Evaluation of Medical Procedures Unit Scheduling
Final Report

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Executive Summary

Introduction

The Medical Procedures Unit (MPU) in the University of Michigan Hospital is experiencing delays in their flow of patients. It is a very active unit that consists of 9 prep bays, 9 procedure rooms, and 11 recovery bays. Therefore, managers of the MPU have asked us to analyze the flow of patients in the unit and to make recommendations to optimize patient flow based on our findings. To improve the operations of the MPU, this project focuses on patient arrival, patient preparation, procedure times, and scheduling.

The scope of our goals and objectives is unchanged from the beginning of our project. The following goals are associated with this project:

- Analyze patient flow process
- Identify causes of imperfect patient flow
- Provide recommendations to increase patient flow
- Minimize patient waiting time
- Maximize physician and prep room utilization

Several methods were taken throughout this project in order to arrive at our conclusions and recommendations. Initially, we conducted a literature search on previous MPU projects, followed by interviews with the current MPU staff in order to gain an understanding of the scope of this project. Our analysis focused on the collection of prep room patient flow information along with data log sheets from individual procedure rooms, followed by entering all of these times into Microsoft Excel spreadsheets. Finally, our conclusions and recommendations were drawn from a variety of findings that were analyzed using Excel.

Findings and Conclusions

After carefully analyzing the current situation in the MPU, we have identified several potential causes of delay.

Arrival time
From a sample of 268 patients, 92% show up on time or early for their appointment. Also, on average, patients show up 29 minutes before their scheduled appointment time. This is not a significant source of delay.

Prep time
The analysis conducted on mean prep time of patients by our analysis team resulted in an average of 23 minutes. This shows that the schedule allows sufficient time for patients to be prepped and this is not a cause of patient delays.
Procedure time
Analysis of procedure times showed that scheduled procedure times correlated with average actual procedure times. There are exceptions, described later in the report, where physicians take longer for procedures than they are scheduled for which makes for delays.

Prep bay assignment
One source of delay in the MPU is the random assignment of prep bays. They are not given on the basis of the next available procedure room, but rather based on appointment time. For example, if procedure room A is running on time, and room B is running late, patients scheduled to enter room B may be waiting in prep bays for a significant amount of time while a patient scheduled for room A must wait in the waiting room.

Overlapping appointments
Analysis of Enterprise Wide Schedule system (EWS) shows another source of delays: overlapping appointments. For example, on several occasions, 45-minute procedures were only given 30 minutes of procedure time. This is an almost guaranteed source of delay.

Appointment time distribution
Finally, based on appointment time analysis, there are more procedures being scheduled in the mornings for the MPU than the afternoon. As a result, morning delays are carrying over into the afternoon, where they finally diminish before the MPU closes.

Room changeover time
Procedure room logs have shown that between any 2 procedures there is an unavoidable downtime averaging roughly 8 minutes. This time is not accounted for in the EWS system.

Recommendations
The following recommendations were made based on our analysis and findings in the MPU.

- **Assign 1 prep bay per procedure room**
  - Assigning 1 prep bay per procedure room will help organize patients and create "pull" systems from each procedure room to its prep bay. Patients will only enter prep when they are due next in a procedure room, greatly reducing post-prep wait times.

- **Account for changeover time in room scheduling**
  - Scheduling 15 minutes of changeover time for every 2 procedures would greatly increase scheduling accuracy.

- **Do not allow double-booking of a procedure room**
  - Double-booking is a source of unavoidable delay. Eliminating the possibility of this in EWS is important for accurate scheduling.
• **Schedule more procedures for the afternoon**
  o Instead of delays originating in mornings and diminishing in afternoons, employing even and accurate scheduling throughout the day will reduce wait times.

• **Create another project analysis team for the MPU staffing levels**
  o Further analysis needs to be done on the efficiency of nurse staffing, concentrating on morning (high volume) hours.
Introduction

The Medical Procedures Unit (MPU) is a department of the University of Michigan Hospitals and Health Centers. The unit serves approximately 70 patients daily who require a variety of medical procedures.

The University of Michigan Hospital has requested a project team to look into the bottleneck problems that are occurring in the MPU. The project analysis team of Sohan Kota, Matt Hartley, Jason Harris, and Martin Jajow were given the task of determining what exactly is causing the delays in the patient flow of MPU.

Purpose of the Project

The purpose of this project is to analyze patient flow through the MPU in order to identify the cause of the backup and provide recommendations to optimize patient flow. The purpose of this report is to provide the findings of our study and present possible recommendations to help optimize the MPU concerning:

- Time variation between scheduled procedure times and actual procedure times
- Delays in procedure rooms, specifically the amount of prep bays scheduled to a specific procedure room
- Time variation between physicians performing similar procedures

Background

The MPU consists of 9 prep bays, 9 procedure rooms, and 11 recovery bays and is operational Monday-Friday from 7:00 A.M. to 7:00 P.M and Saturday from 7:00 A.M. until 5:30 P.M.

Patient procedures are currently scheduled using a system called EWS (Enterprise Wide Scheduling). EWS schedules time in 15-minute blocks, with 30-minutes allocated to nurse prep time and from 30 to 90 minutes scheduled for a procedure, depending on the type of procedure and the physician performing it.

Upon arrival to the MPU, each patient checks in and waits for an available prep bay. When a prep bay becomes free, the patient is taken back to prep where a nurse prepares the patient for the procedure. If a procedure room is open, the patient is moved to the procedure room and the physician performs the scheduled procedure. If all procedures rooms are occupied, the patient waits in the prep room for their specific procedure room to become available. Once the procedure is complete, the patient is taken to a recovery room and, after waiting the required amount of time, leaves the MPU.
The MPU utilizes the Enterprise Wide Scheduling System (EWS) owned by the UMHHC. Each of the nine procedure rooms is independently scheduled based on the physician resource assigned to a given room. Time allocations are pre-determined depending on the type of procedure and the physician performing it. On most days, the physicians from Medicine Gastroenterology (MGI) are allowed to schedule into two rooms simultaneously. In addition, over booking of appointments is a common practice. Over booking is based on the individual physician resource. Consideration for the overall flow of the unit is usually not part of the decision making. In return, more patients are often scheduled for arrival at one time than the nurse and prep room resources can accommodate. Even without over booking, the first cases are all scheduled to arrive at the same time.

**Approach and Methodology**

The following gives a detailed outline of the approach that we took throughout the whole project:

*Literature Search*

Our literature search led to the discovery of 2 previous reports that were relevant to our study. They included a report on prep room utilization, and one report on physician variation.

*Nurse and EWS Scheduler Interviews*

The interviews with the MPU nurses told us the possible reasons why backups occur in the prep bays. Also, by talking with the EWS Scheduler we were able to receive logs of how long procedures are scheduled for each physician.

*Prep Room Data Collection*

A data collection tool was developed to track patient flow within the MPU (mainly the flow through the prep bays). It is attached as Appendix A. Appendix B includes the procedure in we conducted our time studies.

*Collection of Procedure Room Logs*

We received specific procedure room logs from our client that coincide with the data we collected from the prep bays. These logs gave the times when the procedure started and finished along with the physician who performed the procedure and the type of procedure itself. We then matched this EWS information with our time study data to get each observed patient's complete timeline from arriving to the MPU to entering the recovery room.

*Data Input and Analysis*

Once the data was collected it was compiled, entered into Microsoft Excel and organized appropriately. Once in Excel, the data was analyzed and arranged into tables, graphs, and charts in order to best understand the findings.
Hypotheses Considered

Going into the project, we had a few ideas as to why the MPU was experiencing delays:

- Patients were arriving late, leaving little or no time for prep before procedures were due to start
- Patients were not being prepped within the scheduled time
- Procedures were not being scheduled accurately, specifically double-booking or inaccurate procedure times

Findings, Conclusions and Recommendations

Our analysis of the MPU’s scheduling system centered on four main areas: patient arrival time, prep time, procedure time and scheduling.

Patient Arrival Time
Patients are scheduled to arrive 30 minutes before their procedure time to account for preparation time. When they arrive in the MPU, they check in, which takes approximately 2 minutes, then wait to be taken back to a prep bay. If patients arrive late this puts a strain on the patient’s prep and procedure resources. To ascertain the role patient arrival time plays in causing delay in the MPU, we created a distribution of patient arrival times.

![Figure 1: Patient Arrival Times](image)
Our analysis shows that 84% of patients arrive before their scheduled appointment time and that on average patients arrive to the MPU 29 minutes earlier than necessary. Due to the low percentage of patients that arrive late, we concluded that patient arrival time is not causing serious delay in the MPU.

**Recommendations:** None

**Preparation Time**
The MPU schedules 30 minutes per patient for preparation time regardless of the procedure being performed. Once patients are taken to their prep bay, they are asked to change into scrubs. A nurse then comes around, asks necessary health related questions, and threads an IV. The patient waits in prep until their procedure room is available. Due to the value of procedure room and physician resources, it is paramount that if a procedure room is open there is a patient prepped and ready to enter it. The following figure analyzes the average amount of time spent from entering prep to completing prep per patient.

![Time Entered Prep - Time Prep Finishes](image)

**Figure 2: Prep Times**
The data shows that the average amount of time patients are in the prep bays is 23 minutes, well below the scheduled time. We can conclude that prep time is not a key cause of delay in the MPU.

*Recommendations: None*

**Procedure Time**
Depending on the physician and the procedure, different durations are used to schedule patients. To verify the correctness of these times we measured the average difference between the scheduled procedure time and the actual procedure time.

Our analysis of procedure times indicates that on average, physicians are completing procedures in the allotted time or faster. However, only 60% of colonoscopies and 70% of EGDs are being completed on time. This means that a significant amount of procedures are going over their scheduled time, and the resulting delays are not necessarily relieved when another procedure is completed in less than the allotted time. Appendix E contains histograms regarding the completion times of each type of procedure.

Also, while the majority of physicians are using accurate procedure durations, some physicians use times that do not reflect their average procedure times and this causes a backlog of patients. Appendix D contains detailed information about physicians and procedure times.

**Table 1: Procedure Times by Procedure**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Scheduled</th>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
<th>Sample Size</th>
<th>% On time</th>
<th>75% time</th>
<th>90% time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronchoscopy</td>
<td>0:45</td>
<td>0:44</td>
<td>0:45</td>
<td>0:11</td>
<td>22</td>
<td>50%</td>
<td>0:55</td>
<td>1:10</td>
</tr>
<tr>
<td>Colonoscopy</td>
<td>0:45</td>
<td>0:43</td>
<td>0:41</td>
<td>0:14</td>
<td>259</td>
<td>60%</td>
<td>0:55</td>
<td>1:10</td>
</tr>
<tr>
<td>EGD</td>
<td>0:41</td>
<td>0:36</td>
<td>0:34</td>
<td>0:14</td>
<td>131</td>
<td>70%</td>
<td>0:45</td>
<td>1:00</td>
</tr>
<tr>
<td>EGD/Colon</td>
<td>1:15</td>
<td>0:58</td>
<td>0:53</td>
<td>0:17</td>
<td>8</td>
<td>62%</td>
<td>1:25</td>
<td>1:40</td>
</tr>
<tr>
<td>ERCP</td>
<td>1:16</td>
<td>0:57</td>
<td>1:00</td>
<td>0:19</td>
<td>16</td>
<td>76%</td>
<td>1:15</td>
<td>1:30</td>
</tr>
<tr>
<td>Liver Biopsy</td>
<td>0:30</td>
<td>0:26</td>
<td>0:27</td>
<td>0:08</td>
<td>12</td>
<td>81%</td>
<td>0:30</td>
<td>0:35</td>
</tr>
</tbody>
</table>

Another key cause of delay is that between consecutive processes there is an unavoidable downtime averaging 8 minutes and 9 seconds. Therefore, even when physicians are completing their procedures in the scheduled time, this room turnover delay causes subsequent procedures to start late.
Recommendations:
- First, a certain confidence interval should be chosen for on-time completions. Durations for 75% and 90% levels are shown above in Table 1. Using either of these levels in order to determine scheduled times would help reduce the amount of procedures that go over their scheduled time and cause delays. However, if the level is too high, scheduled procedure durations could be too long and cause physician downtime or reduced patient throughput. Choosing the correct level will result in accurate scheduling without causing physician downtime.
- Each of these procedure durations must be calculated for individual physicians, due to their variance among average times. This will greatly improve scheduling accuracy, but will involve a large amount of data collection over the period of at least 2 months.
- Room changeover time must be added in to each of these calculated procedure times. Because EWS is limited to 15-minute increments, we recommend 15 minutes to be added for every 2 procedures to account for room turnover. Again, this is important for scheduling accuracy.

Scheduling
The final potential cause of delay in the MPU is from the scheduling of appointments. EWS allows patients to be scheduled on top of other patients, leaving the physician with guaranteed delay. For example, even if a 45-minute procedure was scheduled for 8:00, the next procedure can be scheduled at 8:30 for the same room and physician. The effects of this delay can be seen in Figure 4. The physician’s first procedure is delayed...
by roughly 15 minutes, but the double-booking that occurs with procedures B and C then increases this delay to more than 1 hour.

Figure 4: Sample Room Schedule

The distribution of appointments by time of day is shown in Figure 5. There are many more procedures being scheduled for the morning than the afternoon. This is one of the main reasons that delays occur in the mornings and carry through to the afternoon. There is simply no way that this amount of procedures can be carried out in the morning.

Figure 5: Distribution of Appointment Times

Figure 6 confirms that due to the front loading of patients in the morning, delays are being transferred to the afternoons, when there are less procedures scheduled. The data above shows that patient delays in the afternoon, on average, are longer than those in the morning. This occurs because some morning procedures are completed on time, while other morning procedures are completed late. This results in a lower average delay than
the afternoon appointments, when almost all procedures are late due to the delays that are carried over from the mornings.

**Figure 6: Average by Appointment Time**

**Recommendations:**
- Do not allow double-booking of procedure rooms. Currently, a warning is shown on the computer screen in EWS when a room is double-booked. However, this warning can be overridden. Since double-booking is a guaranteed source of delay, it should not be allowed at any time.
- Schedule more procedures for the afternoon. With the increased accuracy of procedure times and elimination of double-booking, fewer procedures will be scheduled for the mornings. But with no delays being carried over, it will not be necessary to have so few procedures scheduled for the afternoon. Evening out the schedule as such may not cause the total amount of scheduled procedures to go up. Yet, patient wait times should be significantly reduced because no morning procedures will have to wait until the afternoon to be completed.

**Prep Bay Allocation**
Our final source of delay was something confirmed by observation, not data. At times, multiple patients are in prep who are scheduled for the same procedure room. Since procedure times are very rarely shorter than prep times, there is no reason for this to occur. When it does occur, it can cause problems with prep room availability for the
other procedure rooms. The current situation is represented in Figure 7 below. Also of note is that Patient A2 in Figure 7 will have to wait in the prep bay until Patient A1 is out of the procedure room. This is undesirable for both the MPU and for the patient.

Recommendations:

- Assign 1 prep bay per procedure room. Each prep bay should have a schedule with the same patients as its associated procedure room. Doing so will not only improve organization, but it will also make the process a "pull system," whereby patients only enter prep when they are due to enter the procedure room soon (as soon as the current procedure is finished). This should not cause downtime for physicians because prep times are significantly shorter than procedure times. Also, it will ensure that all 9 prep bay/procedure room combinations exist separately from one another, so delays in one room cannot cause delays in another.

- For the certain times of the day when prep bays are required for procedures, the extra prep bay adjacent to the waiting room can replace the prep bay which is occupied by the procedure.

- Do not schedule more than 5 procedures to start at any one time. This is a scheduling recommendation that is necessary when assigning one prep bay to each procedure room. Because prep for each patient will only be completed shortly before the patient is due to enter the procedure room, it is important that nurses be available at the exact time that a patient is due to enter prep. If more than 5 procedures are beginning at any one time, the nursing staff on duty may not be adequate.
Implementation of a Patient Tracking System

We are aware that there is an ongoing discussion about implementing an electronic scheduling/patient tracking system. We recommend that this system is implemented because it will allow for the following improvements:

- Collects procedure times
  - Having a computer system to collect data will not only save a large amount of time, but will also result in more accurate data

- Accounts for physician variance
  - Exact times can be calculated for each physician-procedure combination. The system can also change these figures if physicians become slower or faster over time

- Optimizes scheduling of patients
  - The system can be set to account for room changeover time. It could also probably be used to make sure more than 5 patients are not scheduled at any one time

- Access to patient-flow analysis
  - Patient-flow analysis can be carried out without manual data collection