Reducing Infusion Pump Alarms Through Structured Interventions

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Background

Disturbing noise heard when walking through a hospital has been linked to a serious and sometimes fatal phenomenon known as alarm fatigue. Alarm fatigue is defined as sensory overload created by an immense number of alarms, which can be either true or false, actionable or nonactionable, and many that are deemed nuisance, all of which result in desensitization of clinicians.[1] Excessive alarm noise has also been linked to sleep disturbances, impaired healing, intensive care unit delirium, decreased patient satisfaction scores, and burnout.[2-4] Alarms hazards have become increasingly significant, and The Joint Commission issued a sentinel event alert directing hospitals to examine the influence of device alarms on patient safety. This led to the development of National Patient Safety Goal (NPSG) 06.01.01.[5] Phase I requires hospitals to identify and manage alarms based on their data, whereas phase II requires hospitals to implement policies and procedures related to their specific alarm issues as well as educate staff on the function of each alarm system.[5,6] Multiple organizations, including The Joint Commission, the Food and Drug Administration, the Association for the Advancement of Medical Instrumentation, the Emergency Care Research Institute, the Healthcare Technology Safety Institute, and the American Association of Critical-Care Nurses have all demonstrated that alarms reduction reduces alarm fatigue.[1,6] Reducing infusion alarms is part of an overall initiative supported at the project site by the chief nursing officer and the magnet coordinator director to comply with the NPSG 06.01.01. Additionally, nursing staff members at the project site have voiced complaints about the frequency of infusion alarms.

There are dangers associated with infusion alarms. An estimated 90% of patients receive infusion therapy during their inpatient hospital stay with 44% not administered as intended due to alarms.[3,7] A patient stops receiving therapy at the time of alarm, which can have a significant influence on treatment outcomes. For example, interruption in a medication with a short half-life could result in an immediate clinical deterioration.[8] Additionally, variations in drug serum concentrations can influence clinical outcomes ranging from subtherapeutic to toxicity.[3] The majority of delays in infusion therapy occur due to an increase of inline pressures before a patient side occlusion (PSO) alarm and air in line (AIL) alarm.[9] For PSO alarms alone, there lies the risk of an unintended bolus following the release of the occlusion and further identifies patient risk following either infusion alarm.

Nuisance alarms are nonactionable alarms (ie, require no clinical intervention by a nurse) that are technically correct but have no clinical significance.[10] For example, pulse oximetry alarms are typically set to alert if a patient's baseline falls below 90%, and the alarm will automatically cease if the patient's level returns to ≥ 90%. The noise level created by nonactionable and excessive alarms has been shown to exceed the recommended limit of 35 dBA (ie, very quiet room fan at low speed at 1 m distance) for daytime and 30 dBA (ie, whisper) for nighttime by the World Health Organization and is attributed to impaired convalescence, increased length of stay, impaired heart rate, decreased patient satisfaction, nurse burnout, and decreased speech clearness.[2,11,12] To put this in perspective, a typical infusion alarm measures at 70 dBA.[13] Imagine the noise created by a pump running on each patient in a 12-bed intensive care unit.[4] Furthermore, false, nuisance alarms (ie, technically correct with no clinical significance)[10] and nonactionable alarms result in disabled alarms, and loss of confidence in the medical device from the excessive noise.[12]

Aceves et al[14] and Lee et al[15] found through their respective analysis of infusion pump error logs that there are opportunities to identify potential causes, device malfunctions, and clinical practice problems to infusion alarms. The examination between alarms and drug, alarm and unit, and time to next alarm can provide direction for efficient interventions to reduce alarms. For example, of the 3681 infusions analyzed in the Aceves et al[14] study, > 50% occurred in the oncology department. Lee et al[15] suggest that further analysis of alarms specific to nurse interaction would provide opportunities to not only reduce

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alarms but also improve patient safety and efficient delivery of intravenous medications through decreased interruptions during drug delivery. Aceves et al[14] found that only 56% of the infusions analyzed were delivered without an interruption. Additionally, infusion restarts ran at a high range of 20 to > 40 times for a single infusion. This places a patient at varying levels of risk dependent upon the medication being infused. Routine analysis of alarm data can strategically lead to improved outcomes. These outcomes include improving the patient experience and providing opportunities for collaboration with purchasing, end users, device manufactures, trainers, and biomedical engineering.[15]

Project Purpose

The purpose of this project was to reduce the number of infusion pump alarms in a medical oncology unit through structured interventions to address the 5 alarms with the highest number occurrences.

Methods

Design

Lean Six Sigma (LSS) and plan-do-check-act (PDCA) have been successfully used together in health care projects[16] (See Figure 1). The LSS process consists of 5 steps: "define, measure, analyze, improve and control."[17] LSS systematically identifies and eliminates waste, which is classified by activities that provide no value—in this case nuisance infusion alarms.[18] PDCA focuses on improving variability in practice, use of data to identify the scope of a problem, and evaluating the continued sustainability of the change.[16,19] The PDCA framework was used as a guide for a systematic approach to review (ie, check) weekly data and make minor adjustments. Definitions used for the purposes of this project are provided in Table 1.

Data Collection

Alarm data were collected from 1 manufacturer of a large-volume infusion pump that delivers continuous and intermittent

Figure 1. **Lean Six Sigma and plan-do-check-act model.**

fluids, medications, blood, and blood products for adult, pediatric, and neonatal populations[20] in a 311-bed midwestern suburban hospital. Alarms and alerts are detected through sensor assemblies utilizing Intel (Santa Clara, CA) microprocessors that count the number of alarms that exceed a preset threshold. The infusion pumps capture each alarm event and include the type, date, and time to the second; unit and device serial numbers; profile; drug; and duration of alarm. This information is wirelessly sent to a server where it can be downloaded into an easy-to-use Excel (Microsoft Corp, Redmond, WA) spreadsheet for easy sorting and analysis. Data are stored in a Microsoft Structured Query Language server and can be retrieved via wireless technology accessible by approved users. The continuous quality improvement data were downloaded weekly by the magnet coordinator director into an Excel spreadsheet and provided to the principal investigator via e-mail who organized and examined the data utilizing pivot tables.

False alarms reduce the validity of the data; therefore, data from infusion devices that were either received or repaired by

Table 1. **Applicable Definitions**

Alarm	Definition
Accumulated air in line alarm	Occurs when a specified number of small air bubbles that do not exceed the air in line limit have passed through the air in line detector
Air in line alarm	Occurs when an air bolus has passed through the air in line detector
Close door alarm	Notification for the clinician to restart the pump
Open door alarm	Occurs when the large volume pump door is opened during an active infusion
Patient side occlusion alarm	Occurs with an increased back pressure being sensed while the infusion is running
Partial patient side occlusion alarm	Occurs when a partial occlusion sensed and detected by the auto restart feature
Safety clamp open	Occurs when the safety clamp device is in the open position while the door is open
Source: Carefusion.[20]	