Optimizing PACU Patient Transport Equipment Management
at C.S. Mott Children’s Hospital and Von Voigtlander Women’s Hospital

Final Report

Submitted To:

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Executive Summary

The staff of the Preoperative Unit and Post-Anesthesia Care Unit (PACU) at C.S. Mott Children’s Hospital and Von Voigtlander Women’s Hospital (CW Hospital) reported experiencing bottlenecks and delays in delivering the correct Patient Transport Equipment (PTE) to its assigned location in a timely manner. To better understand the causes for the PTE delivery delays and improve PTE flow, the CW Hospital Administration asked an IOE 481 student team at the University of Michigan, the CW PACU Equipment Team, to identify the cause of the bottlenecks in the current process and quantify the baseline losses associated with inefficient PTE flow. To address this task, the team conducted observations, interviews, time studies, and data analysis. The findings and conclusions led to recommendations to improve the PTE flow.

Background

The CW Hospital Operating Room (OR) services patients ranging from newborns to senior citizens. Depending on the patient’s age, size, and length of stay, the appropriate PTE provided for a patient at a given stage of the perioperative process may be a stretcher, bed, crib, recliner, or wheelchair. Beyond the variations in the type of PTE essential to support patient flow, limited storage space is available at the Preoperative Unit and PACU for temporarily unused PTE and several operational restrictions constrain where PTE may be stored. Concerns for delayed delivery of PTE stem from the needs to meet scheduled operation times, enable nursing staff to dedicate more time to direct patient care, and reduce excessive workload on PACU Transporters.

Goals and Objectives

The team’s goal was to optimize PTE flow such that the CW Hospital OR will “always have the right equipment, for the right patient, in the right place, at the right time,” as stated by CW Hospital Administration. The team’s conclusions and recommendations:

- Quantify the amounts of each type of PTE needed on a day-to-day basis
- Standardize the PTE cleaning, dressing, and storage policies to minimize non-value-added work, bottlenecks, and confusion in the PTE flow process
- Consider staff satisfaction related to potential process changes
- Quantify baseline loss associated with current PTE flow
- Determine the expected impact and quantify benefit of recommendations

Methodology

The team performed the following tasks to understand the current PTE flow process, identify bottlenecks and delays, and make recommendations to improve the process:

- Conducted literature review to extract ideas about patient and equipment flow
- Observed and interviewed staff critical to PTE flow, comprising 2 Charge Nurses, 3 PACU Transporters, 3 Medical Assistants, 3 Administrators, and 4 Ambassadors
- Toured the University Hospital PACU to compare PTE flow at CW Hospital to the flow within a larger hospital that serves a greater variety of patients
• Conducted time studies on cleaning stretchers (20 samples) and cribs (20 samples), dressing stretchers (50 samples) and cribs (20 samples), and discharging patients in wheelchairs (20 samples)
• Implemented a PACU Transporter workload study, self-collected by the PACU Transporters over 12 days between February 20 and March 7
• Implemented hourly wheelchair availability and recliner usage studies, conducted by PACU Phase II staff over 19 days between February 21 and March 29
• Analyzed historical data spanning July 2012 through January 2013 provided by CW Hospital Administration to quantify time spent in each stage of the perioperative process
• Facilitated live value stream mapping session with Preoperative Unit and PACU staff to identify the root cause for many bottlenecks and issues

**Findings**

The most important findings from the methodology include:

• The mean life cycles of stretchers, cribs, and wheelchairs are 7 hours and 33 minutes, 7 hours and 27 minutes, and 4 hours and 9 minutes, respectively. The variability for each life cycle spans several hours.
• The PACU Phase II Lead Nurse allocates the PACU Transporters between 3 and 5 bays in which they prepare (clean and dress) and store temporarily unused PTE. Often, all of the preparation bays are used at one time. PACU Transporters re-clean approximately 50% of stretchers and 90% of cribs returned from the PACU.
• The PACU Transporters’ primary job responsibility is transporting PTE, followed by dressing PTE, and then cleaning PTE. Searching for PTE comprises about 1% of activity.
• Wheelchair availability fell to 5 wheelchairs or fewer at least once every day and fell to 0 wheelchairs on 8 occasions during the 19-day study. In 15% of discharged patient escorts, the staff member or Ambassador returned to the PACU without a wheelchair. When the PACU has no wheelchairs available, the Unit Host or MAs must leave the PACU floor to retrieve additional wheelchairs. Patient Transport may be contacted to deliver more wheelchairs, but the response time is lengthy and unreliable.
• Recliner usage averaged 0.73 recliners used per hour and matched or exceeded 4 recliners used in one hour on 2 occasions during the 19-day study.
• University Hospital PACU staff clean and dress PTE on a separate floor of the hospital and store approximately 10 prepared PTE in a room near the Preoperative Unit. The CW PACU has no designated storage space for stretchers, cribs, and recliners but wheelchairs are stored along a wall in the PACU. This storage policy violates fire marshal safety restrictions. Furthermore, the wall will be removed to add more bays in the coming years.

**Conclusions**

After a thorough analysis of the data and evaluation of the findings, the team concluded:

• PTE from the PACU cannot be moved to the PACU Transporters’ preparation bays until a space becomes available. As a result, the dirty PTE sits in the PACU bays, inhibiting patient and PTE flow. The PACU Transporters should be able to store prepared PTE
elsewhere to reduce the bottleneck. Providing separate areas for preparing and storing temporarily unused PTE enables efficient PTE flow.

- Many times, escorts culminate in the staff member or Ambassador returning to the PACU without a wheelchair. Also, to reduce aisle blockage and accommodate future expansion, staff should store wheelchairs in a room near the PACU rather than along the PACU wall.
- PTE cleaning responsibilities are shared among PACU Medical Assistants and Nurses and the PACU Transporters, who inspect the PTE for cleanliness. The PACU staff does not always clean the PTE thoroughly or indicate that the PTE was cleaned, so the PACU Transporters must re-clean PTE too frequently.
- Delivery times for cribs and beds from Patient Equipment are excessively variable. Stretcher delivery orders from Patient Transport are untracked, and are therefore unable to quantify reliable lead times for delivery. Consequently, the PACU cannot rely on these outside sources when PTE is needed rapidly.
- Recliners are underutilized and often occupy bays that should be used for patient care.

**Recommendations**

The CW PACU Equipment Team has developed the following recommendations that address the keys issues regarding flow of PTE:

To minimize dependency on off-unit sources of PTE (Patient Transport and Patient Equipment), and also to reduce the bottlenecks resulting from maintaining excessive quantities of PTE, the CW PACU Equipment Team developed an Equipment Management Calculator tool in Microsoft Excel to forecast the daily quantities of stretchers, cribs, and wheelchairs to optimally support PTE flow. The team recommends a policy that relies on this tool to determine the quantity of stretchers and cribs to order from and/or be removed by Patient Transport and Patient Equipment at 9 AM each day. Additionally, the tool displays the expected caseload by perioperative stage and time of day to assist in planning staffing.

In combination with using the Equipment Management Calculator, the CW PACU should follow a standardized procedure for storing temporarily unused PTE to maintain continuous flow. To minimize bottlenecks and aisle blockages, the team recommends that the PACU Transporters store prepared PTE in vacant bays in the Preoperative Unit. This would ensure the PACU Transporters have adequate space to prepare PTE while minimizing congestion in other areas.

The team also recommends a standardized procedure to ensure wheelchairs are returned to the PACU after escorting discharged patients. This standard procedure includes providing training for Ambassadors and Nurses to fully understand their respective responsibilities in maintaining wheelchair flow. Specifically, Ambassadors should be responsible for more duties in the escorting process, including retrieving wheelchairs from storage and escorting a greater percentage of outpatients, while the Nurses should not leave the PACU to escort any patients. Furthermore, wheelchairs should be stored in a room located just outside of the PACU to eliminate the fire marshal violations but still be readily available when needed. The wheelchairs should be managed such that the available count never falls below 5 wheelchairs.
Introduction

The staff of the Preoperative Unit and Post-Anesthesia Care Unit (PACU) linked to the Operating Room (OR) at C.S. Mott Children’s Hospital and Von Voigtlander Women’s Hospital (CW Hospital) report experiencing bottlenecks and delays in delivering the correct Patient Transport Equipment (PTE) to its assigned location. Furthermore, the CW Hospital Administration is concerned that the failure to deliver the PTE on time could delay operation start times, which would be financially detrimental to the hospital. To better understand the causes for the PTE delivery delays and receive recommendations to improve PTE flow, the CW Hospital Administration asked an IOE 481 student team at the University of Michigan, the CW PACU Equipment Team, to identify the cause of the bottlenecks in the current process and quantify the baseline losses associated with inefficient PTE flow. The team conducted a series of observations, interviews, time studies, and analysis to define and recommend an optimized strategy to minimize bottlenecks and quantify the potential impact from the recommendations. This report details the team’s methods, findings, conclusions, and recommendations developed through this study.

Background

Since the opening of C.S. Mott Children’s Hospital and Von Voigtlander Women’s Hospital in December 2011, the new hospital has resolved many of the issues related to facility capacity; however, CW Hospital Administration has become concerned with delays and bottlenecks in Patient Transport Equipment flow. These concerns stem from the need to meet scheduled operation times, enable the nursing staff to dedicate more time to direct patient care, reduce excessive workload on the PACU Transporters, and ensure families are not uncomfortable or waiting longer than expected. This study on PTE flow is the first of its kind for CW Hospital since it opened approximately one year prior to the onset of this project.

Current State

According to CW Hospital Administration, the Operating Room is currently at approximately 76% utilization where 85% utilization is ideal, and an additional room in the OR is expected to open in July 2013. CW Hospital Administration reports that on days with a large number of fast-turnover operations, the PTE bottlenecks and delays seem to be more frequent and significant. These fast-turnover days may be used as indicators of demand for PTE resulting from an expanded OR, thus the PTE flow issues must be resolved to accommodate increases in daily operation throughput and improve overall utilization.

Flow of Patient Transport Equipment. The CW Hospital OR services patients ranging from newborns to senior citizens. Depending on the patient’s age, size, and length of stay, the appropriate PTE required for a patient at a given stage of the perioperative process may be a stretcher, bed, crib, recliner, or wheelchair. In the flow from the Preoperative Unit to the OR, OR staff members transport patients under the age of two years in a crib and patients two years and older on a stretcher. Sometimes, though, small children want to be carried and another staff member, usually a PACU Transporter, will transport the PTE to the OR with the OR staff and patient. After surgery, patients are transported to the Post-Anesthesia Care Unit for recovery.
Patients who will be admitted to the hospital after surgery must be transferred to a bed, while patients who will be discharged are transported in a wheelchair to the exit. Additionally, some younger patients may want to be held by their parents during recovery, at which point the stretcher or crib will be exchanged for a recliner. After patients leave the PACU, whether by wheelchair or bed, the stretcher or crib used to transport them previously into the OR must be cleaned and prepared before being cycled back to the Preoperative Unit for the next incoming patient. Due to the variation and quantity of PTE needed at various stages in the process, the flow of patients is heavily restricted by available PTE.

Preparing and storing Patient Transport Equipment. The PACU Transporters are also responsible for ensuring the cleanliness of PTE after it has been used and preparing it for another patient. Once a piece of PTE is no longer in use, it is brought to a bay between the Preoperative Unit and PACU that is primarily dedicated to the PACU, but is most often used for cleaning, where the PACU Transporters clean it. After the PTE has finished drying, the PACU Transporters dress it with linens and temporarily store it in a vacant patient bay in either the Preoperative Unit or PACU. The current process restricts storing multiple pieces of PTE in a bay. CW Administration reports the PTE flow often bottlenecks at the cleaning and storage stage of the cycle.

To address PTE demands, a copy of the following day’s OR schedule is given to the PACU Transporters each afternoon, which they use to prepare PTE for the following day’s first case patients and ensure the Preoperative Unit will be ready the following morning. Aside from first case planning, the PACU Transporters are responsible for preparing equipment as needed, with little insight or planning to quantities available and needed. Beyond the variations in the type and quantity of PTE essential to support patient flow, limited storage space is available at the Preoperative Unit and PACU for temporarily unused PTE, and several operational restrictions constrain where PTE may be stored. A portion of the bed and crib inventories are stored at and ordered from an off-unit storage unit called the Patient Equipment Garage (PEG), which is not exclusively dedicated to the OR and is staffed by only a few employees. PTE obtained from the PEG must generally be ordered at least an hour in advance to ensure it arrives in time for its intended patient. Stretchers are also stored off-unit and are managed by a different unit called Patient Transport. Patient Transport services all of the University of Michigan Health System (UMHS) and often cannot immediately deliver the stretchers. Consequently, if PTE is needed immediately but PEG or Patient Transport staff is unavailable, the PACU Transporters must search for PTE on other floors of the CW Hospital. Also, PTE may be temporarily stored in restricted aisle ways or doubled up in unused patient bays to compensate the lack of storage space.

Key Issues

To meet scheduled operation times, enable the nursing staff to dedicate their time primarily to patient care, reduce excessive workloads on PACU Transporters, and ensure families are not uncomfortable or waiting longer than expected, the following issues have been addressed:

- Bottlenecks in the cleaning process delay flow of patients
• Variability in type and quantity of PTE required and available complicates quantifying the optimal balance of PTE
• Non-standard process for storing temporary unused PTE leads to confusion and congestion in the PTE cleaning area, Preoperative Unit, and PACU
• Lack of storage space leads to safety issues from aisle blockages and leads to potential fire marshal violations
• Variable reliability of retrieving PTE from off-unit storage, including Patient Transport and Patient Equipment, complicates and delays the process
• Frequently unreturned wheelchairs to the PACU from transporting discharged patients causes the PACU to run out of wheelchairs
• Temporarily unused recliners create congestion due to minimal storage space

Goals and Objectives

The CW Hospital Administration set an operational goal in 2013 for 90% of scheduled surgeries to begin within 30 minutes of the scheduled start time. The CW PACU Equipment Team set intermediate goals to assist the CW Hospital Operating Room in achieving this goal. As stated at the beginning of the project, the team’s goal was to optimize Patient Transport Equipment flow to and from the operating rooms and allow the OR to “always have the right equipment, for the right patient, in the right place, at the right time,” as stated by CW Hospital Administration. To reach this goal, the team executed the following tasks:

• Addressed concerns identified by PACU Transporters, Nurses, Medical Assistants, and Ambassadors through interviews, observations, and workload studies
• Identified bottlenecks and non-value-added work in the current PTE flow through time studies and value stream mapping
• Determined opportunities for reduced equipment delays

With this information, the team developed recommendations that:

• Quantify amount of each type of PTE needed on a day-to-day basis
• Quantify baseline loss associated with current PTE flow
• Standardize PTE cleaning, dressing, and storage policies to minimize non-value-added work, re-work, bottlenecks, and confusion in PTE flow
• Consider staff satisfaction related to potential process changes
• Determine expected impact and quantify benefit of process changes
Project Scope

This project included analysis of only Patient Transport Equipment flow in the Preoperative and Post-Anesthesia Care Units linked to the Operating Room at CW Hospital. The Preoperative Unit also included two patient bays in Radiology, located on the floor below the Operating Room. Additionally, the project focuses specifically on PTE including cribs, stretchers, beds, wheelchairs, and recliners.

Any tasks that take place outside of the specified locations above have not been modified in the team’s recommendations. This included the Procedural Readiness Center, located near the entrance to the Preoperative Unit, used for educating patients and families for upcoming surgeries. The team observed the University Hospital PACU for comparison benchmarking purposes as well as the Patient Equipment Garage to understand the crib and bed ordering and delivery process, but no recommendations affect these areas. Equipment delivery from off-unit sites including the Patient Equipment Garage and Patient Transport, as well as scheduling for the OR, were considered inputs to the flow process that could not be modified.

Data Collection Methods

Between February 19 and March 1, the team conducted initial research consisting of observations, interviews, and a literature search to understand the current PTE flow process. Furthermore, to determine the cycle times for PTE and identify bottlenecks and delays, between March 4 and April 5, the team conducted time studies, workload collections, and PTE usage studies. From the collected data and analysis of historical data, the team developed value stream maps for stretchers, cribs, and wheelchairs. The data enabled the team to make recommendations and quantify their expected impacts.

Conducting Initial Research

The CW PACU Equipment Team researched PACU flow, observed tasks relevant to PTE flow at CW Hospital, and benchmarked procedures at the University Hospital to get acquainted with the process and identify areas and methods for improvement.

Conducting a literature search. The team extracted ideas about general patient and PACU flow through literature research. In an article titled, “Patient Flow in Hospitals: Understanding and Controlling It Better” by Carol Haraden, Ph.D and Roger Resar, M.D. (full article attached after the appendices), the authors suggest that flow problems are often a result of variation among and between departments and one should “view the problem in terms of an interdependent system rather than individual departments.” Throughout the data collection and analysis process, the team used this knowledge and identified variation in the PTE flow process between units of the CW Preoperative Unit and PACU.

Interviewing and observing staff in the PTE flow process. Between February 4 and February 18, the CW PACU Equipment Team observed the tasks relevant to the PTE flow process and interviewed 15 staff members involved in the process, including: 3 PACU Transporters, 2 Charge Nurses, 3 Medical Assistants, 3 Administrators, and 4 Ambassadors. In general, PTE flows through the system as follows:
1. PACU Transporters clean and dress the PTE (stretchers and cribs)
2. PACU Transporters store PTE in empty bays until the Charge Nurse alerts them of need for PTE in a specific bay in the Preoperative Unit
3. PACU Transporters move the PTE to the assigned bay
4. Preoperative Unit Nurses prepare the patient for surgery in the assigned bay
5. OR staff transports the patient on the PTE into the OR for surgery
6. The PTE remains outside the OR for the duration of the surgery
7. OR staff transports the patient on the PTE into Phase I of the PACU for recovery
8. PACU staff treat patients in Phase I
9. PACU staff transport outpatients to Phase II of the PACU and inpatients to inpatient floors
10. PACU staff treat patients in Phase II
11. Medical Assistants and Ambassadors transfer outpatients onto wheelchairs and escort them from building
12. PACU staff may clean stretchers and cribs before returning them to the PACU Transporters
13. PACU Transporters inspect and prepare (as necessary) PTE

Touring the University Hospital PACU. In addition to observations in the PACU at CW Hospital, two members of the team visited the PACU of the University Hospital (UH) to compare methods and PTE flow in a larger hospital setting with a greater variety of patients. The PACU Manager provided a guided tour to show the team where PTE is cleaned and stored at the UH. Specifically, the team wanted to see if the UH PACU had experienced difficulties with managing PTE flow similar to those experienced in the CW PACU and identify the policies or procedures that enabled efficient PTE flow at UH. The tour lasted approximately 1 hour.

Determining PTE Cycle Times

To quantify the average length of use for PTE, the team conducted time studies and acquired historical data. The PTE process includes tasks for cleaning, dressing, transporting, and using the PTE, for which the team collected data to quantify the average time required to complete each task in the process.

Performing time studies of PTE processes. The team performed time studies to determine workloads associated with cleaning and dressing stretchers and cribs and escorting discharged patients in wheelchairs. The team collected 20 samples of cleaning stretchers, 50 samples of dressing stretchers, 20 samples of cleaning cribs, 20 samples of dressing cribs, and 20 samples of escorting discharged patients to their vehicles in wheelchairs. The data collection sheets used for these time studies can be found in Appendix A, Table A-1 and A-2.

To ensure accuracy with the time studies, the team compiled a list of tasks required to complete each process for cleaning, dressing, or transporting PTE and agreed on specific start and stop times for each of the tasks prior to performing the time studies. Additionally, each team member noted variations in the processes, indicating deviations from the typical process and/or obstacles faced in tracking the time.
Collecting PACU Transporter workloads. The team asked both PACU Transporters and Unit Host to record the activities they performed throughout the workday from February 20 to March 7 to quantify the proportion of a typical day spent performing tasks related to PTE flow. To enable the staff to record the data, the team developed a workload recording form based on the job responsibilities reported during the initial interviews. The workload collection forms can be found in Appendix A, Table A-3.

To ensure accuracy and completeness from the Transporter workload recording sheets, the team gave both verbal and written instruction to the staff and checked with them between 2 and 3 times each week to address any issues. Additionally, the team asked the PACU Transporters and Unit Host to complete their forms individually and provide the date on each workload recording sheet to maintain accountability before delivering the sheets to the project clients at the end of each workday to ensure compliance. However, on most days the staff used a single form to record all of their performed tasks in aggregate. Furthermore, the staff indicated that several sheets had no activity recorded for extended durations of time not because they were doing nothing but because they did not have time to record their activities or simply forgot. To ensure that the data accurately reflected typical workloads for the PACU Transporters and Unit Host, the team collected the workload study data for two full days on March 18 and March 27. One of the days was meant to represent a slow day, with a small number of cases, and the other a fast day, with a large number of cases.

Collecting wheelchair availability and recliner usage data. The team implemented a data collection in the PACU Phase II to quantify wheelchair availability and recliner usage. Between February 21 and March 29, the PACU Nurses recorded the number of wheelchairs available for escorting discharged patients at the beginning of each hour and recorded the number of recliners used for patient recovery each hour. Collection sheets for this study can be found in Appendix A, Table A-4.

To ensure accuracy for the wheelchair time studies conducted by the team, the team members agreed on specific start and stop times and recorded any variations and obstacles faced when recording data. To ensure accuracy and compliance for the wheelchair and recliner usage study, the team provided verbal and written instructions to the PACU Nurses and asked the Nurses to deliver completed collection sheets to the clients at the end of each workday.

Collecting historical data. In addition to data the CW PACU Equipment Team collected, CW Hospital Administration provided the team with historical data from July 2012 to January 2013 regarding patient flow through the system, including patient age and status, the times at which each patient arrived to each stage of the perioperative process, and to which bay the patient was assigned. The team used the data to quantify the distributions of time that patients spend in the various stages of the perioperative process as well as the quantities and proportion of patients using each type of PTE. The administration also provided data regarding orders for cribs from the Patient Equipment Garage and their associated delivery times for July 2012 through March 2013.
Developing Project Deliverables

After collecting and analyzing the data, the CW PACU Equipment Team began producing two project deliverables for the client: (1) value stream maps for stretchers, cribs, and wheelchairs, and (2) a tool to facilitate optimal PTE management.

Creating value stream maps for PTE flow. The team developed value stream maps that illustrate the flow of stretchers, cribs, and wheelchairs and conducted two live value stream mapping sessions with PACU staff. During the first session, the team collaborated with one PACU Transporter, one Preoperative Unit Charge Nurse, and the Unit Host to ensure that the value stream maps accurately represented the stretcher and crib flow process. During the second session, the team collaborated with one PACU Phase II Lead Nurse and the Unit Host to ensure that the value stream map accurately represented the wheelchair flow process. Additionally, the sessions provided an opportunity for the staff to discuss the issues they believed most significantly impacted efficient PTE flow and identify them as opportunities for improvement. The value stream maps for stretchers, cribs, and wheelchairs are attached after the Appendix.

Creating the Equipment Management Calculator tool. To assist the Preoperative and PACU staff to better manage PTE on a daily basis, the team developed a tool called the Equipment Management Calculator. The team created the tool in Microsoft Excel so that any of the staff may easily access the tool from the computers in the Preoperative Unit and PACU. After iteratively improving the tool several times, the team met with the client and coordinators to identify additional functionality that may be useful for the staff and then implemented those changes. Finally, the team produced an instructional video to assist staff with using the tool.

Data Analysis and Findings

The team analyzed all data collected to develop recommendations to optimize PTE flow and resolve inefficiencies and delays in transporting PTE from unit to unit.

Initial Observations and Interviews

The observations and interviews of PACU Transporters resulted in several key findings:

- The PACU Transporters are generally allocated between 3 and 5 PACU Phase II patient bays in which they may clean, dress, and temporarily hold PTE. Though officially designated for Phase II of the PACU, these preparation bays offer little patient privacy and are very rarely needed for patient recovery.

- The 3 Preoperative Unit Charge Nurses have different policies regarding storage of temporarily unused stretchers and cribs. While two of the Charge Nurses allow the PACU Transporters to move prepared PTE to vacant bays in the Preoperative Unit, one of the Charge Nurses does not let them do so unless the specific bay will not be used again throughout the day. The PACU Transporters believe they experience more frequent bottlenecks when they are not allowed to store prepared equipment in the Preoperative Unit.
• Nurses and Medical Assistants in the PACU clean roughly 50% of PTE before delivery to the PACU Transporters. The PACU Transporters inspect and evaluate the PTE against their 5 rules and standards for cleanliness. The PACU Transporters and Unit Host clean or re-clean the PTE as necessary. Frequently, the PACU Transporters are away from the preparation bays handling other responsibilities; sometimes they will return to the bay and find delivered PTE but cannot immediately tell if it had already been cleaned, in which case, they must clean it regardless, resulting in possible re-work.

• After PACU Transporters leave at approximately 3:00 PM, the PACU staff must clean and dress all PTE, reducing their time available for direct patient care.

Tour of University Hospital PACU

In addition to observations in the PACU at CW Hospital, the team visited the University Hospital PACU to compare methods and PTE flow in a larger hospital setting with a greater variety of patients. Findings from this observation included:

• UH has storage on the main PACU floor for approximately 8 stretchers and 3 beds, whereas CW Hospital has none.

• UH has a separate room for cleaning PTE, whereas CW Hospital staff clean PTE in empty patient bays.

• UH staff frequently stores multiple pieces of PTE in single bays and the Nurse Manager of the UH PACU reported she was unaware of any regulations preventing these storage policies.

Crib and Stretcher Time Studies

The team analyzed crib and stretcher cleaning and dressing time study data that was collected between February 18 and March 22. The time studies reveal the variation in time required to clean and dress cribs and stretchers, as shown below in Figure 1. Note that the mean times and standard deviations indicated for each task are given in minutes and seconds.
Figure 1. Mean time spent cleaning and dressing stretchers and cribs
(Source: Time study data, IOE 481 Team 4, Data collection period: 2/18/13 – 3/29/13)

Figure 1 shows that cribs require approximately 3 more minutes to clean than stretchers, on average and large variation exists in the time required to clean cribs and stretchers. The time studies also show little variation in mean dressing times between stretchers and cribs, with stretchers taking only 29 more seconds to dress than cribs.

The team also discovered that if the PACU Transporters and Unit Host are not busy, they will work together to clean and dress stretchers and cribs. The team further analyzed the preparation times by the number of staff working on a task, as shown in Table 1 below.

<table>
<thead>
<tr>
<th>Preparation Task</th>
<th>Number of Staff</th>
<th>Mean Time (min:sec)</th>
<th>Standard Deviation (min:sec)</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning Stretchers</td>
<td>1</td>
<td>1:57</td>
<td>1:07</td>
<td>11</td>
</tr>
<tr>
<td>Cleaning Stretchers</td>
<td>2</td>
<td>1:29</td>
<td>0:36</td>
<td>9</td>
</tr>
<tr>
<td>Cleaning Cribs</td>
<td>1</td>
<td>5:16</td>
<td>1:55</td>
<td>11</td>
</tr>
<tr>
<td>Cleaning Cribs</td>
<td>2</td>
<td>4:06</td>
<td>1:28</td>
<td>7</td>
</tr>
<tr>
<td>Cleaning Cribs</td>
<td>3</td>
<td>3:16</td>
<td>1:26</td>
<td>2</td>
</tr>
<tr>
<td>Dressing Stretchers</td>
<td>1</td>
<td>1:12</td>
<td>0:28</td>
<td>40</td>
</tr>
<tr>
<td>Dressing Stretchers</td>
<td>2</td>
<td>0:49</td>
<td>0:18</td>
<td>10</td>
</tr>
<tr>
<td>Dressing Cribs</td>
<td>1</td>
<td>0:38</td>
<td>0:10</td>
<td>17</td>
</tr>
<tr>
<td>Dressing Cribs</td>
<td>2</td>
<td>0:46</td>
<td>0:21</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 1 shows that, except for dressing cribs, having more workers contributing toward preparing a stretcher or crib reduced the time needed. However, the total time spent by all workers together was smallest when only one person contributed. For example, though having 2 staff members help to dress a stretcher reduced the mean time from 1 minute and 12 seconds to just 49 seconds, the total time spent is 1 minute and 39 seconds because it required two people.

**PACU Transporter Workload Studies**

The PACU Transporter workload data that was self-collected was deemed comparable to that collected by the CW PACU Equipment Team on the representative slow and fast days. The mean number of tasks performed per person, amongst 2 PACU Transporters and the Unit Host, by time of day is depicted in Figure 2 below.

Figure 2 shows that the PACU Transporters and Unit Host perform the greatest number of tasks per person between 7:00 AM and 8:00 AM and during the period in which one or more of them are on lunch break between 11:30 AM and 1:00 PM.

Additionally, the team evaluated the frequency with which the PACU Transporters perform their primary job responsibilities, as shown in Figure 3.
Figure 3. PACU Transporter primary job responsibilities
(Source: PACU Transporter workload study, IOE 481 Team 4, Data collection period: 2/20/13 – 3/27/13)

Figure 3 shows that more than half of the tasks the PACU Transporters perform are related to transporting PTE. Furthermore, approximately 53% of the Transporting PTE task is spent moving PTE to another bay for storage rather than an assigned bay for immediate use.

The data also indicates that the PACU Transporters clean PTE approximately half as much as they dress PTE, suggesting that approximately half of all PTE delivered to the preparation bays is already cleaned. Additionally, the data suggests that they rarely must search for PTE when none is available in the Preoperative Unit or PACU.

Wheelchair Time Studies

The wheelchair escort time studies were performed to quantify the length of time it takes to escort a patient from the PACU and return the wheelchair back to storage. The escort process was split into 9 stages: walk from PACU to elevator, wait for elevator, ride elevator down, walk from elevator to vehicle, wait for patient departure, walk from vehicle to elevator, wait for elevator, ride elevator up, and walk from elevator to PACU. Each stage was timed and averaged for 20 samples. The mean stage times are given in Table 2.
Table 2. Escort process time study statistics
(Source: Time study data, Data collection period: 2/18/13 – 3/29/13, Sample size: 20)

<table>
<thead>
<tr>
<th>Escort Stage</th>
<th>Mean Time (min:sec)</th>
<th>Standard Deviation (min:sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk from PACU to elevator</td>
<td>1:17</td>
<td>0:30</td>
</tr>
<tr>
<td>Wait for elevator</td>
<td>0:50</td>
<td>0:37</td>
</tr>
<tr>
<td>Ride elevator down</td>
<td>0:28</td>
<td>0:09</td>
</tr>
<tr>
<td>Walk from elevator to vehicle</td>
<td>1:40</td>
<td>1:31</td>
</tr>
<tr>
<td>Wait for patient departure</td>
<td>4:01</td>
<td>3:33</td>
</tr>
<tr>
<td>Walk from vehicle to elevator</td>
<td>1:35</td>
<td>1:12</td>
</tr>
<tr>
<td>Wait for elevator</td>
<td>0:25</td>
<td>0:34</td>
</tr>
<tr>
<td>Ride elevator up</td>
<td>0:29</td>
<td>0:12</td>
</tr>
<tr>
<td>Walk from elevator to PACU</td>
<td>1:27</td>
<td>1:17</td>
</tr>
<tr>
<td><strong>Entire Escort Process</strong></td>
<td><strong>12:19</strong></td>
<td><strong>2:58</strong></td>
</tr>
</tbody>
</table>

The escorts took approximately 12 minutes on average, with waiting for the patient to depart accounting for nearly one-third of the entire escort process time. Through observation, the team noticed that the extended stage time was due to the patient and Ambassador needing to wait for a parent to retrieve the vehicle before returning to the PACU. The team also analyzed this escort process by grouped activity. Figure 4 shows the proportion of time spent walking, riding and waiting for the elevator, and waiting for the patient’s departure.

![Figure 4. Escort process time study by activity](image)

The data shown above in Figure 4 suggests that approximately half of the escort process is spent walking while a third of the time is spent waiting for the patient to depart. While the time spent walking cannot be reduced, due to physical distance, the departing process should be reduced through standardization. Furthermore, in 15% of the patient escorts, the staff member or Ambassador returned to the PACU without bringing the wheelchair or a replacement along.
Wheelchair Availability and Recliner Usage

The CW PACU often experiences wheelchair shortages, especially on days with heavier caseloads. For this reason, the team asked the PACU Nurses to track the amount of wheelchairs on-hand at the beginning of each hour. The mean number of wheelchairs available each hour is represented in Figure 5 below.

In general, the PACU begins each day with 10 wheelchairs on-hand. As shown in Figure 5, the number of wheelchairs available steadily decreases throughout the day. Furthermore, wheelchair availability fell to 5 wheelchairs or fewer at least once every day and fell to 0 wheelchairs on 8 occasions during the 19-day study, primarily because of staff and Ambassadors not returning wheelchairs after escorting a patient. As mentioned previously, in 15% of discharged patient escorts, the staff member or Ambassador returned to the PACU without a wheelchair. When the PACU has no wheelchairs available, the Unit Host or MAs must leave the PACU floor to retrieve additional wheelchairs. Patient Transport may be contacted to deliver more wheelchairs, but the response time is lengthy and unreliable.

The CW PACU has 5 recliners available, which are usually stored in unused PACU patient bays. To determine how often patients were using the recliners and if the PACU could better utilize them, the team asked the PACU Nurses to track the number of recliners used each hour. The mean number of recliners used per hour is represented below in Figure 6.
Figure 6 shows that the mean recliner utilization never exceeded 1.5 uses per hour, or less than 30%. Furthermore, during the 19-day collection, 4 or 5 recliners were used in a single hour only twice.

**Historical Data**

The client provided historical data from the patient database regarding check-in times at each perioperative phase for all patient operations and procedures at the CW OR from July 1, 2013 through January 25, 2013. The team analyzed the data to determine crib delivery times from the PEG; typical times spent in each phase of the perioperative process; distribution of start times in each phase of the perioperative process; mix of inpatients, outpatients, and admit-day-of-procedure (ADP) patients; mix of patients by type of PTE needed (stretchers versus cribs); and trends in caseload by weekday and month.

**Crib delivery times.** Analyzing the historical data for crib delivery times revealed a significant response time in delivering PTE from the Patient Equipment Garage to the PACU upon request. The team investigated these delivery times for cribs from the PEG to the PACU and found inconsistencies. Figure 7 shows the distribution of crib delivery times from July 2012 through March 2013.
Figure 7 appears to be slightly skewed right, which indicates that crib delivery times vary towards longer delivery times. Judging by this distribution, crib delivery time after request is unpredictable and lengthy; this may delay the operation schedule. Table 3 shows the mean, standard deviation, minimum, and maximum of the distribution from Figure 7.

Table 3. Statistics of crib delivery times to operating room
(Source: Historical data, Data collection period 7/1/2012 – 3/22/2013, Sample size: 39)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Delivery Time (hr:min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0:44</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0:39</td>
</tr>
<tr>
<td>Minimum</td>
<td>0:04</td>
</tr>
<tr>
<td>Maximum</td>
<td>3:49</td>
</tr>
</tbody>
</table>

The standard deviation of 39 minutes indicates that there is high variation in the length of time it takes for cribs to be delivered from the PEG to the CW PACU. The PEG Supervisor indicated that the mean delivery time to the PACU exceeded that of the mean delivery time to the rest of CW Hospital because the orders from the PACU never included information regarding the patient associated with the order. The PACU Transporters order multiple cribs at one time, rather than one at a time, and thus did not include patient information. Consequently, the PEG treats orders without patient information as low priority.
Perioperative process stage times. The perioperative process for most patients at CW Hospital can be classified into the time spent in the following areas: (1) Waiting Area, (2) Preoperative Unit, (3) Operating Room, (4) PACU Phase I, and (5) PACU Phase II. In addition, outpatients and ADP patients will spend some amount of time in a waiting area outside the Preoperative Unit when they arrive to the hospital. Also, inpatients and ADP patients will not enter Phase II of the PACU in most cases. Table 4 displays the mean time spent in each stage along with their standard deviations and sample sizes for all scheduled cases Monday through Friday between July 1, 2013 and January 25, 2013.

<table>
<thead>
<tr>
<th>Perioperative Stage</th>
<th>Mean Duration (hr:min)</th>
<th>Standard Deviation (hr:min)</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waiting Area</td>
<td>0:13</td>
<td>0:21</td>
<td>4,763</td>
</tr>
<tr>
<td>Preoperative Unit</td>
<td>1:25</td>
<td>0:46</td>
<td>5,451</td>
</tr>
<tr>
<td>Operating Room</td>
<td>1:57</td>
<td>1:53</td>
<td>5,942</td>
</tr>
<tr>
<td>PACU Phase I</td>
<td>1:13</td>
<td>0:43</td>
<td>5,071</td>
</tr>
<tr>
<td>PACU Phase II</td>
<td>1:06</td>
<td>0:45</td>
<td>3,446</td>
</tr>
</tbody>
</table>

Table 4 shows there are large standard deviations for each stage in the perioperative process relative to the mean times, indicating high variability within the processing times. The largest variability happens in the Operating Room, which is expected due to the variety in type and severity of operations performed. A large deviation is also expected for both phases of recovery in the PACU, as recovery time depends on many factors including severity, type of surgery, and health conditions of the patient. These processing times and variation are important to consider when quantifying the cycle time of PTE.

Distribution of perioperative process phase start times. Though Table 4 displays the typical time spent in each stage of the perioperative process, it does not demonstrate the relationship between each of the stages. To reveal the trend in stage start times, the team determined the distribution of starting times in each stage by hour of day. Then the team determined the percentage of all cases that entered each stage by hour of day. Figures 8 through 12 depict this distribution for each of the stages from 6:00 AM to 6:00 PM. All other stage start times were considered negligible as they are outside of normal operational hours for the CW OR.
Figure 8. Waiting area start time distribution
(Source: Historical data, Data collection period 7/1/2012 – 1/25/2013, Sample size: 4,818)

Figure 9. Preoperative Unit start time distribution
(Source: Historical data, Data collection period 7/1/2012 – 1/25/2013, Sample size: 5,389)
Figure 10. Operating room start time distribution
(Source: Historical data, Data collection period 7/1/2012 – 1/25/2013, Sample size: 5,907)

Figure 11. PACU Phase I start time distribution
(Source: Historical data, Data collection period 7/1/2012 – 1/25/2013, Sample size: 5,194)
Figures 8 through 12 above show the general flow of PTE through the system in a typical day. Nearly 50% of patients enter the Preoperative Unit before 9:00 AM. Nearly two-thirds of all OR procedures have started by 12:00 PM and Phase I of the PACU receives patients fairly uniformly between 8:00 AM and 3:00 PM, while the peak utilization of Phase I falls between 9:00 AM and 4:00 PM. These trends are important to the PTE flow study as they indicate when and where the largest demand for PTE occurs throughout the day.

*Case mix by patient status.* The need for PTE is significantly affected by whether the patient is an inpatient, outpatient, or ADP patient. For example, inpatients may arrive directly to the OR from inpatient floors or arrive to the Preoperative Unit already on the appropriate type of PTE. Most outpatients require a wheelchair during the escort process at the end of Phase II. The team determined the percentage of scheduled cases by patient status (Figure 13) and the mean numbers of total scheduled cases and first cases per day (Monday through Friday) by patient status (Table 5).
Table 5. Case statistics by patient status  
(Source: Historical data, Data collection period 7/1/2012 – 1/25/2012, Sample size: 5,943)

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Inpatients</th>
<th>Outpatients</th>
<th>ADP Patients</th>
<th>Total Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Cases Per Day</td>
<td>6.25</td>
<td>25.26</td>
<td>10.49</td>
<td>41.56</td>
</tr>
<tr>
<td>Cases Per Day St. Dev.</td>
<td>2.48</td>
<td>6.70</td>
<td>3.36</td>
<td>9.56</td>
</tr>
<tr>
<td>Mean First Cases Per Day</td>
<td>1.34</td>
<td>6.04</td>
<td>4.06</td>
<td>11.31</td>
</tr>
<tr>
<td>First Cases Per Day St. Dev.</td>
<td>0.94</td>
<td>1.97</td>
<td>1.64</td>
<td>2.62</td>
</tr>
</tbody>
</table>

As Figure 13 indicates, 60% of patients at the CW OR receive outpatient procedures, accounting for approximately 25 total cases and 6 first cases each day. Nearly every one of these outpatients will require a wheelchair for the escort process. Inpatients, however, account for 15% of procedures, or about 6 cases per day (2.5 first cases), and may not require any new PTE when they arrive to the CW OR. Finally, the operating room handles roughly 10.5 ADP patients each day, with about 4 occurring during the first cases of the day. In total, the CW OR sees approximately 42 patients on a typical weekday.

Case mix by PTE needs. The historical data included patient ages for each case performed at the CW OR between July 1, 2012 and September 30, 2012. To determine the case mix by PTE needs, the team assumed that patients under the age of 2 years old required a crib and all other patients required a stretcher. This assumption was based on the general guidelines the PACU Transporters follow when preparing the Preoperative Unit bays for cases. Figure 14 displays the case mix. The team also analyzed the OR, PACU Phase I, and PACU Phase II durations for cases requiring stretchers and cribs, displayed in Tables 6 and 7 respectively. It was assumed that Waiting Area and Preoperative Unit durations were not significantly different from the overall process times, given in Table 4, for either stretchers or cribs.

![Image](image_url)
As Figure 14 shows, nearly 4 out of 5 patients require a stretcher. In comparison to the overall perioperative stage process durations (see Table 4), cases for patients that need cribs tend to require more time in the operating room but slightly less time recovering in both phases of the PACU. Contrastingly, cases for patients that need stretchers tend to require less time in the operating room but more time in the PACU.

**Caseload trends.** The team analyzed the historical data to determine if there were any trends in the number of emergent, non-emergent, and scheduled cases on weekly and monthly bases. The mean numbers of cases per day for each weekday is shown in Figure 15, categorized by case type. The mean numbers of cases per day for each month are shown in Figure 16, categorized by case type.
Figures 15 and 16 show that the mean number of cases is relatively steady throughout the regular workweek of Monday to Friday as well as by month of the year.
Value Stream Mapping

The team developed the value stream maps to illustrate the flow of stretchers, cribs, and wheelchairs and assess the current situation, locate bottlenecks, non-value added tasks, and other sources of waste that can be eliminated from the process. Using the analyzed historical and time study data, the team determined most process times for stretchers, cribs, and wheelchairs. To complete any missing data, the team led a live value stream mapping session with one of the Preoperative Unit Charge Nurses, a PACU Lead Nurse, an PACU Transporter, and the Unit Host. The mean cycle and value-added times for wheelchairs, cribs, and stretchers are shown below in Figure 17.

![Mean cycle and value-added time by PTE type](image)

The mean cycle time for stretchers is 7 hours and 33 minutes, including approximately 3 hours and 54 minutes of value-added time. Furthermore, nearly all stretchers require at least 2 hours and 47 minutes but no longer than 14 hours and 46 minutes to complete a cycle.

The cycle time for cribs is similar to that of stretchers; however, operations for crib patients, in general, require longer OR times but shorter PACU times than stretcher patients. Also, cleaning cribs is a longer process than cleaning stretchers. Overall, the mean cycle time for cribs is 7 hours and 27 minutes, including approximately 3 hours and 27 minutes of value-added time. Furthermore, nearly all cribs require at least 2 hours and 37 minutes but no longer than 14 hours and 59 minutes to complete a cycle.

The cycle time for wheelchairs is generally much shorter than those of stretchers and cribs. The mean cycle time is 4 hours and 9 minutes, but may range from 24 minutes to 9 hours and 13 minutes. However, the majority of the cycle time, usually about 3 hours, is spent in storage. In total, the value-added time for a wheelchair is about 15 minutes per cycle.

In addition to verifying and completing the missing process times, the live value stream mapping sessions provided the participants with an opportunity to discuss additional issues with PTE flow that are not immediately apparent in a typical cycle. The participants identified trends of failed inspections for cleanliness in stretchers and cribs delivered from PACU staff to the PACU Transporters and issues arising from minimal storage space for temporarily unused PTE. They also indicated that poor communication amongst staff intensifies the challenges in managing PTE. The team incorporated the issues discussed as storm clouds in the value stream maps.
Conclusions

Upon completion of the data collection and analysis, the team developed a series of conclusions to assist in developing recommendations to the CW Hospital PACU.

Need for standard policy for storing temporarily unused PTE

The process of storing temporarily unused PTE is one of the largest factors inhibiting effective PTE flow through the perioperative process. The observations revealed that the Charge Nurses in the Preoperative Unit have different policies regarding where to store PTE until it is needed. The variation that results from a non-standard policy causes some confusion and frustration amongst the staff. Furthermore, the PACU Transporters believe they experience more frequent bottlenecks when they are not allowed to store prepared equipment in the Preoperative Unit. Pictures showing the resulting congestion from not being allowed to move stretchers and cribs into the empty bays of the Preoperative Unit are shown in Appendix B. The PACU Transporter workload study indicates that approximately 53% of PTE needs to be stored temporarily. The storage issue results when there is more PTE available than is currently needed, but the PACU Transporters maintain possession of the PTE because the off-unit storage locations are unreliable to remove and/or return PTE as it is needed.

The current wheelchair storage policy, in which wheelchairs are lined up along a wall in the PACU, violates fire marshal regulations and will not be feasible when additional bays are added to the PACU. Alternatively, the wheelchairs may be stored in a room approximately 130 feet down a hallway from PACU Phase II that could hold up to 10 wheelchairs. Some Nurses oppose storing the wheelchairs in the room because it would require them to leave the PACU area while retrieving a wheelchair. However, if the Nurses utilize the services of Ambassadors, they would not be responsible for retrieving the wheelchairs, as the Ambassadors could bring one when they are called back to escort a patient.

Need for better Ambassador utilization

Through interviews with Medical Assistants and Ambassadors, who escort discharged patients to their vehicles in wheelchairs, the team learned about the complications involved in returning wheelchairs to the PACU after escort. The wheelchair usage study indicated that approximately 15% wheelchairs do not return to the PACU after escort, at which point the Unit Host or Medical Assistants must leave the PACU to obtain more wheelchairs. The wheelchair time studies helped to identify some of the reasons why many wheelchairs aren’t being returned to the PACU, including:

- An Ambassador may not be available or is available but not asked to escort the patient. Instead, a Nurse or Medical Assistant escorts the patient to the elevator before returning to the PACU.

- If patients park at a distant structure, such as the Taubman Center parking structure, the escorting staff or Ambassador may not walk with the patient all the way to their vehicle.
Patients may have other appointments at the hospital to attend after surgery and are transported there on the wheelchair from the PACU.

When Ambassadors escort patients to the entrance of the parking structure but not all the way to their vehicles (for liability reasons), they allow the family to take the wheelchair to the vehicle and return to the PACU without a replacement.

All of these situations result in a wheelchair leaving the PACU without being returned. Additionally, as determined from the live value stream mapping session, when Nurses in the PACU have few patients to tend to, the Nurses and Medical Assistants escort patients to the elevator without calling an Ambassador because they have time available to do so. However, the Nurses never walk the patients all the way to their vehicles, so the wheelchair does not return.

**Need for standard cleaning and dressing procedures for stretchers and cribs**

The PACU Transporters re-clean approximately 50% of stretchers and 90% of cribs that are delivered from the PACU staff. The PACU staff is generally very busy and attempts to clean the PTE as quickly as possible. However, rushing through cleaning the PTE results in frequently missed spots that are noticeable. Therefore, the PACU Transporters have to re-clean the PTE, which is unnecessary double-work.

**Need for more reliable PTE delivery from Patient Transport and Patient Equipment**

As suggested in the conclusion regarding the need for standard storage policies, the reliability of off-unit storage locations, including Patient Transport and Patient Equipment, is excessively variable. Analysis of the historical crib delivery times indicate the lead time between ordering and receiving PTE from the PEG is 44 minutes. This lengthy lead time severely limits the PACU Transporters in preparing the right PTE for the right patient in a timely manner.

**Need for increased recliner utilization**

The recliner usage data indicates that the average number of recliners used in one hour is consistently less than 2 recliners. The PACU currently has five recliners available that are usually stored in unused patient bays. Due to the lack of sufficient storage space, these recliners create congestion in the PACU and all five recliners are rarely needed at one time. The PACU could make 1 or 2 of the recliners available for use in other units of the hospital or, when the PACU Transporters and Preoperative Unit are short on stretchers and cribs, ask recovering patients if they would like to move onto a recliner for the remainder of their recoveries, thus increasing recliner utilization and enabling improved PTE flow.
Recommendations

The team has developed recommendations that address the key issues regarding PTE flow. Ultimately, these recommendations will help ensure that the right piece of equipment is delivered to the right place, for the right patient, at the right time.

Forecast optimal quantity of PTE necessary required to support continuous flow

Acquiring and storing more PTE than necessary is the largest inhibitor for effective PTE flow in the perioperative process due to bottlenecks and congestion. On the other hand, having too little PTE can delay the operating room if PTE is unavailable due to heavy dependence on off-unit storage locations, including Patient Transport and Patient Equipment. The team recommends several procedures to standardize the PTE flow process and effectively forecast the optimal quantity of PTE needed to maintain continuous flow without delays.

Calculate the daily demand for stretchers and cribs. The team developed a strategic tool, called the Equipment Management Calculator, using Microsoft Excel to automatically calculate the daily quantities of stretchers, cribs, and wheelchairs needed to facilitate having the right amount of PTE available at all times and accommodate efficient PTE flow. The tool takes as input the daily OR schedule and, based on each patient’s age, scheduled surgery start time and duration, and status (inpatient, outpatient, or admit-day-of-procedure), outputs the expected quantities of cribs and stretchers needed at every hour of the day. The calculation provides knowledge to the PACU Transporters to forecast when PTE should be ordered from or removed by Patient Transport and Patient Equipment. The team has produced an instructional video to train new users how to properly use the Equipment Management Calculator, provided with the IOE 481 project materials.

Pre-dispatch stretchers and cribs in vacant Preoperative Unit bays. To eliminate confusion between the PACU Transporters and the Preoperative Unit Nurses resulting from two different policies for storing PTE, the team recommends one standard method for storing temporarily unused PTE. To determine the best policy, whether to store PTE in vacant Preoperative Unit bays or in the preparation bays, the team constructed a decision matrix to rate 4 decision criteria. The team surveyed 2 Preoperative Unit Charge Nurses, the Unit Host, and 2 PACU Transporters to rate the alternatives with respect to walking distance, aisle and bay congestion, convenience, and available preparation space based on a 0 - 5 rating, where a lower score indicating an undesirable option and a higher score indicating a desirable option. Table 8 shows the ratings for each criteria and the resulting decision.
Table 8. Decision matrix of storage options for temporarily unused PTE

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>PACU Transporter</th>
<th>Preoperative Unit Bays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking Distance</td>
<td>3.50</td>
<td>3.25</td>
</tr>
<tr>
<td>Bay and Aisle Congestion</td>
<td>1.25</td>
<td>4.25</td>
</tr>
<tr>
<td>Preoperative Unit and Patient Convenience</td>
<td>3.25</td>
<td>3.50</td>
</tr>
<tr>
<td>Preparation Space Availability</td>
<td>2.75</td>
<td>4.25</td>
</tr>
<tr>
<td><strong>Score</strong></td>
<td><strong>10.75</strong></td>
<td><strong>15.25</strong></td>
</tr>
</tbody>
</table>

The results from the decision matrix indicate that pre-dispatching temporarily unused PTE to vacant bays in the Preoperative Unit is the better option in terms of eliminating congestion in the aisles and bays of the Preoperative Unit and PACU as well as providing the greatest amount of preparation space. With these results the team recommends adhering to the following standardized procedure when storing temporarily unused PTE:

1. When PACU staff delivers a stretcher or crib to the preparation bays, the PACU Transporters should first consult the Equipment Management Calculator to determine if the PTE will be needed for the current or next day.

2. If the PTE is not needed, the PACU Transporters should alert Patient Transport or Patient Equipment to remove it. If the PTE is needed, the PACU Transporters should first clean and dress the PTE, then transport it to an assigned Preoperative Unit bay if available. If there is no current assigned bay, the PTE should be moved to a vacant bay in the Preoperative Unit to reduce congestion in the cleaning area and PACU. The PACU Transporters currently annotate a laminated floor plan of the Preoperative Unit, to visually display which type of PTE (stretcher or crib) is stored in each bay. The team recommends storing this sheet in a centralized location where the Charge Nurse can also have access to the information to aid in assigning patients to bays.

3. When the PACU Transporters begin preparing PTE for the following day’s first cases, they should contact both of the off-unit storage locations to bring and/or remove PTE as determined by the Equipment Management Calculator.

*Reduce the amount of re-cleaning done by PACU Transporters.* Due to the various number of staff members responsible for cleaning PTE, the Preoperative Unit and PACU should implement a universal signal to visually indicate whether PTE is clean. The team recommends placing a sign that reads “CLEAN” on all PTE that has been cleaned to easily identify clean versus dirty equipment. With this process, the PACU Transporters can assume responsibility for cleaning PTE if no sign is in place. This recommendation will require informative training to all Nurses, Medical Assistants, PACU Transporters, and Unit Host working in the Preoperative and PACU units. This policy will reduce the frequency with which PACU Transporters re-clean a piece of equipment simply because they did not know if it was cleaned already, even if it appeared clean.
To decrease the frequency with which the PACU Transporters must re-clean PTE due to spots missed by the PACU staff, the hospital administration should provide training on proper cleaning procedures for the PACU staff. Specifically, written instructions for a standard cleaning process for both stretchers and cribs should be documented with sufficient visual aids to enable all staff to meet the standards for cleanliness necessary to pass inspection. Following a standard procedure will not only reduce the frequency of re-work by the PACU Transporters, but will also reduce the variability in time required to clean PTE. Furthermore, when the PACU is overwhelmed with patients, the staff member delivering the PTE to the PACU Transporters could indicate which steps in the cleaning process have been completed if they did not have time to clean the entire stretcher or crib before delivery.

*Utilize Ambassadors to escort discharged patients on wheelchairs*

To ensure wheelchairs are returned to the PACU after escorting patients, the team recommends two steps to control the wheelchair flow.

*Provide training and standardization for Ambassadors.* Since the Ambassadors have a vitally important role in returning wheelchairs to the PACU, the team recommends a more thorough training process for the Ambassadors. Part of this training should include instruction for obtaining and returning wheelchairs. Specifically, Ambassadors should never return to the PACU without a wheelchair. If they allow the patient to go to their car with a wheelchair, they should replace it with another in order to maintain as close to 10 on-hand wheelchairs at all times. Additionally, if the on-hand count ever drops below 5 wheelchairs, the Unit Host should be notified so that she may search for or order more. The Equipment Management Calculation tool also indicates the expected number of wheelchairs needed for patient escorts each hour, providing an additional means for effectively planning daily wheelchair use.

*Improve communication with off-unit storage units.* According to the Patient Equipment Garage Supervisor, orders placed to the Patient Equipment Garage (PEG) should include information regarding the patient that needs the equipment. Because the PACU Transporters often order multiple pieces in order to cover their needs throughout the day, the orders are given low priority and therefore are not delivered as soon as possible, leading to excessive lead times or unfulfilled orders. The PACU Transporters should always include the patient’s information in the crib order form to properly communicate to the PEG staff that the piece of equipment is needed right away. The team relayed the above information to the PACU Transporters in late March; however, there has not been sufficient data available to determine if any reduction in time and variability resulted. Additionally, the PACU Transporters should use the Equipment Management Calculator to determine the number of cribs to order each day. Furthermore, they should make the associated order determined by the tool each day at 9 AM to establish a reliable and consistent delivery relationship with the PEG.

**Expected Impact**

The CW PACU Equipment Team expects that if the proposed recommendations are followed, the CW Hospital PACU will realize a more efficient flow of Patient Transport Equipment through the perioperative process. These improvements in efficiency include: a reduction in
variability for the cleaning and storing process, quantification of the optimal amount of PTE needed, effective communication between the PACU and off-unit equipment storages, a reliable system to maintain wheelchairs to support escorting patients from the PACU, and a clearly defined process that considers restrictions and the potential for fines.

The Equipment Management Calculator will benefit the PACU by allowing the PACU Transporters to quantify the optimal balance of PTE needed to support patient flow. The tool will provide them with knowledge to forecast needs for PTE and increase communication with off-unit storage sites by allowing them to be more proactive in ordering equipment. This tool will in turn reduce the delay of patient flow that stems from unavailable PTE as well as congestion from excessive PTE that inhibits flow. Specifically, the team expects that use of the Equipment Management Calculator to accurately forecast PTE needs will enable the staff to reduce the non-value-added waiting time for stretchers, cribs, and wheelchairs by 1 hour each.

Through Ambassador and staff training and standardization of the escort process, the PACU will retain wheelchairs which will eliminate the need for the Medical Assistants and Unit Host to search for equipment and rather dedicate their time primarily to assisting patients. Furthermore, storing the wheelchairs in a room rather than along a wall in the PACU will help the staff proactively adjust to the changes in policy which will be necessary when the wall is removed for additional bays.

Overall, the proposed standardized procedures and recommended tools will reduce congestion, bottlenecks, and delays which will allow the PACU staff to meet scheduled operation times and allow for future OR expansion.
Appendix A: Data Collection Forms

Table A-1 displays the data collection form used for time studies of PTE preparation including cleaning and dressing with linens.

Table A-1. Equipment Preparation Time Data Collection Form

<table>
<thead>
<tr>
<th>Equipment Type (circle)</th>
<th>Arrival Time (hr:min)</th>
<th>Cleaning Time (sec)</th>
<th>Number of Cleaners</th>
<th>Dressing Time (sec)</th>
<th>Number of Dressers</th>
<th>Special Notes (staff positions, interruptions, other issues)</th>
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</thead>
<tbody>
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33
Table A-2 displays the wheelchair time study collection sheets used by the team

Table A-2. Wheelchair Time Study Sheet

<table>
<thead>
<tr>
<th>Wheelchair Activity</th>
<th>Clock Time</th>
<th>Notes (parking garage, delays, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PACU to Elevator</td>
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<td>Wait time for elevator</td>
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<td>Elevator ride</td>
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<td>Elevator to garage</td>
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<td>Say goodbye</td>
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<td>`Garage to elevator</td>
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<td>Wait time for elevator</td>
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<tr>
<td>Elevator ride</td>
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<tr>
<td>Elevator to PACU</td>
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</tbody>
</table>
Table A-3 displays the data collection form used for self-collection by the PACU Transporters and Unit Host.

Table A-3. Transporter Workload Study (2-sided)

Instructions for PACU Transporter Workload Study
This form is for use by the PACU Transporters and Unit Host to perform self-collection of data for the CW PACU Equipment Team. Each day, each PACU Transporter and Unit Host should record the frequency of tasks they performed. This data will be coupled with observed data and used to analyze the bottlenecks and delays that occur in the PTE flow process.

<table>
<thead>
<tr>
<th>Work Task</th>
<th>7:00 – 7:30</th>
<th>7:30 – 8:00</th>
<th>8:00 – 8:30</th>
<th>8:30 – 9:00</th>
<th>9:00 – 9:30</th>
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### Table A-3 (Continued)

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</table>
Table A-4 shows the wheelchair availability and recliner usage collection sheets designed for PACU Nurses to self-collect data.

Table A-4. Wheelchair and Recliner Usage Self-Collect sheets

**Instructions:**

**Wheelchair Court:** At the beginning of each hour, please count how many wheelchairs are available for use in the PACU. (Please make a note if you know of additional wheelchairs in the equipment closet)

**Recliner Usage:** Throughout the day, please add a tally for each recliner used by a patient or family member.

*Please put sheet in Kristie’s mailbox outside her office door at the end of the day*

<table>
<thead>
<tr>
<th>Time</th>
<th>Wheelchair Count</th>
<th>Recliner Usage</th>
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</thead>
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<td>8:00 am</td>
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Appendix B: Pictures of PACU Congestion

The two pictures below display the congestion and aisle blockages resulting from having more than needed PTE and insufficient storage space. These aisle blockages violate fire marshal regulations.