Improving Patient Wait Times for Oncology

Team 29 VA Process

Sana Fathima, Courtney Hall, Ousmane Kaba, Gun Hee Lee, Zeba Munshi, Christopher Noerjadi, Rebecca Sharpe, Mario Wijaya

Client Contact: LaGaunda Jones
Faculty Advisor: Dr. Julie Swann

Atlanta VA Medical Center

April 10th, 2017

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

**Problem**
Time spent from Check-in to Treatment Chair: **99 minutes**
Target time: **45 minutes**

**Additional Opportunity:**
Expansion

**Scenarios**
- Lab Understaffing
- Physician Constraints
- Treatment Scheduling
- Community Based Outpatient Clinic

**Scheduling Tool**
- Nurse Overtime

**Final Solution**
Client Background

Veterans Affairs Medical Center (VAMC)

- Provides health care services to veterans
- From general check-ups to surgeries
- More than 130,000 enrolled Veterans

The Oncology Department

- 40 - 60 patients per day
- Recurring appointments
- 35 types of treatment
- Treatment duration range varies
- Oncology Treatment Center resources:
  ○ 6-7 nurses
  ○ 15 Chairs & 3 Beds
System Description

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Percentage of patient type</th>
<th>Total time from Front Desk to Physician or Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician Only</td>
<td>26%</td>
<td>70 minutes</td>
</tr>
<tr>
<td>Treatment Only</td>
<td>52%</td>
<td>99 minutes</td>
</tr>
<tr>
<td>Both</td>
<td>22%</td>
<td>146 minutes</td>
</tr>
</tbody>
</table>

*See Appendix Pages 22 for distributions.*
### System Description

**Patient Type** | **Percentage of patient type** | **Total time from Front Desk to Physician or Treatment**
--- | --- | ---
Physician Only | 26% | 70 minutes
Treatment Only | 52% | 99 minutes
Both | 22% | 146 minutes

*See Appendix Page 22 for distribution.*
# System Description

*See Appendix Page 22 for distribution.*

<table>
<thead>
<tr>
<th>Patient Type</th>
<th>Percentage of patient type</th>
<th>Total time from Front Desk to Physician or Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician Only</td>
<td>26%</td>
<td>70 minutes</td>
</tr>
<tr>
<td>Treatment Only</td>
<td>52%</td>
<td>99 minutes</td>
</tr>
<tr>
<td>Both</td>
<td>22%</td>
<td>146 minutes</td>
</tr>
</tbody>
</table>
Problem

Data Collection:
- VistA (Veterans Information System and Technology Architecture)
- CPRS (Computerized Patient Record System)
- Time study observations
- Nurse assignment sheet
- Scenario testing using validated simulation model

Scenario testing using validated simulation model

Methodology

Treatment Center
- Reduce time spent from Front Desk to Treatment to target time:
  - Treatment only: 45 minutes
  - Physician and treatment: 1 hour and 15 minutes

Expansion
- Best usage of space
  - Number of beds vs chairs

Problem
- Best usage of space
  - Number of beds vs chairs

Methodology

Treatement Center
- Reduce time spent from Front Desk to Treatment to target time:
  - Treatment only: 45 minutes
  - Physician and treatment: 1 hour and 15 minutes

Expansion
- Best usage of space
  - Number of beds vs chairs

Methodology

Data Collection:
- VistA (Veterans Information System and Technology Architecture)
- CPRS (Computerized Patient Record System)
- Time study observations
- Nurse assignment sheet
- Scenario testing using validated simulation model
Problem - Lab

Long Wait Times

- Time until lab results released
  - Average time: **1 hour and 23 minutes**
  - Standard Deviation: **36 minutes**
- Wait time for lab check-in
  - Average time: **40 minutes**
  - Standard Deviation: **10 minutes**
- Over **60%** of oncology patients delayed

*For breakdown by day, see Appendix Page 35*
Problem - Lab

Long Wait Times

- Time until lab results released
  - Average time: **1 hour and 23 minutes**
  - Standard Deviation: **36 minutes**
- Wait time for lab check-in
  - Average time: **40 minutes**
  - Standard Deviation: **10 minutes**
- Over **60%** of oncology patients delayed

![Graph showing percentage of patients who waited over an hour for lab results - Monday](chart.png)
Problem - Lab

Long Wait Times

- Time until lab results released
  - Average time: **1 hour and 23 minutes**
  - Standard Deviation: **36 minutes**
- Wait time for lab check-in
  - Average time: **40 minutes**
  - Standard Deviation: **10 minutes**
- Over **60%** of oncology patients delayed

Solutions

- CBOC: Community Based Outpatient Clinics
  - Lab work, non-specialized treatment
  - 13 locations feed to Atlanta VAMC
- Up to **80%** of patients can go to CBOC
- Hire more phlebotomists due to long wait times and process times

*For breakdown by day, see Appendix Page 35*
Problem - Physician Constraints

**Current State**
- No full time physician for Oncology
- Room availability issue
- Each physician has different appointment lengths
  - From 15 minutes to 1 hour

**Current Process**
- Assigning treatment time and type
- Unable to see oncology schedule
- Great variability in number of patients into treatment center on a daily basis

**Solutions**
- Better visibility of treatment grid
- Balancing oncology appointments with physician visits

<table>
<thead>
<tr>
<th>Appointment Duration</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 min</td>
<td>21</td>
<td>18</td>
<td>16</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>30 min</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>45 min</td>
<td>7</td>
<td>9</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 min</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>43</td>
<td>33</td>
<td>13</td>
<td>35</td>
</tr>
</tbody>
</table>

Physician appointment availability
Problem - Treatment

Scheduling
- Treatment Scheduling Procedure
  - Appointments scheduled between 7:30 am - 3:00 pm
  - Physicians request appointment
  - Schedulers place appointment
    - Overbooking Policy
- Current Scheduling Grid

Solutions
- Provide Excel tool to help schedule patients
- Change from 1 grid to 6 grids
- Nurses will do return to clinic orders
- Create better communication with nurses and physicians

VistA Grid
- No One Scheduled
- 3 Patients Scheduled
- 10 Patients “Overbooked”
Problem - Nurse Overtime

- Charge nurse comes in early to assign patient and handles late patients
- Analysis:
  - Total of 1830 hours of overtime
  - 4 nurses worked 77% of total overtime hours

*Nurse Overtime*

*For cost comparison, see Appendix Page 49*
Problem - Nurse Overtime

- Charge nurse comes in early to assign patient and handles late patients
- Analysis:
  - Total of 1830 hours of overtime
  - 4 nurses worked 77% of total overtime hours

*Nurse Overtime

*For cost comparison, see Appendix Page 49*
Problem - Nurse Overtime

Nurse Overtime

- Charge nurse comes in early to assign patient and handles late patients
- Analysis:
  - Total of 1830 hours of overtime
  - 4 nurses worked 77% of total overtime hours

*For cost comparison, see Appendix Page 49
Problem - Nurse Overtime

Nurse Overtime

- Charge nurse comes in early to assign patient and handles late patients
- Analysis:
  - Total of 1830 hours of overtime
  - 4 nurses worked 77% of total overtime hours

Solutions

- Due to hiring freeze:
  - Re-allocating available treatment nurses to assist
  - Scheduling Scenarios/Tool

*For cost comparison, see Appendix Page 49
Deliverables

Treatment Center
- Scheduling guidelines
- CBOC percentage
- New VistA grid design
- Scheduling tool and documentation

Expansion
- Scheduling guidelines
- CBOC percentage
- Layout within the federal guidelines

&
Simulation - Validation

Front Desk to out of Oncology Treatment Center

Beta Distribution
Mean: 234 mins
SD: 129 mins

Kolmogorov-Smirnov Test:
Test Statistic: 0.0223
Failed to reject Null Hypothesis

Anderson-Darling Test:
Test Statistic: 0.36276
Failed to reject Null Hypothesis

Simulation Output

Beta Distribution
Mean: 232 mins
SD: 97 mins

*Refer to appendix pages 25-28 for all other days and appendix page 34-35 for simulation inputs and distributions
# Simulation - Treatment Scenario

<table>
<thead>
<tr>
<th>Time</th>
<th>Treatment Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 AM</td>
<td>Short (3 - 22 minutes)</td>
</tr>
<tr>
<td>9 AM</td>
<td>Short</td>
</tr>
<tr>
<td>10 AM</td>
<td>Short Medium (22 - 85 minutes)</td>
</tr>
<tr>
<td>11 AM</td>
<td>Medium (85 - 130 minutes)</td>
</tr>
<tr>
<td>12 PM</td>
<td>Medium Long (130 - 205 minutes)</td>
</tr>
<tr>
<td>1 PM</td>
<td>Long (More than 205 minutes)</td>
</tr>
<tr>
<td>2 PM</td>
<td></td>
</tr>
<tr>
<td>3 PM</td>
<td></td>
</tr>
<tr>
<td>4 PM</td>
<td></td>
</tr>
<tr>
<td>5 PM</td>
<td></td>
</tr>
</tbody>
</table>

Best treatment scheduling scenario from simulation
## Scheduling Tool

Created using Excel VBA
## Scheduling Tool

<table>
<thead>
<tr>
<th>Chair 1</th>
<th>Chair 2</th>
<th>Chair 3</th>
<th>Chair 4</th>
<th>Chair 5</th>
<th>Chair 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:30 AM - 11:00 AM</td>
<td>11:00 AM - 11:30 AM</td>
<td>11:30 AM - 12:00 AM</td>
<td>12:00 PM - 12:30 AM</td>
<td>12:30 PM - 1:00 AM</td>
<td></td>
</tr>
</tbody>
</table>

### Created using Excel VBA

<table>
<thead>
<tr>
<th>Button Type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule Patient</td>
<td>Schedule a patient into the grid by selecting Times, Duration, and Bed Or Chair from the drop-down list located in F23, F28, E25</td>
</tr>
<tr>
<td>Undo</td>
<td>Delete the most recent patient scheduled into the grid</td>
</tr>
<tr>
<td>Delete Entire Grid</td>
<td>Delete the entire grid of scheduled patients</td>
</tr>
<tr>
<td>Delete Specific Appointment</td>
<td>Delete a specific appointment from the grid by selecting Times, Duration, and Bed Or Chair from the drop-down list located in F23, F28, E25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Times</th>
<th>Duration</th>
<th>Bed or Chair</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30:00 AM</td>
<td>30 minutes</td>
<td>Chair 2</td>
</tr>
</tbody>
</table>
Scheduling Tool

<table>
<thead>
<tr>
<th>Times</th>
<th>7:30:00 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair 1</td>
<td></td>
</tr>
<tr>
<td>Chair 2</td>
<td></td>
</tr>
<tr>
<td>Chair 3</td>
<td></td>
</tr>
<tr>
<td>Chair 4</td>
<td></td>
</tr>
<tr>
<td>Chair 5</td>
<td></td>
</tr>
<tr>
<td>Chair 6</td>
<td></td>
</tr>
</tbody>
</table>

**Duration**: 30 minutes

**Bed or Chair**: Chair 2

---

Schedule Patient

Created using Excel VBA
# Scheduling Tool

<table>
<thead>
<tr>
<th></th>
<th>7:30 AM - 8:00 AM</th>
<th>8:00 AM - 8:30AM</th>
<th>8:30 AM - 9:00 AM</th>
<th>9:00 AM - 9:30 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Appointment Time](image)

- Appointment Time: 7:30 AM
- Duration: 30 minutes
- Bed or Chair: Chair 2

Created using Excel VBA
Scheduling Tool

Created using Excel VBA
# Scheduling Tool

<table>
<thead>
<tr>
<th>Chair/Bed</th>
<th>7:30 AM - 8:00 AM</th>
<th>8:00 AM - 8:30 AM</th>
<th>8:30 AM - 9:00 AM</th>
<th>9:00 AM - 9:30 AM</th>
<th>9:30 AM - 10:00 AM</th>
<th>10:00 AM - 10:30 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair 1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chair 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 5</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chair 8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Chair 9</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Chair 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Bed 1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total     | 2                 | 5                 | 6                 | 5                 | 5                 | 4                 |
Scheduling Tool - Grid Design

Phase 1: 6 grids

- 6 scheduling grids representing 6 nurses
- Each half hour has [3] for 3 chairs
  - 1:3 nurse to chair ratio
- 1 nurse trained with scheduling tool
- Implement guidelines

“This tool will reduce my time scheduling patients each morning”
“It is a very useful tool, that will help keep our 6 grids straight”
Scheduling Tool - Grid Design

**Phase 1: 6 grids**
- 6 scheduling grids representing 6 nurses
- Each half hour has 3 for chairs
  - 1:3 nurse to chair ratio
- 1 nurse trained with scheduling tool
- Implement guidelines

**Phase 2: 18 Grids**
- Transition to 18 grids
  - 1 grid per chair
- Each half hour has [1] for 1 patient
- Train all nurses to use scheduling tool

---

**VistA Grid for Chair 1**

<table>
<thead>
<tr>
<th>TIME</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR 14</td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
</tr>
<tr>
<td>MO 17</td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
</tr>
<tr>
<td>TU 18</td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
</tr>
<tr>
<td>WE 19</td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
<td><img src="grid1.png" alt="Grid" /></td>
</tr>
</tbody>
</table>
Expansion Options

**Alternative 1: Cost Conservative**
- 1 bed per exam room (3 total)
- 1 chair per recovery room (6 total)

**Alternative 2: Maximum Resources**
- 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)

**Alternative 3: Hybrid**
- 2 beds, 2 chairs in exam room 1
- Convert room 2 into physician exam room
- Convert room 3 into physician exam room
- 1 chair per recovery room (6 total)
Expansion Options

**Alternative 1: Cost Conservative**
- 1 bed per exam room (3 total)
- 1 chair per recovery room (6 total)

**Alternative 2: Maximum Resources**
- 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)

**Alternative 3: Hybrid**
- 2 beds, 2 chairs in exam room 1
- Convert room 2 into physician exam room
- Convert room 3 into physician exam room
- 1 chair per recovery room (6 total)
Expansion Options

Alternative 1: Cost Conservative
- 1 bed per exam room (3 total)
- 1 chair per recovery room (6 total)

Alternative 2: Maximum Resources
- 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)

Alternative 3: Hybrid
- 2 beds, 2 chairs in exam room 1
- Convert room 2 into physician exam room
- Convert room 3 into physician exam room
- 1 chair per recovery room (6 total)
Expansion Options

Alternative 1: Cost Conservative
- 1 bed per exam room (3 total)
- 1 chair per recovery room (6 total)

Alternative 2: Maximum Resources
- 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)

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

Simulation Scenario Testing Results: Time Spent from Front Desk to Treatment

*The scenario that includes the expansion has 30% more patients with 10 more chairs/beds, 4 more physicians, 2 more triage nurses from 6AM-3PM

*All scenarios include scheduling guidelines

See Appendix page 42 for break down of time spent
Valuation

1. Time Saved: Scheduling
   - Current Time: 99 minutes
   - New Improved Time: 67 minutes
   - Time saved: 32 minutes

   Savings: Scheduling
   - Nurse Overtime: $90,624/year
   - Reducing time to 67 minutes will save: $186,500/year
   - Total Savings: $277,124

2. Time Saved: 1 + CBOC
   - Current Time: 99 minutes
   - New Improved Time: 37 minutes
   - Time saved: 62 minutes

   Savings: 1 + CBOC
   - Nurse Overtime: $90,624/year
   - Reducing time to 37 minutes will save: $256,439/year
   - Total Savings: $347,063

3. Time Saved: 2 + Expansion
   - Current Time: 99 minutes
   - New Improved Time: 24 minutes
   - Time saved: 75 minutes

   Savings: 2 + Expansion
   - Nurse Overtime: $90,624/year
   - Reducing time to 24 minutes will save: $332,204/year
   - Total Savings: $422,828
Valuation

1. **Time Saved: Scheduling**
   - Current Time: 99 minutes
   - New Improved Time: 67 minutes
   - Time saved: 32 minutes

   **Savings: Scheduling**
   - Nurse Overtime: $90,624/year
   - Reducing time to 67 minutes will save: $186,500/year

   $277,124

2. **Time Saved: 1 + CBOC**
   - Current Time: 99 minutes
   - New Improved Time: 37 minutes
   - Time saved: 62 minutes

   **Savings: 1 + CBOC**
   - Nurse Overtime: $90,624/year
   - Reducing time to 37 minutes will save: $256,439/year

   $347,063

3. **Time Saved: 2 + Expansion**
   - Current Time: 99 minutes
   - New Improved Time: 24 minutes
   - Time saved: 75 minutes

   **Savings: 2 + Expansion**
   - Nurse Overtime: $90,624/year
   - Reducing time to 24 minutes will save: $332,204/year

   $422,828
Thank you for your time!
Appendix- Flow

Distribution of Physician Only Patients

Mean:
70 minutes
Appendix - Flow

Distribution of Treatment Only Patients

Mean:
99 minutes
Appendix- Flow

Mean: 146 minutes
Appendix- Lab

Below are the percentages of patients who wait longer than an hour for lab results by day.
Appendix- Simulation Inputs  (part 1 of 2)

Below is part one of the input distributions and data sources for the simulation model.

<table>
<thead>
<tr>
<th>Process type</th>
<th>Location</th>
<th>Probability distribution in Arena</th>
<th>Probability distribution</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab waiting time and blood drawn to be processed (6am – 9am)</td>
<td>Lab</td>
<td>NORM(30,10)</td>
<td>Normal(30,10)</td>
<td>Time study &amp; expert opinion</td>
</tr>
<tr>
<td>Lab waiting time and blood drawn to be processed (9 am – 1 pm)</td>
<td>Lab</td>
<td>NORM(60,10)</td>
<td>Normal(60,10)</td>
<td>Time study &amp; expert opinion</td>
</tr>
<tr>
<td>Lab waiting time and blood drawn to be processed (After 1 pm)</td>
<td>Lab</td>
<td>NORM(30,10)</td>
<td>Normal(30,10)</td>
<td>Time study &amp; expert opinion</td>
</tr>
<tr>
<td>Processing of blood samples</td>
<td>Lab</td>
<td>$8.52 \times \text{GAMM}(1, 13.96)/\text{GAMM}(1, 14.23)$</td>
<td>Pearson Type VI(0, 8.52, 13.96, 14.23)</td>
<td>Historical data (CPRS)</td>
</tr>
<tr>
<td>Front desk check in service time</td>
<td>Medical clinic</td>
<td>TRIA(3,5,7)</td>
<td>Triangular(3,5,7)</td>
<td>Time study</td>
</tr>
<tr>
<td>Triage service time</td>
<td>Triage</td>
<td>$1.64 \times \text{GAMM}(1, 9.73)/\text{GAMM}(1, 4.54)$</td>
<td>Pearson Type VI(0, 1.64, 9.73, 4.54)</td>
<td>Historical data (CPRS)</td>
</tr>
</tbody>
</table>
## Appendix - Simulation Inputs (part 2 of 2)

Below is part two of the input distributions and data sources for the simulation model.

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

**Monday Patient Data**
Normal
Mean: 252 min
SD: 119 min

**Monday Simulation Output**
Beta
Mean: 247 min
SD: 101 min

**Kolmogorov-Smirnov Test:**
Test Statistic: 0.0221
Failed to reject Null Hypothesis

**Anderson-Darling Test:**
Test Statistic: 0.31020
Failed to reject Null Hypothesis
Appendix - Simulation Validation

**Tuesday Patient Data**

Beta
Mean: 239 min
SD: 125 min

**Tuesday Simulation Output**

Beta
Mean: 233 min
SD: 99.2 min

**Kolmogorov-Smirnov Test:**
Test Statistic: 0.01983
Failed to reject Null Hypothesis

**Anderson-Darling Test:**
Test Statistic: 1.10846
Failed to reject Null Hypothesis
Appendix - Simulation Validation

Thursday Patient Data

Weibull
Mean: 205 min
SD: 106 min

Thursday Simulation Output

Beta
Mean: 217 min
SD: 95.4 min

Kolmogorov-Smirnov Test:
Test Statistic: 0.0263
Failed to reject Null Hypothesis

Anderson-Darling Test:
Test Statistic: 0.98035
Failed to reject Null Hypothesis
Appendix - Simulation Validation

**Friday Patient Data**

Erlang
Mean: 201 min
SD: 109 min

**Friday Simulation Output**

Beta
Mean: 214 min
SD: 93 min

Kolmogorov-Smirnov Test:
Test Statistic: 0.01369
Failed to reject Null Hypothesis

Anderson-Darling Test:
Test Statistic: 0.32196
Failed to reject Null Hypothesis
Appendix- Expansion (part 1 of 2)

The resources, costs, and measurements are listed below, as well as the expansion space.

<table>
<thead>
<tr>
<th>Clearance Measurements</th>
<th>Length (ft)</th>
<th>Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Bed</td>
<td>11.5</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual Measurements</th>
<th>Length (ft)</th>
<th>Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair (Oncology)</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Bed (Oncology)</td>
<td>11.5</td>
<td>9</td>
</tr>
<tr>
<td>Chair (GI Space)</td>
<td>8</td>
<td>7.5</td>
</tr>
<tr>
<td>Bed (GI Space)</td>
<td>Not Measured</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost Parameters</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Chair</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Cost of Bed</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>Portable Oxygen + suction + air</td>
<td>$300.00</td>
</tr>
</tbody>
</table>
## Appendix - Expansion (part 2 of 2)

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Room 1</th>
<th>Room 2</th>
<th>Room 3</th>
<th>Recovery Rooms</th>
<th>Added beds</th>
<th>Added chairs</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 beds, 2 chairs</td>
<td>4 chairs</td>
<td>2 chairs</td>
<td>6 chairs</td>
<td>2</td>
<td>14</td>
<td>$31,800.00</td>
</tr>
<tr>
<td>2</td>
<td>2 beds, 2 chairs</td>
<td>2 beds</td>
<td>2 chairs</td>
<td>6 chairs</td>
<td>4</td>
<td>10</td>
<td>$31,200.00</td>
</tr>
<tr>
<td>3</td>
<td>2 beds, 2 chairs</td>
<td>1 bed, 1 chair</td>
<td>2 chairs</td>
<td>6 chairs</td>
<td>3</td>
<td>11</td>
<td>$29,700.00</td>
</tr>
<tr>
<td>4</td>
<td>2 beds, 2 chairs</td>
<td>4 chairs</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>3</td>
<td>12</td>
<td>$31,500.00</td>
</tr>
<tr>
<td>5</td>
<td>2 beds, 2 chairs</td>
<td>2 beds</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>5</td>
<td>8</td>
<td>$30,900.00</td>
</tr>
<tr>
<td>6</td>
<td>2 beds, 2 chairs</td>
<td>1 bed, 1 chair</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>4</td>
<td>9</td>
<td>$29,400.00</td>
</tr>
<tr>
<td>7</td>
<td>4 chairs</td>
<td>4 chairs</td>
<td>2 chairs</td>
<td>6 chairs</td>
<td>0</td>
<td>16</td>
<td>$28,800.00</td>
</tr>
<tr>
<td>8</td>
<td>4 chairs</td>
<td>2 beds</td>
<td>2 chairs</td>
<td>6 chairs</td>
<td>2</td>
<td>12</td>
<td>$28,200.00</td>
</tr>
<tr>
<td>9</td>
<td>4 chairs</td>
<td>1 bed, 1 chair</td>
<td>2 chairs</td>
<td>6 chairs</td>
<td>1</td>
<td>13</td>
<td>$26,700.00</td>
</tr>
<tr>
<td>10</td>
<td>4 chairs</td>
<td>4 chairs</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>1</td>
<td>14</td>
<td>$28,500.00</td>
</tr>
<tr>
<td>11</td>
<td>4 chairs</td>
<td>2 beds</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>3</td>
<td>10</td>
<td>$27,900.00</td>
</tr>
<tr>
<td>12</td>
<td>4 chairs</td>
<td>1 bed, 1 chair</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>2</td>
<td>11</td>
<td>$26,400.00</td>
</tr>
<tr>
<td>13</td>
<td>1 bed</td>
<td>1 bed</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>3</td>
<td>6</td>
<td>$20,700.00</td>
</tr>
<tr>
<td>14</td>
<td>Exam room</td>
<td>Exam room</td>
<td>Exam room</td>
<td>6 chairs</td>
<td>0</td>
<td>6</td>
<td>$10,800.00</td>
</tr>
<tr>
<td>15</td>
<td>2 beds, 2 chairs</td>
<td>Exam room</td>
<td>Exam room</td>
<td>6 chairs</td>
<td>2</td>
<td>8</td>
<td>$27,000.00</td>
</tr>
<tr>
<td>16</td>
<td>Exam room</td>
<td>Exam room</td>
<td>1 bed</td>
<td>6 chairs</td>
<td>1</td>
<td>6</td>
<td>$20,100.00</td>
</tr>
<tr>
<td>17</td>
<td>Exam room</td>
<td>2 beds</td>
<td>Exam room</td>
<td>6 chairs</td>
<td>2</td>
<td>6</td>
<td>$23,400.00</td>
</tr>
<tr>
<td>18</td>
<td>Exam room</td>
<td>1 bed, 1 chair</td>
<td>Exam room</td>
<td>6 chairs</td>
<td>1</td>
<td>7</td>
<td>$21,900.00</td>
</tr>
<tr>
<td>19</td>
<td>2 beds, 2 chairs</td>
<td>1 bed, 1 chair</td>
<td>Exam room</td>
<td>6 chairs</td>
<td>3</td>
<td>9</td>
<td>$29,100.00</td>
</tr>
</tbody>
</table>
## Appendix - Simulation Results

The table shows a detailed breakdown of process and waiting times from Check-in to Treatment for each scenario tested.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Check-In Wait Time (minutes)</th>
<th>Check-In Process Time (minutes)</th>
<th>Triage Waiting Room (minutes)</th>
<th>Triage Process Time (minutes)</th>
<th>Treatment Waiting Room (minutes)</th>
<th>Lab Process Wait Time (minutes)</th>
<th>Check-In to Treatment Center (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current State</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>7</td>
<td>47</td>
<td>30</td>
<td>95</td>
</tr>
<tr>
<td>Scheduling Guidelines</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>15</td>
<td>30</td>
<td>67</td>
</tr>
<tr>
<td>CBOC Patients</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>15</td>
<td>0</td>
<td>37</td>
</tr>
<tr>
<td>Expansion*</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>8</td>
<td>30</td>
<td>54</td>
</tr>
<tr>
<td>CBOC Patients with Expansion*</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>7</td>
<td>8</td>
<td>0</td>
<td>24</td>
</tr>
</tbody>
</table>

*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.
### Appendix- Nurse Overtime

<table>
<thead>
<tr>
<th>Cost Comparison of Overtime Hours</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Overtime of all nurses</strong></td>
<td>1829:55</td>
</tr>
<tr>
<td>(hours:minutes)</td>
<td></td>
</tr>
<tr>
<td><strong>Additional cost spent on overtime</strong></td>
<td>$109,795</td>
</tr>
<tr>
<td>(Assume 1.5 x $40 nurse hourly wage x 1829:55)</td>
<td></td>
</tr>
<tr>
<td><strong>Salary of 1 nurse</strong></td>
<td>$100,800</td>
</tr>
<tr>
<td>(total over 63 weeks)</td>
<td></td>
</tr>
</tbody>
</table>

The table shows overtime data collected over 63 weeks.
The figure shows the number of patients that are within a 20 mile radius of a CBOC. 80% of patients fall within this range. A random sample of 526 patient zip codes were used.
Appendix- Indirect Cost

Scheduling guideline

\[
\frac{20,074 \text{ visits}}{\text{year}} \cdot \frac{32 \text{ min}}{\text{visits}} \cdot \frac{1 \text{ hr}}{60 \text{ mins}} \cdot \frac{$17.42}{\text{hr}} = $186,500/\text{year}
\]

CBOC guideline

\[
\text{CBOC } \left[0.4 \cdot 20,074 \frac{\text{visits}}{\text{year}} \cdot \frac{62 \text{ min}}{\text{visits}} \cdot \frac{1 \text{ hr}}{60 \text{ mins}} \cdot \frac{$17.42}{\text{hr}}\right] + \text{Non CBOC } \left[0.6 \cdot \frac{$186,500}{\text{year}}\right]
\]

\[= $256,439/\text{year}\]

Both

\[
\text{CBOC } \left[0.4 \cdot 20,074 \frac{\text{visits}}{\text{year}} \cdot \frac{75 \text{ min}}{\text{visits}} \cdot \frac{1 \text{ hr}}{60 \text{ mins}} \cdot \frac{$17.42}{\text{hr}}\right] + \text{Non CBOC } \left[0.6 \cdot \frac{$262,266.81}{\text{year}}\right]
\]

\[= $332,204/\text{year}\]
## Appendix - VistA Scheduling Grid

Here is a before and after look of the scheduling grid design.

### Before

<table>
<thead>
<tr>
<th>TIME</th>
<th>DATE</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR 14</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO 17</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TU 18</td>
<td></td>
<td>[2]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WE 19</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TH 20</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR 21</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO 24</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TU 25</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WE 26</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TH 27</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FR 28</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO 31</td>
<td></td>
<td>[3]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### After

<table>
<thead>
<tr>
<th>TIME</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR 14</td>
<td>[1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MO 17</td>
<td>[1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TU 18</td>
<td>[1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WE 19</td>
<td>[1]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

53