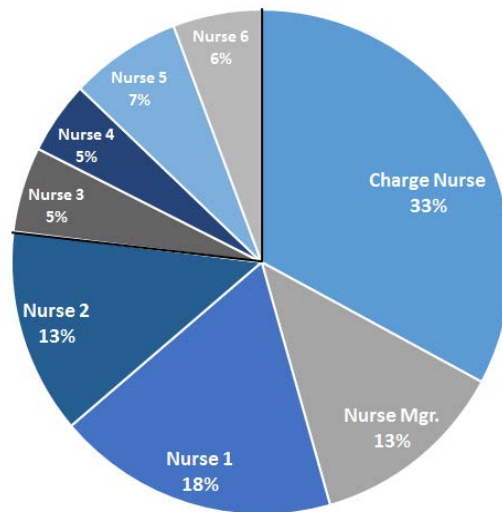


Figure 6. Nurse Overtime Breakdown

³ Refer to Table A in Appendix Section 7.1. for data sources.

4.5. Expansion

The Oncology Department has been allocated additional space in order to accommodate future growth. Figure 7 shows a schematic of the additional space. In order to analyze how to best utilize the additional space, we examined the dimensions of the recovery rooms and of the individual exam rooms, and also looked into the cost effectiveness of the additional treatment chairs/beds. The dimensions of the expansion area is as follows:

- Exam room 1: 19' 2.43" by 17' 1.94"
- Exam room 2: 16' 5.31" by 17' 1.94"
- Exam room 3: 14' 7.50" by 17' 1.94"
- Recovery rooms: 7' 5.01" by 9' 1.75"

The dimensions used for each bed and each chair are respectively 11.5' by 9' and 8' by 9' considering the federal guidelines on clearance between chairs and between chairs and beds.

The cost of each chair is \$1,500 and the cost of each bed is \$3,000. We also need to take into account the portable oxygen suction, and the air (this is a mandated requirement for each treatment chair/bed), which are \$300. For example, if we added 6 chairs and 3 beds in total, that would equate to a cost of \$20,700. Taking into account these restrictions and costs, we came up with multiple ways to use the new space⁴:

Our first option was to be cost conservative, which included:

- 1 chair per recovery room (6 total)
- 1 bed per exam room (3 total).

The second option uses the maximum resources possible, which included:

- 2 beds, 2 chairs in exam room 1
- 4 chairs in exam room 2
- 2 chairs in exam room 3
- 1 chair per recovery room (6 total)

Finally, the last option uses a hybrid model in each exam room, meaning we included:

- 2 beds, 2 chairs in exam room 1
- Convert exam room 2 into a physician exam room
- Convert exam room 3 into a physician exam room
- 1 chair per recovery room (6 total)

⁴ For all feasible layout options, refer to Appendix Section 7.5.

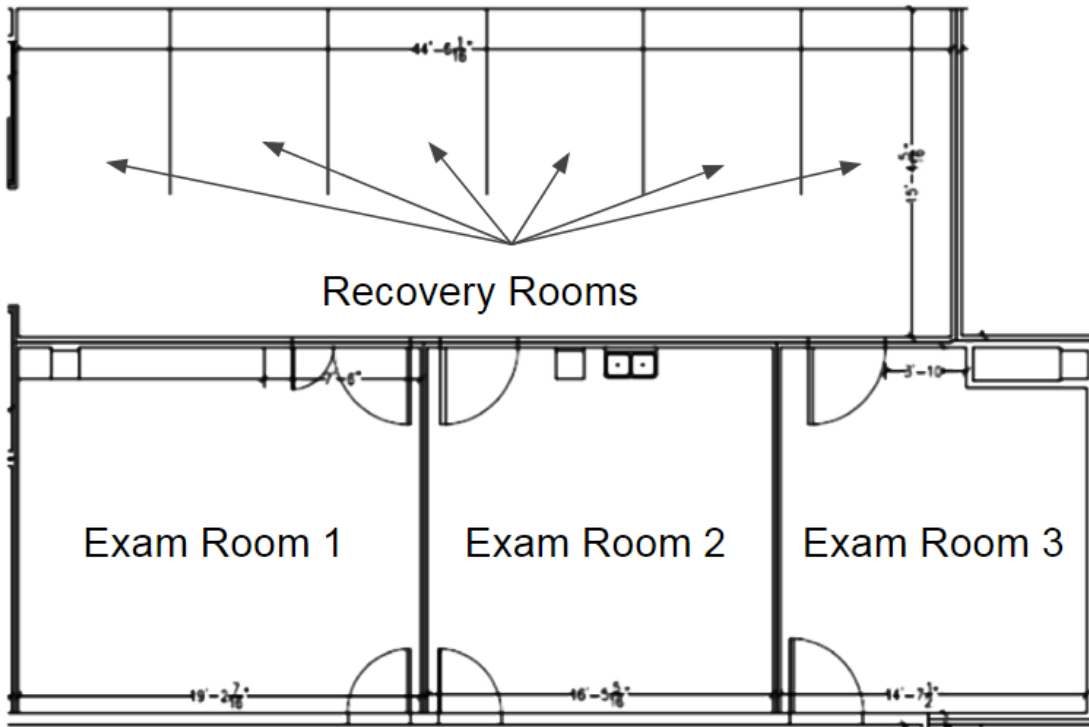


Figure 7. Additional Space Schematic

4.6. No Show Metrics

After examining 20 weeks' worth of treatment records from nurse assignment sheets, we found that 20% of patients that have treatment appointments are not treated because of cancellations, no treatment, or no show. The following terms are defined by the department for internal uses:

- “Cancelled” includes patients who called and cancelled their appointment or cancelled after seeing a physician.
- “No Treatment” are patients that go to the treatment center but have complications before their treatment starts or their lab results do not allow them to receive treatment.
- “No Show” are patients that do not show up at their appointment.
- “Other” includes patients that are admitted to the ER, are sent to radiology or any other department.

We grouped “No-Show” and “Cancelled” together (15.48%) because those patients did not use any resources. “No Treatment” patients and “Other” (4.52%) still use the resources from lab to physician visit and checkout afterwards. Therefore, they are grouped together.

Refer to Figure 8 for a breakdown of these occurrences. The most frequent reason for a patient not receiving treatment is because the appointment was canceled, which is because cancer treatments rely heavily on how the patient feels and on Triage vital levels.

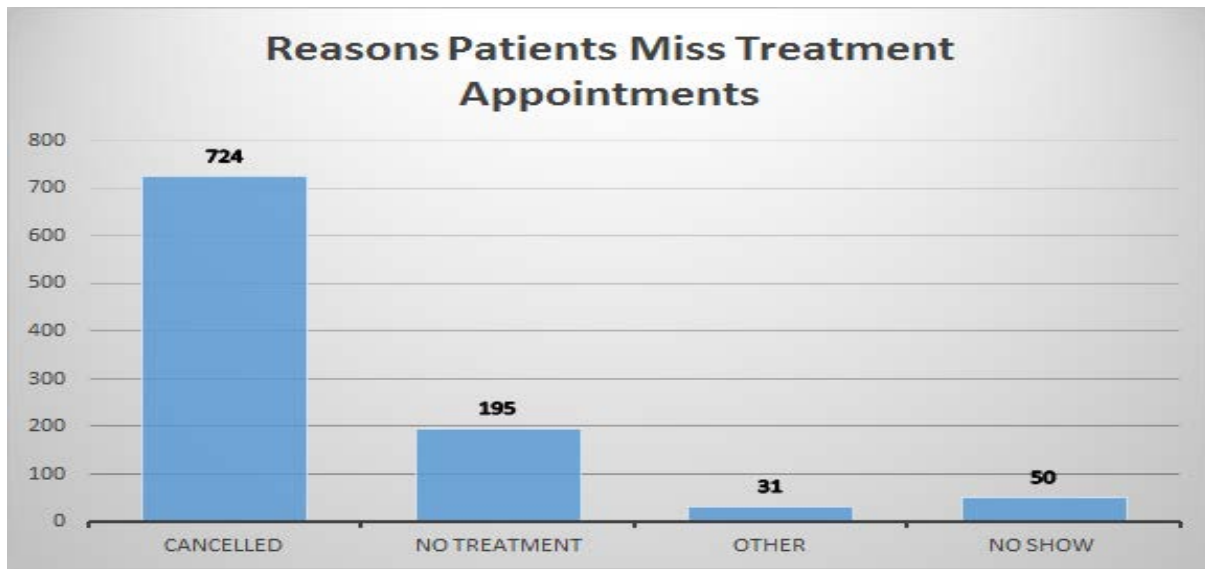


Figure 8. Breakdown of Different Reasons Patients Miss Appointments⁵

4.7. Simulation Model

We have developed a simulation model using Arena software to validate the current state of the system and to run different scheduling scenarios. Using a simulation model is necessary because of the significant amount of variability in the system, including the various types of patients in the system.

The simulation model is structured similar to the patient flow. By analyzing historical data, we found that 48% of patients go to the physician and 52% of patients go to the treatment center after Triage. In addition, we found that 26% of patients that have both a physician and treatment appointment on the same day.

However, an important distinction in the simulation model is that the treatment lengths are divided into five different categories to best represent the different treatment lengths and their variability. Five categories were used in order to reduce the variability of the utilization of the chairs and beds.

The different categories of durations include:

- Short: 3 to 22 minutes
- Short-Medium: 22 minutes to 1 hour and 25 minutes
- Medium: 1 hour 25 minutes to 2 hours 10 minutes

⁵ Data was collected from 20 weeks worth of unseen patients. Specific dates can be seen in Table A in Appendix Section 7.1.

- Medium-Long: 2 hours 10 minutes to 3 hours 25 minutes
- Long: More than 3 hours and 25 minutes

4.7.1. Validation

In order to test different scheduling scenarios, the simulation must be validated using past data so that any solutions concluded can be applicable to the real system. The inputs of the simulation include: patient arrivals, resources for each process, and the process times (process time inputs can be found in Appendix Section 7.2 Table B and C). The treatment duration times were divided into the 5 categories (short, short-medium, medium, medium-long, and long). The outputs of the simulation include: the time spent in the system, specifically from check in at front desk to before treatment, and the waiting times at each process.

The distribution for the time a patient checks-in at the front desk to when the patient leaves the treatment center is shown in Figure 9. We will focus on Wednesdays because they are the busiest treatment days during the week. The outputs for the other days of the week can be found on Figure B in Appendix Section 7.2. The collected samples on Wednesday follows a beta distribution with a mean of 234 minutes and a standard deviation of 129 minutes.

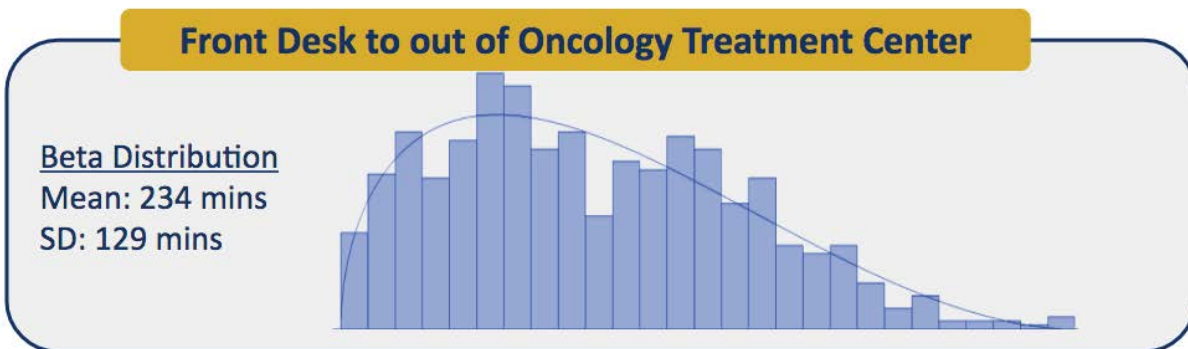


Figure 9. Front Desk to Treatment Center Data⁶

**The x-axis of the graph denotes the time duration and the y-axis denotes the frequency of patients that experienced that duration.*

⁶ This distribution is based off of 750 samples.

The simulation output, as shown below in Figure 10, shows the time a patient checks in at the front desk to when the patient leaves the treatment center from the simulation for Wednesday. It also has a beta distribution with a mean of 232 minutes, but with a standard deviation of 97 minutes.

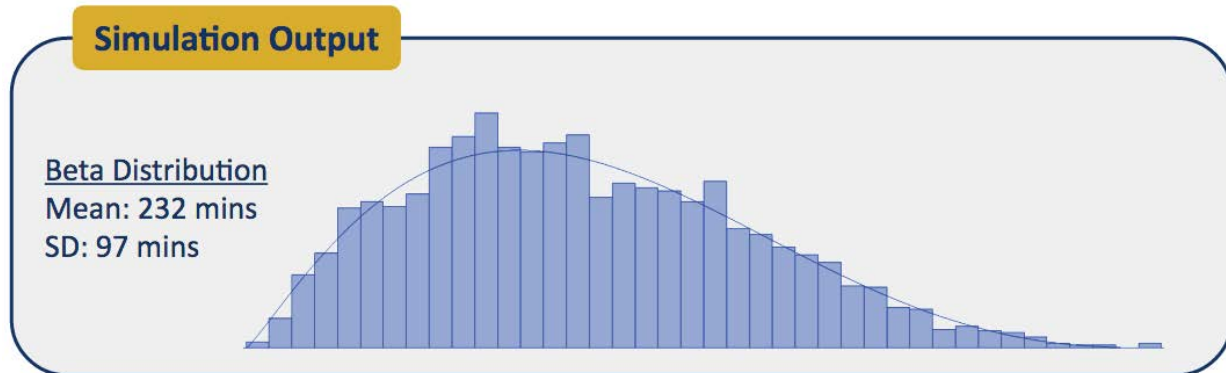


Figure 10. Simulation Output

**The x-axis of the graph denotes the time duration and the y-axis denotes the frequency of patients that experienced that duration in the simulation.*

To further validate the simulation model, we tested the distribution's fit to the data with the Kolmogorov-Smirnov test and the Anderson-Darling test. Both tests failed to reject the null hypothesis, meaning these tests confirm that the simulated output matches the historical data and scenario testing can be performed with the simulation. These tests can be found in the Appendix Section 7.2.

5. Deliverables

After validating the simulation model, the next steps were to focus on the deliverables assigned to the team by the Oncology Department. These deliverables encompass our solutions and suggestions for the department to reduce patient wait time.

5.1. Return-to-clinic Orders from Physician to Nurse

Nurses will assign the future patients' appointments since they are the main point of contact in the continuity of care and physicians will decide the type of treatment patients receive. This change has been implemented.

5.2. Nurse Overtime and Lab Analysis

Results from our nurse overtime data analysis has been provided to the Oncology Department in order to help them reallocate resources to prevent nurse overtime.

From Lab collection and release data, we determined that hiring for the Lab must be prioritized since the majority of patients, both in and outside of the Oncology Department, as well as the nurses, are affected by the delays in the Lab. Currently, the VAMC has begun the hiring process for more phlebotomists.

5.3. Scheduling Grid and Tool

We have developed an implementation scheme for redesigning the scheduling grid for the treatment center. There are 7 grids instead of 1, one for each nurse that works each day and a floating nurse. For a side by side comparison between the old grid and new grid, see Appendix Section 7.3. Each half hour block will have '[3]' for 3 chairs, creating a 1 to 3 ratio of nurses to patients. In order to properly show the number of patients in the treatment center, we have developed a scheduling tool that will be shared amongst all the nurses and the physicians. Figure 11 shows a small portion of the scheduling tool. This will be particularly useful for physicians to communicate with the nurses as to when to schedule a patient for treatment. This has been implemented.

	7:30 AM - 8:00 AM	8:00 AM - 8:30AM	Times	7:30:00 AM
Chair 1			Duration	30 minutes
Chair 2			Bed or Chair	Chair 2
Chair 3				Chair 2
Chair 4				Chair 3
Chair 5				Chair 4
				Chair 5
				Chair 6
				Chair 7
				Chair 8
				Chair 9

Figure 11. VBA Scheduling Grid

The scheduling tool has three drop down lists corresponding to the time, duration, and the specific chair. Once the nurse chooses the time he/she wants to schedule the patient, he/she can confirm the appointment, and the visualization tool updates showing a “1”, meaning a patient is scheduled for that specified time duration and chair. Every nurse is assigned 3 to 4 chairs each shift, so a nurse will see the scheduled patients that correspond to their assigned chairs for the shift. Finally, patients who are scheduled adjacent to each other in the same chair will be represented with different colors to visually differentiate the starting and ending times of each patient.

After discussing this implementation with the IT Department (who designs and manages the scheduling grids) and the Oncology Department, they have concluded that the new scheduling visualization tool accurately captures the treatment utilization and fits the current department needs.

5.4. CBOC as Lab Alternative

After testing different percentages of patient volumes to send to CBOCs, we found that sending 40% of patients to a CBOC is ideal. Anything above 40% will either present the same wait time or increased wait time (due to an increased patient arrival rate into the treatment center) for patients. Therefore, 40% of Oncology patients should be sent to their respective CBOC locations for lab work to be completed.

5.5. Simulation

We created a simulation, which allowed us to accurately represent the system. This simulation--once validated--was used to test various scheduling, expansion and CBOC scenarios. The simulation will be given to the VAMC's industrial engineer so that any changes that the department wishes to make can be tested before being implemented.

5.6. Expansion

Of the three layouts explained in depth in Appendix Section 7.5 (i.e. 'Cost Conservative', 'Maximum Resources', and 'Hybrid'), our final solution is the 'Hybrid'. We chose this solution with 10 beds/chairs and 2 exam rooms because adding more than 10 beds/chairs will not impact patient waiting time. This solution considers a 30% increase in patient visits by 2022. This was calculated from a rough forecast using total cancer patients served by the Atlanta VAMC from 2005 to 2016. The forecasted demand assumes a constant increase from year to year and can be seen in Appendix Section 7.7.

5.7. Treatment Scheduling Guideline Solution

After testing various patient scheduling guideline scenarios, the best scheduling strategy can be seen in Figure 12.



Figure 12. Best Scheduling Scenario

When scheduling patients, 67% of short treatments should be scheduled from 8:00 AM to 1:00 PM and the remaining 33% should be scheduled from 4:00 PM to 5:00 PM. Short-Medium treatments should be scheduled from 12:00 PM to 4:00 PM. Medium treatments should be scheduled 12:00 PM to 5:00 PM. Medium-Long treatments should be scheduled from 8:00 AM to 2:00 PM. Finally, Long treatments should be scheduled from 8:00 AM to 3:00 PM. This scheduling scheme allows enough time for all treatment lengths to be finished within operating hours so that nurse overtime is reduced by 95% and allows for a level utilization of the treatment center.

6. Project Valuation

After running the different scenarios in our simulation, including the suggested scheduling guidelines, scheduling guidelines with CBOC, and scheduling guidelines with CBOC and use of the Expansion space, we were able to quantify the time saved seen in Figure 13.

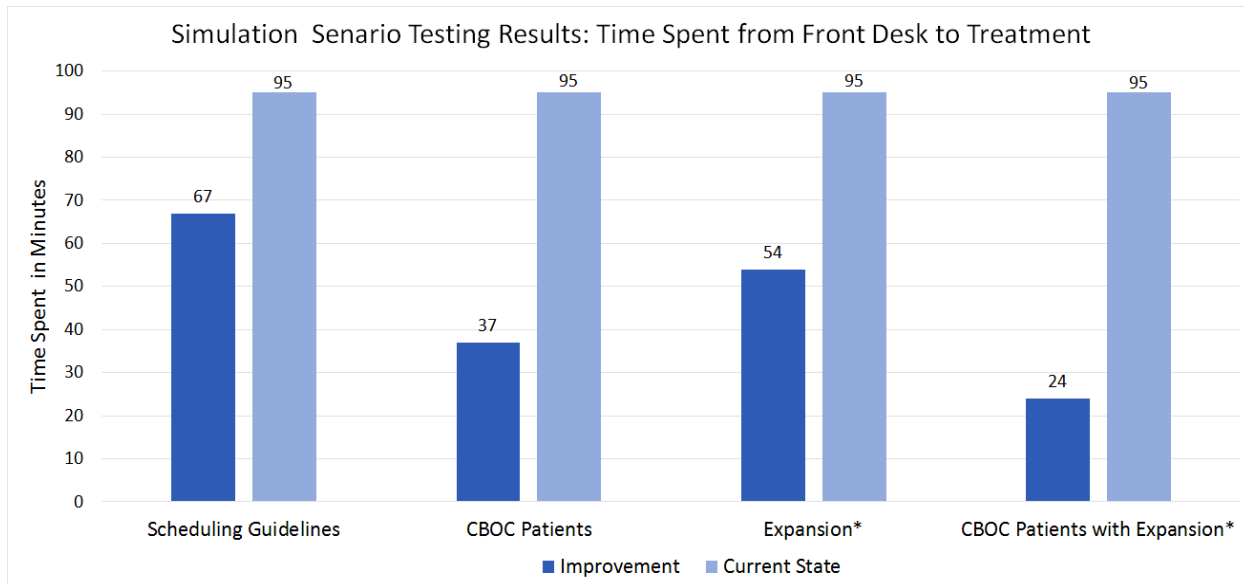


Figure 13. Simulation Output

After running the scheduling guidelines scenario, the time from front desk to starting treatment improved to 67 minutes compared to the original 99 minutes. Even though this does not meet that VAMC target time of 45 minutes from check-in to treatment, this scenario allows the VAMC to save 32 minutes. The 32 minutes saved amounts to an indirect savings of \$186,500/year, which is calculated in Appendix Section 7.6. When nurses are able to manage when patients start and end their treatments with the scheduling guidelines, it limits the number of patients left in the system after 6 PM. This results in a reduction in nurse overtime by 95% equating to a savings of \$86,093 per year. In total, the scheduling guidelines scenario saves the VAMC a total of \$272,593 each year.

The second scenario, labeled CBOC Patients in Figure 13, combines the new scheduling guidelines along with sending 40% of Oncology patients to a CBOC. This reduced the time between check in to starting treatment to 37 minutes, which is below the VAMC's target metric of 45 minutes. The total amount of time saved including nurse overtime and the indirect savings of 52 minutes (taking into account of the extra 10 minutes spent at a CBOC for lab testing) is \$319,218 each year.

Finally, we tested the savings with scheduling guidelines, CBOC patients, and the new utilization of the expansion space. This solution improved the front desk to starting treatment time to a total of 24 minutes saving 75 minutes. The total amount of time saved including nurse overtime and the indirect savings of 65 minutes (taking into account of the extra 10 minutes spent at a CBOC for lab testing) is \$367,984 each year. A breakdown of calculations for the indirect saving can be seen on Appendix Section 7.6.

We suggest for the Oncology Department of the Atlanta Veterans Affairs Medical Center to use the last scenario shown in Figure 13, which includes scheduling guidelines, sending 40% of patients to CBOCS, and using the new expansion space for physicians exam rooms and treatment chairs/beds.

7. Appendix

7.1. Data Collection

The Data Source Table shows the date ranges for each data type collected along with where or who provided the data.

Table A. Type of Data and Sources

Data Collected	Period of Collection	Data Source
Lab Check-in times	January 12, 2017, February 7, 2017, and February 9, 2017 - February 10, 2017	Time study in January 2017 and February 2017
Patient Check-in times	Oct 2015 to Jan 2017	VistA
Triage Check-in times	Oct 31 to Nov 4 2016 Dec 6 to Dec12 2016	CPRS
Physician appointment times	Oct 2015 to Jan 2017	CPRS
Treatment appointments and duration of treatment	Complete months: Jun, Jul, Oct to Dec 2016 Jan 2017 Partial Months: Jan, Aug, Sep 2016	Nurse Patient Assignment Sheets (written record)
Overtime of nurses in treatment center	Oct 1, 2015 to Jan 8, 2017	Nurse Timesheet
Nurse schedule	Complete months: Jun, Jul, Oct to Dec 2016 Jan 2017 Partial Months: Jan, Aug, Sep 2016	Nurse Patient Assignment Sheets (written record)
Room/Physician schedule	Oct 2015 to Jan 2017	Dr. Ribeiro, Physician Scheduler

7.2. Simulation Model

Tables B and C, together, show all the inputs for our simulation. The probability distribution based on collected data can be found in the fourth column. The probability distribution used for the simulation can be found in the third column.

Table B. Simulation Inputs I

Process type	Location	Probability distribution in Arena	Probability distribution	Source
Lab waiting time and blood drawn to be processed (6am – 9am)	Lab	NORM(30,10)	Normal(30,10)	Time study & expert opinion
Lab waiting time and blood drawn to be processed (9 am – 1 pm)	Lab	NORM(60,10)	Normal(60,10)	Time study & expert opinion
Lab waiting time and blood drawn to be processed (After 1 pm)	Lab	NORM(30,10)	Normal(30,10)	Time study & expert opinion
Processing of blood samples	Lab	86.52 * GAMM(1, 13.96)/GAMM(1, 14.23)	Pearson Type VI(0, 86.52, 13.96, 14.23)	Historical data (CPRS)
Front desk check in service time	Medical clinic	TRIA(3,5,7)	Triangular(3,5,7)	Time study
Triage service time	Triage	1.64*GAMM(1,9.73)/GAMM(1,4.54)	Pearson Type VI(0,1.64,9.73,4.54)	Historical data (CPRS)

Table C. Simulation Inputs II

Process type	Location	Probability distribution in Arena	Probability distribution	Source
Physician service time	Exam rooms	TRIA(15, 20, 30)	Triangular(15,20,30)	Time study
Short treatment time	Oncology treatment center	TRIA(3,15,20)	Triangular(3,15,20)	Historical data (Nurse assignment sheet)
Short Mid treatment time	Oncology treatment center	JOHN(-0.31,0.56,65.03,21.33)	Johnson Bounded Continuous(21.33,86.36,-0.31,0.56)	Historical data (Nurse assignment sheet)
Mid treatment time	Oncology treatment center	84.16 + 48.14 *BETA(1.47, 1.27)	Beta(84.16, 132.3, 1.47, 1.27)	Historical data (Nurse assignment sheet)
Mid Long treatment time	Oncology treatment center	JOHN(-0.28,0.64,79.55,127.79)	Johnson Bounded Continuous(127.79,207.35,-0.28,0.64)	Historical data (Nurse assignment sheet)
Long treatment time	Oncology treatment center	203.92 + WEIB(66.17,1.16)	Weibull(203.92,66.17,1.16)	Historical data (Nurse assignment sheet)
Front desk check out service time	Medical clinic	TRIA(3,5,7)	Triangular(3,5,7)	Time study

Figures C through F, shows the distribution of the real data for each day of the week compared to the simulated distribution on the same day. Each simulated output shows the results from the Kolmogorov-Smirnov Test and the Anderson-Darling Test.

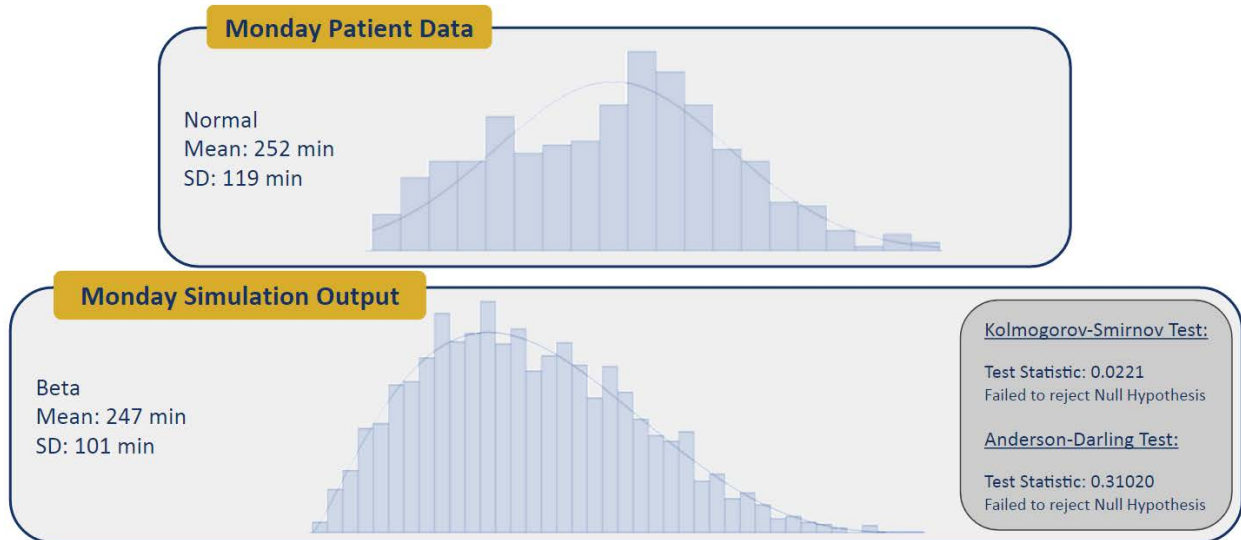


Figure A. Simulation Output for Monday

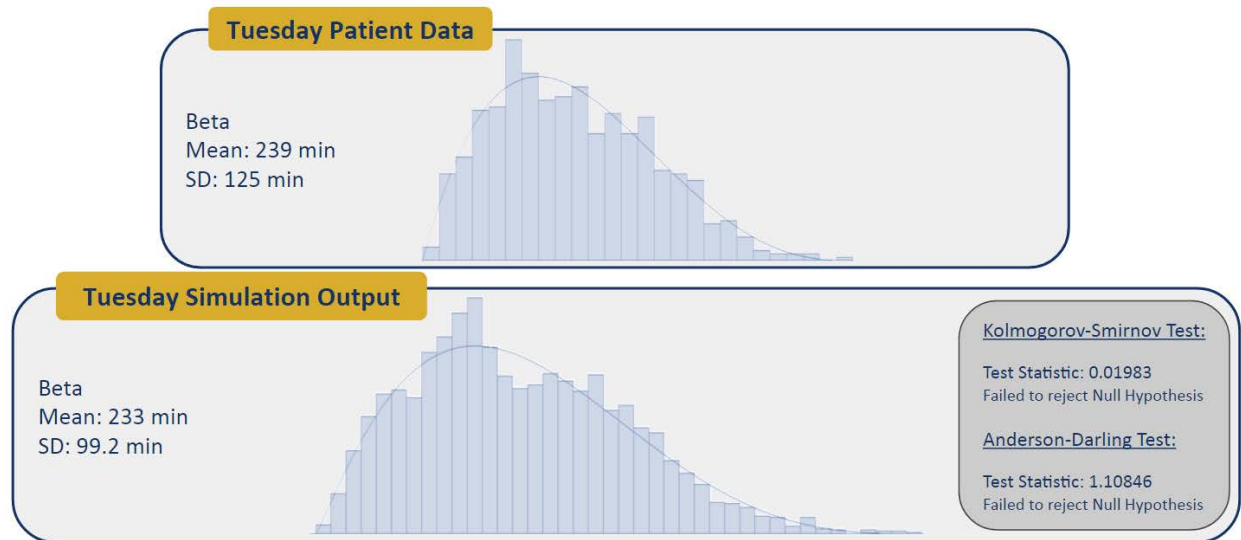


Figure B. Simulation Output for Tuesday

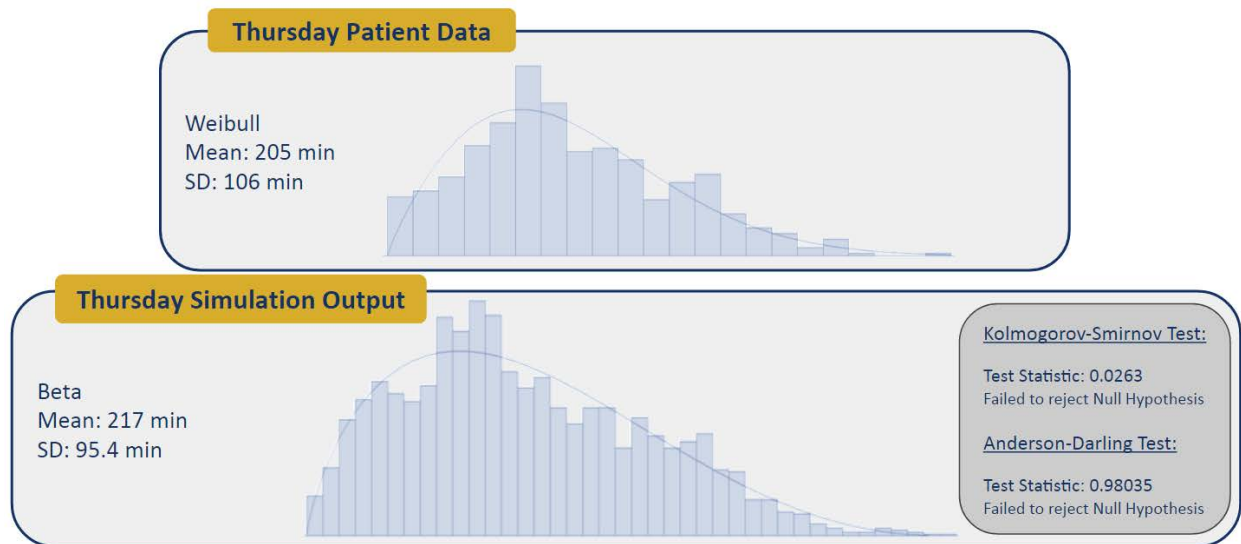


Figure C. Simulation Output for Thursday

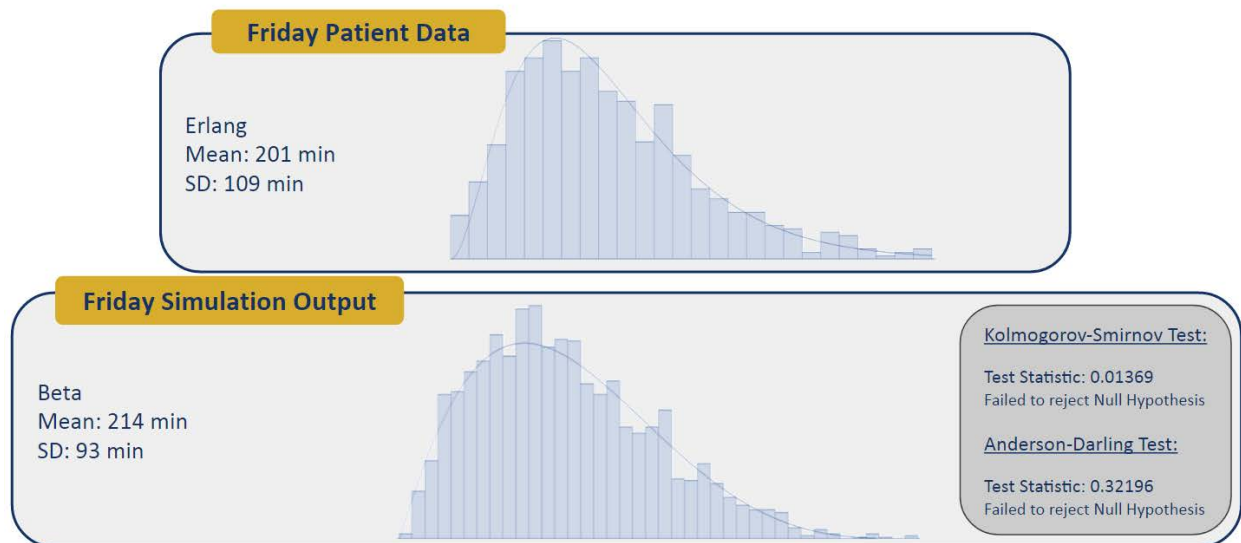


Figure D. Simulation Output for Friday

Table D shows the waiting times and process times from the simulation for Treatment Only patients. The first row is the simulated current state of the system and validated our model, the second row shows the simulation results with the Scheduling Guidelines only, next row is the Scheduling Guidelines with sending 40% of patients to CBOC. The fourth row tested using the Expansion Space with the Scheduling Guidelines and the last simulation tested was having Scheduling Guidelines with 40% of patients send to CBOCs and using the Expansion Space

Table D. Simulation Results

	Check-In Wait Time (minutes)	Check-In Process Time (minutes)	Triage Waiting Room (minutes)	Triage Process Time (minutes)	Treatment Waiting Room (minutes)	Lab Process Wait Time (minutes)	Check-In to Treatment Center (minutes)
Current State	3	5	3	7	47	30	95
Scheduling Guidelines	3	5	7	7	15	30	67
CBOC Patients	3	5	7	7	15	0	37
Expansion*	3	5	1	7	8	30	54
CBOC Patients with Expansion*	3	5	1	7	8	0	24

*The scenario that includes the expansion has 30% more patients with 10 more chairs/beds, 4 more physicians, 2 more Triage nurses from 7AM-3PM

7.3. Treatment Scheduling Grid

The “Original VistA Grid” is a picture of what the scheduling grid looked like at the beginning of the project. One grid was used for all 18 chairs and 6 nurses with appointments starting every 30 minutes. A [3] stood for no the system at that time, [0] stood for 3 patients patients in the system, and [B] stood for 5 patients in the system. For every letter past B is another patient in the system at that time.

The “Updated VistA Grid” has one grid that represents one nurse, so there are now 7 grids to reflect the workload of each nurse. This grid is also in 30 min appointments. The numbering system from [3] to [0] follows the same logic as before but the updated grid does not allow to the system to schedule more than 3 patients every half hour.

Original VistA Grid

TIME DATE	7	8	9	10	11	12	1	2	3							
FR 14	[3]	[C]	[C]	[D]	[D]	[J]	[F]	[J]	[G]	[I]	[D]	[D]	[0]	[A]	[1]	[3]
MO 17	[3]	[0]	[C]	[A]	[0]	[D]	[B]	[E]	[E]	[C]	[0]	[0]	[1]	[2]	[2]	[3]
TU 18	[2]	[B]	[0]	[D]	[D]	[H]	[D]	[D]	[F]	[D]	[D]	[A]	[1]	[1]	[1]	[2]
WE 19	[3]	[B]	[C]	[F]	[A]	[C]	[A]	[C]	[0]	[D]	[A]	[0]	[0]	[1]	[0]	[1]

Updated VistA Grid

TIME DATE	7	8	9	10	11	12	1	2	3							
FR 14	[3]	[2]	[2]	[3]	[2]	[2]	[2]	[3]	[3]	[3]	[3]	[1]	[0]	[3]	[3]	[3]
MO 17	[3]	[3]	[3]	[3]	[3]	[3]	[2]	[1]	[2]	[2]	[2]	[3]	[2]	[2]	[2]	[2]
TU 18	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[3]
WE 19	[3]	[2]	[0]	[0]	[1]	[2]	[3]	[3]	[3]	[3]	[3]	[3]	[3]	[1]	[0]	[0]

Figure E. Before and After VistA Grids

7.4. Treatment Duration Boxplots

Figures J through O show the box and whisker plots for the treatment duration times. The plots were used to validate the estimated treatment durations by the Oncology Department.

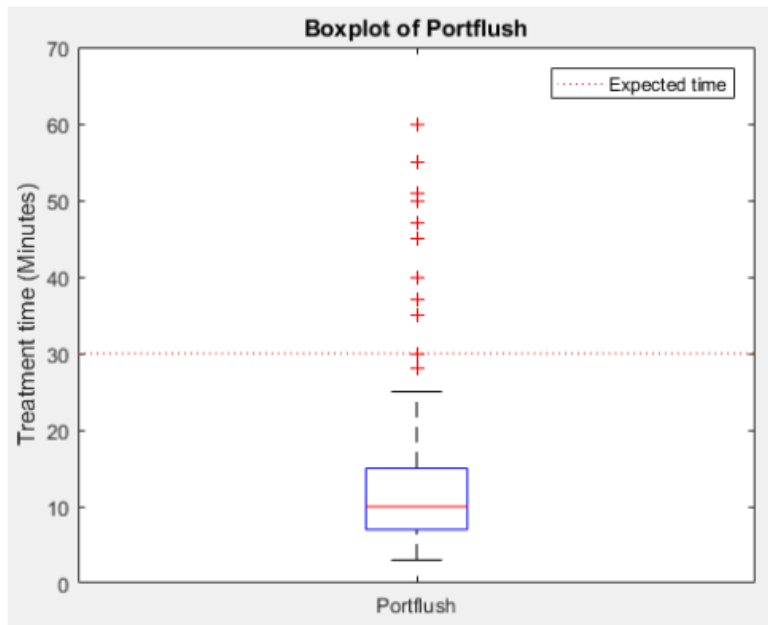


Figure F. Portflush Boxplot of Treatment Duration

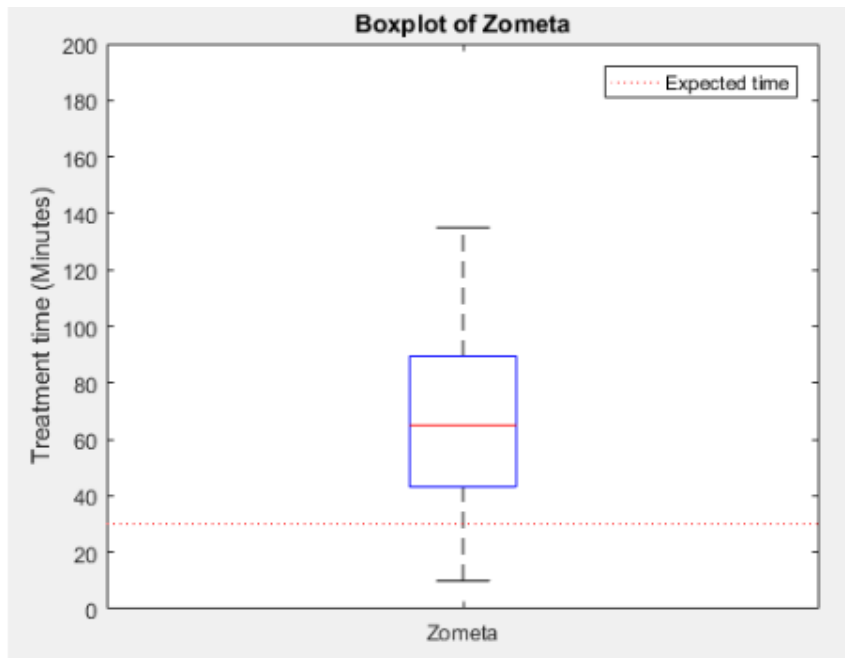


Figure G. Zometa Boxplot of Treatment Duration

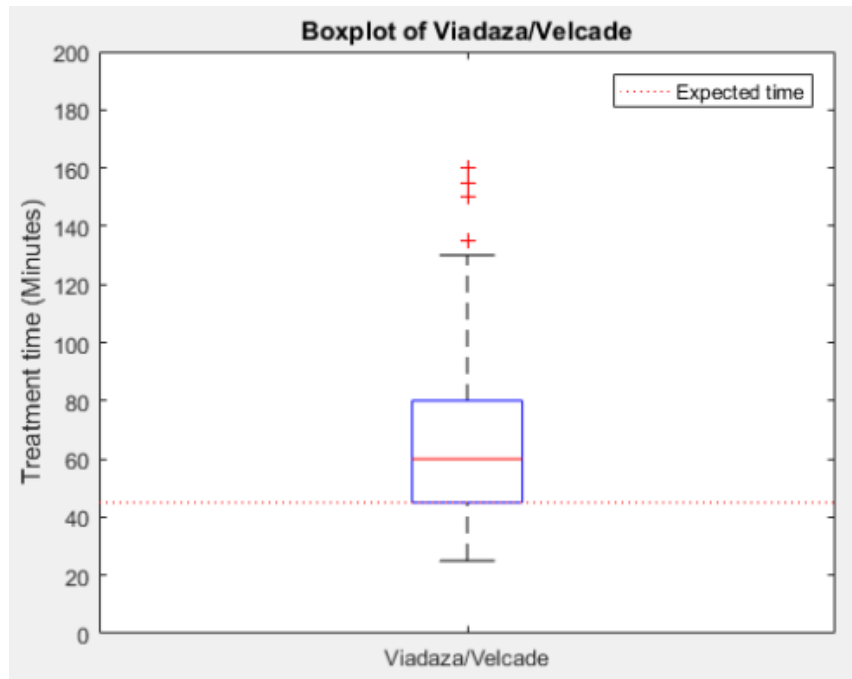


Figure H. Viadaza/Velcade Boxplot of Treatment Duration

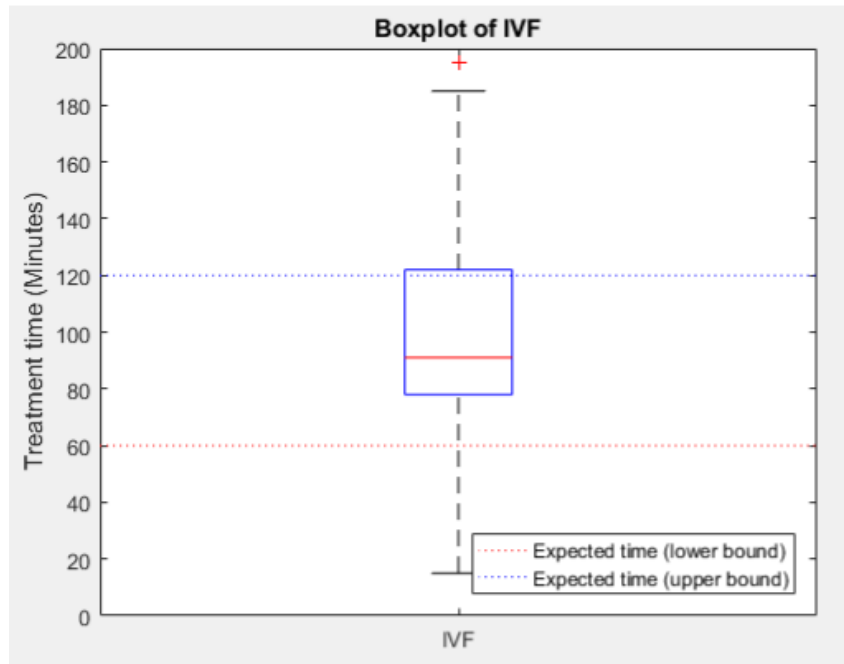


Figure I. IVF Boxplot of Treatment Duration

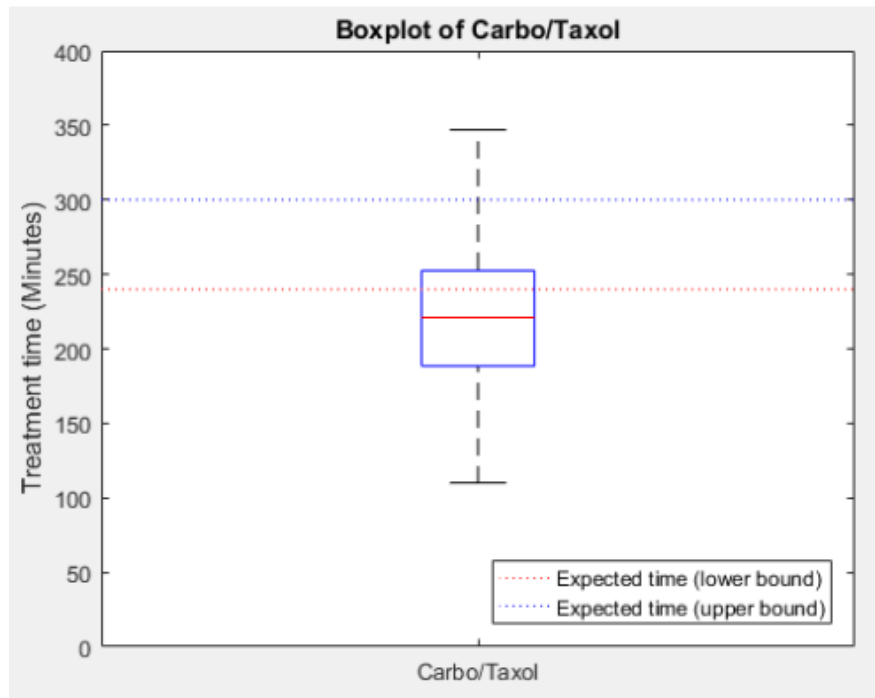


Figure J. Carbo/Taxol Boxplot of Treatment Duration

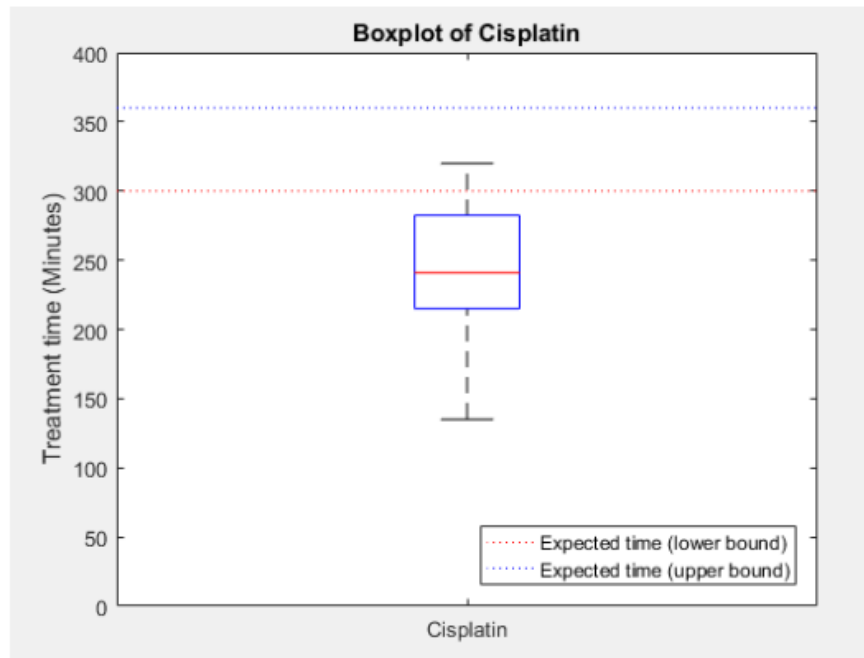


Figure K. Cisplatin Boxplot of Treatment Duration

7.5. Expansion

The layout of the expansion space can be seen in Figure L along with the cost and space associated with furniture that could be used for that space in Figure M. These costs come into play in Table E when looking at number of resources needed for each possible alternative. Alternative 1 is the most expensive option, Alternative 13 is the cheapest without physician exam rooms, and Alternative 15 gives a mixture of treatments beds/chairs with physician exam rooms.

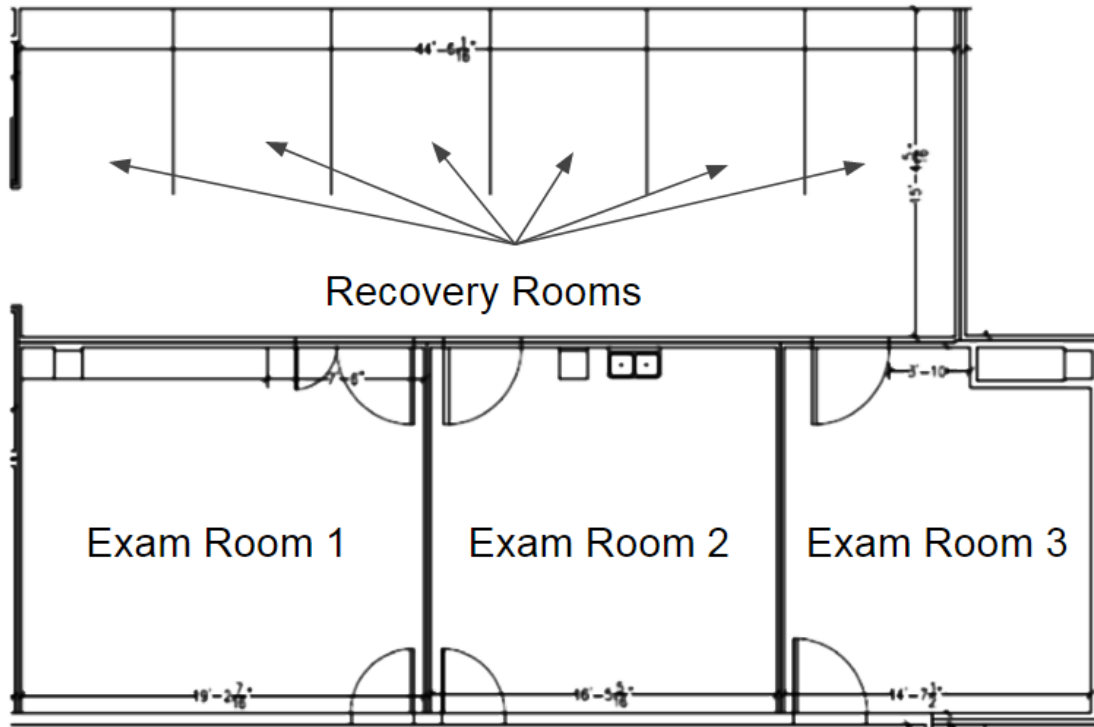


Figure L. Expansion Layout

Clearance Measurements	Length (ft)	Width (ft)
Chair	8	8
Bed	11.5	9

Actual Measurements	Length (ft)	Width (ft)
Chair (Oncology)	7	6
Bed (Oncology)	11.5	9
Chair (GI Space)	8	7.5
Bed (GI Space)	Not Measured	

Cost Parameters	Price
Cost of Chair	\$1,500.00
Cost of Bed	\$3,000.00
Portable Oxygen + suction + air	\$300.00

Figure M. Expansion Cost

Table E. Expansion Costs

Alternatives	Room 1	Room 2	Room 3	Recovery Rooms	Added beds	Added chairs	Estimated Cost
1	2 beds, 2 chairs	4 chairs	2 chairs	6 chairs	2	14	\$31,800.00
2	2 beds, 2 chairs	2 beds	2 chairs	6 chairs	4	10	\$31,200.00
3	2 beds, 2 chairs	1 bed, 1 chair	2 chairs	6 chairs	3	11	\$29,700.00
4	2 beds, 2 chairs	4 chairs	1 bed	6 chairs	3	12	\$31,500.00
5	2 beds, 2 chairs	2 beds	1 bed	6 chairs	5	8	\$30,900.00
6	2 beds, 2 chairs	1 bed, 1 chair	1 bed	6 chairs	4	9	\$29,400.00
7	4 chairs	4 chairs	2 chairs	6 chairs	0	16	\$28,800.00
8	4 chairs	2 beds	2 chairs	6 chairs	2	12	\$28,200.00
9	4 chairs	1 bed, 1 chair	2 chairs	6 chairs	1	13	\$26,700.00
10	4 chairs	4 chairs	1 bed	6 chairs	1	14	\$28,500.00
11	4 chairs	2 beds	1 bed	6 chairs	3	10	\$27,900.00
12	4 chairs	1 bed, 1 chair	1 bed	6 chairs	2	11	\$26,400.00
13	1 bed	1 bed	1 bed	6 chairs	3	6	\$20,700.00
14	Exam room	Exam room	Exam room	6 chairs	0	6	\$10,800.00
15	2 beds, 2 chairs	Exam room	Exam room	6 chairs	2	8	\$27,000.00
16	Exam room	Exam room	1 bed	6 chairs	1	6	\$20,100.00
17	Exam room	2 beds	Exam room	6 chairs	2	6	\$23,400.00
18	Exam room	1 bed, 1 chair	Exam room	6 chairs	1	7	\$21,900.00
19	2 beds, 2 chairs	1 bed, 1 chair	Exam room	6 chairs	3	9	\$29,100.00

7.6. Indirect Saving

Figure N breaks down the indirect savings for each type of testing that was needed to find the solution. The final savings for the Expansion, CBOC, & Scheduling Guidelines provide an indirect savings \$281,891 per year and a direct savings of \$86,093 from a 95% reduction in nurse overtime. The average hourly cost of a veteran's salary is \$17.42 (Krueger). This hourly rate is the estimated cost a veteran would give up when waiting at the hospital.

Scheduling guideline

$$20,074 \frac{\text{visits}}{\text{year}} * 32 \frac{\text{minutes}}{\text{visits}} * \frac{1 \text{ hour}}{60 \text{ minutes}} * \frac{\$17.42}{\text{hour}} = \$186,500/\text{year}$$

CBOC & scheduling guideline

$$\left[0.4 * 20,079 \frac{\text{visits}}{\text{year}} * \frac{62 \text{ minutes saved} - 10 \text{ minutes cost}}{\text{visit}} * \frac{1 \text{ hour}}{60 \text{ minutes}} * \frac{\$17.42}{\text{hr}} \right] \\ + \left[0.6 * 186,500 \frac{\text{visits}}{\text{year}} \right] = \$233,125/\text{year}$$

Expansion, CBOC, & scheduling guideline

$$\left[0.4 * 20,079 \frac{\text{visits}}{\text{year}} * \frac{75 \text{ minutes saved} - 10 \text{ minutes cost}}{\text{visit}} * \frac{1 \text{ hour}}{60 \text{ minutes}} * \frac{\$17.42}{\text{hr}} \right] \\ + \left[0.6 * 20,079 \frac{\text{visits}}{\text{year}} * \frac{45 \text{ minutes saved}}{\text{visit}} * \frac{1 \text{ hour}}{60 \text{ minutes}} * \frac{\$17.42}{\text{hr}} \right] \\ - \left[\begin{array}{l} \text{Equipment Cost} \\ \$27,000 \end{array} \right] = \$281,891/\text{year}$$

Figure N. Indirect Saving Calculations

7.7. Forecasted Patient Growth

Figure O shows the actual data provided from 2005 to 2016 and projected forecast assuming constant growth. From 2017 to 2022, there will be 30% growth of patients' visits to the Oncology Treatment Center, not taking into account of extreme circumstances like the ending of wartime.

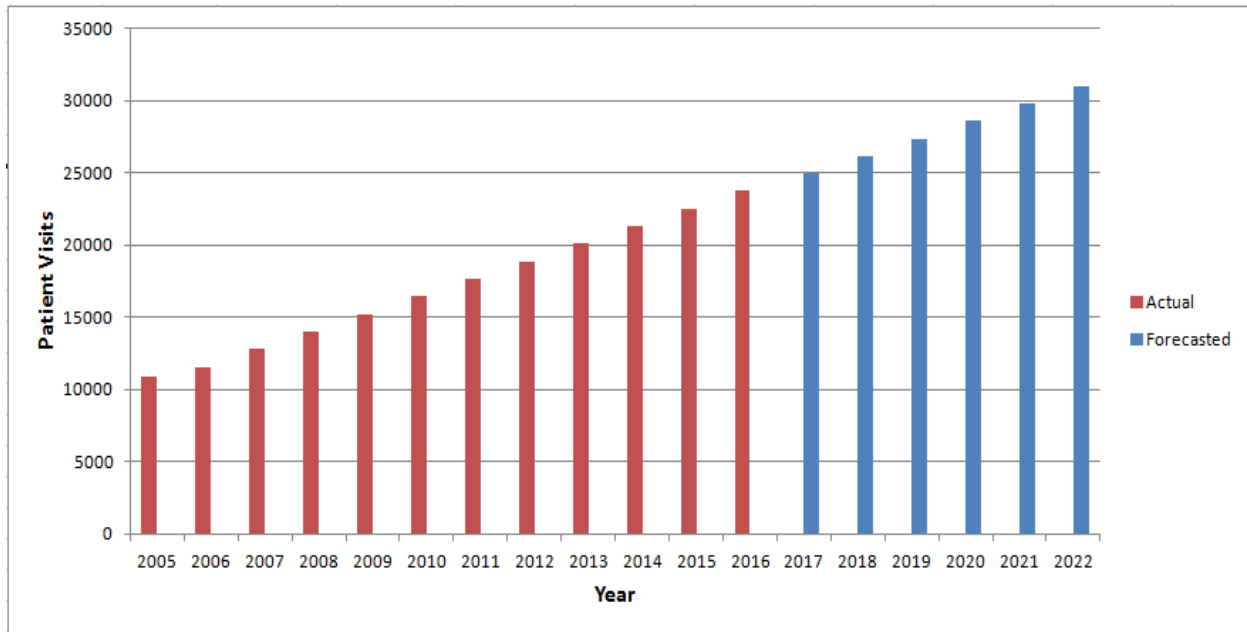


Figure O. Forecasted Growth

8. References

Krueger, A. B. (2009, February 09). *A Hidden Cost of Health Care: Patient Time*. Retrieved from https://economix.blogs.nytimes.com/2009/02/09/a-hidden-cost-of-health-care-patient-time/?_r=0