University of Michigan Health System
Programs and Operations Analysis

Analysis of Linen Utilization throughout Inpatient Units in the University Hospital

Final Report

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Introduction

The Laundry Department at the University of Michigan Health System (UMHS) supplies linen to support the entire Health System, Ancillary areas and College. Most recently, the addition of the Observation Unit, the addition of Cardiovascular Center (CVC), and increased patient activity has impacted the volume of linen to meet the demands. Production data shows an increasing trend of the amount of annual linen processed, thus increasing the total institutional expenses for linen. Based on the current trends, future years' linen consumption will also increase. In addition, the increase may add to the footprints of the environment because more utilities and chemicals will be needed to support the linen processing.

Some of the reasons that may be attributed to higher linen use are: lack of or inconsistent bed changing policy across the different inpatient units, and inappropriate utilization and material handling of linen. The IOE 481 Project Team, consisting of senior students from the Department of Industrial and Operations Engineering from the University of Michigan, was engaged to study the various bed changing practices across the inpatient units in the University Hospital and quantify the potential institutional savings, if any, that could be generated by improving the bed changing practices. Furthermore, through observations, the team identified the opportunities for improvements in utilization and material handling of linen. From the analysis, the team recommends the potential institutional savings that could be generated by improving the bed changing practices. The team also presents visual identifications of waste in linen use and handling in the inpatient units of the University Hospital. The purpose of this report is to present the team’s findings and recommendations on the study.

Background

The Laundry Department at UMHS washes linen for the entire hospital system that consists of approximately 850 beds. The most widely used linen in the entire hospital system includes bed sheets, pillowcases, blankets, towels, and gowns. Within the last 5 years, linen consumption has shown a steady increase from 7.1 million pounds to 8.2 million pounds, projected for the current fiscal year. The increase in linen consumption has also increased the total institutional expenses to support the linen. Furthermore, the increase is a concern for the environment because of the higher amount of utilities and chemicals that will be used.

According to the Facility Audit Report of UMHS' linen services by Standard Textile, Inc. (2009), UMHS used 1.07 lbs per adjusted patient day more than its peers in 2009. In response to this issue, the current utilization and material handling of linen in the hospital is being questioned. The two suspected causes of higher linen use are: lack of or inconsistent bed changing policy across, and inappropriate utilization and material handling of linen.

First, each unit has a different practice on the quantity and types of linen used on a bed, because nurses in each unit change patients' beds based on their experiences and how the nurses were first oriented. Moreover, nurses reported that it is a common practice for nurse aides to stock clean linen in patients’ rooms early in the morning. The nurses will use this linen to change the patient’s bed later in the day. From the nurses’ perspective, this practice eases their bed changing
task as the linen required is ready in the patients’ rooms during bed changing time. However, if a patient is discharged before bed changing time, the unused clean linen in the patient room is considered as soiled linen. This event was observed at the laundry where bundles of unused linen are often found in soiled bags at the laundry. From infection control perspective, the linen left in the patient room may not be used as it may have been contaminated. From a lean perspective, the linen left in the patient room is linen waste that adds to the linen consumption.

Second, linen is intended solely for patients' use and thus, usage of linen outside of patients’ purposes, such as towels used for mopping, is considered inappropriate. This problem is often observed in the hospital and it contributes to linen waste. Although some observation of wash cloths being used for rags was evident, currently a program of using colored rags is being implemented to alleviate this problem. Nonetheless, pockets of areas that use patient wash cloths for cleaning still exist.

To reduce the current linen consumption, it was requested of the team to perform a study on the inconsistent bed changing practices across all inpatient units in University Hospital and to quantify the potential, if any, institutional savings that could be generated by improving the bed changing practices. In addition, the team was asked to identify the opportunities for improvement in utilization and material handling of linen, including inappropriate uses of linen.

**Goals and Objectives**

The primary goal of this project was to identify the opportunities for improvements in the utilization and material handling of linen. Accomplishing this goal will raise the awareness of hospital staff on linen waste and inform any potential institutional savings that could be generated by improving the bed changing practices. To achieve the goal, the team examined various bed changing practices across all inpatient units in University Hospital through observations and interviews. The team also identified the waste of inappropriate utilization and material handling of linen across the University Hospital.

**Methods**

The team performed the following methods to collect and analyze data on the current practices.

**Literature Search**

The team researched a previous study to gain more insight on the topic. The research results have helped the team to understand the nature of the project and helped the team to determine the appropriate steps in collecting the data. An article titled “Now You See It, Now You Don’t: A Campaign to Stop Linen Loss” (2007) written by Janice Larson, Encompass Textiles and Interiors, focused on the ways the inpatient unit staff can participate in ensuring rational linen consumption. Some common practices, such as taking linen that is not immediately used into the patient’s room, may contribute to linen waste. The information gathered from the article has further shaped the team’s methods in observing linen utilization and handling around the inpatient units. A full reference for the article can be found in Appendix A.
Supporting Data Received
The following supporting data received from the project client were used to support the analysis and to quantify the potential institutional savings:
- 3Q 2009 Report by Solucient, LLC, comparing the performance of UMHS’ Laundry Department to that of comparable hospitals
- Weight and processing cost of all linen used in UMHS
- Actual Expenses Trends data from 2006 to projected 2010 by the Laundry Department
- Utility Analysis Data from July 2007 to February 2010 by the Laundry Department
- Reports for BedTracking Statistics from March 2009 to February 2010 by Environmental Services

Survey on Laundry Department’s Performance
The team sent two surveys on the Laundry Department’s performance electronically to the nurse manager of all inpatient units in the University Hospital. The purpose of the surveys was to determine:
- overall satisfaction of laundry services
- quality of linen provided
- existence of “green” initiative effort as it pertains to linen

Observation on Clean Linen Distribution Process
Accompanied by a stock keeper responsible for distributing clean linen to the clean holding rooms, the team observed the distribution of clean linen from the main laundry stock room in the hospital to three clean holding rooms in the University Hospital.

![Figure 1: Observation on clean linen distribution process](image)

The observation took four hours and provided insight into the current linen utilization in the inpatient units at the University Hospital.

Interview with Nurse Managers on Linen Usage
The team met with the nurse managers from three inpatient units and one surgical unit in the University Hospital. The interviews aimed to gather nursing perspectives regarding linen utilization throughout their corresponding unit. The interviews focused on:
- linen waste that was observed in their respective units
- feedback that the nurse managers might have on the current linen utilization
- performance of the laundry department
Interview with Nurse Technicians on Bed Changing Practices
The team interviewed the nurse technicians from 20 inpatient units in the University Hospital. The purpose of the interviews was to determine:
- the existence of written bed changing practice
- the quantity and types of linen used in the current bed changing practice
- the practice of stocking linen in patients’ rooms
- the range of bed changing time in each unit

The team also performed physical observations and counted the quantity and type of linen used for bed changing in at least 3 rooms of each 20 inpatient units to verify the accuracy of the interview results. The data collected from the observations were used to quantify the potential savings.

Comparison of Discharge Patient Data
Each inpatient unit has a patient discharge board that lists the patient names and the patients’ status of stay, either discharging or staying for the day. From the team’s interviews and observations, eight inpatient units stock linen for bed changing purposes early in the morning. The interview also indicates that the nurse technicians of the eight units do not stock linen for patients who are going to be discharged. The nurse technicians of the 8 inpatient units reported that they check the patient discharge board at 7:30 a.m. to determine which patients are going to be discharged that day. Therefore, the team collected patient initials from the patient discharge board at 7:30 a.m. from the 8 inpatient units that stock linen, and later compared them to the actual number of discharges that occurred that day. The team calculated the difference from the comparison, which is the number of discharges unknown to the nurses at 7:30 a.m. The number of unknown discharges was divided by the total discharges to obtain the proportion of the total number of discharges that are unknown to the nurse technicians at 7:30 a.m. The proportion was later used in quantifying the potential savings.

Observation of Clean Linen Left in Patient Rooms after Discharges
The team, assisted by Environmental Services personnel, observed rooms of newly discharged patients from the eight inpatient units that stock linen and collected data on the excess clean and unused linen left in the rooms of newly discharged patients. Any clean and unused linen found in the room would be considered as soiled linen due to infection control. The Environmental Services personnel notified the team of the rooms of newly discharged patients that would be cleaned by the housekeeping. Upon being notified, one of the team members immediately went
to the specified room and looked for two different aspects of clean linen left: linen used for the bed and any additional clean linen found in the rooms.

First, the team observed 30 rooms of newly discharged patients and looked for a stack of clean linen for bed changing and observed the condition of the patient bed. If a clean stack of linen for bed changing, as shown in Figure 3 below, was found or the patient bed was still neatly made, it was an indication that the nurse technicians were unaware of the patient being discharged and stocked linen early in the morning. The team considered that a set of linen used for a bed was being wasted in the rooms found in either of the previous two conditions. Whereas, a room observed with a messy bed was not considered as wasting linen, because the team could not accurately indicate whether the bed had been changed by the nurse technicians. Second, the team observed 18 rooms of newly discharged patients and looked for any clean and unused linen left in the room in addition to the linen for bed changing purposes, as shown in Figure 4.

![Figure 3: Linen stack in a patient room](image1.png)  ![Figure 4: Additional clean linen found](image2.png)

**Quantification of Potential Savings**

Based on the data collected, the team calculated the potential savings on the two aspects of clean linen left in the patient rooms after discharges: linen for bed changing purposes and any additional clean linen left.

First, the team calculated the proportion of the rooms of newly discharged patients that were observed to have clean linen for bed changing purposes. The proportion was multiplied by 2009’s total number of discharges of each of the 8 inpatient units based on the Reports for BedTracking Statistics provided by Environmental Services to obtain the annual number of discharges where clean linen for bed changing purposes are wasted. The result was then multiplied by the weight and processing cost of the set of linen used on the bed according to the respective bed changing practices of each unit. The final result indicates the potential savings in
terms of processing cost and weight of linen used for bed changing purposes. The equation of the potential savings calculation for each inpatient unit is shown below.

\[
Proportion = \frac{Number \ of \ Rooms \ with \ Clean \ Linen \ for \ Bed \ Changing \ Left}{30} \quad (1)
\]

\[
Potential \ Savings = Proportion \times Annual \ Discharges \times \text{Avg Weight of 1 stack of linen (or Avg Cost)} \quad (2)
\]

Second, the team analyzed the additional clean linen found other than that used for bed changing. The team then classified the data on two categories: no additional clean linen found in the room and additional clean linen found. Then, the team calculated the average weight and average processing cost of the clean linen found. The average weight and processing cost of each category was then multiplied by 2009’s total number of discharges based on the Reports for BedTracking Statistics provided by Environmental Services to indicate the potential institution savings. The equation of the potential savings calculation is shown below.

\[
Proportion = \frac{Number \ of \ Rooms \ with \ Additional \ Clean \ Linen \ Left}{18} \quad (3)
\]

\[
Potential \ Savings = Proportion \times Annual \ Discharges \times \text{Average Weight (or Average Cost)} \quad (4)
\]

The team also estimated the potential reduction in linen usage per adjusted patient days. The team’s calculation is shown in the equation below.

\[
Potential \ Reduction = \frac{Potential \ Savings \ in \ Linen \ Processed}{2009 \ Adjusted \ Patient \ Days} \quad (5)
\]

**Quantification of Environmental Impact**

The team averaged the usage per pound of linen processed for electricity, gas and water found in Utility Analysis data from July 2007 to February 2010 provided by the Laundry Department. The average usage per pound of each utility was then multiplied to the potential savings of linen processing calculated previously. The final results indicate the usage of each utility that can be saved from reducing the potential savings of linen processing.

\[
Environmental \ Impact = \text{Average usage per pound} \times \text{Potential savings of linen processing} \quad (5)
\]

**Observation of Inappropriate Utilization and Handling of Linen**

The team performed an approximately 10-hour observation each week for 4 weeks on the current utilization and material handling of linen. The observations covered all inpatient units in the University Hospital, including Operation Rooms and Intensive Care Units. The team also observed C.S. Mott for four hours to gain a different perspective on the linen utilization. The team stratified the observations between weekends and weekdays, and times of the day, such as morning and evening. While performing the observations, the team identified and photographed inappropriate utilization and handling of linen.
Findings and Conclusions

Based on the analysis of data collected and provided, the team determined the following findings and conclusions on the current bed changing practice, the current linen utilization across the inpatient units, the increase in linen consumption over the years and the potential savings that could be generated by improving the current practices.

Inconsistent Bed Changing Policy across Inpatient Units
From the interviews with the nurse technicians, the team found that 17 out of 20 inpatient units do not have a written standard on bed changing policy. The inconsistency of the bed changing practice is also indicated by the varying quantities and type of linen used on a bed.

Various Nurse Managers’ Perspectives on Current Linen Utilization
The nurse managers’ perspectives on the current linen utilization shared in the 4 interviews and survey results from 49 respondents are summarized as follow:
- Laundry Department’s performance has been improving in the last few years
- Overall, Laundry Department’s performance is 4.2 from a rating of 5
- Linen is taped and used as props
- Linen’s quality has been decreasing (e.g. blanket is too thin)
- Bath blanket’s size is not big enough to cover patients with a single blanket
- Washcloths are preferred to be folded
- Washcloths fall on the floor from plastic bag in clean holding rooms

Correlation between Increase in Linen Consumption and Adjusted Patient Days
The team analyzed the hospital linen consumption and adjusted patient days for the last four years from the “Actual Expenses Trends” data. The result of the analysis, as summarized in Table 1, shows that the increase in hospital linen consumption is directly proportional to the increase in the annual number of adjusted patient days.

<table>
<thead>
<tr>
<th></th>
<th>FY06</th>
<th>FY07</th>
<th>FY08</th>
<th>FY09</th>
</tr>
</thead>
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<tr>
<td>Linen usage (lb)</td>
<td>6,876,231</td>
<td>6,977,342</td>
<td>7,358,253</td>
<td>7,527,512</td>
</tr>
<tr>
<td>Adj pat days</td>
<td>432,297</td>
<td>455,096</td>
<td>470,156</td>
<td>486,472</td>
</tr>
<tr>
<td>lb/adj pat days</td>
<td>15.91</td>
<td>15.33</td>
<td>15.65</td>
<td>15.47</td>
</tr>
</tbody>
</table>

For further analysis, the team calculated and compared the linen consumption per adjusted patient days for the last four fiscal years to the benchmark given by Standard Textile, Inc. The results were graphed as shown in Figure 5 below.
Figure 5: UMHS has been using more linen per adjusted patient days than comparable hospitals for the last four years

(Based on Actual Expenses Trends Data FY06 – FY10 and Facility Audit Report 2009 by Standard Textile, Inc.)

Figure 5 shows that the linen consumption per adjusted patient days is fairly consistent within a close range throughout the last four years, with an average of 15.59 and a standard deviation of 0.25. Compared to Standard Textile’s benchmark for comparable hospitals, UMHS has been using 1.19 pounds per adjusted patient days more than its peers in average throughout the four years.

Communication Gap in the System

Figure 6 below shows the process flow of nurse technicians in deciding to stock linen for bed changing at 7:30 a.m. until the physicians round at 9 a.m.

In the interviews, nurse technicians reported that they do not stock linen in a patient room if they know the patient is going to be discharged that day. However, our observation on discharge patient data for two days concluded that 95% of the discharges every day are unknown to the nurse technicians at 7:30 a.m. Therefore, communication gap exists in the system because nurse technicians stock linen in patient rooms at 7:30 a.m., but attending physicians, who decide whether a patient is staying or discharging, only perform their rounds after 9 a.m. This communication gap in the system may result in clean and unused linen left in discharged rooms.
Potential Savings on Bed Changing Practices
The team’s observation on newly discharged rooms shows that 58% of discharged patient rooms have clean and unused linen for bed changing left. Based on this proportion and the historical data of last year’s number of discharges for the eight units which stock linen, the team calculated the number of discharges in which clean and unused linen for bed changing was wasted. From the bed changing practice on the eight inpatient units, and the weight and processing cost of each type of linen, the team concluded that 103,176 pounds of linen processed are wasted and there is a potential institutional savings of $57,779. As a result, the linen usage per adjusted patient day can be reduced by 0.2 lbs. More detailed data analysis can be found in Appendix B.

Potential Savings on Additional Clean Linen Left
The team’s observation indicates that 44% of the newly discharged rooms do not have any additional clean linen left, while the remaining 56% of the rooms have additional clean linen found. The average weight and proportion of each are summarized in Figure 7 below.

![Figure 7: 56% of newly discharged rooms have additional clean linen left](image)

(Based on IOE481 Team 4’s observation on 18 rooms of newly discharged patients in March 2010)

Based on total number of discharges in 2009 from Reports of BedTracking Statistics by Environmental Services, the team calculated the potential savings as summarized in Table 2 below.

<table>
<thead>
<tr>
<th>Percentage (%)</th>
<th>Average Weight (lb)</th>
<th>Potential Savings (lb)</th>
<th>Cost per lb ($)</th>
<th>Potential Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Linen Found</td>
<td>56</td>
<td>3.01</td>
<td>165,458.26</td>
<td>0.56</td>
</tr>
</tbody>
</table>

| Total          | 165,458.26         | 92,656.62              |

If this practice can be improved, there is a potential reduction of 165,458 lbs of linen processing and the institution may potentially save $92,656.62. Furthermore, the linen usage per adjusted patient days can be reduced by 0.35 lbs.
Potential Reduction in Environmental Impact

Based on the survey results from 6 respondents, 50% of the inpatient units have an active “Green” initiative effort as it pertains to linen. From the previous analysis, the total potential savings on linen processed from clean linen for bed changing left and additional clean linen found is 268,634 lbs. The team then calculated the potential savings on utilities usage, as summarized in Table 3 below, if a reduction in 268,634 lbs of linen processing is achieved.

Table 3: Potential savings in linen processing may reduce the usage of 1,020 ccf of water, 36,373 ccf of gas and 9,832 kwh of electricity

<table>
<thead>
<tr>
<th>Average Usage</th>
<th>Potential Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (ccf/lb)</td>
<td>0.0023 1,020.81</td>
</tr>
<tr>
<td>Gas (ccf/lb)</td>
<td>0.0834 36,373.09</td>
</tr>
<tr>
<td>Electricity (kwh/lb)</td>
<td>0.0225 9,832.03</td>
</tr>
</tbody>
</table>

Unorganized Clean Holding Rooms

The team observed that some clean holding rooms are less organized than others, as displayed in Figure 8 and Figure 9 below.

Figure 8 shows that linen on the shelf can be very messy as compared to the shelf in Figure 9. In the interviews, most nurses reported that they prefer not to use unfolded and messy linen for patient purposes because the linen looks used and may give a bad impression to the patients. Therefore, messy linen depicted in Figure 8 will probably be considered as soiled linen even though it is clean. Moreover, clean washcloths were observed on the floor in Figure 9. When the nurses take washcloths from the plastic bag of washcloths on the top shelf, some washcloths may fall to the floor. In comparison, the clean holding room in the Figure 8 uses a tote to store the washcloths from the big bag. The nurses take the washcloths from the totes and thus, eliminate
washcloths falling off to the floor. In addition to washcloths, messy pillow cases were also often observed on the shelves of some clean holding rooms. However, the team observed that the use of totes would also help to better organize the pillow cases.

The hospital regulation states that the doors of clean holding rooms are always supposed to be closed for infection control. However, the team observed that most inpatient units in the University Hospital do not follow the regulation. The open doors of clean holding rooms allow access to visitors and patients to take linen by themselves. From an infection control perspective, this practice may contaminate the clean linen stored in the clean holding rooms. Moreover, the patients and visitors tend to make the linen stored messy because they are not familiar with the types of linen. In comparison, the team identified that the clean holding rooms at C.S. Mott are always locked and thus, only unit staff can enter. As a result, the linen on the shelves is more organized than that of University Hospital. The team also observed that the labeling the shelves may differentiate the types of linen nurses need and avoid the nurses from taking the wrong linen. See Appendix C for more photographs of unorganized clean holding rooms.

Inappropriate Utilization of Linen

The team found some practices in UMHS in which linen is inappropriately used. Some of the inappropriate practices, as shown in Figure 10 and 11 below, include washcloths used as door stopper and towels used as floor mat.

![Figure 10: Washcloths used as door stopper](image1.png)  ![Figure 11: Towels used as floor mat](image2.png)

Linen, such as towel and blankets, is also often used as props in some units in the hospital. Inappropriate utilization of linen may damage the linen and contribute to higher institutional expense to support buying new linen. For instance, taping blanket to be used as props, as shown in Figure 12, often leaves permanent glue stain on the linen that cannot be cleaned by washing. See Appendix D for more photographs of inappropriate utilization of linen.
Recommendation

Based on the team’s findings and conclusions, the potential annual institutional savings to the current practices sum up to $150,435 and there is a potential to reduce linen processing by 268,634 lbs. Moreover, there is a potential reduction in linen usage per adjusted patient days by 0.55 lbs. Potential reduction in linen processing may also lead to reduction in the usage of 631 ccf of water, 22,395 kwh of electricity and 6,055 ccf of gas. The team has developed recommendations to improve the current bed changing practices and general recommendations for linen waste around the inpatient units.

Bed Changing Practice

The team recommends nurses to change beds only for the patients who are definitely staying. The patients who are unsure of being discharged can wait for their bed changing after the physicians rounds. This practice will ensure that no clean linen for bed changing is being wasted.

The team also encourages the nurse technicians to stock linen for patient purposes in the available nurse servers outside the patients’ rooms. This practice will avoid rewashing the clean linen left in the rooms after the patients are discharged.

General Improvements in Linen Waste

The team recommends establishing a green partnership between Nursing and Laundry department to work together in implementing green practices throughout the inpatient units. The two departments can build green campaigns in the inpatient units to raise the awareness of the environmental impact of linen waste.

The team recommends inpatient units to secure their clean holding rooms by installing code door lock to avoid unauthorized access. Furthermore, the team also recommends using storage holdings, such as totes, to organize small linen items, such as washcloths and pillowcases, to avoid them being dropped on the floor. These recommendations will reduce the amount of rewashing clean linen.
**Expected Impact**

Implementing these recommendations should result in the following outcomes:

- Reduced annual linen consumption, which will also lead to reduced institutional expenses to support the linen
- Less footprints of the environment due to fewer usage of chemicals and utilities
- Improvement in UMHS’ linen consumption as compared to its peers from the current 15.47 lbs per adjusted patient days to approximately 14.92 lbs per adjusted patient days
- Increase in inpatient unit staff awareness on linen waste and its impacts
Appendix A: References

### Appendix B: Calculation of Potential Savings on Bed Changing Practices

<table>
<thead>
<tr>
<th>Units that Stock Linen for Bed Changing</th>
<th>Historical Annual Patient Discharge[^2]</th>
<th>Waste Rate</th>
<th>Number of Discharge Waste</th>
<th>Potential Saving (lb)</th>
<th>Cost per lb ($)</th>
<th>Potential Savings ($)</th>
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<tr>
<td>1</td>
<td>4,081</td>
<td>0.58</td>
<td>2,367</td>
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<th>Pounds of One Stack (lbs)</th>
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[^2]: Historical annual patient discharge data is used to calculate potential savings.
Appendix C: Additional Pictures of Unorganized Clean Holding Rooms

- Pillow cases without totes
- Pillow cases in totes
- Unlocked clean holding rooms
- Locked clean holding rooms
Appendix D: Additional Pictures on Inappropriate Utilization of Linen

Towel used as pillow

Towel used as a mat on a maintenance cart

Glue residual on a bedspread