Applying LEAN Six Sigma Strategies to Manage Missing Medications in a Tertiary Acute Care Hospital

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2015-2016
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In partial fulfillment of the Hospital Pharmacy Residency Program
Applying LEAN Six Sigma Strategies to Manage Missing Medications in a Tertiary Acute Care Hospital

2015-2016 Residency Project

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8/26/2016
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Abstract

Background:
Despite implementation of automated dispensing cabinets (ADCs) at Kingston General Hospital (KGH), there continue to be reports of medications unavailable at administration time (missing medications). This can result in a significant barrier to providing optimal patient care.

Objectives:
To determine the root causes of missing medications at KGH.
To apply LEAN Six Sigma strategies to implement and measure an opportunity for improvement related to inpatient drug distribution.

Methods:
We investigated 83 medications reported missing to pharmacy in December 2015. Analyses of these findings were utilized to select a pharmacy process change expected to improve availability of medications at the point of care. A pilot intervention was tested on three patient care units with a descriptive and quantitative determination of missing medications compared pre and post-change.

Results:
The leading reason for missing medications was “nurse was unable to locate” (medication was actually on the Nursing Unit) accounting for 27.70% (n=23). Of medications that were truly missing, one-third were related to ADC patient-specific bins (n=20). After implementation of a software configuration and key inventory changes to ADCs, the proportion of missing medications from the three pilot wards relative to the entire hospital decreased significantly, from 23.93% to 12.36% (p=0.0357). Analyses were limited by small sample size.
Conclusion:
Missing medications are part of a complex drug distribution and storage system in hospitals with decentralized dispensing models. Using a LEAN Six Sigma approach to select and implement a process change was successful in resolving the targeted cause of missing medications. Effective expansion of this initiative would require further investment of pharmacy resources and continuous re-evaluation by involved staff.

Keywords:
medication
LEAN
Six Sigma
dispensing cabinet

Word Count Abstract: 265

Word count manuscript text (without abstract or references): 3152

Word count (references, tables and figures): 3633
Introduction

A missing medication occurs when a drug supplied from pharmacy is unavailable for the nurse to administer to the patient at the time it is scheduled or required. Missing medications create a significant barrier to operational efficiency for both pharmacy and nursing staff, in addition to jeopardizing patient safety and quality of care.

The use of automated dispensing cabinets (ADCs) in patient care areas to support a decentralized dispensing model has been shown to increase patient safety and improve timely access to medications. [1] Specifically, ADCs have been shown to decrease missing medications in hospital distribution systems. [2] Undoubtedly, the infrastructure of the hospital’s network of medication distribution programs, equipment and staff must be aligned to operate synchronously to achieve these intended results.

Kingston General Hospital (KGH), a 440 bed tertiary acute care teaching hospital, recently converted from a centralized unit dose dispensing model to the use of ADCs on all nursing units. With this change, staff have encountered multiple challenges and have had to adapt processes to minimize disruptions to the distribution chain and preserve the timely, accurate supply of medications. However, at KGH, nursing and pharmacy departments continue to cite missing medications as a concern.

There is a paucity of data reporting strategies to optimally manage hospital distribution systems to minimize missing medications. LEAN and Six Sigma are two complementary systematic process improvement tools originating from the manufacturing industry (Figure 1). [3] [4] LEAN Six Sigma strategies have been widely demonstrated to be successfully transferrable to health care settings, including the medication use system. [3] [5] [6] [7]
tools provide a framework with which to solve complex process problems in a multifactorial environment. In addition to LEAN projects having been reported to be successful to address missing medications, KGH has previously applied LEAN principles to numerous other initiatives in the hospital. These projects have achieved cost savings and standardized workflow in support of improved patient care.

This project used LEAN Six Sigma methodology to assess the distribution processes at our hospital. Its primary objectives were to establish the root causes of missing medications and determine whether applying LEAN Six Sigma continuous improvement tools would subsequently decrease the number of missing medications at KGH.

Methods

Refer to Figure 2 for a flow diagram outlining of the methods of the study. A description of the format of automated dispensing cabinets at KGH and a complete set of definitions of key terms are respectively found in Appendices A and B.

Baseline Investigations

A prospective analysis of missing medications reported to pharmacy was conducted at Kingston General Hospital the week of December 14 -18, 2015 over variable 8-hour blocks within pharmacy operating hours (0730h to 2200h). Results of this analysis were then used to devise the subsequent interventions, data collection, and measurements of the study.

Missing medications were tracked in real-time using the Missing Medication Documentation Form (Appendix E). The following data were collected from telephone discussion and/or direct encounter with pharmacy and nursing staff: date, time, technician accepting request, nursing unit, medication name, strength and dosage form, if the medication was for a new order (entered < 24 hours previous), unit or multi-dose format, formulary status,
cost per dose, and whether the medication was missing on >1 consecutive occasion (“repeat” missing). The primary reason for the medication being missing was assigned one of eight predefined categories by the primary investigator. A sample data entry sheet can be found in Appendix F.

Medications were included in the study only if they were dispensed for inpatients and the order had been received and entered into the pharmacy information system. Controlled substances and medications prepared by the pharmacy’s centralized intravenous admixture system (CIVAS) were excluded since the distribution processes regulating these medications differ substantially and would require separate assessment of interventions. Requests for refills of depleted multi-dose medications were not considered to be missing medications.

The principal investigator, supported by stakeholder representatives, conducted a series of meetings to identify and confront the primary distribution-related causes for missing medications. Preliminary work involved examining the steps of Six Sigma and principles of LEAN methodology applied to healthcare in conjunction with critical observation of pharmacy and nurse personnel performing duties. Two SIPOC (Suppliers, Inputs, Process, Outputs, Customers) Diagrams (Figures 6a and 6b) were constructed to identify all the essential elements of the processes in question prior to conducting a root cause analysis. The analysis (also known as Cause and Effects, Fishbone, or Ishikawa diagram) was completed for the top three root causes under the primary identified cause (Figures 7a-c). Possible process improvements were brainstormed and plotted on PICK (Possible, Implement, Challenge, Kill) charts to identify solutions that would generate the highest impact with minimal required effort and/or resources (Figures 8a-c).

Interventions
Two key interventions were applied to a subset of nursing units (Connell 9 (C9), Connell 10 (C10), and Kidd 7 (K7); also referred to as the “experimental group”) over February – March 2016 as a pilot Plan-Do-Study-Act (PDSA) cycle. The first intervention applied a setting in the ADC software program that automatically assigns items defined within equivalent dose groups into the patient-specific bin. The second intervention involved standardizing both cabinets on the nursing unit and expanding the ADC stock to include a greater number of dosage strengths for commonly used medications. Specific details of the interventions and their rationale can be found in Appendix C.

**Comparative Retrospective Analysis**

After the interventions were complete, a retrospective quantitative analysis was conducted comparing the proportion of missing medications pre-intervention (December 2015), and post-intervention (March 2016). These missing medications were subject to the same definition and inclusion criteria as in the baseline prospective investigations.

For the comparative retrospective analysis, the data was collected from the pharmacy information system, extracted as the “Timeline Report” and included the following: date, time, patient name, medication name, strength, dosage form, dose and dosing schedule, nursing unit location, and quantity charged.

**Reassessment**

As a continuous quality improvement project, data was collected to assess the effectiveness of each intervention according to Plan-Do-Study-Act methodology. To assess the effect of the first intervention, the pharmacy manager recorded the number of patient-specific items that were assigned pre and post-change and computed the additional workload created for technicians filling patient-specific bins, in addition to tracking missing medication calls regarding these items (Figure 9).
To assess the effect and sustainability of the second intervention, the cabinets on experimental nursing units were appraised by assessing congruence of the floor stock assigned to each cabinet three months after instituting the changes.

Representing “customers” of the pharmacy’s operations, twelve nurses (eight who work routinely in the experimental group units and four from “control” units) were informally surveyed post-interventions to gage perceptions on missing medications, specifically with respect to automated dispensing cabinets and patient-specific bins. Open and closed-ended questions were used to guide the brief survey to capture themes and to assist in planning for continuous improvement of this project. The data sheet can be found in Appendix G.

Statistical Analysis

Descriptive statistics including frequencies and percentages were used to analyze data from the baseline investigations. The categorical data were analyzed by cross-tabulations to test for associations with the collected variables, using the Pearson Chi-Square or Fisher’s Exact test as appropriate. The retrospective comparative analysis utilized the Pearson Chi-Square test to compare the number of missing medications (relative to the affected nursing units vs. entire hospital) pre and post-intervention. The a priori p-value for statistical significance was 0.05, and the study aimed to achieve a 50% relative decrease in the measure. Statistical analyses were performed by the hospital statistician using IBM SPSS version 23 for Windows (Armonk, New York, 2015). Descriptive statistics and qualitative summaries were used to report data from the reassessment phases of the continuous improvement cycles.

Approval for the study was granted by Queens University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board (HSREB) in conjunction with the Residency Advisory Committee (RAC) for the Kingston General Hospital Pharmacy Residency Program.
Any protocol changes, including the plan for interventions and comparative retrospective analysis, were within the confines of the ethics submission and approved and documented in the Project Scope Revision Log (Appendix D). There are no conflicts of interest among any of the study investigators to describe.

Results

Baseline Investigations

A total of 83 missing medications identified by a convenience sample were investigated during the baseline data collection period (Table 1). Of these, 25 (30.5%) were not actually missing and located on the inpatient unit. For truly missing medications, 20 were “not in the patient-specific bin”, 14 were due to patient transfer, and 7 were due to errors in pharmacy order entry (Table 2, Figure 5). The nursing units most commonly implicated for missing medications included intensive care unit (ICU) and general medicine units (Figure 4); with 17% of all documented requests originating from Kidd-2 ICU (K2ICU), 11% from Davies-4 ICU, 12% from C10, and 10% from C9 medicine floors. The time block with the highest collection of missing medications was from 0730h to 1029h in the morning (Figure 3). Multivariate analyses failed to reveal any meaningful significant differences among the time blocks, with the exception of repeat missing medications (those missing on two or more consecutive occasions, at least 4 hours after pharmacy had re-dispensed the medication), which were more commonly encountered later on in the day. Seventy percent of repeat missing medications occurred after 1630h. However, these incidental findings must be interpreted with caution given small numbers and since the convenience sample of missing medications was not evenly distributed across time blocks. Repeat missing medications were also more likely to be truly missing (two-sided $p = 0.028$) which was consistent with observed staff concerns of some medications being persistently reported missing. Although it was not statistically significant, there was a greater proportion of
multi-dose items, such as inhalers, eye drops, nose sprays, and topical preparations that were “false missing” (41.2%) compared with unit-dose items (27.7%).

Comparative Retrospective Analysis

There were a total of 117 missing medications meeting inclusion criteria for the five-day pre-intervention data collection period (Table 3). Of these, 28 medications were missing from C9, C10, and K7 nursing units (“experimental group”). At the post-intervention data collection period, there were a total of 89 missing medications, indicating a lower absolute number overall (Figure 10). Post-intervention, only 11 missing medications were from the experimental group nursing units. Therefore, the proportion of missing medications originating from the experimental group significantly decreased from 23.9% to 12.36% after the interventions, representing a relative 48.3% decrease (p=0.0357).

Of the twelve nurses surveyed, ten (83.3 %) had overall positive feedback about automated dispensing cabinets and did not perceive missing medications to be problematic for their workflow. Five nurses (41.7 %) noticed that missing medications were diminished compared to six months ago, and nine (75.0 %) felt comfortable using the “select equivalent meds” feature from the automated dispensing cabinets in order to retrieve the most suitable dose for the patient. Noted themes were consistent with nurses perceiving fewer requests to pharmacy for missing medications, and that if missing medications did occur, they tended to be with patient-specific items. Of note, nurses had concern that pharmacy is simply not fast enough for processing new orders that require initial doses sent to the floor, signalling the value of automated dispensing cabinets for timely medication administration.
Data indicated excellent congruence of floor stock three months after optimization, with 88% similarity between A and B cabinets (Table 4) and 95% similarity for individual cabinets (Table 5).

Discussion

This study identified that missing medications most commonly occur due to poor storage practices, knowledge gaps among nursing staff, patient transfers, limitations of pharmacy information systems, and pharmacy errors at our hospital. The fact that a substantial percentage of missing medications were not truly missing suggests potential deficiencies in the storage and procurement of medications (especially multi-dose items) on nursing units. The leading drug-distribution causes were related to order entry practices and poorly optimized configuration of patient-specific bins in the ADCs, which was consistent with reports from pharmacy technician staff in the initial planning stages of the project. The baseline investigations enabled not only observation, but immersion into the interconnected processes between nursing and pharmacy departments affecting missing medications. We were able to collect several characteristics of missing medications from the entire hospital to narrow our focus. Of all patient care areas, K2ICU produced the greatest proportion of missing medications; which may be due to the unique set up of six individual dispensing cabinets throughout the unit, which increases the complexity of supplying medications. The high proportion of missing medications from C9 and C10 medicine floors is likely attributed to larger patient loads in addition to extensive medication profiles in this patient population. Owing to the adequate sample size of the baseline analysis and thorough follow-up of each missing medication in real-time, we can be confident that the results reflect the distribution of true causes of missing medications at KGH. Despite this, causes of missing medications are difficult to classify, since the primary cause for the missing medication
may depend on other factors or reasons. Interpretation of the cause under a single label is thus subject to bias. In future studies, devising a systematic and validated scheme for classification of missing medications is recommended. We recognize some limitations to the baseline investigational analysis; we did not track missing medications on weekends, and the convenience sample resulted in non-uniform tracking throughout the day.

The retrospective comparative analysis demonstrated a significantly lower proportion of missing medications originating from the three experimental group nursing units, suggesting that the improvements were effective in reducing the intended measure of missing medications. Considering the low baseline numbers for missing medications at KGH, our positive findings may be valid.

However, the measure for missing medications (Timeline Report) used in this retrospective analysis has several limitations. First, the report does not capture missing medications from automated dispensing cabinet depletion, which may commonly occur after weekends, due to insufficient pharmacy inventory, or if there is a surge in the demand for a particular medication. Technological limitations of the report’s data capacity limited its inclusion to missing medications for orders created 60 days prior to the run date. This excludes some older orders which may have been reported as missing medications. However, older orders are less likely to become missing medications, and since our measure was computed as a proportion, this is not expected to significantly impact the results.

The major limitation of the retrospective analysis and PDSA cycle was the small sample size. Substantial manual manipulation of the report was necessary in order to obtain data, and for this reason, we were limited to a 5-day comparison period for missing medications. It is not known whether expanding our measurement would change the results. Developing a more
accurate quantitative measure of missing medications is desirable and suggested for future studies.

By nature of the pre-test post-test design and the considerable time elapsed between measurements, the significant finding in the retrospective analysis is also subject to bias. The data are vulnerable to becoming skewed from exogenous events, such as minor changes in procedures or staff. In the case of this study, minor technology glitches with the pharmacy information system were addressed along the way, potentially decreasing missing medications in patient-specific bins. Therefore, although we were able to demonstrate a significantly lower proportion of medications on the experimental group floors, we cannot exclude the possibility of a Type I Error. Finally, our results do not apply to missing medications from intravenous admixtures or controlled substances, which must be evaluated separately, but still contribute to the operational barriers experienced by pharmacy and nursing departments.

Reassessment of the interventions revealed that the floor stock changes remained stable after the implementation of floor stock optimization at three months (5% deviation on average for each cabinet). Most of the discrepancies were noted to be reflective of controlled substances, which follow specific pharmacy policies for addition to ADCs, and as a result of a hospital-wide changeover of electrolyte supply.

The ADC charge pharmacy technician estimated the floor stock optimization required 15 hours of dedicated time to complete per inpatient unit. For average technician wages at Kingston General Hospital, this would translate into a human resource cost of approximately $400 per nursing unit. This does not include the potential cost of necessary equipment (e.g. additional ADC drawers) as it is applicable, or the cost attributed to maintaining inventory of ADCs once optimized. Given the weighted issue of inconsistent floor stock among ADCs identified in the
root cause analysis, this suggests that our interventions are sustainable and within reasonable required resources to maintain.

Recommendations for Future Research

Owing to time constraints, not all elements of the Six Sigma steps were completed; specifically, the value stream map for the ideal state of the improved pharmacy process system was not constructed. This would have served as a valuable reference tool for staff to maintain standardization and efficiency, and would be recommended for further development in the quality improvement initiative for missing medications at KGH.

Given the results of the pilot study and positive feedback from pharmacy and nursing staff, the project team agreed to accept and continue the changes implemented on the three experimental floors in the study. We recommend that other nursing units be considered for the same interventions, particularly those with dual cabinets and with a high volume of missing medications. It should become the duty of a dedicated staff member trained in the system of automated dispensing cabinets and pharmacy information systems who monitors and implements these changes.

Finally, subsequent opportunity analysis of other leading causes of missing medications using LEAN Six Sigma approaches is strongly encouraged for future projects. Each root cause of missing medication would require a unique assessment. Nurse education, training, and reorientation strategies are imperative to ensure successful flow of medication to the patient. In this case, a prospectus outlining the retrieval of a medication from the automated dispensing cabinet using the “Select Equivalent Med” function shall be distributed as the pharmacy-led contribution. Similarly, pharmacy technician training on order entry and standardization of this process is likely to reduce missing medications by reducing errors and supporting seamless
integration of information systems. A mandatory information session will be held to standardize practices for pharmacy order entry that minimize missing medications.

Conclusion

Missing medications are part of a complex drug distribution system at Kingston General Hospital. A consistent and readily available supply of medication is dependent on the interface of technology, inventory control, pharmacy and nursing staff, and defined procedures. By identifying the leading root causes of missing medications at our hospital, LEAN and Six Sigma theorems provided a systematic approach to evaluate and introduce effective opportunities for improvement. Adequate investment of resources and continued re-evaluation of practices are necessary to sustain these successes and ensure they remain relevant. Ultimately, this strategy has the potential to decrease missing medications and improve satisfaction of nursing staff and patients.
Acknowledgements

Wilma Hopman, Statistician, for providing data analysis

Tammy Irish, ADC Charge Technician, for assistance with the interventions

Ron Koob, for assistance with Pharmacy Informatics

Veronique Briggs and Alan Smith, Pharmacy Co-Directors, for their ongoing support and assistance with implementation of interventions

All KGH Pharmacy Technicians, for assistance with collection of data
References


Tables

1. Demographic Characteristics of Medications (Baseline Investigations)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Frequency (n=83)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not truly missing</td>
<td>25</td>
<td>30.5</td>
</tr>
<tr>
<td>New Order</td>
<td>24</td>
<td>28.9</td>
</tr>
<tr>
<td>Multi-dose item</td>
<td>18</td>
<td>21.7</td>
</tr>
<tr>
<td>Repeat missing</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Non-formulary item</td>
<td>7</td>
<td>8.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location (Nursing Unit)</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidd-2 ICU</td>
<td>14</td>
<td>16.9</td>
</tr>
<tr>
<td>Connell 10</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Davies-4 ICU</td>
<td>9</td>
<td>10.8</td>
</tr>
<tr>
<td>Connell 9</td>
<td>8</td>
<td>9.6</td>
</tr>
<tr>
<td>K6</td>
<td>6</td>
<td>7.2</td>
</tr>
<tr>
<td>K9</td>
<td>6</td>
<td>7.2</td>
</tr>
<tr>
<td>K3</td>
<td>5</td>
<td>6.0</td>
</tr>
<tr>
<td>C3 + C3(short stay)</td>
<td>5</td>
<td>6.0</td>
</tr>
<tr>
<td>K7</td>
<td>4</td>
<td>4.8</td>
</tr>
</tbody>
</table>

2. Primary Reasons for Missing Medications (Baseline Investigations)

<table>
<thead>
<tr>
<th>Identified Primary Reason</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>nurse unable to locate</td>
<td>23</td>
<td>27.70%</td>
</tr>
<tr>
<td>not in patient-specific bin</td>
<td>20</td>
<td>24.10%</td>
</tr>
<tr>
<td>patient transfer</td>
<td>14</td>
<td>16.90%</td>
</tr>
<tr>
<td>ADC wardstock depleted</td>
<td>8</td>
<td>9.60%</td>
</tr>
<tr>
<td>pharmacy order entry issue</td>
<td>7</td>
<td>8.40%</td>
</tr>
<tr>
<td>pharmacy inventory issue</td>
<td>5</td>
<td>6.00%</td>
</tr>
<tr>
<td>could not identify</td>
<td>4</td>
<td>4.80%</td>
</tr>
<tr>
<td>pharmacy dispensing error</td>
<td>2</td>
<td>2.40%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>83</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
3. Comparative Retrospective Analysis Summary Results

<table>
<thead>
<tr>
<th>Number of Missing Medications (%)</th>
<th>Pre-Interventions December 2015</th>
<th>Post-Interventions March 2016</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group (C9, C10, K7)</td>
<td>28 (23.93)</td>
<td>11 (12.36)</td>
<td>39</td>
</tr>
<tr>
<td>Control group (All other floors)</td>
<td>89 (76.07)</td>
<td>78 (87.64)</td>
<td>167</td>
</tr>
<tr>
<td>Total</td>
<td>117</td>
<td>89</td>
<td>206</td>
</tr>
</tbody>
</table>

\[\chi^2 = 4.410; \ p = 0.0357\]

4. Congruence between A and B cabinets on a unit post-interventions

<table>
<thead>
<tr>
<th>% Similarity of Floor Stock A vs B cabinets</th>
<th>March 2016 (At completion of Interventions)</th>
<th>June 2016 (3 months after completion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K7</td>
<td>89.0</td>
<td>90.4</td>
</tr>
<tr>
<td>C9</td>
<td>88.8</td>
<td>84.3</td>
</tr>
<tr>
<td>C10</td>
<td>88.7</td>
<td>87.7</td>
</tr>
</tbody>
</table>
5. Congruence between individual cabinets post-interventions

<table>
<thead>
<tr>
<th>% Similarity of Floor Stock</th>
<th>Individual Cabinets</th>
<th>June 2016 (3 months after interventions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K7A</td>
<td>95.3</td>
<td></td>
</tr>
<tr>
<td>K7B</td>
<td>98.5</td>
<td></td>
</tr>
<tr>
<td>C9A</td>
<td>95.0</td>
<td></td>
</tr>
<tr>
<td>C9B</td>
<td>95.0</td>
<td></td>
</tr>
<tr>
<td>C10A</td>
<td>91.7</td>
<td></td>
</tr>
<tr>
<td>C10B</td>
<td>95.5</td>
<td></td>
</tr>
</tbody>
</table>
Figures

Figure 1: LEAN Six Sigma Framework

**LEAN Focus on value-added solutions**

- **Define**: What is the problem?
- **Measure**: How are we doing?
- **Analyze**: What are the sources of system failure?
- **Improve**: Which solution(s) will be implemented?
- **Control**: How can we sustain the improvements?

**Plan** → **Do** → **Study** → **Act**
Figure 2: Map of Methods

Baseline Prospective Investigations
DECEMBER 2015

Process Mapping, Root Cause Analysis, Intervention Analysis
JAN 2016

INTERVENTIONS
(K7, C9, C10 Nursing Units)
FEB - MAR 2016

1. Software Setting for PSB
2. Standardization of ADC Floor Stock

Comparative Retrospective Analysis
Proportion of Missing Meds

Pre
DECEMBER 2015
Post
MARCH 2016

REASSESSMENT

Workload Additional PSB Items
FEBRUARY 2016
Customer Experience Nurse Survey
APRIL 2016
Sustainability Floor Stock Deviation
JUNE 2016

PSB: Patient-specific bin; ADC: Automated dispensing cabinet
Figure 3: Baseline Investigations, Time of Recorded Missing Medications

![Time of day medications went missing for tracked items](image)

Figure 4: Baseline Investigations, Missing Medications by Nursing Unit

![Missing Medications by Nursing Unit](image)

K = Kidd, C = Connell, B = Burr, D = Davies, ICU = Intensive Care Unit
Figure 5: Baseline Investigations, Reasons for Missing Medications

Identified Primary Reason for Missing Medications

- Nurse unable to locate 28%
- Not in patient-specific bin 24%
- Omnicell wardstock depleted 10%
- Pharmacy inventory issue 6%
- Pharmacy order entry issue 8%
- Could not identify 5%
- Pharmacy dispensing error 2%
- Patient transfer 17%
- Pharmacy inventory issue 6%
- Could not identify 5%
- Pharmacy dispensing error 2%
**Process Name: Pharmacy Order Entry**

**Order to be entered with correctly matched patient on Pharmacy Information System (PIS) Order Tab screen**

**Pharmacy Technician enters order using the appropriate mnemonic for the medication, and selects strength, dosing schedule, time, directions**

**Pharmacy Technician chooses dosage strength according to available strengths in the ADC in the patient's location. If multiple strengths, the lowest strength is entered (trial and error process)**

**Pharmacy technician fills the unit quantity field to send a 24 hour supply of medication (until the PSB will be filled) if the medication is not normally stocked on the floor ADC**

**Pharmacy technician completes entry of order including any supplementary notes and therapeutic interchanges and consults with Pharmacist about Medispan® warnings not previously anticipated**

**Once processed, pharmacy technician initials order and places it on the outside window for the dispensary technician to check**
<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Inputs/Specifications</th>
<th>Process</th>
<th>Outputs/Requirements</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Care Orders</td>
<td>Pharmacy Technician entering orders with knowledge of wardstock</td>
<td>See Steps Above</td>
<td>Order profiled in PIS</td>
<td>Dispensary and Wardstock Pharmacy Technicians</td>
</tr>
<tr>
<td>Nursing and ward clerk staff</td>
<td>Order which has been reviewed and marked to enter by Pharmacist</td>
<td></td>
<td>Order profiled in ADC for floor stock items</td>
<td>Nurses able to access medication from ADC profile</td>
</tr>
<tr>
<td>to send order</td>
<td>Pharmacy Information System (PIS)</td>
<td></td>
<td>Patient Specific Bin (PSB) assigned to patient for non-floor stock items by next report time</td>
<td>Patients</td>
</tr>
<tr>
<td>Pneumatic Tube System</td>
<td>Interface between ADC and PIS displaying med attribute (Ctrl-Acc Cab)</td>
<td></td>
<td>Label prints for orders requiring submission of interim dose(s)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Wardstock technician alerted of requirement to fill PSB via restock report (0730 &amp; 1730 h)</td>
<td></td>
</tr>
</tbody>
</table>
**Process Name:** Configuration of Patient Specific Bins (PSBs) in Automated Dispensing Cabinets (ADCs)

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Inputs/Specifications</th>
<th>Process</th>
<th>Outputs/Requirements</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients and Prescribers</td>
<td>Order Entry Pharmacy Technician</td>
<td>See Steps Above</td>
<td>Information System Pharmacist (responsibilities include maintaining medication catalogue with attributes and new entries)</td>
<td>Wardstock Pharmacy Technicians</td>
</tr>
<tr>
<td>Nursing and ward clerk staff to send order</td>
<td>Order for a medication not already stocked in the ADC on the unit where the patient is located</td>
<td></td>
<td>Correct strength of medication must be selected by entry technician</td>
<td>Nurses able to access medication from ADC profile</td>
</tr>
<tr>
<td></td>
<td>PIS</td>
<td></td>
<td>In the Restocking set up screen in ADC software (Omnicentre®), medication must be checked “on” for “PSB Autofill” to be included in Restock reports</td>
<td>Patients</td>
</tr>
<tr>
<td></td>
<td>ADC Interfacing capability with PIS and ability to synthesize data to generate report</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Order entered in the PIS for a medication not normally stocked in the floor cabinet**

**Medication is profiled to the patient’s ADC profile on the unit through an interface between PIS and ADC software**

**ADC Software** (program for PSB is “Singlepointe”) recognizes that a medication is not normally stocked in the cabinet and must be configured to a patient-specific bin

**At the next corresponding report time (either 0730h or 1730h), a PSB Restock List will print for each ward, issuing the new medication to the PSB in the ADC that is assigned for that patient bed location on the unit**

**The Report will calculate a PAR (minimum) level for the number of unit dose medications to restock based upon the required dose**

**Pharmacy wardstock technician reads report and selects medication from the dispensary in order to fill the cabinet’s PSB**
| Electronic patient profile on ADC | Medications that are available in multiple strength denominations must not be linked in equivalent dose groups in order to be included in a PSB (Exclusion: software setting “Include items even if equivalent dose is stocked” enables to fill a PSB when linked strength in cabinet)

Medication from the master list must be included in the local database for that floor

Patient must remain in the same location by the time the PSB Restock report prints |
Figure 7a: Cause and Effect Analysis, Equivalent Dose Medications

Problem: Medication will not display on Restock List if there is a linked strength in the cabinet, leading to missing medications

Equipment
- ADC software and Pharmacy Information System not well-synced operationally

Process
- No step for floor stock technician to manually inspect PSB restock list
- No clear guidelines for maximum # tablets per “dose”
- No clear procedure on entry of separate orders/strengths

People
- Nurses unaware of how to use equivalent dose feature
- Inconsistent technician entering practices; speculation that entering lowest strength solves problem

Management
- Incomplete roll out of order entry manual and SOP; mixed messages to staff
- Reluctance to trial and error of system/setting changes

Materials
- Floor stock list not easily accessible
- Medications within an equivalent dose group not identifiable / marked

- Floor stock and equivalent dose groups not reassessed or monitored

Floor stock and equivalent dose groups not reassessed or monitored
Figure 7b: Cause and Effect Analysis, Pharmacy Order Entry

Problem: Inconsistent quantities sent for initial doses, leading to missing medications

- **Equipment**
  - Pharmacy Information System (PIS) does not alert technician if a dose must be sent
  - Item attribute in PIS may be incorrectly assigned
  - Lack of calculators at entry station

- **Process**
  - One size fits all training rule to send 24 hour supply not always applicable
  - Procedure for sending interim doses not consistently defined
  - Patient Specific Bin (PSB) fill times not guaranteed (lack of standardization)
  - Extraneous distractions; forget to change quantity field
  - Nursing administration times not always aligned with pharmacy
  - Patients transfer and may require new interim doses

- **People**
  - Confusion between # of doses and # of tablets
  - Entry technicians perform calculations in head under pressure
  - Not all technicians trained/scheduled the order entry role to same extent
  - Lack of communication between staff

- **Materials**

- **Environment**

- **Management**

Figure 7c: Cause and Effect Analysis, Floor Stock and PSB Assignment

- **Equipment**
  - No capacity to override PSB assignment at order entry
  - ADC software does not prompt user to location of PSB medication at the patient profile screen
  - Poor interfacing between pharmacy software and ADC software; systems do not have same capability to interpret received data

- **Process**
  - Unclear procedure for sending interim doses for medications that could be PSB or floor stock
  - Lack of routine floor stock reassessment by pharmacy staff
  - Competing priorities: technician fills PSB and is called stat to replenish floor stock
  - Lack of time to check both cabinets and sign into second cabinet for the remaining medications
  - Inconsistent, unclear labelling of bed numbers on ADCs to indicate PSB assignment
  - Insufficient space for all PSBs in one cabinet
  - Floor stock is not standardized across both cabinets on the same ward

- **People**
  - Nurse unaware to check alternate cabinet
  - Nurse may remove from floor stock instead of PSB, floor stock becomes prematurely depleted
  - Pharmacy technicians add or remove stock items without approval or review
  - Incomplete or inadequate training for new staff on ADC operation

- **Environment**
  - No enforcement of policy to manage control of floor stock

- **Management**
  - Human resource constraints

**Problem:** When there are two cabinets on a nursing unit, the PSB and floor stock are commonly cross-assigned, leading to missing medications
Figure 8a: PICK Chart, Equivalent Dose Groups

- **Implement**
  - Apply setting for PSBs: "Include item where equivalent dose med stocked"
  - Provide more rigorous ADC training and education for nursing staff on dose equivalency function
  - Make mandatory that technician print double label upon call of missing medication to prompt wardstock technician to manually add and monitor PSB (status quo +1)
  - Update order entry manual for Combination Orders

- **Challenge**
  - Program Pharmacy Information System (PIS) to identify all available cabinet strengths of a particular medication at the order screen
  - Hold training and re-education session on order entry updates for pharmacy technicians
  - Include all strengths of a tablet in the cabinet if they are linked
  - Manually customize dose linkage groups by medication

- **Possible**
  - Enable Omnicentre ADC reports and PIS screens to identify linked medications by a marking
Figure 8b: PICK Chart, Pharmacy Order Entry

**Intervention Analysis (PICK Chart)**
**Pharmacy Order Entry**

- Develop a chart that outlines how many doses to send based upon time of day and dosing schedule
- Train a subset of employees dedicated to specialize in order entry
- Increase training on wardstock for pharmacy technicians who complete order entry
- Develop an SOP for the process of sending interim doses
- Provide education to pharmacy technicians (on calculations and to abolish the 24 hour supply rule)
- Strengthen communication between wardstock and entry technicians RE ward fill times
- Keep dedicated calculators at order entry
- Program BDM to automatically calculate required # of unit dose items based upon time

- Standardize procedure for timing of PSB fill
Intervention Analysis (PICK Chart): Floor Stock and PSB Assignment

- Standardize floor stock to be the same across both automated dispensing cabinets (ADCs) on a unit
- Clearly label cabinets and fridges with proper bed number for PSB
- Educate nurses regarding PSB assignment
- Analyze usage on floors with more than one cabinet to optimize stocked medications; have technician reassess on monthly basis
- Remove ADC software setting
- Program interface between pharmacy and ADC software that redirects user to appropriate cabinet
- Post reminder in med room to check alternate cabinet for PSB
- Enable Omnicenter (ADC Software) to indicate patient-specific medications on the patient profile

Figure 8c: PICK Chart, Floor Stock and PSB Assignment
Figure 9: Intervention #1 Assessment Workload

Impact of software setting on patient-specific bin stocking (workload measurement)  
February 2-9, 2016

Number of items assigned to patient-specific bins (PSBs)

Nursing unit
Figure 10: Retrospective Comparative Analysis Results

**Missing medications pre and post-change**

<table>
<thead>
<tr>
<th>Date</th>
<th>Number of missing medications per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-Dec</td>
<td>5</td>
</tr>
<tr>
<td>15-Dec</td>
<td>15</td>
</tr>
<tr>
<td>16-Dec</td>
<td>20</td>
</tr>
<tr>
<td>17-Dec</td>
<td>15</td>
</tr>
<tr>
<td>18-Dec</td>
<td>30</td>
</tr>
<tr>
<td>14-Mar</td>
<td>20</td>
</tr>
<tr>
<td>15-Mar</td>
<td>15</td>
</tr>
<tr>
<td>16-Mar</td>
<td>20</td>
</tr>
<tr>
<td>17-Mar</td>
<td>15</td>
</tr>
<tr>
<td>18-Mar</td>
<td>20</td>
</tr>
</tbody>
</table>

- Other floors
- Experimental Group (K7, C9, C10)
Appendices

A. Description of Automated Dispensing Cabinets at KGH

The floor stock inventory kept in the automated dispensing cabinets (ADCs) at KGH is customized to specific demands and volume of the nursing unit. Some nursing units with a high patient volume are equipped with two ADCs (A and B), which were intended to contain identical floor stock (this was not preserved). Each automated dispensing cabinet has several bins reserved for patient-specific medications that are not already stocked in the cabinet’s wardstock. ADCs range in size and the largest capacity at Kingston General Hospital are termed “double-wall”.

B. Definition of Terms

**Equivalent Dose**: Term used to describe a dose that can be totaled in more than one way using different strengths of the same medication

**Equivalent Dose Group**: Predefined collection of medications available in multiple strengths that are linked in the pharmacy information system and ADC software

**Patient-Specific Bin (PSB)**: A compartment in the ADC intended for storage of unit dose medications that are not routinely floor stocked

**Missing Medication**: A medication that is not available for the nurse to administer at the time it is due (for a scheduled medication) or necessary (for PRNs). Several categories of missing medications were established:

- **New**: Order for the medication was entered by pharmacy <24 hours after discovered missing
- **Refill**: Order was entered ≥24 hours since personnel have reported it missing
• **Repeat**: medications found to be missing on two or more consecutive occasions, at least 4 hours after the pharmacy has resent the medication

• **False missing**: medication that is not truly missing and was appropriately delivered to the floor in a timely manner

**SIPOC Diagram**: A type of process map that identifies its basic elements; the Suppliers, Inputs, Process (and its boundaries), Outputs, and Customers. The SIPOC diagram is often completed at the beginning of a project to align its scope and goals before work is planned.

**PICK Chart**: Process tool used to prioritize opportunities for improvement. Each opportunity is assigned a relative score for estimated impact and required resources and plotted onto four quadrants: Possible (low impact, low resource), Implement (high impact, low resource), Challenge (high impact, high resource), and Kill (low impact, low resource)

**Plan-Do-Study-Act (PSDA) Cycle**: A four-step model for efficiently testing a change to a process (often on a small scale) in pursuit of continuous quality improvement of the larger scale

**Kaizen**: term to describe a method of accelerated process improvement conducted and implemented immediately (also referred to as “opportunity burst”)
C. Description of Interventions

The project team elected to target the leading pharmacy-related cause for missing medications (“not in patient-specific bin”) and its associated root causes. One of the issues under this umbrella cause was that the pharmacy information system would not trigger assignment of medications linked in an equivalent dose group (e.g. medications that are available in multiple strengths, see Appendix B) to the patient-specific bin. During the investigations period, a software update to the information system that manages patient-specific inventory became available, providing a setting that would direct all medications into patient-specific bins independent of the strengths available in floor stock. Enabling this feature was expected to decrease the number of missing medications, as it would circumvent the issue with the equivalent dose groups. However, it would also directly increase the volume of patient-specific bin items to be filled and managed by pharmacy. The first intervention was run as a rapid improvement cycle (Kaizen, see Appendix B) and trialed for a week period on C9, C10, K6 and K7. Pharmacy staff tracked workload measurements for stocking patient-specific bins. It was decided by the pharmacy manager that the increase in patient-specific item volume was negligible and justifiable in the context of a perceived decrease in missing medication requests.

The second intervention was chosen as a complement to the initial Kaizen opportunity, since the software setting functions optimally when floor stock is standardized across both cabinets. A pharmacy technician trained in ADCs was assigned the task, which was completed on three of the four inpatient units (C9, C10 and K7). Steps followed:

i. Using the current Floor Stock Inventory Report, compared the A and B cabinet inventory to identify discrepancies
ii. Using the PAR vs. Usage Report, identified items that are not often used on that floor and removed these

iii. Using the Equivalent Dose Groups Report, identified medication strengths which could be added to the floor stock for that unit and added these

iv. Using the PSB report, identified items that are frequently assigned as PSBs and added these, space permitting

Finally, both cabinets on C9 were physically expanded to contain an additional drawer of medications

The nursing units targeted (C9, C10, and K7) were among those identified in the baseline analysis as having the greatest proportion of missing medications and each unit houses two double-wall ADCs.
## D. Project Scope Revision Log

<table>
<thead>
<tr>
<th>#</th>
<th>Date</th>
<th>Requested by</th>
<th>Proposed Change</th>
<th>Assessment and Impact Summary</th>
<th>Final Decision/ Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>2016-01-25</td>
<td>Project Manager, Maria Marchese</td>
<td>A subset of the missing medications whose reason for being missing was originally labelled as “not in PSB” will have to be re-classified as “impacted by order entry” and a new proportion (of total 83 missing medications) will be recalculated for this category.</td>
<td>After the stakeholder meeting discussing the results of the data collection, the project team selected order entry and setup of patient specific bins (PSBs) as a prioritized area to focus our interventions. Many medications that are missing from PSBs are closely related to how medications are profiled in the pharmacy information system (PIS) and interfaced with ADC software.</td>
<td>NOT ACCEPTED</td>
</tr>
<tr>
<td>1.1</td>
<td>2016-01-25</td>
<td>Patient Quality Advisor, Sue McIlroy</td>
<td>A value stream map will not be conducted for the initial state. Instead, the project team will engage in root cause analysis to examine the underlying problems at order entry that are causing missing medications. Possible solutions to several priority issues will be brainstormed and documented. The future state map displaying the ideal processes and procedures will be constructed at a later date and serve as a tool for continuous improvements in this project field.</td>
<td>The issues behind missing medications were successfully identified from the Pareto-style analysis of the December initial investigations period. It was deemed unnecessary to produce a current state map as it would not serve any additional value and would also be difficult to force a “fit” for mapping errors.</td>
<td>ACCEPTED</td>
</tr>
<tr>
<td>1.2</td>
<td>2016-01-25</td>
<td>Preceptor, Nancy Burge</td>
<td>Success for the project will be defined as a 50% relative decrease in the proportion of medications that are classified as being impacted by pharmacy order entry, from the initial data collection period in December, to the final data collection period in the Spring (date TBD). The Timeline report may be produced at the conclusion of the interventions.</td>
<td>As we will be focusing only on issues related to order entry, it would not be wise to utilize the Timeline report as the primary measure of success for the project. As described in the project management plan, and confirmed through sequential run comparisons, the Timeline report has limitations; it appears to be highly variable, and does not capture all medications that may be reported as missing. In addition, it would be difficult to predict and demonstrate a significant reduction in total missing medications if only a subset will be impacted by the project.</td>
<td>ACCEPTED; Wilma Hopman, statistician for the project, has approved this amendment as it relates to the statistical analysis.</td>
</tr>
</tbody>
</table>
### 1.3 2016-01-25

**Preceptor, Nancy Burge**

The project manager will undertake a subsequent data collection period in the Spring of 2016, aiming to follow up on approximately 80 missing medications with the same inclusion and exclusion criteria as defined in the study protocol. It will be conducted in a similar manner to the December data collection with the following exception: Rather than assigning one of eight categorical reasons for being missing, missing medications will be labelled as either “impacted by order entry” or “other-not impacted by order entry”. The final percentage of total missing medications during the data collection period determined to be impacted by order entry will be compared to the initial percentage to determine success.

This post-change measurement is more specific in its ability to confidently assess the impact of the project’s interventions. This method closely mirrors the pre-test data collection and would replace the report measure. It would be outside of the time constraints of this study and irrelevant to reproduce categorization of all potential reasons for missing medications (e.g. nurse unable to locate) that were not targeted in the interventions.

**NOT ACCEPTED** (due to availability of Timeline Report to now give location)

### 1.4 2016/03/18

**Patient Quality Advisor, Sue McIlroy**

The project manager should engage in surveying front-line nursing staff to obtain some opinions of missing medications.

Would enrich the results and obtain a qualitative perspective on the impact of the PDSA cycle intervention. Provides data to support or refute the statistical findings

**Accepted**

**Other updates:** Gunther Ha, Pharmacy IS Specialist, has relocated from KGH, and subsequently will be removed from the Project Team List. PY Lau, an Information Systems Pharmacist at KGH, will fulfill this role along with Ron Koob for the remainder of the project.

Planned interventions (PDSA cycles) will be emailed to RAC committee as requested once finalized by project team.
### E. Missing Medication Documentation Form

The technician who receives the request for the missing medication will document the time, their initials, and any other relevant information pertaining to the medication and its potential cause for being missing. The technician will then proceed to print a duplicate no charge label from the patient profile in the Pharmacy Information System. If the technician deems that the medication must be sent, it will be recorded and investigated further by the project manager.

<table>
<thead>
<tr>
<th>#</th>
<th>Time</th>
<th>Label If label unavailable: Gather ward, CR#, medication</th>
<th>Sent?</th>
<th>Initial</th>
<th>Notes / Reason for Missing /Insights</th>
</tr>
</thead>
</table>
| 1 |      | ✓  | MM | Ex. 0906h –C9 – CR XXXXXXX, venlafaxine XR 150 mg, pt admitted last night and pharmacy missed entry  
Or  
0906h –D4ICU –CR XXXXXX, tetracycline 250 mg, was in PSB, nurse now found |
| 2 |      |  |   | |
| 3 |      |  |   | |
| 4 |      |  |   | |
### Missing Meds Data Entry Sheet

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Tech</th>
<th>Pt. code</th>
<th>ward</th>
<th>medication</th>
<th>Collateral med info</th>
<th>Sent or not</th>
<th>Actually missing or not</th>
<th>new vs refill</th>
<th>Repeat?</th>
<th>Dosage Form type (oral solid, oral liquid, topical preparation, multi-dose)</th>
<th>Formulary vs. NF vs. Pat Own</th>
<th>Cost / sent dose</th>
<th>Identified Primary Reason</th>
<th>Notes and Comments</th>
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<tbody>
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</tr>
</tbody>
</table>
G.  Survey of Nursing Staff Data Sheet

Date: _____________________________

Ward:

☐ K7
☐ C9
☐ C10
☐ K9 (no changes)
☐ K6 (no changes)
☐ K4 (no changes)

Name (optional):______________

Open-ended Feedback:

_____________________________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________

Specific Questions:

Have you noticed a change in the demand for missing medications on this floor, specifically for Omnicell® and patient specific bins (effective March 2016)? Increase? Decrease?

The Omnicell® stock in each cabinet is more equal and expanded to contain a larger variety of strengths for drugs that come in multiple strengths. Were you informed? Have you noticed? Has this improved your ability to prepare medications in a timely fashion? If not, what barriers have you come across?

Have you had any difficulties accessing medications that are profiled correctly in Omnicell® using the equivalent dose option? Do you find that providing the most appropriate strength(s) to make up a patient’s dose will improve patient care by decreasing burden of # of pills?