Improving the Scheduling Process of Referred Radiation Oncology Patients

Final Report

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Executive Summary

The Radiation Oncology Center at the University of Michigan Hospital recently decreased from two CT scan machines to one. Members of the center were concerned that this change would lead to workflow problems, including delays, when patients become add-ons. Add-on patients are patients who have a CT scan simulation performed on the same day as their consultation without a scheduled simulation appointment. The staff at the center wanted to know if there were trends to predict which patients would become add-ons so they could be scheduled for a simulation appointment on the same day as their consultation. IOE 481 Team 3 was assigned to collect and analyze data on the patients at the center and develop recommendations to prevent CT scan workflow delays. Specifically, Team 3 was tasked with attempting to decrease the number of add-on patients by 50%. The current scheduling process at the center includes a call or fax from an outside referring doctor, a consultation with a University doctor, a CT scan simulation, and finally the radiation treatment itself. The call center sets up the consultation after going through a phone questionnaire with the patient. Outpatients are not scheduled to have a simulation on the same day as their consultation. To decrease the number of add-ons, the team was asked to find predictors for patients who become add-ons. Therefore, patients who met those predictors could be scheduled to have their simulation on the same day as their consultation.

Background

When attending doctors believe it is valuable to get one of their patients treated as soon as possible, they can choose to have the patient become an add-on after the patient’s consultation. The team was informed that 2-3 patients become add-ons per day. Having enough add-ons to increase the total number of simulations in a day above eight could lead to the CT scan machine getting behind schedule. According to a resident, having 7-8 total simulations per day would be the ideal amount to avoid workflow delays and staff working overtime. Team 3 will address the problem of add-ons potentially causing workflow delays by providing recommendations on how to predict which patients will be add-ons.

Methodology

The team performed five types of tasks to evaluate and improve the current scheduling situation at the center.

- **Discussed the situation with clients.** First, the team met with the Director of Clinical Operations and a resident to develop a list of factors for which patients get added on.
- **Collected patient data.** The team then created a spreadsheet collecting simulation and CareWeb data on add-on patients. Data regarding all 71 add-on patients from November 3, 2011 to March 20, 2012 was collected. The data included patient demographics, referring physician, attending doctor, cancer diagnosis, and whether a patient was an inpatient or outpatient.
- **Analyzed patient data.** The team performed ANOVA tests and two sample T-tests with Minitab software comparing the number of add-ons and simulations on each day of the week. These tests showed the team the sample means of add-ons and simulations per day as well as whether or not they were significantly different. The team used an alpha value
of .05 for these tests to determine if there was 95% certainty that the number of simulations and add-ons per day varied across the days of the week.

- Interviewed call center staff, doctors, and residents. Based on the findings showing higher numbers of add-ons on Thursday and Friday, the team interviewed a doctor and two residents that work in clinic on those days of the week. The team also interviewed the call center staff to get further guidance towards developing recommendations.

- Developed recommendations for improving the workflow. The team created a three-step triage to schedule patients of the doctors with the most add-ons on Thursday and Friday who likely would have become add-ons for simulations on the same day as their consultation.

Findings

From the collected data and Minitab tests, the team made the following findings. Currently the number of add-ons per day ranges from .692 on Monday to 1.4 on Friday. These add-on statistics are already at least 50% less than the estimated 2-3 add-ons per day that some of the residents and staff believed were being performed per day. Thursdays and Friday have both the greatest number of add-ons and the greatest number of total simulations run per day. As Table 1 shows, Thursday and Friday are the only two days of the week that are slightly above the ideal 7-8 simulations per day range at 8.357 and 8.733 simulations per day respectively.

Table 1: Simulations and add-ons per day are lower than expected

<table>
<thead>
<tr>
<th>Day of the Week</th>
<th>Mean Number of Simulations</th>
<th>Mean Number of Add-Ons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>7.538</td>
<td>.692</td>
</tr>
<tr>
<td>Tuesday</td>
<td>7.357</td>
<td>.786</td>
</tr>
<tr>
<td>Wednesday</td>
<td>7.867</td>
<td>.867</td>
</tr>
<tr>
<td>Thursday</td>
<td>8.357</td>
<td>1.0</td>
</tr>
<tr>
<td>Friday</td>
<td>8.733</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Conclusions

After analyzing the data, the team realized fewer simulations and add-ons are being run per day than expected. The goals of decreasing the number of add-ons to 1-2 per day and the number of simulations to 7-8 per day are being met with the exception of the number of simulations on Thursday and Friday. The discrepancy between the perceived number of add-ons per day and the actual number of add-ons per day may have been caused by recall bias. Overall, the team has found that the center does have enough scheduling capacity to fit in their patients.

Therefore, the team shifted its goal to reducing the add-ons on Thursday and Friday which have the most add-ons. The team has found that Dr. A and Dr. K tend to have the most add-on patients.
on Thursday and Friday respectively. From the data collected, Dr. A’s patients account for 28.6% of add-ons on Thursday and Dr. K’s patients account for 36.4% of add-ons on Friday.

**Recommendations**

The team recommends a three-step pre-consultation triage for Dr. A and Dr. K’s patients to flag patients that could be add-ons and schedule them for a simulation. The first step will be that the call center asks the patient about the following:

- Ask if the patient would be available for a same day simulation after explaining the significance and possible patient requirements for a simulation such as fasting beforehand
- Ask if the patient is experiencing a large amount of pain due to the cancer on a 1-10 scale
- Ask if the patient is planning on receiving treatment at this center
- Ask if takes more than an hour for the patient to get to the center

If the patient answers each of these questions with a yes, the patient will be flagged as a potential add-on and the call center will tell the patient to plan on having a simulation on the same day as their consultation. At the second step, a resident will review the flagged patient’s medical records to ensure the patient has all necessary paperwork and determine whether the patient should be an add-on. This will be performed within 24 hours of the resident being assigned to this patient.

Finally, if the resident decides that the patient is a suitable add-on, the patient will be scheduled to have a simulation on the same day as their consultation. The call center will call the patient to let them know whether or not they will actually have the simulation.

The Call Center workers have expressed a willingness to ask these questions and the residents expressed that they expect that this triage process can help improve the workflow. The team expects that the three-step triage will decrease the number of add-ons on Thursdays and Fridays, which will lead to a decreased chance of over scheduling the CT scan machine.

As a second recommendation, the Director of Clinical Operations has expressed concerns about the number of canceled simulation appointments at the center. The team looked at the cancellation data and there is a sample mean of .746 cancelled simulations per day. Therefore, the team recommends that the center request a project for a future IOE 481 team to study the causes of cancelations in order to decrease the number of them.
Introduction

The Radiation Oncology Center at the University of Michigan Hospital expressed interest in decreasing the wait time between patient consultation and simulation, and then, the initiation of the treatment process. The current referral scheduling process involves a call or fax from an outside doctor, a consultation with a University doctor, a CT scan simulation, and, finally, the radiation treatment itself if indicated. Staff members believe that the referral scheduling process is inefficient and results in increased anxiety and wasted travel time for the patient. In the current system, no measures exist to identify referral patients who are ready to begin treatment immediately after their scheduled consultations. These patients, called add-ons, have their CT scan simulations performed on the same day as consultation, without a scheduled appointment for the CT scan. Scheduling problems can occur due to these add-on patients.

Due to recent operation changes, the Radiation Oncology Center has the use of only one CT scanner to perform treatment simulations. As a result, fewer simulations can be performed in a single day, causing a need to decrease the number of same day add-ons and causing a need for a more efficient scheduling method. The IOE 481 student team from the University of Michigan was asked to examine the current patient referral scheduling process used by the Radiation Oncology Center, and to identify ways to target patients eligible for same day treatment. The team was tasked with decreasing the number of same day outpatient add-ons by 50%, down to between 1 and 2 per day, and then to develop a plan to more efficiently schedule these patients. In the early stages of our data analysis, it was discovered that the add-on levels were in fact at acceptable levels, contrary to the common perception within the hospital. This finding caused a change in the scope of the project, narrowing the focus to the variability in the number of add-ons and simulations for Thursday and Friday due to the fact that these two days have the most volatility in the number of add-ons and simulations run. IOE 481 Team 3 has been assigned to develop recommendations for decreasing the number of add-ons. This report documents changes that occurred to the project, details the team’s data collection and analysis methods, as well as presenting our finalized conclusions and recommendations.

Background

The University of Michigan Hospital’s Radiation Oncology Center plans and administers radiotherapy treatments. The path through Radiation Oncology begins after a patient’s diagnosis and referral to the center. Upon referral:

1. The patient has a consultation appointment scheduled through the radiation oncology call center.
2. At this consultation, University of Michigan doctors gather data to develop a plan of treatment.
3. If the patient agrees to the treatment plan, a CT scan simulation is then scheduled.

At this point, patients are usually told to return at a later date for this simulation appointment; however, sometimes the patient is placed into CT simulation as a same day add-on, without a
prior appointment. After this simulation has been completed, a 2-5 day planning period ensues before the patient begins radiation treatment.

Under the current system at the University of Michigan Radiation Oncology Center, no steps exist to identify add-on patients prior to their consultation. The advantages of same day add-on simulations include faster consultation to treatment times for the patient, decreased patient anxiety, as well as decreased patient travel time. However, since these add-on patients do not have scheduled simulation appointments, they can disrupt the daily flow of the department. Disadvantages include over booking the CT scanner, overtime work for staff and therapists, and prolonged wait times for previously scheduled patients. The focus of this project was to limit the number of same day add-ons by identifying them prior to consultation. This step will ensure the patient receives all the advantages of same day simulation, and helps eliminate the negative effects of add-ons.

**Goals and Objectives**

The primary goal, as stated at the beginning of this project, was to reduce the current outpatient add-on level by 50%, down to between 1 and 2 per day. This target value was given by the Director of Clinical Operations as a feasible level of improvement. Due to the time-intensive nature of the simulations, 7 to 8 simulations per day would be ideal. Also, referral scheduling will be improved with the decrease of same day add-ons. To achieve this goal, the student team first examined the current referral scheduling process, looking for patterns or identifiers of patients eligible for same day consultation and CT scan simulation. Data acquired from electronic medical records (EMRs), CareWeb, was used to formulate recommendations on:

- Changing the standard procedures used for patient scheduling and reducing the number of same day add-ons
- Identifying patients ready to begin treatment on the same day as their scheduled consultation
- Pre-scheduling patients for same day consultation and CT scan simulation
- Increasing patient satisfaction

The project’s goals were adjusted slightly part way through the team’s data collection. Early analysis showed that the mean number of add-ons per day was below 1, which is already within the project’s stated goals. This finding lead to the team changed the focus to variability in the number of add-ons and simulations for Thursday and Friday because these two days have the most volatility in the number of add-ons and simulations run.

**Key Issues**

The issues below are the driving force for this project.

- The outpatient add-ons disrupt the efficient use of CT scanner resources
- There were no steps, prior to consultation, to identify add-on patients to who are able to start treatment immediately
• The referral to start of treatment process is inefficient
• Some referring physicians provide more medical history and test data information than others

Project Scope

This project included only the process from the point of referral to the end of the simulation at the University of Michigan Hospital Radiation Oncology Department. The procedure begins when a Medical Oncologist, surgeon, RO, or primary care physician refers the patient. The patient then goes through a referral process, a consultation, and a simulation of how to treat the patient’s specific type of cancer. The referral scheduling process concludes when the patient has begun radiation treatment. This project also analyzed how same day add-ons are chosen for simulation.

Any department outside of the Radiation Oncology Department was not included in the project. Any patients who are not patients referred to, or diagnosed at, the University of Michigan Hospital were also not included in this project. Any patients who are being treated solely for the pain associated with cancer were also not included in this project.

Data Collection

Data was collected by Team 3 every Thursday from January 26 to March 22, 2012. On these days the team obtained patient data sheets from the hospital recording system, Care Web. The data on these sheets were recorded every time a patient arrived at the University of Michigan Radiation Oncology Department for a consultation appointment. The data collected was patient demographics that may show a trend in the add-on scheduling process. The team would then record the pertinent data from these sheets into a Master Excel sheet. This data included:

• The city/state of patient residence
• The date of consultation appointment
• Whether the patient was an inpatient or outpatient
• The patients radiation oncologist
• The patients referring physician
• Whether or not the patient was a lean patient
• The type of cancer diagnosed
• If the patient was a same day add-on
• The patients registration number

Currently, 71 patients are recorded in the Master Excel sheet with consultation dates from November 3, 2011 to February 22, 2012.
Data Analysis for Add-ons

Analyzing data for add-ons was done by calculating the true mean values of add-ons and simulations run per day, determining if there were any statistical differences in the add-on and simulations run data on a day-to-day basis, and determining if there was a referring physician who showed trends of consistently referring an add-on patient. All of these questions were answered by analyzing the Master Excel sheet.

Mean Values of Add-ons

When calculating the true mean values the data was broken up into six sections, five sections for every day of the working week and then one for all the data combined. The first step in separating the data was to pull all the add-on and simulation information from the Master Excel sheet and sort it into the days of the week. Next, Team 3 calculated the mean values for add-ons and simulations run. In Table 2 below, the mean values by day of the week and overall means values can be viewed.

<table>
<thead>
<tr>
<th>Day of the Week</th>
<th>Mean Add-ons</th>
<th>Mean Simulations Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>.692</td>
<td>7.54</td>
</tr>
<tr>
<td>Tuesday</td>
<td>.786</td>
<td>7.36</td>
</tr>
<tr>
<td>Wednesday</td>
<td>.867</td>
<td>7.87</td>
</tr>
<tr>
<td>Thursday</td>
<td>1.00</td>
<td>8.36</td>
</tr>
<tr>
<td>Friday</td>
<td>1.40</td>
<td>8.73</td>
</tr>
<tr>
<td>Overall</td>
<td>.958</td>
<td>7.99</td>
</tr>
</tbody>
</table>

As can be seen by Table 2, the mean add-on values are already at the desired range of between 1 and 2 add-ons per day. This tells the Radiation Oncology Department that no problem in the number of add-ons per day exists. Another way of viewing the mean values for add-ons and simulations displayed in Table 2 can be seen in Appendices 1 and 2. Appendix 1 shows the mean number of add-ons per day and Appendix 2 shows the mean simulations run per day of the week in a line chart. The values of 1-5 on the x-axis represent Monday through Friday with 1 being Monday and 5 being Friday.

ANOVA Testing of Add-ons

Because the mean values are at the desired range, Team 3 decided to test if there were any statistical significant differences in mean values of add-ons and simulations run for each day of
the week. To do this an ANOVA test was performed. By performing an ANOVA test, every day of the week would be able to be compared in terms of their mean values. The test was run by transferring the add-on and simulation data from the Master Excel sheet to Minitab. Before the test was run, another column was created, called days of the week, in order to group the data. The ANOVA tests run for add-ons and simulations can be seen in Figures 1 and 2 below.

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>4</td>
<td>4.41</td>
<td>1.10</td>
<td>1.03</td>
<td>0.397  (1)</td>
</tr>
<tr>
<td>Error</td>
<td>66</td>
<td>70.46</td>
<td>1.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>74.87</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S = 1.033  R-Sq = 5.89%  R-Sq(adj) = 0.19%

<table>
<thead>
<tr>
<th>Level</th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>13</td>
<td>0.692</td>
<td>0.947</td>
</tr>
<tr>
<td>Tuesday</td>
<td>14</td>
<td>0.786</td>
<td>1.051</td>
</tr>
<tr>
<td>Wednesday</td>
<td>15</td>
<td>0.867</td>
<td>0.990</td>
</tr>
<tr>
<td>Thursday</td>
<td>14</td>
<td>1.000</td>
<td>1.177</td>
</tr>
<tr>
<td>Friday</td>
<td>15</td>
<td>1.400</td>
<td>0.986</td>
</tr>
</tbody>
</table>

Pooled StDev = 1.033

Figure 1: ANOVA test output for the number of add-ons per day
Figure 2: ANOVA test output for the number of simulations run per day

Figures 1 and 2 are described below. The described outputs are the bolded numbers in the two figures.

1. The highlighted p-value of 0.397 shows no statistical difference in the mean values of add-ons per day of the week exists. A 95% confidence interval was used, meaning a p-value of 0.05 or less would show that a statistical difference exists.

2. The highlighted portion shows the mean values of the add-ons per day of the week. These values show insight into which days can accommodate more add-ons. Monday and Friday show a difference of 0.708 in the number of add-ons per day. Because this difference is so high for the number of add-ons, Monday and Friday will be analyzed together later in this memo.

3. The highlighted p-value of 0.418 shows no statistical difference in the mean values of add-ons per day of the week exists. A 95% confidence interval was used, meaning a p-value of 0.05 or less would show that a statistical difference exists.

4. The highlighted portion shows the mean values of the number of simulations run per day of the week. These values provide insight into which days can accommodate more simulations. Currently the only days above 8 simulations run are Thursdays and Fridays.
T-test for Add-ons

Based on the data found from the ANOVA testing, the team further investigated the statistical difference between the number of add-ons on Monday and Friday. The mean differential of 0.708 was far enough apart, and with a sample size of 71 patients, the team hypothesized that with more data collection a significant difference in mean add-ons would exist between Monday and Friday.

This statistical analysis was done using a t-test to determine if a statistical difference exists in the means of the number of add-ons between Monday and Friday only. Appendix 3 shows that the p-value for this t-test is .064. To have a true significant difference, the p-value would need to be .05, but with the limited amount of data the team feels that a statistical difference is probable between the two days of the week, and will be shown once more data is collected. Currently, the means are assumed to have a statistical difference with 95% confidence between the two days, because of the small sample size.

Referring Physician Trends

After the ANOVA and t-tests were run, Team 3 looked for any trends with the referring physician. The specific trend analyzed was a referring physician who consistently has their patients accepted as add-on patients. If a referring physician showed this trend, the Call Center would request that the referred patient be added to the simulation schedule right after their consultation appointment. This would allow the hospital to better gauge how many simulations they would have on a given day.

Upon further analysis on the referring physicians, not enough recurring physician referrals happened to provide any significant findings in terms of trends.

Data Analysis for Variance on Thursday and Friday

Analyzing data for the altered scope was done by calculating which doctors accounted for the highest percentage of add-ons on Thursday and Friday and interviewing a Radiation Oncologist, the Radiation Oncology Call Center, and 3 Resident Oncologists. Calculations were performed by extracting data from the Master Excel sheet.

Percentage of Add-ons per Doctor

With the new scope of the project being focused on the variability and high simulation running totals on Thursday and Friday, the team looked at reasons this was happening. Team 3 calculated the percent of add-ons each doctor had on either Thursday or Friday. Tables 3 and 4 below show the percentages of add-ons attributed to each doctor and are sorted by letters of the alphabet to protect privacy.
Table 3: Percentage of Add-ons Attributed to each doctor on Thursday

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Percentage of Add-ons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28.6%</td>
</tr>
<tr>
<td>B</td>
<td>14.3%</td>
</tr>
<tr>
<td>C</td>
<td>21.4%</td>
</tr>
<tr>
<td>D</td>
<td>14.3%</td>
</tr>
<tr>
<td>E</td>
<td>7.1%</td>
</tr>
<tr>
<td>F</td>
<td>14.3%</td>
</tr>
</tbody>
</table>

Table 4: Percentage of Add-ons Attributed to each doctor on Friday

<table>
<thead>
<tr>
<th>Doctor</th>
<th>Percentage of Add-ons</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18.2%</td>
</tr>
<tr>
<td>B</td>
<td>4.5%</td>
</tr>
<tr>
<td>E</td>
<td>9.1%</td>
</tr>
<tr>
<td>F</td>
<td>4.5%</td>
</tr>
<tr>
<td>G</td>
<td>4.5%</td>
</tr>
<tr>
<td>H</td>
<td>4.5%</td>
</tr>
<tr>
<td>I</td>
<td>4.5%</td>
</tr>
<tr>
<td>J</td>
<td>13.6%</td>
</tr>
<tr>
<td>K</td>
<td>36.4%</td>
</tr>
</tbody>
</table>

These values in the table come from the 14 add-on patients on Thursdays and the 21 add-ons on Fridays.
Looking at the data from these tables, Dr. K has the highest percentage of add-on patients on Friday at 36.4% and Dr. A has the highest percentage of add-on patients on Thursday at 28.6%. The rest of the doctors on Tables 3 and 4 have negligible percentages of add-ons.

Next, Team 3 looked at what days these doctors worked in clinic because that is when they see patients for their consultation appointments. Dr. A works in clinic on Tuesday and Thursday and Dr. K works in clinic on Friday.

Since Dr. K works in clinic on Friday, Team 3 tried to find ways to make the Radiation Oncology Department aware in advance of when Dr. K will have an add-on patient.

Because Dr. A works more than one day of the week they were interviewed to find out why so many of their patients are add-ons on Thursday. They said that they add patients to simulation in case of an emergency or if the patient lives more than an hour away. If the patient is having difficulties breathing or is in physically handicapping pain, the patient will be added on.

*Interviews of the Call Center and Residents*

In order to become aware of the add-ons for both Dr. A and Dr. K, Team 3 interviewed the Call Center and residents of Dr. A and Dr. K. The interview questions for the Call Center were:

1. What do you think of asking a patient “If it is possible, would you be willing to go straight into simulation after your consultation appointment?”
2. Would you ask a patient if they are currently having difficulties breathing?
3. Would you ask a patient if they are having pain to the point where it is physically handicapping?
4. Will adding these three questions to ask patients increase the workload too much?
5. Can you see these questions being beneficial to becoming aware of add-on patients in advance?

Before the interview began the Call Center was given a brief outline about the scope and history of the project. They were told that two doctors account for the majority of add-ons on Thursday and Friday and that the new patient questions would be asked only in the case of Dr. A or Dr. K being the patients Radiation Oncologist. The Call Center was also told that by asking a patient these questions it could create a way to flag a patient as a potential add-on. Depending how the patient answers the questions, they could be flagged as an add-on by the Call Center.

The answers to each interview question for the Call Center are labeled according to the number of the question asked above.

1. The Call Center said that they were fine with asking a patient if they are willing to go straight into simulation if it is possible.
2. The Call Center said that they were fine asking a patient if they were having difficulties breathing.
3. The Call Center said they were uncomfortable about asking about pain because they were not familiar with all of medical terminology that could be used.
4. The Call Center said that these questions would not add any extra burden on their workday as they already have to call a patient before their consultation appointment.
5. The Call Center was very supportive about asking questions to patients and thought that it would make scheduling add-on patients for Thursday and Friday less variable.

Next, the Resident Oncologists were interviewed to gain insight on what they thought of the questions being asked to the patients and if they had any more ideas of what to add. The interview questions for the Residents were:

1. What do you think of having the call center ask the three new questions?
2. Do you think by adding these questions there will be improvements in preparing for the number of patients heading into simulation?
3. What do you think of a three step triage format
   a. The call center asks the patient the three new questions
   b. If there is reason to believe after the questions have been asked that the patient should become an add-on the residents will do a brief overview of their history before the consultation appointment.
   c. Resident does or does not recommend a patient as an add-on.

Before the interview began the Residents were told everything that was told to the Call Center.

The answers to each question asked are labeled according to the number of the question asked above.

1. The Residents said that these were good questions to ask patients before consultation but asking a patient if they are having breathing problems would get very few responses. They also addressed the Call Centers concerns about asking a patient about pain, by just saying a patient to rate their own pain on a scale of 1-10.
2. The Residents all said that it would be great to have a guide before hand to as who might be an add-on. They also suggested that two more questions be asked to the patient. The questions are “Do you plan on remaining at the University of Michigan for your treatment?” and “Can we have a phone number that we can reach you at any time of the day?” Asking a patient about staying at the University of Michigan is important because if the patient plans on leaving, they will be asked to go through simulation at the other hospital. This makes it useless to have a patient be added on as a patient at the University of Michigan. Asking a patient about a phone number is important because they will need to know if they are going to be scheduled the same day for simulation or if they will need to come in another day.
3. The Residents responded very well to the initiation of a three-step triage. Their only concern was that they would have to go over patient history earlier than they normally do. Residents normally go over patient case history the night before or the day of the patient’s consultation appointment.
Besides answering these questions there were two other things that the Residents thought would be helpful. The first one is to tell the Residents at the beginning of the day how many openings are available to add-on patients. Knowing how many openings is important because it allows the Residents to choose the most crucial patients to add to simulation. The second thing Residents would like is to have all patients who are not add-on patients, schedule their simulation appointments in the morning to allow for more room in the afternoon for the add-on patients. The Call Center cannot force a patient to take a morning slot, but the Call Center can give the patients an incentive. The incentive would be that the earlier the patient books their simulation appointment the less likely they are to be delayed by an add-on patient.

Findings and Conclusions

Upon completing the project with the University of Michigan’s Radiology and Oncology Center, the team developed a series of findings and conclusions. Originally, the team had been asked to decrease the average number of add-ons, as mentioned in the Goals and Objectives section. However, the team discovered through the course of this project that the goal had already been met. The average number of add-ons was well below the desired number given to the team by the Radiology and Oncology Center. Because of this information, the team found that the problem with add-ons is perceived and not actual. The team believes this is recall bias, a psychology-related problem. Humans tend to remember the “bad” events in their lives more prevalently, even though these events tend to be rarer in occurrence. This is referred to as recall bias.

After concluding that the average add-on level is low enough, the team turned their focus to a problem that had become obvious during the course of the project. There exists a large amount of variance on Thursdays and Fridays. The number of add-ons on these days can fluctuate greatly week to week. The team found that this variance occurs for the patients being seen by Dr. Tsien and Dr. Kong. Interviews were conducted to find a possible reason for this phenomena but the team concluded that it appears to be arbitrary. The team’s final conclusion is that the CT scanner is rarely running at full capacity and there is the opportunity for more simulations to be run on the scanner.

Recommendations

The team recommends having Dr. Tsien and Dr. Kong focus on attempting to schedule their patients for simulation prior to their consultations. By scheduling these potential add-ons ahead of time, the variance in the number of add-ons for Thursdays and Fridays will be reduced. This can be done with the help of four questions added to the questionnaire that the Call Center uses when scheduling consultation appointments:

- Ask if the patient would be available for a possible same day simulation
- Ask if the patient is experiencing a large amount of pain due to their cancer
- Ask if the patient plans on receiving treatment at the University Hospital
- Ask how long it takes the patient to get to the University Hospital
The team interviewed four Call Center workers and they expressed their willingness to ask the three stated questions. These questions will help identify possible add-ons and allow the CT scanner to be made ready for the possibility of a same day simulation. The team has developed a potential script for the Call Center to use when scheduling patients for consultation:

“Hello, I’m calling from the University of Michigan Hospital about your upcoming consultation appointment with Dr. A/K. I wanted to ask you a few questions to see if we would be able to schedule you for a same day simulation. Firstly, are you available to have a simulation performed on the same day as your consultation? (Answer) It is possible you will have to fast in preparation for your simulation. Is this ok with you? (Answer) I have a quick question regarding your current condition. On a scale from 1 to 10, 10 being an extreme amount of pain, how much pain is your cancer causing you right now? (Answer)

Another set of questions I have for you dealing with your location in regard to the University Hospital. How long does it take you to get to the University Hospital? (Answer) Do you plan on staying here for your radiation treatment or are you considering going back home for treatment? (Answer)

Thank you for taking the time to answer these questions. A resident will review your information in the next 24 hours and we will call you to inform you of your consultation appointment time and subsequent simulation time. Just to let you know, the simulation will involve a CT scan, which can take up to an hour, depending on the location of your cancer. It can also require fasting beforehand. We will make sure to call you at least 24 hours before your consultation to inform you of any scheduling changes that may have occurred with your simulation and any necessary preparation you may need to do for your simulation.”

After the implementation of these questions, follow-ups should be done to ensure that the questions are having a positive impact on the work process. Figure 3 shows a flowchart detailing how the process will work after the suggested changes are made.
Figure 3: New Work Flow Process

The Call Center script would be part of a three step triage to identify potential add-ons. The steps of the triage would be as follows:

1. Call Center asks the patients the script questions
2. Residents will review cases flagged as potential add-ons within 24 hours of the cases being identified
3. The patient is or is not recommended to be scheduled for a same day simulation and then must be notified by the Call Center scheduling changes or preparation needs

One final recommendation is that the Radiology and Oncology Center apply for a student team next semester to examine the number of patient cancellations and the reasoning behind these cancellations. The client expressed some concern about this topic but it was not within the project scope. Therefore the team was unable to investigate the causes of the cancellations. This future student team should also examine the newly installed MRI’s effect on the work flow simulation. The team will need to take into consideration that a patient may have to be simulated on both the CT scanner and the MRI and these simulations cannot be performed on the same day.

**Expected Impact**

If the recommendations are put into place in the Radiology and Oncology Center, the simulation scheduling process will result in fewer add-ons. The Call Center will be able to get a precise and
consistent feel for which patients will potentially be add-ons and workers can schedule a time for the patients on the CT scanner. By scheduling potential add-ons early, the flow of simulations on the CT scanner can be regulated, which will ensure there is never an overload of simulations on the machine. Overall, this will mean less stress for all involved with the scheduling and performing of simulations.
Appendix 1: Line chart of the mean value of add-ons by day of the week
Appendix 2: Line chart of the mean value of simulations run by day of the week

![Simulations Run Mean vs Day of Week](image-url)
Appendix 3: T-test for the number of add-ons on Monday and Friday

Two-Sample T-Test and CI: Friday, Monday

Two-sample T for Friday vs Monday

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StDev</th>
<th>SE Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friday</td>
<td>15</td>
<td>1.400</td>
<td>0.986</td>
<td>0.25</td>
</tr>
<tr>
<td>Monday</td>
<td>13</td>
<td>0.692</td>
<td>0.947</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Difference = mu (Friday) - mu (Monday)
Estimate for difference: 0.708
95% CI for difference: (-0.046, 1.461)
T-Test of difference = 0 (vs not =): T-Value = 1.93 P-Value = 0.064 DF = 25
Appendix 4: Process Flow Chart

1. Patient is diagnosed by a surgeon/medical oncologist
2. Patient is referred to the University Hospital through a call, e-mail, or fax
3. Referrals go through the Call Center
4. Appointments for consultations are scheduled by the Call Center
5. Simulations are performed immediately after the consultation or scheduled for a later time
<table>
<thead>
<tr>
<th>Reg #</th>
<th>City/State</th>
<th>Date of Service</th>
<th>Patient Type</th>
<th>RO</th>
<th>Referring</th>
<th>Diagnosis</th>
<th>Lean? (0=no; 1=yes)</th>
<th>Plan</th>
</tr>
</thead>
</table>

Appendix 5: Data Collection Form