Patient Flow Analysis
Pulmonary Clinic - University of Michigan Hospitals

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Glossary

**Encounter:** Any interaction between a staff member and a patient. A separation of more than two minutes is defined as a separate encounter.

**Initial Wait Time:** (Wait for the First Provider) The time from the end of Check-in to the start of the first encounter with a care provider.

**Length of Stay (LOS):** The total time a patient is in the clinic. LOS is measured from the start of check-in to the end of check-out.

**Room Utilization:** The amount of time a room is in use for service only. This excludes the time that the patient may spend waiting in the room.

**Total M.D. Service Time (TST-M.D.):** The total time that the patient spends with the physician during their appointment.

**Total Service Time (TST):** The total time spent in encounters with the patient.

**Wait Time:** The amount of time a patient is in the clinic but not receiving service from a provider. Wait time is measured as the time from the end one service encounter to the start of the next encounter.
Executive Summary

In response to increasing complaints from physicians, patients, and staff in the Pulmonary Clinic at the Taubman Center at the University of Michigan Hospital, a study of the patient flow within the clinics of Dr. Charles Watts, M.D., was requested by Dr. Galen Toews, M.D., Director of Internal Medicine. Because both physicians felt that the Pulmonary Clinics within the Briarwood facility were more efficient, the clinics at the Briarwood facility were also studied in an effort to contrast the two clinics and to determine the best methods of operation at both. It was hypothesized that the problems within the Taubman Clinic were related to the scheduling practices of the clinic, the physical setup of the clinic and the interaction of the clinic with other departments such as Radiology.

The objectives of the study were to provide recommendations to minimize patient wait times in the clinic and to increase the percentage of patient service time verses the percentage of patient wait time within the clinics. In an effort to evaluate these issues, time studies at both clinics were performed to determine wait times, service times, arrival times and length of stay. Other issues involved physician utilization, room utilization and time statistics related to the patients’ arrival times.

From the data obtained through patient flow analysis, it was determined that the length of stay at Taubman was on average longer than the length of stay at Briarwood. This was attributed to the longer wait times, the need to visit other clinics for testing procedures, and a smaller availability of exam rooms. With regards to the total service times, the M.D. service times and the wait times, results were varied between new and return visit populations and between clinics. The patient scheduling templates at both clinics were found to be ineffective as many of the patients were often seen on a first come first served basis. This method not only caused a bottleneck of examination rooms, but contributed to increased waiting of later patients. It was found that the percentage of service time at both clinics was higher than that of wait times, however, this value was lower at Taubman than at Briarwood.

In order to minimize patient wait time in the clinic and increase the percentage of service time verses the percentage of wait time within each clinic, several opportunities for improvement were identified. These are as follows:

- In order to correctly schedule patients according to the time required for their visit, return visit patients should be defined as those who have been seen by Dr. Watts before, not just as patients who have been seen within the clinic before.
- When pre-appointment testing is required, inform patients of the necessity to arrive early for their test procedures.
- The practice of seeing patients on a first come first served basis should be eliminated and the current scheduling template should be followed more closely, or a new scheduling template should be evaluated for use.
- Extra time should be allotted in the middle of the afternoon to allow the physician to make up for any time lost in the first half of the clinic.
- Return visits should be scheduled into the first clinic appointment time slot, as most return visits were found to arrive early and have a smaller probability of needing testing (a bottleneck within the clinic at Taubman).
1.0 Introduction and Background

Due to increasing complaints from physicians, staff and patients within the Pulmonary Clinic at the University of Michigan Medical Center, Dr. Galen Toews, M.D., Division Head of Pulmonary Medicine, requested that a study be performed within the clinic in an effort to minimize patient wait times and increase the percentage of service time versus percentage of wait time within the clinics. The clinics under the supervision of Dr. Charles Watts were chosen to be studied at the Taubman Center and at the Briarwood Clinic. Dr. Watts’ clinics were chosen for the study as a result of his prior experience in both the hospital and private practice settings.

The goals and objectives of this project were as follows:

• Minimize the patient wait times within the clinic.
• Increase the percentage of service time versus the percentage wait time within the clinics.
• Compare the two clinics to suggest a more efficient system of operation for both.

This study was aimed toward improving the operations at the Taubman and Briarwood clinics and analyzed the activities and methods used by the physician, nurses, clerks and other providers working in the clinics.

Key issues that were identified for this project included:

• Current patient flow problems related to scheduling methods.
• Pre-appointment tests and scheduling.
• Current room utilization.

1.1 Approach and Methodology

The focus of this project involved performing the following tasks:

• Meeting with clients and coordinator to determine the focus of the project and the expected outcomes.
• Observing both clinics to determine patient flow and develop flow charts of both clinics.
• Developing a data collection sheet completed by the provider during the patient’s visit. This sheet was used to calculate the mean service and wait times and to identify bottlenecks within the clinic. (Note that a visit was defined as the time from check-in to check-out.)
• Completing a data analysis to determine service and wait times, physician and clinic utilization, appropriate scheduling templates, and distributions of patient arrival times.
• Interviewing clients and clinic staff to determine their views of the clinic and
its operations. In addition, the interviews were used to determine some of the suggestions for improvement within the clinic.

- Determining the impact of other clinics on the efficiency of the Pulmonary Clinic (Radiology, Pulmonary Function Lab).
- Summarizing data for presentation, including suggestions for improvement within the clinics.

1.1.1 Interviews with the Staff

Clerks, nurses, technicians and the physician were interviewed to obtain an understanding of the inner workings of the Pulmonary Clinics at both facilities. In addition, all staff members' suggestions were taken into account during data collection in an effort to improve the data collection sheet and reduce the burden on the staff. It was essential that all staff members be updated weekly to carry out the project successfully and maintain cooperation on the project.

1.1.2 Time Study

The data collection sheet was used to collect wait and service times during a patient's visit to the clinics. Service times collected included total clinic staff service times and M.D. service times. Wait times included time spent in waiting rooms prior to appointment, time spent waiting for tests, time spent waiting for the physician in the exam room and time spent waiting to check out. Each data sheet followed the patient through their appointment at the Pulmonary Clinic from the time of check-in to check-out. A copy of the data collection sheet is located in the Appendix.

Data was collected for five weeks at the Briarwood Clinic and for four weeks at the Taubman Clinic. Data was gathered at the physician's Tuesday clinic at Taubman (Feb. 28, March 7, 21 and 28) and at his Wednesday and Thursday afternoon clinics at Briarwood (February 8, 15, 16, 22, 23 and March 1, 2, 8 and 9).

It is important to note that the resulting data that was analyzed consisted of sample sizes, n = 11 (NP = 4, RV = 7) at Taubman and n = 45 (NP = 7, RV = 38) at Briarwood. Due to the variation in sample sizes between the two clinics, some error in assuming a direct comparison could have resulted. In addition, the sample size of n = 11 at Taubman could have lead to a misrepresentation in the data analysis of the clinic operations.

1.1.3 Direct Observation of Clinic

In addition to data collected on the data sheets, time was spent in each clinic to determine the flow of patients through the clinic and the different environments within each clinic. Flowcharts showing patient flow through the clinics are located in Section 3.0.
1.2 Limitations

Because the analysis of the Briarwood and Taubman Clinics was restrained by time and methodology factors, several limitations should be defined.

- Client Generated Data: Although data collection by the providers of care is a practical way to obtain data, there are possible concerns regarding accuracy, completeness, and reliability of data. In addition, it was assumed that data was collected in an unbiased manner.

- Incomplete Data: Incomplete data was eliminated from the analysis. Problems with this occurred at the beginning of the data collection period and at both clinics when patients left to have testing performed.

- Sample Size: The discrepancy between the sample sizes of 11 at the Taubman clinic and 45 at the Briarwood clinic may have caused errors in the results obtained. This gap between sample sizes was unavoidable in this study as there were two clinics per week at Briarwood and only one per week at Taubman.

2.0 Current Process Flow Description

2.1 Taubman

Currently at Taubman, the patients arrive at the Pulmonary Clinic first to register. From there they are sent to the appropriate clinic if they are scheduled to have tests done prior to their appointment. Upon the patient’s return to the Pulmonary Clinic, they typically wait in the waiting area to be taken back to an examination room by a medical assistant. Once called back, the medical assistant weighs the patient and checks their blood pressure prior to taking them to an examination room. Once in the examination room, the patient waits to be seen by the physician. Upon completion of the examination, the physician will determine if the patient needs further testing or, in some cases, if the patient needs to have a first set of tests performed. If the patient needs testing at this point, they will either be asked to make a test appointment for a later date or they will be sent immediately for testing and asked to return to the clinic following their test for another consultation with the physician. When the patient has completed their appointment, they proceed to the cashier to check-out and schedule a possible return visit. The above is illustrated on the following page.
Figure 1. Taubman Flowchart
2.2 Briarwood

Currently at Briarwood the patients arrive to the clinic, check-in and then wait for a medical assistant to call them back for either testing or their appointment. Typically at Briarwood if a patient needs to have an x-ray performed, they arrive early, have the x-ray taken and bring the results with them to the appointment. When the patient is called back by the medical assistant, they have their blood pressure and weight taken. If the patient needs to have a spirometry or pulmonary function test done, a technician can perform this in the same clinic and quickly obtain their results. If tests such as these are needed, they are typically done thirty minutes before the patient is scheduled to see the physician. The scheduling practice takes this into account. Following their test, the patient is placed in an examination room and waits to be seen by the physician. Upon completion of the examination the physician determines if the patient needs further testing or, in some cases, if the patient needs to have a first set of tests performed. If the patient needs testing at this point, they will be sent immediately for testing and will be seen again by the physician following their tests. In some cases if an x-ray is required and cannot be done immediately, the patient will be asked to schedule an appointment for a later date. When the patient has completed their appointment, they proceed to the cashier to check-out and schedule a possible return visit.
Figure 2. Briarwood Flowchart
3.0 Results and Conclusions

3.1 Patient Population

There is a significant difference between the patient populations at the two clinics. Many of the patients at the Briarwood facility are long-time patients of the physician and their medical history has been monitored accordingly. The patients in the Taubman clinic are usually in need of more lengthy visits, and although most are classified as return visits because they have been seen in the clinic before, these are often patients who have never been seen by the physician (Dr. Watts) and require the same type of examination as a new patient.

The following table shows the break down of the types of schedule characteristics and alterations within the clinics. This chart shows that there was a higher percentage of no-shows and cancellations at Taubman.

Table 1. Schedule Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Briarwood</th>
<th>Taubman</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-Show</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Add-On</td>
<td>15%</td>
<td>13%</td>
</tr>
<tr>
<td>Cancellation</td>
<td>17%</td>
<td>24%</td>
</tr>
<tr>
<td>Regularly Scheduled</td>
<td>65%</td>
<td>58%</td>
</tr>
</tbody>
</table>

3.2 Data Summary

The table on the following page summarizes the data collected during the study at both the Briarwood and Taubman Clinics.
<table>
<thead>
<tr>
<th>Min. Early/Late</th>
<th>Min Early/Late</th>
<th>Wait in Waiting</th>
<th>Wait in Waiting</th>
<th>Wait for</th>
<th>Exam 1</th>
<th>Exam 2</th>
<th>Exam 3</th>
<th>Check-out</th>
<th>Length of</th>
<th>Length of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Test</td>
<td>After Test</td>
<td>Room from Appt</td>
<td>Room from Arrv</td>
<td>Test</td>
<td>Time</td>
<td>Time</td>
<td>Time</td>
<td>Time</td>
<td>Stay Apt</td>
<td>Stay Arrv</td>
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<tr>
<td>Min</td>
<td>-120</td>
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<td>0</td>
<td>0</td>
<td>14</td>
<td>7</td>
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<td>0</td>
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<td>0:30</td>
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<tr>
<td>Mean</td>
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<td>1</td>
<td>6</td>
<td>10</td>
<td>28</td>
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<td>4</td>
<td>9</td>
<td>1:20</td>
<td>2:34</td>
</tr>
<tr>
<td>Std Dev</td>
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<td>2.69</td>
<td>6.68</td>
<td>4.89</td>
<td>27.91</td>
<td>28.35</td>
<td>8.34</td>
<td>11.91</td>
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<td>0:22</td>
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<tr>
<td>Min</td>
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<td>-1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.19</td>
<td>0:34</td>
</tr>
<tr>
<td>Max</td>
<td>60.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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<td>0.00</td>
<td>0.08</td>
<td>0.22</td>
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<td>Std Dev</td>
<td>23.28</td>
<td>13.10</td>
<td>23.36</td>
<td>14.27</td>
<td>14.16</td>
<td>24.74</td>
<td>26.58</td>
<td>18.04</td>
<td>0.27</td>
<td>0.32</td>
</tr>
<tr>
<td>Mean</td>
<td>-23.67</td>
<td>17.67</td>
<td>29.00</td>
<td>27.00</td>
<td>26.50</td>
<td>55.50</td>
<td>79.25</td>
<td>39.50</td>
<td>4.00</td>
<td>2:18</td>
</tr>
<tr>
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<td>-5.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>33.00</td>
<td>15.00</td>
<td>25.00</td>
<td>3.00</td>
<td>2:04</td>
</tr>
<tr>
<td>Max</td>
<td>55.00</td>
<td>55.00</td>
<td>55.00</td>
<td>55.00</td>
<td>38.00</td>
<td>73.00</td>
<td>105.00</td>
<td>50.00</td>
<td>5.00</td>
<td>2:35</td>
</tr>
<tr>
<td>Std Dev</td>
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<td>28.75</td>
<td>31.17</td>
<td>24.76</td>
<td>17.79</td>
<td>18.69</td>
<td>18.61</td>
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<td>1.41</td>
<td>0:16</td>
</tr>
<tr>
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<td>-4.43</td>
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<td>21.00</td>
<td>20.00</td>
<td>11.00</td>
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<td>23.70</td>
<td>6.20</td>
<td>1:22</td>
</tr>
<tr>
<td>Max</td>
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<td>17.00</td>
<td>80.00</td>
<td>37.00</td>
<td>21.00</td>
<td>80.00</td>
<td>104.00</td>
<td>60.00</td>
<td>8.00</td>
<td>1:41</td>
</tr>
<tr>
<td>Std Dev</td>
<td>28.30</td>
<td>30.21</td>
<td>30.90</td>
<td>20.07</td>
<td>9.40</td>
<td>8.60</td>
<td>28.06</td>
<td>26.22</td>
<td>2.49</td>
<td>0:13</td>
</tr>
</tbody>
</table>

Table 2. Data Summary Compiled from Data Collection Sheets
The summary statistics in the table were compiled from the data collection sheets used during the analysis and were separated into overall, new patient and return visit summaries for each clinic. Further analysis of this data is provided in the figures on the following pages.

As can be seen in the following pie charts, the percentage of service time is greater than the percentage of wait time, however, this percentage should be increased at both clinics.

![% Service vs. % Wait - Briarwood](image)

**Figure 3. Percent Service vs. Percent Wait at Briarwood Clinic**

Although the results were better for the Briarwood Clinic than for the Taubman Clinic, improvements could be made to increase the percentage of service times further.

![% Service vs. % Wait - Taubman](image)

**Figure 4. Percent Service vs. Percent Wait at Taubman**

Note that the patient spends almost an equal time waiting to be seen in the clinic as they do actually being seen. These results are the reasons for both staff and patient dissatisfaction within the clinic.
3.3 Arrival Times

The following graphs show the results of the patients’ arrival times to both clinics. Surprisingly, the results for the two clinics showed that typically patients arrived early to their appointments. The results were different at Taubman, however, following a patient’s test appointment.

As shown in Figure 5. above, patients arrive earlier for their scheduled appointments at Briarwood than at Taubman. Note that these are arrival times to the clinic prior to a test procedure. This can be attributed to the fact that patients have found that they are able to be seen and finish their appointment earlier at Briarwood if they arrive to the clinic prior to their appointment time. Typically, if the physician is available when a patient arrives, he or she will be taken back and examined if possible. Another reason for the difference in the amount of time early for an appointment is that it is much easier to find parking at Briarwood than at Taubman. It is possible that a patient may arrive early for an appointment at Taubman, but have trouble parking and arrive late to the reception area.
The following figure shows the significant difference in patient arrival times following a test procedure at the Taubman Clinic. As testing was not determined to affect patient arrival times at Briarwood, the data is not included in the graph.

Figure 6. Minutes Early or Late to Pulmonary Clinic Following Testing

Figure 6. shows that patients at Taubman arrived to the clinic approximately 2.5 minutes late overall following a test procedure. It is interesting to note that the new patients arrived to the clinic approximately 17 minutes late following a test procedure, while the return visit patients arrived early to the clinic following testing. The complexity of new patient's testing and evaluation could be one reason for the significant difference in arrival times between new and return visit patients. Briarwood data is not represented in this figure because data was not collected for this aspect of the study.
3.4 Wait Times

The following graphs show the different wait time characteristics at both clinics. It is important to note that a wait times was defined as any time that a patient was not with a care provider or other staff member.

Figure 7. Wait Time in Waiting Room from Time of Appointment

Figure 7. shows that patients are required to wait longer in waiting rooms from the time of their appointment at Taubman than at Briarwood. Generally, the physician has more rooms available for use at Briarwood than at Taubman. During data collection, the physician used 5 rooms at Briarwood and 4 rooms at Taubman. The availability of exam rooms makes it possible for staff to take patients to an examination room more quickly. In addition, it is also possible for patients to miss hearing their name called by a staff member when it is time for their appointment. This is a particular problem at Taubman due to the fact that several clinics operate out of the same reception area. As such, it is very difficult for the staff to keep track of the patients that have missed their name being called.
Due to the number of patients arriving before their scheduled appointment time it was deemed necessary to also analyze the amount of waiting time from the patient's arrival time. As in the previous figure, waiting times are also shorter at Briarwood than at Taubman. This can also be attributed to the number of available exam rooms and the first come first served system which is currently being used in both clinics. As in the above, it is also possible for patients to miss hearing their name called by a staff member when it is time for their appointment.

Figure 9. Wait Time in Exam Room for M.D.

Figure 9. shows that patients wait longer in the exam room for the physician at Briarwood than at Taubman. This can be attributed to the fact that exam rooms are more readily
available at Briarwood and patients are typically placed in the exam rooms to wait rather than left in the waiting room.

![Diagram](Wait from Time of Arrival to First Encounter with M.D.)

**Figure 10.** Wait Time from Arrival to First Encounter with M.D.

At Taubman, patients spend more time in the clinic waiting to see the physician than do patients at Briarwood. This is important, as this is a factor that significantly affects the patients’ view of the clinic’s efficiency. The large wait between the time that the patient arrives in the clinic and sees the physician suggests a serious problem in the scheduling template.

![Diagram](Wait Time for a Test Procedure)

**Figure 11.** Wait Time for a Test Procedure

The amount of time that a patient waits for a test procedure such as a Spirometry or a Pulmonary Function Test is shown in Figure 11. During the study of the clinic, there was
no data collected on new patients needing tests at the time of their appointment at the Taubman Clinic which explains the value of zero. The large wait for the overall patient population at Taubman could be due to the congestion of the clinic and the lack of in-house testing as is available at Briarwood.

Figure 12. Wait Time for Check-Out

As shown in Figure 12., the wait time to check-out is significantly larger at Taubman than at Briarwood. This is due to the congestion at Taubman that arises from multiple clinics utilizing the same check-out area.
3.5 Service Times

The following graphs show the difference in both total service time and M.D. service time between the two clinics. Note that service time was defined as any time that the patient was with a care provider or staff member.

![Total Service Time Graph]

**Figure 13. Total Service Time**

Service time is longer at Taubman, especially for new patients, because it is necessary for the patients to visit other departments within Taubman to have various tests performed. At Briarwood, pulmonary function tests are done either in-house or before the time of appointment, and x-rays are done in a separate building. Since patients are required to leave the Pulmonary Clinic at Taubman and at Briarwood for these tests, data collection for the wait times and service times was not performed.
Total service time for the physician is higher at Taubman for the overall patient population and return visits. This could be related to the definition of a return visit patient at Taubman. At Taubman, patients are classified as return visits if they have visited the Pulmonary Clinic before, even if they have never been a patient of the physician who they are seeing. This increases the M.D. total service time, as the physician must then completely analyze the return visit patient’s chart as if the patient was a new patient due to their unfamiliarity with the patient’s medical history.

Figure 14. Total Service Time - M.D.
3.6 Length of Stay

The following graphs show the difference in length of stay at both clinics. The patient length of stay at both clinics was determined both from time of arrival and from time of appointment.

**Figure 15. Length of Stay from Time of Appointment**

There is a substantial difference in the length of stay from appointment time at the two clinics. The stay is much larger at Taubman. This is due to the large difference in testing procedures and the increased wait times at Taubman.

**Figure 16. Length of Stay from Time of Arrival**
The length of stay from time of arrival was analyzed to show how a patient’s early arrival to Briarwood affects the total time spent in the clinic. During the data collection period, it was noted that many patients at Briarwood arrived as much as 90 minutes early to their appointment and are typically in and out of the clinic more quickly than had they arrived at their scheduled time.

3.7 Percent Time Spent with Patients

The following graphs show the percent of time the physician spent with patients in each clinic for a four hour period.

![Figure 17. Percent Time Spent with Patients at Briarwood](image)

The percentage of time spent with new patients is lower. This can be attributed to the lower volume of new patients in the clinic.
The percent of physician time utilized by new patients is higher than that utilized by return visits. In actuality, the results are fairly close, illustrating the high number of patients classified as return visits, but requiring the same interaction as a new patient.

3.8 Room Utilization

The formula used for determining room utilization was as follows:

\[
\text{Room Utilization} = \frac{\text{(Average Service Time in Minutes) (Average Number of Visits per Day) }}{\text{(Minutes Clinic is in Operation) (Number of Rooms Available)}}
\]

Table 3. Room Utilization at Both Clinics

<table>
<thead>
<tr>
<th>Results</th>
<th>Briarwood</th>
<th>Taubman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Service Time</td>
<td>23.67</td>
<td>30.25</td>
</tr>
<tr>
<td>Average Number of Visits/Day</td>
<td>6.67</td>
<td>5.5</td>
</tr>
<tr>
<td>Minutes Clinic is in Operation</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>Number of Rooms Available</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Room Utilization</td>
<td>13.2%</td>
<td>17.3%</td>
</tr>
</tbody>
</table>

The percentages in Table 3. suggest that there are more rooms available than necessary for the volume of patients that are seen within the clinic.
3.9 Time Statistics by Appointment

The following graphs show the relationship between arrival times, wait times, total service times, M.D. service times and length of stay verses the appointment times within both clinics.

**Figure 19.** Appointment Time verses Arrival Time at the Briarwood Clinic

As can be seen from the above figure, the majority of patients are arriving earlier than their appointment time in almost every case. This is a positive finding, however, most of these patients are seen closer to their arrival time than to their appointment time suggesting a first come first served clinic practice.

**Figure 20.** Appointment Time verses Arrival Time at the Taubman Clinic

Although most patients are arriving early for their appointment at Taubman, once they are seen for testing, they return to the clinic late for their appointment. In addition, the
patients that arrive early at Taubman are seen on a first come first served basis, violating the current scheduling template.

As is apparent from the above graph, there appear to be two distributions of data; one in the early afternoon and one in the late afternoon. The wait times, total service times, and length of stay all increase during the early afternoon and late afternoon peaks. As such, this should indicate the need to alter the current scheduling practices to alleviate these peak wait times.

Figure 22. shows that there are two distributions for the total service times and for the M.D. service times.
The above figure shows a normal distribution of wait time, total service time, and length of stay, excluding the outlier at 3:05 pm. This shows that the average wait time, total service time and length of stay is greatest at the 1:25 pm appointment time.

The above graph illustrates the approximate normal distribution of the total service times and total M.D. service times at Taubman. This shows that the service times are greatest during the middle of the clinic and are less at the beginning and ending clinic times. The increase in service times in the middle of the clinic could be one of the factors relating to the increased wait times in the middle of the clinic. In addition, decreased service times at
the end of the clinic suggest a possible rush to get patients through the clinic by the end of
the day.

3.10 Current Scheduling Templates for Briarwood and Taubman

The following figures show both the current scheduling templates used at Briarwood and
at Taubman in addition to a proposed template. The actual templates were taken from
days during the study period of the clinic.

| Clinic Schedule for Dr. Charles Watts, M.D. - Briarwood Clinic |
|------------------|------------------|------------------|------------------|------------------|------------------|
| 1:00 PM          | RV               | NP              | NP              | RV              | NP/RV            |
| 1:20 PM          | RV               |                 |                 |                 |                  |
| 1:40 PM          | RV               |                 |                 |                 |                  |
| 2:00 PM          | RV               | NP              | NP              | NP              |                  |
| 2:20 PM          | RV               |                 |                 |                 |                  |
| 2:40 PM          | RV               |                 |                 | RV              | NP               |
| 3:00 PM          | RV               | NP              | RV              | RV              | NP               |
| 3:20 PM          | RV               | RV              | RV              | RV              | RV               |
| 3:40 PM          | RV               | RV              | RV              | RV              |                  |
| 4:00 PM          | RV               | RV              | RV              | RV              |                  |
| 4:20 PM          | RV               |                 |                 | RV              |                  |

Figure 25. Current Briarwood Scheduling Template

As can be seen in the Briarwood scheduling template, the physician is able to see many
more patients at Briarwood than at Taubman in the same amount of time. This can be
attributed to the efficient testing practices at Briarwood. At this facility the physician is
able to send people to have a spirometry and receive the test results quickly. In addition,
the layout of the clinic allows the physician to move quickly between exam rooms in an
effort to see several patients concurrently. One problem, however with this template, is
that there is an extreme variance in scheduling from day to day. In addition, the number of
new patients and return visit patients varies from day to day as well. Additionally, it is
shown that new patients are sometimes scheduled for only a twenty minute block of time
and are also occasionally scheduled at the same time that a return visit patient is
scheduled.
Clinic Schedule for Dr. Charles Watts, M.D. - Taubman Center

<table>
<thead>
<tr>
<th>Time</th>
<th>Feb. 14</th>
<th>Feb. 21</th>
<th>Feb. 28</th>
<th>March 7</th>
<th>March 21</th>
<th>March 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:00 PM</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>RV</td>
<td>RV</td>
<td></td>
</tr>
<tr>
<td>1:20 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:40 PM</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
<tr>
<td>2:00 PM</td>
<td>NP</td>
<td>RV</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td></td>
</tr>
<tr>
<td>2:20 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2:40 PM</td>
<td>RV</td>
<td></td>
<td></td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
<tr>
<td>3:00 PM</td>
<td>NP</td>
<td>NP</td>
<td>RV</td>
<td>NP</td>
<td>NP</td>
<td></td>
</tr>
<tr>
<td>3:20 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:40 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:00 PM</td>
<td>NP</td>
<td></td>
<td></td>
<td>RV</td>
<td>RV</td>
<td></td>
</tr>
<tr>
<td>4:20 PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 26. Current Taubman Scheduling Template

The low patient volume shown in the above scheduling template is of concern as it results in low physician utilization. Currently the majority of new patients are scheduled at 1:00, 2:00 and 3:00 pm. It is interesting to note that the largest wait and service times occur between 2:00 and 3:00 pm at Taubman. As shown above, from 1:45 to 2:45 pm, there is a solid block of patients scheduled. This scheduling template does not allow for any extra time for the physician to catch up or to review new patient’s charts.

In an effort to eliminate some of the scheduling problems shown in the above templates, the following figure illustrates possible scheduling alternatives, in addition to the physician utilization for each method suggested.

<table>
<thead>
<tr>
<th>Appt. Time</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
<th>Method 4</th>
<th>Method 5</th>
<th>Method 6</th>
<th>Method 7</th>
<th>Method 8</th>
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</thead>
<tbody>
<tr>
<td>13:00</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
<tr>
<td>13:20</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>14:00</td>
<td></td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
<tr>
<td>14:20</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
<tr>
<td>15:00</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
<td>NP</td>
</tr>
<tr>
<td>15:20</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16:00</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
<td>RV</td>
</tr>
<tr>
<td>16:20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.D. Utilization</td>
<td>52%</td>
<td>62%</td>
<td>69%</td>
<td>79%</td>
<td>89%</td>
<td>66%</td>
<td>75%</td>
<td>85%</td>
</tr>
</tbody>
</table>

Figure 27. Proposed Templates with M.D. Utilization Times
As was stated earlier in the report, new patients arrive an average of 17 minutes late to the Pulmonary Clinic at Taubman following a test procedure. In addition, there has historically been a problem with having tests read from noon to 1 pm (the start time of the Pulmonary Clinic). As such, the above templates show return visit patients scheduled for the beginning time slots of the clinic. The reasoning behind this is that the probability of a return visit patient needing a test (.57) is less than the probability of a new patient needing a test (.75) and should therefore minimize the number of patients who are late to appointments scheduled at 1 pm. Note that having late patients at 1 pm tends to make the rest of the clinic fall behind. Wherever possible, a twenty minute time block was left open in front of a new patient visit to allow the physician to catch up if the clinic is running behind or to review the new patient’s chart.

The physician utilization times ranged from 52% (2 NP, 4 RV) to 89% (3 NP, 6 RV). As the current number of patients seen per clinic is 6.7 at Briarwood and 5.5 at Taubman. These patient mixes were determined to be accurate representatives of patient volumes that the clinics could accommodate during the operating time of four hours.

3.11 Simulation Description

In order to assist in recommending new scheduling templates, a simulation was performed using the GPSS/H simulation software package. The clinic flow was modeled with a varied number of rooms, new patients and return visit patients. The clinic was also modeled with different variations of service and wait times. In order to run the simulation it was assumed that all service and wait times were normally distributed. This was determined to be a valid assumption because patients are scheduled at certain times throughout the day providing a more deterministic process than that of a process with random arrival times such as an emergency room. Inaccuracies in the simulation model were attributed to the relatively small sample sizes which lead to high variability within the data. The clinic model was simulated for four hours of operation per day over a ten day period to reflect the period in which data was collected. In addition, the simulation model was initially run assuming that four rooms were available for the physician, which was the maximum number of rooms currently available at Taubman. When the number of rooms was decreased to three there was no change in the simulation output, therefore, three rooms were used for the remainder of the simulation models. The tables which follow summarize the simulation output for the two clinics under different circumstances.

Table 4. Results of Simulation Model for Taubman

<table>
<thead>
<tr>
<th>SIMULATION RESULTS FOR TAUBMAN CLINIC</th>
<th>11 Patients Current Service and Wait Times</th>
<th>3 NP, 6 RV Current Service and Wait Times</th>
<th>3 NP, 4 RV Current Service and Wait Times</th>
<th>2 NP, 4 RV Current Service and Wait Times</th>
<th>2 NP, 5 RV Current Service Times, WaitTime = 10+5</th>
<th>2 NP, 4 RV Current Service Times, WaitTime = 10+5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician Utilization</td>
<td>73%</td>
<td>73%</td>
<td>67%</td>
<td>66%</td>
<td>71%</td>
<td>67%</td>
</tr>
<tr>
<td>Room Utilization</td>
<td>85%</td>
<td>72%</td>
<td>62%</td>
<td>57%</td>
<td>62%</td>
<td>49%</td>
</tr>
<tr>
<td>Mean NP Throughput</td>
<td>N/A</td>
<td>1.9</td>
<td>1.3</td>
<td>1.5</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Mean RV Throughput</td>
<td>N/A</td>
<td>3.9</td>
<td>2.3</td>
<td>2.7</td>
<td>3.1</td>
<td>3.4</td>
</tr>
<tr>
<td>Mean Total Throughput</td>
<td>5.3</td>
<td>5.8</td>
<td>3.6</td>
<td>4.2</td>
<td>4.9</td>
<td>5.4</td>
</tr>
</tbody>
</table>
Table 5. Results of Simulation Model for Briarwood

<table>
<thead>
<tr>
<th>SIMULATION RESULTS FOR BRIARWOOD CLINIC</th>
<th>11 Patients Current Service and Wait Times</th>
<th>3 NP, 6 RV Current Service and Wait Times</th>
<th>3 NP, 4 RV Current Service and Wait Times</th>
<th>2 NP, 4 RV Current Service and Wait Times</th>
<th>2 NP, 5 RV Current Service Times, Wait Time = 10+/5</th>
<th>2 NP, 4 RV Current Service Time = 22/40+/5, Wait Time = 10+/5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physician Utilization</td>
<td>80%</td>
<td>79%</td>
<td>75%</td>
<td>72%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Room Utilization</td>
<td>73%</td>
<td>76%</td>
<td>62%</td>
<td>45%</td>
<td>61%</td>
<td>44%</td>
</tr>
<tr>
<td>Mean NP Throughput</td>
<td>N/A</td>
<td>1.7</td>
<td>2.0</td>
<td>3.1</td>
<td>3.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Mean RV Throughput</td>
<td>N/A</td>
<td>3.2</td>
<td>2.2</td>
<td>1.6</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Mean Total Throughput</td>
<td>6.2</td>
<td>4.9</td>
<td>4.2</td>
<td>5.1</td>
<td>5.4</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Initially, the model was run with a maximum of eleven patients with no restraint on the type of patient using the current wait and service times determined by the data analysis. This number of patients was chosen to model a scenario in which all but one of the twelve available patient slots were filled. The results for this run are shown in the first column of the above tables. It is interesting to note that only half of the scheduled patients are able to leave the clinic during the allotted time. In both clinics the physician is utilized between 70 and 80 percent which is surprisingly low due to the heavy patient load which was scheduled. Upon analysis of data collected it was determined that no more than three new patients were seen per clinic during the course of the study. Therefore, the model was run using the scenario of three new patients and six return visits which resulted in nearly the same physician utilization as the first model, but lower total throughput. The decrease in total patient throughput results from forcing the model to schedule three new patients rather than randomly schedule the type of patient as was done in the previous run. Next, the clinic was simulated with three new patients and four return visits. This simulation resulted in substantially lower throughput and physician utilization. This result was not expected and was attributed to the extreme variation in the data. Next, the number of new patients was reduced to two. When the model was run with two new patients and four return visits physician utilization decreased, but total patient throughput increased. In an effort to increase physician utilization, the number of return visits was increased to five while continuing to schedule two new patients into the model. As expected physician utilization increased, as did total patient throughput.

The clinics were also modeled with varied wait and service times. Assuming that physician service time does not change, the model was run using current service times and wait times of five to fifteen minutes in the waiting room and in the exam room. These wait times were determined as a reasonable amount of time that a patient would expect to wait while at their appointment. This model resulted in little change in physician utilization while increasing the amount of throughput. Although throughput had increased, the total number of patients entering the system were not able to exit before the allotted four hours had passed. To remedy this problem the service time for the physician was changed to twenty plus or minus five minutes for return visits and forty plus or minus five minutes for new patients. These times are the values which are currently allotted per patient during scheduling. This change in the model resulted in minimal change in patient throughput and physician utilization. It was determined that not all patients could exit the system before the allotted four hour due to the variation in testing, wait and service times.
and the chance that patients may need to see the physician more than one time during a stay at the clinic.

Using current wait and service times determined from the data analysis, it was concluded that scheduling three new patients and six return visit patients maximized patient throughput and physician utilization. This schedule also allows for two twenty minute blocks of physician time to review patient information or to account for lateness due to variation in service and wait times.
4.0 Recommendations

In order to achieve the goals of the patient flow analysis in both the Briarwood and Taubman Clinics, the following recommendations have been made:

- Define return visits as patients seen previously by the attending physician.
- Stress the importance of early arrival when test procedures are necessary.
- Study further the patient arrival times to the clinic (Taubman) following a test procedure.
- Eliminate first come first served scheduling practices to follow scheduling template.
- Schedule return visit appointments at 1:00 pm (start time of clinic) to reduce the probability of a late appointment at this time.
- Allot time in the middle of the clinic for the physician to catch up.
- Determine reason for higher percentage of cancellations at Taubman than at Briarwood.
- Eliminate variability in patient type scheduling at Briarwood and at Taubman.

Currently when a patient schedules an appointment at Taubman, their classification as a return visit patient is based on whether or not they have been previously seen in the clinic. This results in patients being scheduled for an incorrect amount of time as they must be treated as a new patient by the physician. This should be changed so that a return visit patient is defined as a patient who has previously been seen by the physician.

As was shown in the data analysis, patients who require testing at Taubman arrive late to the clinic following their test appointment. It is important to note that the majority of these patients arrived to the Pulmonary Clinic 30 - 40 minutes early prior to their test appointment but were late for their appointment following the test procedures. It is recommended that the patient arrive even earlier to begin their test appointment. In addition, it is recommended that the patient’s test appointment be scheduled at a time 50 - 60 minutes before their appointment in the Pulmonary Clinic.

In order to accurately determine the above, our study concluded that a further analysis of patient arrival times before and after their test should be completed. In addition, wait times in the test department should be determined. This analysis should determine if performing the test procedures in a separate department is a bottleneck in the Pulmonary Clinic’s operations.

Eliminate the first come - first served scheduling techniques. Set specific arrival times for patients and ask that they do not arrive early in expectation of being treated early. The first come - first served technique works against the scheduling template and reduces the probability that all patients will be seen on time.

Currently the scheduling of new patients at Taubman occurs at 1:00, 2:00 and 3:00 pm. The data shows that the longest wait times occur around 2:00 pm and that typically the
Clinic appointment slots are all filled from 1:00 to 2:00 pm. It is recommended that return visit patients be scheduled in the 1:00 pm times slots to allow new patients scheduled at 1:20 pm extra time to finish their test appointment. Return visit patients should have some idea of wait times and constraints (parking availability) at Taubman and have a lower probability of needing a test. As such, they should have a higher probability of arriving to the Pulmonary Clinic on time. Additionally, it is recommended that the 20 minute time slot be left open before a new patient to be used for physician catch up time or to review the upcoming new patient's chart. It is also recommended that new patients not be scheduled at the end of the clinic as the likelihood that they may need further testing and a second visit with the physician is greater than that of a return visit patient.

Because of the high percentage of cancellations at Taubman, further research should be done to determine the cause. The reason for the difference in percent of cancellations at the two clinics may be due to the sample of data used to calculate these percentages, or due to the fact that patients are being seen elsewhere. This matter should be investigated in an effort to reduce the number of cancellations.

The extreme variation in scheduling from day to day at Briarwood, should be eliminated by determining a set number of new and return visit patients within the clinic. Using the simulation analysis set at current wait and service times, it is recommended that three new patients and six return visit patients be scheduled during each clinic to maximize physician utilization. Using the Excel spreadsheet application and determining an analysis of scheduling using cancellation rates, probable patient mix and M.D. service time, it is recommended that three new and six return visit patients be scheduled to maximize physician utilization.

Using the results of the simulation analysis for Taubman, it is recommended that three new and six return patients be scheduled to maximize physician utilization. This result was the same again using the analysis of scheduling using cancellation rates, probable patient mix and M.D. service time.

Possible Observed Recommendations:

- Increase parking at Taubman Clinic.
- Make Pulmonary Clinic self-sufficient by moving the test procedures and equipment into the clinic.
5.0 Appendix
Signed Proposal
March 31, 1995

Dr. Watts,

Please find the enclosed project proposal that we have been following during the analysis of your clinics at both the Taubman and Briarwood Clinics. It is required that your signature be on the proposal prior to our presentation of our findings at the end of the semester. As such, we would greatly appreciate it if you could read over and sign the enclosed proposal for us to pick up sometime next week. In addition, we would like to schedule a time that we could present our project and recommendations to you. Please let us know when you would be available to do this. We will finalize our project for presentation to the class on April 17th. As such, we would like to give our presentation to you, Tatiana Baily and Dr. Galen Toews sometime during the week of April 17th or the week of April 24th. Feel free to contact one of us or Liz Othman with your availability.

Thank you again for your cooperation and support of our project.

Sincerely,

Laura A. Drake, Robert Fry and Sara Naylor

Phone Numbers:

Liz Othman: 936-2469
Laura Drake: 668-2807
Project Proposal

Patient Flow Analysis
Pulmonary Clinic - University of Michigan Hospitals
Dr. Galen Toews, M.D., Director
Dr. Charles Watts, M.D., Staff Physician

Laura Drake
Robert Fry
Sara Naylor

IOE 481
March 31, 1995
patient's visit. This sheet will be used to calculate the mean service and wait times in addition to the bottlenecks within the clinic and will be completed by each provider from check-in to check-out.

3. The impact of other clinics on the efficiency of the Pulmonary Clinic will also be taken into consideration (Radiology, Pulmonary Function Lab and the Blood Drawing Station).

4. Once a problem is determined, the appropriate resources will be evaluated and suggestions for improvement will be made.

Proposed Approach:

The project will be evaluated using the following approach:

1. Initial consultation with clients and coordinator to determine the focus of the project and the expected outcomes.

2. Observe both clinics to determine patient flow and develop flow chart.

3. Interview clients and clinic staff to determine their views of the clinic and its operations. In addition, the interviews will be used to determine some of the suggestions for improvement within the clinic.

4. Collect data from each clinic and analyze using the Excel spreadsheet application.

5. Analyze data to determine mean patient flow time, wait times and bottlenecks within the clinic.

6. Summarize data for presentation, including suggestions for improvement for the clinic.

Expected Impact and Outcomes:

Service/Organization Changes: Expect to make suggestions to improve patient flow throughout the clinics. Expect to maximize patient/doctor contact while minimizing patient wait time.

Quality Changes: Expect to make suggestions to improve the efficiency of the clinic to enhance patients' visits to the clinic. Expect to shorten patients' visits and improve the scheduling problems. These will also help to improve doctors' jobs within the clinic. Expect to make suggestions to improve staffing levels of clinics.

Cost Reductions: Any rework will be identified.
System Changes: May impact current methods of scheduling patients.

Facility and Equipment Changes: Use examination rooms for patient/doctor visitation rather than as a waiting room for patients.

**Project Team and Experience**

In an effort to develop solutions for these problems, the following people will be involved:

**Clients:**
- Galen Toews, M.D.
  Division Head, Pulmonary Medicine
  University of Michigan Hospitals
- Charles Watts, M.D.
  Staff Physician, Pulmonary Medicine
  University of Michigan Hospitals

**Dept. Director:**
- Tatiana Baily
  Division Administrator, Pulmonary Clinic
  University of Michigan Hospitals

**Project Coordinator:**
- Elizabeth Othman
  Senior Clinical Systems Analyst
  University of Michigan Hospitals

**Project Staff:**
- Laura Drake
- Robert Fry
- Sara Naylor
- IOE 481 Students, University of Michigan

**Support Required from Operating Entities**

Assistance for the project will be generated from the doctors, nurses, desk clerks and administrators within the clinic. Support will be provided in the following manner:

1. Physicians and staff will be asked to fill out the data form that is attached to each patient’s chart.

2. Interviews will be conducted by the project staff to further determine physicians’ and clinical staff problems within the clinics and their suggestions for improvement.

Data collection will be analyzed using the Excel spreadsheet application.
Schedule

Weekly Meetings with Coordinator Begin

January 30, 1995 - Project Proposal Outline Due

Meetings with Client Begin

February 6, 1995 - Project Proposal Due

Week of February 6, 1995 - Begin Data Collection at Both Clinics

March 6, 1995 - Interim Report and Presentation Due

Beginning of April - Finish Data Collection

April 16, 1995 - Final Report and Presentation Due

Project Proposal Signatures

Dr. Charles Watts, M.D.

Liz Othman, Coordinator

Laura Drake, Student Engineer

Robert Fry, Student Engineer

Sara Naylor, Student Engineer
Data Collected for Analysis
## Overall Summary of Taumuit Clinics

<table>
<thead>
<tr>
<th>Date</th>
<th>Class</th>
<th>Name</th>
<th>Status</th>
<th>Start Time</th>
<th>End Time</th>
<th>Original</th>
<th>Mins</th>
<th>Actual</th>
<th>Mins</th>
<th>Patient</th>
<th>Mins</th>
<th>Start Room</th>
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<th>End Room</th>
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<th>Total</th>
<th>Mins</th>
<th>Time</th>
<th>Mins</th>
<th>NO Service</th>
<th>Length of</th>
<th>Length of</th>
<th>Field Service Time per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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**Notes:**
- Class: [Class Code]
- No Service: [Number of No Services]

**Legend:**
- Time: [Time Duration]
- Length of: [Length of Time]
- Field Service Time per Day: [Field Service Time per Day]

---

*Page 1*
Data Collection Sheet
Pulmonary Clinic Patient Flow Data Sheet

Please fill out the following upon patient’s arrival to the clinic:

1. Time of Patient's Appointment in Pulmonary Medicine: __________

2. Patient Type:   NP   RV

Questions 3 and 4 for Taubman Clinic Use Only

3. Was the patient seen today for testing prior to their appointment in the Pulmonary Clinic?   Y   N

4. If yes, what time was their test appointment scheduled for?
   Time: __________

*Dept:

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<th>Provider Type</th>
<th>Activity Performed During Encounter</th>
<th>Start Time of Encounter</th>
<th>End Time of Encounter</th>
<th>Comments</th>
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<td>Check-Out</td>
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</tbody>
</table>

* Definition of Encounter: Any face to face meeting between provider and patient. A physical separation of 2 or more minutes is another encounter.