Analysis of Medication Delivery Errors in Medical/Surgical Unit

Mirjana Polovina, Radmila Polovina, MallikChowdary Yenigella and Shi-Jie (Gary) Chen

Department of Industrial and Systems Engineering
Northern Illinois University
DeKalb, IL 60115, USA

Abstract

An increased number of medication errors and adverse events threaten patient safety and quality of services provided, which is alarming and has become the national concern. Without understanding the medication delivery system (i.e., prescribing, transcribing, dispensing, administering, and monitoring), it is difficult to improve the processes and reduce medication delivery errors. The objectives of this study are to identify different types of medication delivery errors and reduce the factors causing them for a medical/surgical unit in a hospital. Value stream mapping is used to help the healthcare providers visualize the medication delivery system in the unit and understand inefficiencies in the processes. Cause-and-effect diagram is used to identify possible causes of failures. Failure mode and effect analysis is used to analyze the root causes of medication delivery errors. The results of this study allow the healthcare providers to understand the vital areas that need to be addressed to reduce or eliminate medication delivery errors, increase patient safety and improve the quality of care provided.

Keywords
Medication delivery errors, six sigma, DMAIC, value stream mapping, cause-and-effect diagram, failure mode and effect analysis

1. Introduction

According to the Institute of Medicine (IOM), “four of five U.S. adults take at least one medication (i.e., prescription, over-the-counter drug, vitamin/mineral, or herbal supplement), and almost a third take at least five different medications” [1]. Medication errors might happen at any time during medication use process, regardless of care setting. Mistakes made during medication delivery could cause harm to the patient and ruin the hospital reputation (e.g., lose state certification, low retention rate, costly liability claims, etc.). In addition, Medication errors made by nurses could have shocking consequences not only for the patient but also for the nurse’s careers [2]. However, hospitals are faced with increased number of medication errors and adverse events that threaten patient safety and quality service [1].

Patients with chronic illness or disease are hospitalized, while others receive help in the emergency department or from their primary care physician. Patients expect to get better by managing the illness during hospital stay. This is usually done through medications and patients do not anticipate to get harmed with medications. However, in its census report in 2007, IOM stated that “at least 44,000 people, and perhaps as many as 98,000 people, die in the hospitals each year as the result of medical errors that could have been prevented” [1]. Furthermore, IOM stated that on average “a hospital patient is subject to at least one medication error per day with considerable variation in error rates across facilities” [1]. This fact is very alarming, so hospitals and health care providers should work together on identifying the causes of these errors to prevent such incidents. According to IOM, medication error is “any error occurring in the medication-use process” [1]. In other words, an error could happen in any of the following medication delivery processes: prescribing, transcribing, dispensing, administering, and monitoring. Research has indicated that medication errors could be categorized into several groups based on which process step they happened (from prescribing to monitoring), medication dose (overdose, under dose, missed dose, wrong dose), choice of drug (wrong medication, wrong time, wrong frequency, known allergy, adverse drug reaction), and incidence (incorrect labeling, incomplete order, sound-alike drug, look-alike drug) [3-5]. These medication delivery errors could be prevented and should not be happening [1].
Without understanding the medication delivery system (i.e., prescribing, transcribing, dispensing, administering, and monitoring), it is difficult to improve the processes and reduce medication delivery errors. The objectives of this study are to identify different types of medication delivery errors and reduce the factors causing them for a medical/surgical unit in a hospital. To achieve the objectives, the study follows Six Sigma's DMAIC cycle (define, measure, analyze, improve, and control). Prior research has shown that DMAIC could be used practically anywhere in the healthcare environment as a starting point for a Six Sigma improvement initiative [6-10]. The study was done in a small rural hospital that is well supported and respected by the community. The Medical/Surgical unit holds 25 beds and provides care for the patients admitted with a variety of medical conditions.

2. Define Phase
During this phase, the problems that the hospital encountered were identified. These problems included the increased number of medication delivery errors and improper medication administration documentation, which were placing risk to patient safety and hospital reputation. To reduce medication delivery errors and improve patient safety, the following requirements were defined: increasing the error reporting, transforming the attitude from a punitive to a non-punitive approach, and increasing staff’s consciousness about medication delivery errors. Data were collected by direct observations, interviews with staff (i.e., pharmacists, pharmacy technicians, nurses, and directors), and archival records for the current medication delivery processes at the medical/surgical unit.

3. Measure Phase
In this phase, a process map (Figure 1) and a value stream map (Figure 2) were created for better understanding the unit’s medication delivery system. Understanding process flows is one important step in the process improvement effort. The process map includes the medication delivery processes of prescribing, transcribing, dispensing, administering, and monitoring, as well as the interactions between these processes. The value stream map highlights the number of medication delivery errors in each process, different types of flows (i.e., manual, material or electronic), inventories, suppliers, and ways of communication (i.e., phone calls, faxes, verbal or paper).

The value stream map shows the medication delivery journey from supplier to patient. The hospital receives medications from a local vendor. Once the medication purchase order is sent to the vendor, it arrives the next day. Upon delivery, the pharmacist places a yellow sticker (with medication name and a code) on each medication box which is then stored in a cabinet or a shelf in the pharmacy. After that, the pharmacist signs off the purchasing order. At the medical/surgical floor, there are two medication dispensing units: the Pyxis Medstation and the wall unit. The wall unit usually stores medications that are brought by patient, pain medications, and equipment to dispense medication. In order for a patient to receive a medication, a physician needs to prescribe it.

In addition to the process name and major steps within the process, the process box in the value stream map (Figure 2) contains the number of errors, the time period from which data were collected and the person(s) responsible for each process. Errors are considered as non-value added activities that threaten patient safety and seriously decrease quality of care provided. From the map (Figure 2), it could be seen that the number of errors in prescribing, transcribing, dispensing and monitoring is low when compared with the administering process. Incident data were collected over a twelve-month period (Table 1 shows the 3.38 sigma level of medication delivery errors in the unit). At the bottom of the process box, one can find an icon that represents the staff who is in charge of that process. Accordingly, a physician is responsible for prescribing medication, nurses (RN and LPN) are responsible for transcribing, administering and monitoring, while the pharmacist transcribes physician’s order to pharmacy order and takes care of medication dispensing.

The kaizen bursts represent the type of incidents that should be reduced to a minimum or eliminated. For example, when wrong dose is placed inside the Pyxis Medstation, it is possible, if not checked, that the patient receives extra or lower dose of the prescribed medication. This could be a life threatening situation, because if received in lower dose, the physician might not see wanted medication’s effect and might order a higher dose. Also, when medications are left with patient and not monitored there is a risk that the patient may not take them. Once again, if medications are not taken, a physician might decide to increase the dose which could harm the patient.
Figure 1: Process map of medication delivery system at the medical/surgical unit
4. Analyze Phase

In this phase, we conducted interviews with nurses and the pharmacist to determine possible causes of medication delivery errors. Rather than using the traditional cause categories such as people, equipment, environment, and materials, we decided to focus on the processes related to medication delivery (i.e., prescribing, transcribing, dispensing, administering, and monitoring) and communication as potential causes, which are placed in boxes at the end of each “rib of the backbone” [11]. A cause-and-effect diagram (Figure 3) was constructed based on the interview responses and our observations as well. The diagram was used to identify the causes of medication delivery errors. It was determined that the increased number of medication delivery errors put in jeopardy patient’s safety and quality of care provided. This was considered as a problem and medication errors were placed in a box at the right side of the cause-and-effect diagram. Then, root causes for each process were identified and were placed under each category as small bones. Finally, we analyzed the diagram and came to the following conclusions:

- Medication delivery errors that were happening during prescribing, transcribing, dispensing, and administering processes have one root cause in common, that is interruption(s).

Table 1: Sigma Level of medication delivery errors at the medical/surgical unit

<table>
<thead>
<tr>
<th>Process Opportunities:</th>
<th>40,177</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defects:</td>
<td>1,208</td>
</tr>
<tr>
<td>DPMO</td>
<td>30,067</td>
</tr>
<tr>
<td>Defect (%)</td>
<td>3.01%</td>
</tr>
<tr>
<td>Yield (%)</td>
<td>96.99%</td>
</tr>
<tr>
<td>Sigma Level</td>
<td>3.38</td>
</tr>
</tbody>
</table>
• Errors that were happening in dispensing, administering and monitoring have a root cause of not following procedures or protocols.
• Workload is a common root cause for medication delivery errors in transcribing, administering, and monitoring.
• Some of the errors were caused by human factors due to stress and the habit of doing things their way.
• Overall, there was no system control in place to prevent errors from recurring other than disciplining staff.

Pareto chart was used to analyze causes by ranking them from the most to the least significant. This technique is also known as “80-20 rule” because 80% of problems come from 20% of causes [7]. From the value stream map in Figure 2, it could be seen that the administering process accounts for the most medication delivery errors (1176 or 97.4%). Figure 4 shows the Pareto chart of medication delivery errors in the administering process.
FMEA was performed to identify different ways that a process could fail and the effect of those failures [7]. Mistakes in the healthcare can be very costly and dangerous, resulting in the loss of patient's life or in staff endangerment. Therefore, detection of possible failures and errors is very important in the healthcare. FMEA was constructed using guidelines from [7]:

1. Study process and list all process steps.
2. Determine failure modes that may occur in each process step.
3. Determine the effect of the failure modes in the process.
4. Identify the causes that might cause the process to fail.
5. Determine the rate of occurrence and the likelihood of detection of each failure.
6. Determine the severity of the failure and rate it.
7. Using a risk priority code, rank failures according to their severity.
8. Determine existing detection and prevention process controls.
9. Determine what type of action is needed and in what time frame.
10. Recommend the corrective action controls to reduce the failure.
11. Determine who is responsible for taking an action and who needs to be made aware of failures.
12. Monitor the process and if necessary repeat all the steps of the FMEA.

The first step in creating the FMEA table is to identify processes and the function of the process in which errors occur. Then, the process steps are analyzed with the failure modes that are identified. The main failure modes in the medical/surgical unit included: incomplete order, physician's order not verified, wrong medication storage, incorrect dose or drug, Medication Administration Record (MAR) not updated, medications given early or late, and improper patient identification. The severity rate was assigned based on the effect of a potential failure mode. This rate can vary from no effect to catastrophic effect. The potential failure causes were identified either by interviewing the nursing staff, pharmacy personnel, and managers or by direct observation of medication delivery process. The failure causes that occurred more frequently were: interruptions by people or by phone calls, workload, human factors, not following protocols/procedures, and improper medication preparation or storage. Once the causes were identified, frequency of occurrence and likelihood of detection were estimated and entered into the FMEA table. The failures were ranked based on the risk priority number (RPN) which is calculated by multiplying the severity rate with the occurrence and the detection rate. The improvement actions were recommended based on the RPN number failure severity (the larger the RPN the more severe is the cause.). Some of the suggested actions included: new forms, CPOE, improved training program, and quality assurance. Furthermore, the healthcare providers were identified who would be responsible for implementing the changes and monitoring the medication delivery process in order to reduce the chance of failure recurring again. Table 2 shows the FMEA table.

5. Improve Phase

Based on the recommendations from the stakeholders (i.e. physicians, pharmacist, nurses, director of quality, etc.) and data analysis (FMEA, Pareto, cause-and-effect diagram), we identified actions needed for process improvement. These improvement actions were made in the form of kaizen events, which were implemented, as follows:

Kaizen Event #1: Introduce a new Physician’s Orders form
Kaizen Event #2: Improve the current Medication Administration Record form
Kaizen Event #3: Introduce a new PRN/Refusal form
Kaizen Event #4: Introduce a new Medication Inadvertent Incident Report form
Kaizen Event #5: Organize and label the medication room
Kaizen Event #6: Label the medication cart
Kaizen Event #7: Determine a non-punitive approach and anonymous error reporting
Kaizen Event #8: Provide education training for error prevention
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing order</td>
<td>Slip in envelope</td>
<td>Delay in administration</td>
<td>4</td>
<td>Too busy</td>
<td>Double check</td>
<td>Double check report</td>
<td>1</td>
<td>81</td>
<td>Eliminate</td>
<td>New order form</td>
<td>Registered Nurse, Licensed Practical Nurse, Physician</td>
<td>Long term</td>
</tr>
<tr>
<td>Transcribing the prescription for medication</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verifying order</td>
<td>Unreadable arm bands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timing order</td>
<td>Slips in memory</td>
<td>Delay in administration</td>
<td>4</td>
<td>Human error</td>
<td>Double check</td>
<td>Double check report</td>
<td>1</td>
<td>140</td>
<td>Eliminate</td>
<td>No delay</td>
<td>RN, LPN, DON</td>
<td>Long term</td>
</tr>
<tr>
<td>Disposing meds to cup</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposing meds</td>
<td>Skin in memory</td>
<td>Delay in administration</td>
<td>4</td>
<td>Human error</td>
<td>Double check</td>
<td>Double check report</td>
<td>1</td>
<td>140</td>
<td>Eliminate</td>
<td>No delay</td>
<td>RN, LPN, DON</td>
<td>Long term</td>
</tr>
<tr>
<td>Medication administered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medication not administered</td>
<td>Unreadable arm bands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meds left within patient</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Control Phase
In this phase, the medication process was evaluated and improvements were monitored to assure that proper procedures are followed. Decisions were made to whether or not to accept the change, abandon it or repeat the improvement cycle [7]. Also, it was determined how the kaizen events should be monitored to ensure sustainability. The outcomes of improvement were shared with staff and managers to prevent the errors from resurfacing.

Monitoring the medication delivery processes is to assure that proper procedures are followed. Standardizing the procedures would help prevent medical staff from doing things “their way”. With the new incident reporting form in place, nursing staff is encouraged to report all medication incidents. Reported errors need to be carefully investigated and analyzed by the quality manager and the quality improvement team to identify causes and develop a plan of action for reducing or eliminating the errors. It was recommended that the managers should develop weekly control charts to monitor the number of incidents in each medication delivery process. If the number of errors increases, the quality manager must perform root-cause analysis to determine the reasons for the incident increase. Also, errors should be discussed in daily huddles and bi-weekly meetings. By doing so, all medical staff will be kept in the loop of what is being done regarding the improvement efforts for error prevention. While reviewing the reported incidents, quality manager needs to closely monitor whether or not the report is filled properly. If necessary, a brief error reporting workshop (session) should be offered to the healthcare providers to make sure that everybody knows how to do it. To ensure that errors are not happening during documentation (i.e., MAR updating), nursing staff must re-check MARs for any discrepancy after each medication pass and before leaving the shift. The new forms helped standardize the medication incident reporting, medications ordering process and medication documentation, and helped identify different types of errors and causes. The DMAIC cycle should be repeated all over again, until the six sigma level is reached.

7. Conclusions
This study followed six sigma’s DMAIC cycle along with related tools (i.e., process mapping, value stream mapping, cause-and-effect diagram, Pareto chart, and FMEA) to help identify causes of medication delivery errors and reduce the errors for the medical/surgical unit in a hospital. According to this study, we have also made the following recommendations to the management and healthcare providers, which will help improve the process, ensure patient safety, and provide a better quality of care in the future:

1. Standardize the training program to reflect past experiences with medication errors and lessons learned.
2. Ensure that staff cannot work around the system and understand why employees are developing work-arounds and eliminate them. Though one nurse stated that “it is boring to do things the same way, which feels like being a robot,” standardizing procedures is a first step in error prevention.
3. Medications should not be prepared early and left on the counter top or medication cart, unless it is ordered by the physician.
4. MAR and Physician’s orders must be carefully read. We understand that with all environmental noises (i.e., interruptions, distractions, etc.) it is hard to concentrate, but it is important to stay focused on what is being done. Mistakes during medication preparation and administering could lead to patient harm.
5. Medications must be counted at the end of each shift. This will determine whether medications are administered or not.
6. Identify and minimize the failure causes like interruptions and eliminate them. By limiting interruptions during a medication pass, nursing staff who administer medications will be more focused on the task, which will reduce errors.
7. Incorporate quality at the source, principally at the pharmacy. This means the right medication with the right dose for the right patient is prepared and delivered to the medication room. By doing this, errors like wrong drug and wrong dose could be prevented.
8. Promote confidential error reporting system.
9. Nursing staff should never order medications without the Physician’s order.
10. Pharmacy personnel should occasionally check medications labels, storage location and remove expired, deteriorated, and recalled drugs. If not removed, medication might be administered to patients, which could increase a chance of patient harm. A monthly audit should be established and the records kept in the pharmacy.
11. Pharmacy should consider implementing medication unit dose system. Medications will be stored in a ready to administer form. This would help prevent errors of omission and commission.
12. Pharmacy must have an alternative form of medications (i.e., liquid) for those patient who have difficulties with swallowing tablets.
References