

ALARM MANAGEMENT ON AN INPATIENT SURGICAL UNIT

by

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ABSTRACT

Alarm fatigue is a rapidly growing problem in hospitals across the nation, contributing to missed care opportunities and patient safety events. The purpose of the improvement project was to refine the use of audible alarms on an inpatient surgical unit by decreasing the frequency of false and non-actionable alarms, in turn decreasing clinician alarm fatigue and, ultimately, improving patient safety. The biggest culprit of false alarms we found on this type of unit that is of particular concern is the pulse oximetry alarm. Evidence from the literature indicated that capnography was superior to pulse oximetry in the detection of respiratory depression. Although capnography monitoring equipment was available, the current policy on monitoring patients post-operatively at the community hospital in Montana required the use of pulse oximetry and did not include the use of capnography. After determining that there was a gap in practice, an evidence-based practice project was implemented to include the use of capnography for monitoring patients post-operatively. By ensuring that audible alarms are specific to the patient condition, decreasing the frequency of false and non-actionable alarms, alarm fatigue should be lessened. Two policies were put in place that included the use of capnography, one directed at the monitoring of patients using patient-controlled analgesia and one directed at the monitoring of all high-risk patients receiving opioid analgesia. Education of staff regarding the practice change was multi-faceted and included both in-person and online education of the policy changes and both the cognitive and psychomotor aspects on the use of capnography. Additionally, competency validation was assessed in both the cognitive and psychomotor domains. Full assessment of the results of the practice change will take place in 2017.

REVIEW OF LITERATURE

Alarm Fatigue

Clinical alarms are intended to alert caregivers of potential problems with their patients, but the sheer number of alarms today can cause clinicians to become desensitized and ignore, disable, or silence alarms, compromising patient safety. “Alarm fatigue” is a term used to describe the alarm desensitization that occurs in clinicians due to the constant nature of audible alarms in the hospital setting, many of which are clinically insignificant (AACN Practice Alert, 2013; Blake, 2014; Daniels, 2014; ECRI Institute, 2014; George & Martin, 2014; Guardia-LaBar et al., 2014; Hannibal, 2011; The Joint Commission, 2013b; Purbaugh, 2014; Sendelbach & Funk, 2013; Stokowski, 2014; Tanner, 2013; Ulrich, 2013; Wallis, 2010). Nurses lose trust in the alarms because of the high number of false positive alarms in a phenomenon similar to that found in the cautionary tale *The Boy Who Cried Wolf* (Sendelbach & Funk, 2013; Stokowski, 2014). When nurses consistently respond to many false or non-actionable alarms, they may become desensitized and delay their response the next time those alarms occur. This is problematic when an alarm is alerting the nurse to a situation requiring immediate intervention.

According to an American Association of Critical-Care Nurses’ Practice Alert, the average number of alarms in an intensive care unit has increased from six in 1983 to 40 in 2011 (2013, p. 83). A study conducted in a 15-bed medical progressive care unit reported an average of 942 alarms per day (Graham & Cvach, 2010, p. 32). In one

intensive care unit at Johns Hopkins Hospital, the average alarm per bed per day was found to be 771 (Association for the Advancement of Medical Instrumentation, 2012, pp. 3-4). The alarms that were designed and intended to keep patients safe have become a safety hazard.

Nurses must determine criticality each time an alarm sounds and prioritize their actions based on other tasks at hand. Alarms often require a trip to the bedside to assess the patient or troubleshoot the alarm, disrupting the nurse's workflow and, in turn, increasing the risk for error (Cvach, 2012; Stokowski, 2014). In a nationwide survey of healthcare personnel related to concerns about clinical alarms, 76% of respondents agreed or strongly agreed with the statement, "Nuisance alarms occur frequently" (Healthcare Technology Foundation, 2011, p. 4). Seventy-one percent of respondents agreed or strongly agreed with the statement, "Nuisance alarms disrupt patient care" (Healthcare Technology Foundation, 2011, p. 4). Finally, 78% of respondents agreed or strongly agreed with the statement, "Nuisance alarms reduce trust in alarms and cause caregivers to inappropriately turn alarms off at times other than setup or procedural events" (Healthcare Technology Foundation, 2011).

Not only does the number of alarms lead to alarm fatigue in caregivers, but as a result patient safety is compromised and patient satisfaction is decreased. A study of patients post-discharge from a critical care unit found that the third principle stressors identified were "not able to sleep" and "hearing the buzzers and alarms from machinery", topped only by "having tubes in your nose or mouth" and "being in pain" (Hweidi, 2005, p. 232). Based on the latest data from a national survey on patient experience, only 61%

of patients reported that the area around their room was always quiet at night. Of the 11 topics on the survey, “Patients who reported that the area around their room was ‘Always’ quiet at night” received the second lowest score, with “Patients who ‘Strongly Agree’ they understood their care when they left the hospital” scoring the lowest (Centers for Medicare and Medicaid Services, 2013). Although hospitals are supposed to be a place of healing, alarms contribute significantly to what is already a noisy environment (Herman & Biddulph-Krentar, 2014, p. 1). The World Health Organization “Guidelines for Community Noise” recommends that noise levels in hospitals not exceed 30 decibels (Berglund, Lindvall, & Schwela, 1999, p. 62), however, measured hospital noise has been shown to be much higher, with one study reporting a 24-hour continuous hospital noise level average of 63.5 decibels (Park et al., 2014, p. 1). The noisy hospital environment can cause sleep disturbances, elevation in blood pressure, interfere with pain management, and impede the healing process (Herman & Biddulph-Krentar, 2014, p. 1).

Common sources of alarms found in the hospital setting include physiological monitors, patient safety alarms, and technical alarms. Physiological monitors include vital signs and electrocardiographic (ECG) monitors, pulse oximetry devices (SpO₂), and ventilators. Patient safety alarms include patient call lights, bed exit alarms, and chair exit alarms. Technical alarms include sequential compression devices (SCDs), intravenous pumps, feeding pumps, and patient-controlled analgesia pumps (Hannibal, 2011; Purbaugh, 2014; Sendelbach & Funk, 2013; Stokowski, 2014).

Actionable alarms are designed to alert clinicians that attention is required for the device or the patient (Stokowski, 2014, p. 2). Non-actionable alarms, often referred to as

nuisance alarms, are true alarms that do not require clinical intervention; an example would be a brief drop in oxygen saturation that does not require treatment (Stokowski, 2014, p. 2). False alarms are caused by non-physiologic events such as patient movement, electrodes connecting intermittently, poor sensor placement, or broken cables and may require intervention to ensure the alarm is functional in case of a real event (Stokowski, 2014, p. 2). Various studies have shown the instance of false alarms among all alarm occurrences to be as high as 85-99% (Association for the Advancement of Medical Instrumentation, 2011; Stokowski, 2014).

Several issues have been identified as contributors to false and non-actionable alarms. Default parameters on monitors are often too narrow and not patient specific, alerting caregivers to conditions that are not clinically significant (Association for the Advancement of Medical Instrumentation, 2012; ECRI Institute, 2014). In order to avoid missing a true event, parameters on alarm devices are set tightly, increasing sensitivity at the cost of decreased specificity (Sendelbach & Funk, 2013, p. 379). Alarm systems with a high sensitivity and low specificity generate a high number of false alarms (Sendelbach & Funk, 2013, p. 379). ECG monitors and pulse oximetry use electrodes and probes placed on the patient's body that often become loose and fall off, sometimes simply because of poor adhesive abilities (Graham & Cvach, 2010; Sendelbach & Funk, 2013). Patient movement can also cause equipment that is properly placed to lose an accurate signal, setting off a false alarm (Graham & Cvach, 2010; Purbaugh, 2014; Tanner, 2013).

With true alarms potentially occurring only 1% of the time, nurses lose trust and may respond less often or react with less urgency, possibly failing to respond to a

clinically significant event. Research by Bliss, Gilson, and Deaton (1995) showed if an alarm is accurate 90% of time, individuals will respond 90% of the time. If an alarm is accurate 10% of the time, individuals will only respond 10% of the time (p. 2306).

According to the Institute of Medicine report, *To Err is Human*, as many as 98,000 people die each year from medical errors that occur in hospitals (Institute of Medicine, 2000, p. 1). “Health care is a decade or more behind other high-risk industries in its attention to ensuring basic safety” (Institute of Medicine, 2000, p. 5). The major contributing factors to the sentinel events reported to The Joint Commission between 2009 and 2012 were absent or inadequate alarm systems, improper alarm settings, alarm signals not audible in all areas, and alarm signals inappropriately turned off (The Joint Commission, 2013b, p. 2). The Joint Commission is a not-for-profit organization that accredits and certifies healthcare organizations across the United States based on certain performance standards (The Joint Commission, 2015a, para. 1). Between January 2009 and June 2012, 98 alarm-related sentinel events were reported to The Joint Commission (The Joint Commission, 2013b, p. 1). A sentinel event is defined as “an unexpected occurrence involving death or serious physical or psychological injury, or the risk thereof” (The Joint Commission, 2013c, p. 1). Of the 98 alarm-related sentinel events, 80 resulted in death, 13 in permanent loss of function, and five in unexpected additional care or extended stay (The Joint Commission, 2013b, p. 1).

The issue of alarm fatigue drew national attention when The Boston Globe ran a front-page article about a patient who died at Massachusetts General Hospital after the alarm on his heart monitor had been turned off (Kowalczyk, 2010). An additional case

garnered the public's attention in 2012 when a 17 year-old girl died in the recovery room after a routine tonsillectomy because her monitoring equipment was not set properly and was muted (Crites, 2013).

In 2015, for the fourth year in a row, The Emergency Care Research Institute designated alarm fatigue number one on the list of the top ten health technology hazards (ECRI Institute, 2014, p. 3). The Joint Commission, further reinforcing the importance of this issue in 2013, approved alarm management as a 2014 National Patient Safety Goal (The Joint Commission, 2013a, p. 1).

National Patient Safety Goals are set by The Joint Commission to help those accredited organizations address areas of concern related to patient safety (The Joint Commission, 2015b, para. 1). Based on input from a panel of patient safety experts, The Joint Commission determines the highest priority safety issues and how best to address them (The Joint Commission, 2015b, para. 2). The 2014 National Patient Safety Goal on alarm management reads, "improve the safety of clinical alarm systems" (The Joint Commission, 2013a, p. 3) and was to be conducted in two phases. Phase one, beginning January 2014, required hospitals to establish alarm system safety as a priority and identify which alarms to manage (The Joint Commission, 2013a, p. 1). In Phase two, beginning January 2016, hospitals were expected to develop and implement policies and procedures for managing alarms and provide education on alarm system management to the organization (The Joint Commission, 2013a, p. 1).

Evidence-based practice recommendations for decreasing the frequency of alarms includes replacing ECG electrodes daily, widening default parameter settings, ensuring

modified parameters are patient specific, using technology that incorporates short delays, and using pagers or cell phones to notify nurses of changes in patient condition (AACN Practice Alert, 2013; Association for the Advancement of Medical Instruments, 2012; Cvach, 2012; George & Martin, 2014; Sendelbach & Funk, 2013). Additionally, the importance of establishing interdisciplinary teams to develop policies and procedures related to alarm management is highlighted in the literature (AACN Practice Alert, 2013; Association for the Advancement of Medical Instrumentation, 2011; The Joint Commission, 2013b).

Driven not only by regulatory requirements, but also patient safety concerns and the effects that excessive alarms have on caregivers has led to an urgency for hospitals to create processes to deal with alarm fatigue (Guardia-LaBar et al., 2014). By focusing on alarm management and, in turn, reducing the number of alarms, the issue of alarm fatigue will solve itself (Purbaugh, 2014; Stokowski, 2014).

Capnography

Capnography is a non-invasive method of monitoring the physiologic process of ventilation (Carlisle, 2014, p. 24) A nasal cannula is applied to the patient and captures exhaled breath, measuring the amount of carbon dioxide (CO₂) at the end of each exhalation (Carlisle, 2014, p. 24). Capnography provides instantaneous information about ventilation, directly measuring how effectively CO₂ is being eliminated by the pulmonary system (Krauss, Silvestri, & Falk, 2016, para. 2). An increased level of exhaled carbon

dioxide indicates decreased ventilation (Carlisle, 2014, p. 24). Capnography monitoring additionally includes the measurement of respiratory rate (Carlisle, 2014, p. 24).

Results from a literature search have shown capnography to be a superior monitoring technique for hypoventilation when compared to pulse oximetry (Burton et al., 2006; Hutchison & Rodriguez, 2008; Kopka et al, 2007; McCarter et al., 2008). “In one study, pulse oximetry identified only 33% of patients with respiratory distress, whereas capnography identified 100% of patients” (McCarter et al., 2008, p. 29).

Opioid induced respiratory depression (OIRD) is a decrease in ventilatory function secondary to opioid administration (Carlisle, 2014, p. 22). As the respiratory rate decreases, carbon dioxide builds up in the lungs (Carlisle, 2014, p. 24). Whereas pulse oximetry monitors the oxygen level in the blood, capnography measures exhaled carbon dioxide. Because the exhaled CO₂ level rises before the oxygen saturation in the blood decreases, capnography detects respiratory depression earlier than pulse oximetry (Carlisle, 2014, p. 24). “Early detection promotes timely rescue, particularly on med-surg units where nurse-to-patient ratios are higher and critical events are less likely to be witnessed” (Carlisle, 2014, p. 22).

In addition to detecting respiratory depression earlier than pulse oximetry, capnography is a more accurate indicator of compromised ventilation in patients receiving supplemental oxygen. Supplemental oxygen may artificially boost blood oxygen saturation, potentially masking compromised ventilation (Carlisle, 2014, p. 24). “Patients receiving supplemental oxygen commonly maintain O₂ sat above 90%, masking hypercarbia effects. So capnography is especially important for these patients” (Carlisle,

2014, p. 24). In patients receiving supplemental oxygen, pulse oximetry may remain normal for as long as three minutes after the patient becomes apneic (Carroll, 2002, p. 56).

Finally, capnography is a more specific method of monitoring for OIRD than pulse oximetry. As Sendelbach and Funk (2013) described, alarm systems with a low specificity generate a high number of false alarms (p. 379). Pulse oximetry measures oxygenation whereas capnography monitors ventilation, the physiologic process most indicative of OIRD. Pulse oximeters measure the pulse rate in addition to oxygenation, which is not specific to respiratory depression. Often, the alarm for the pulse oximeter will sound secondary to a brief drop or increase of the pulse rate, which is a non-actionable alarm. Since the pulse oximeter probe is attached to the patient's finger, patient movement or poor tissue perfusion often causes a loss of signal, generating a high number of false alarms.

Capnography detects respiratory depression earlier, is more accurate for patients receiving supplemental oxygen, and a more specific method of monitoring ventilatory status than pulse oximetry. For these reasons, capnography should be implemented to improve patient safety, decrease the frequency of false alarms, and decrease alarm fatigue.

Clinical Nurse Leader Role

The Clinical Nurse Leader (CNL) is in an ideal role to lead the unit team in alarm management. The Clinical Nurse Leader role was first proposed in 2003 by the American

Association of Colleges of Nursing to address the changing needs of the health care delivery system (American Association of Colleges of Nursing [AACN], 2007, p. 3). According to the document, White Paper on the Role of the Clinical Nurse Leader, the CNL is a master's prepared generalist who functions at the microsystem level (AACN, 2007).

Clinical Nurse Leader roles include clinician, outcomes manager, client advocate, educator, information manager, systems analyst/risk anticipator, team manager, member of a profession, and lifelong learner (AACN, 2007). "The CNL... is educated to bring high-level clinical competence to the point of care. Although not a managerial role, the CNL serves as a resource person for the interdisciplinary patient care team and assumes a horizontal leadership role within the team" (Moore & Leahy, 2012, p. 139).

In order to lead the team in the improvement process and affect change, the Clinical Nurse Leader must have a vision and a leadership style to articulate and convey their vision throughout the organization. Transformational leadership is "based on building relationships and motivating staff members through a shared vision and mission" (AANAC, 2014, p. 2). "The role of the transformational leader is to satisfy the needs of followers and thus motivate them to high levels of performance" (Barker, 2006, p. 16). Democratic leadership is a style similar to transformational leadership in which the leader encourages participation, group interaction, open communication, and shared decision making (AANAC, 2014; Greenfield, 2007; Murphy, 2005). Shared-decision making increases accountability and buy-in, and the democratic leader builds trust, respect, and commitment (Goleman, 2000, p. 85).

In a systematic review performed by Cummings et al. (2009), transformational leadership was shown to improve nursing job satisfaction, organizational commitment, nurse empowerment, and team productiveness. Not only do effective leaders directly influence the team they are guiding, positive leadership behaviors have shown to reduce patient adverse events and complications and increase patient satisfaction (Wong & Cummings, 2007, p. 517-518).

LOCAL PROBLEM

Setting

An alarm assessment and management project was planned for a rural hospital in a small community in the western United States. The hospital's inpatient Surgical Unit contains 20 beds for pre and post-operative care. Criteria for admission to the Surgical Unit require that the patient be in good or fair condition. Good condition is defined as stable vital signs that are within normal limits and the patient is conscious and comfortable (American Hospital Association, n.d.). Fair condition is defined as stable vital signs that are within normal limits and the patient is conscious, but may be uncomfortable (American Hospital Association, n.d.).

In 2014, the average daily census on the Surgical Unit was 15 patients. According to a microsystem assessment conducted in September 2014, the top six diagnoses for patients admitted to the Surgical Unit included total knee arthroplasty, fracture, total hip arthroplasty, spinal surgery, appendectomy, and cholecystectomy. In September 2014, patients ranged in age from 16-94, with the most common age bracket being 65-74 years old. Average patient length of stay on the Surgical Unit is 2-3 days.

The staffing mix on the Surgical Unit includes nurses and nurse aides. The nurse-to-patient ratio is 1:4 during the day shift (7 AM-7 PM) and 1:5 during the night shift (7 PM-7 AM). Depending on patient census, there may be zero to two nurse aides at any given time. All 34 nurses employed on the Surgical Unit are Registered Nurses. Of the 34 nurses, 28 have baccalaureate degrees and six have associate degrees.

Audible alarms on the Surgical Unit include patient call lights, intravenous pumps, sequential compression devices, pulse oximetry, and bed and chair exit alarms. The majority of alarms have default parameters, which can be customized to be patient specific. There is currently no formal procedure in place to customize alarm parameters.

After approval from the Institutional Review Board at Montana State University, the author conducted 10 hours of direct observation of the type and frequency of audible alarms on the Surgical Unit. Over the 10 hours of observation, an audible alarm occurred 130 times. The top five most common alarm types on the Surgical Unit were the patient call bell, intravenous pump, bed exit alarm, “other”, and the pulse oximeter. There was an average of 13 patients and seven staff members on the unit during the 10 hours of observation.

Intended Improvement

The aim of this project is to refine the use of audible alarms, ensuring specificity to the patient condition being monitored for, and decrease the frequency of false and non-actionable alarms on the Surgical Unit at a rural community hospital. Decreasing the frequency of false and non-actionable alarms will, in turn, decrease clinician alarm fatigue and, ultimately, improve patient safety. The intended improvement begins with patient admission to the Surgical Unit and ends when the patient is discharged from the hospital. The goal will be to determine evidence-based interventions for ensuring alarm systems are condition-specific and reducing the frequency of false and non-actionable alarm instances. It is important to address this issue now because the need to improve

clinical alarm management has been identified both nationally and locally. As referenced previously, The Joint Commission approved a National Patient Safety Goal on clinical alarm safety, identifying it as a high priority safety issue in hospitals nationwide (The Joint Commission, 2013a). In addition to the data and hospital goals provided by The Joint Commission, local observation on the Surgical Unit determined that audible alarms were occurring frequently and therefore an important process upon which to focus for improvement.

Of the top five alarm types observed on the Surgical Unit at the rural hospital, only the pulse oximeter is used to monitor for and alert the nurse directly of a change in the patient's physiological condition. The pulse oximeter is a device that uses a probe placed on the patient's finger to measure the oxygen level in the blood (Johns Hopkins Medicine, n.d.). Many patients are monitored by pulse oximetry post-operatively to detect for respiratory depression, a life-threatening complication of opioid analgesia (Carlisle, 2014, p. 22). However, the pulse oximeter generates a high number of false and non-actionable alarms due to patient movement, poor tissue perfusion, and the additional monitoring of the patient's heart rate, which is non-specific for respiratory depression. Additionally, evidence shows that capnography is superior to continuous pulse oximetry in detecting respiratory depression in patients receiving opioids (Burton et al, 2006; Hutchison & Rodriguez, 2008; Kopka et al, 2007; McCarter, 2008). Based on the overwhelming evidence highlighting capnography as more effective than pulse oximetry in detecting respiratory depression and the direct impact on patient safety, as well as the

high number of false and non-actionable alarms generated by the pulse oximeter, the pulse oximeter alarm was chosen as the focus for the improvement project.

A Clinical Nurse Leader student, with the support of the Surgical Unit Manager, the Surgical Unit Based Council Members, the Surgical Unit Staff, the Quality Department, and the Alarm Management Committee, led this improvement project.

METHODS

Evidence-Based Plan of Action

Prior to the practice change, the standard for monitoring post-operative patients for opioid induced respiratory depression on the Surgical Unit was continuous pulse oximetry. Capnography monitoring equipment was available; however, a policy had not been put in place to require its use. After conducting a literature search and finding that capnography is superior to pulse oximetry in early detection of respiratory depression, implementing a policy on monitoring that includes the use of capnography was necessary to standardize the process. In addition to developing and implementing a policy on the use of capnography, staff education, nurse competency validation, and follow-up monitoring was essential to ensure the practice change had been effective.

Lewin's Theory of Planned Change guided the practice change. This theory involves the three phases of unfreezing, moving, and refreezing (Shirey, 2013, p. 69).

The first phase, unfreezing, involves preparing for a change. "Unfreezing may begin with nurse leaders conducting a gap analysis illustrating discrepancies between the desired and current state" (Shirey, 2013, p. 70). For this evidence-based practice project, a gap was found between best practice and the current practice in the organization. Additionally, as part of preparing for a change, in the unfreezing phase, the factors for and against change are identified (Shirey, 2013, p. 70). A successful practice or process change requires "strengthening the driving forces and/or weakening the restraining forces" (Shirey, 2013, p. 70).

In order to strengthen the driving forces, the project leader discussed the evidence-based practice change with the Surgical Unit Based Council prior to implementation. “The Magnet model identifies the importance of empowering nurses to act on their own autonomous decisions and promotes a transformational leadership style that encourages shared governance structures to effectively implement change in practice” (Toole, Meluskey, & Hall, 2016, p. 287).

The restraining forces, or the barriers to implementing the practice change, were discussed with the frontline staff, the Surgical Unit Based Council. “Identifying and understanding the barriers perceived by staff and developing targeted approaches to alleviate these issues can help foster this change in practice” (Toole, Meluskey, & Hall, 2016, p. 290).

The second phase, moving, is where the change takes place. The moving phase involves “creating a detailed plan of action and engaging people to try out the proposed change” (Shirey, 2013, p. 70). The second phase included developing a policy, providing staff education, and ensuring staff competence in the evidence for and application of capnography.

The third phase, refreezing, involves sustaining and stabilizing the change “so that it becomes embedded into existing systems such as culture, policies, and practices” (Shirey, 2013, p. 70). In the third phase, real-time audits of the use of capnography will ensure the practice change has been successfully implemented.

Patient Population Analysis

A patient population analysis was conducted on 100 patients who had been discharged from the Surgical Unit in September 2016. The data points included age, diagnosis, length of stay, supplemental oxygen use while in the hospital, number of opioid pain medication doses while in the hospital, and monitoring equipment used. The average patient age was 61 and the average length of stay was 2.3 days. Ninety percent of the patients did not use oxygen at home, but required supplemental oxygen at some point during their hospitalization. On average, each patient received 13 total doses of opioid pain medication during their hospital stay, with the minimum amount being zero doses (only three patients required no opioid pain medication) and the maximum amount being 75 doses of opioid pain medication over eight days. Of the 100 patients, 27 were monitored with continuous pulse oximetry. None of the patients were monitored using capnography. One patient had a respiratory event requiring naloxone, a medication used to reverse the effects of opioid medications, and assisted breathing with a bag-valve-mask. The patient recovered fully.

The Intervention

The author led the change in policy for patient-controlled analgesia to include the use of capnography. The policy, titled “Patient-Controlled Analgesia (PCA) – Adults” (Appendix A), includes guidance on monitoring, patient and family education, and documentation. If the provider orders routine monitoring on a patient using patient-

controlled analgesia, the exception being patients who are receiving palliative or end-of-life care, the nurse is required to utilize continuous, electronic monitoring either in the form of pulse oximetry or capnography. If the patient's oxygen demand increases, the nurse is required to apply capnography if not already in place and monitor closely for respiratory depression. Supplemental monitoring, per policy, for a patient using patient-controlled analgesia includes nursing assessment of pain score, sedation level, and respiratory rate.

A second policy was developed to guide the monitoring of patients who are receiving opioids, either in oral form or intravenously, who are not using PCA. The policy, titled "Opioid Analgesics Monitoring" (Appendix B), was developed with input from the Quality Department and all Clinical Educators. Similar to the policy on patient-controlled analgesia, high risk patients receiving opioids are to be continuously, electronically monitored and if their oxygen demand increases, the nurse will apply capnography monitoring if not already in place. Per the policy, the designation of "high risk" encompasses long length of time receiving general anesthesia during surgery, patients with a history of snoring or obstructive sleep apnea, obesity, concurrent administration of other sedating medications such as benzodiazepines, opioid naïve patients, opioid habituation or increased opioid dose requirements, pre-existing pulmonary or cardiac disease, smoking, and pediatric patients.

The content of both policies was guided by evidence. The policies specified the importance of monitoring patients who are receiving supplemental oxygen with capnography as opposed to pulse oximetry. Each of the monitoring policies state that

patients who have an increase in oxygen demand are required to be monitored using capnography.

A literature review determined the time frame for monitoring patients post-operatively. One study addressed the timing of post-operative respiratory events. Of 62 post-operative patients who had a respiratory event, 77.4% had the event in the first 24 hours postoperatively (Taylor et al., 2005, p. 755). This knowledge was used to guide the policy on the duration of monitoring patients post-operatively.

Both policies underwent review by several hospital-wide committees for approval. Small work groups were created to initially develop, review, and update the policies with input from all inpatient nursing departments, the Quality Department, and the Information Technology department. The final drafts of each policy were presented to the Evidence-based Practice Council, a Shared Governance council consisting of direct-care nurses and nursing staff, nurse educators, and department managers. The Chief Nursing Officer provided final approval for each policy.

Barriers to implementing the use of capnography were explored with the Surgical Unit Based Council. Barriers discussed included lack of equipment, lack of staff knowledge on the benefit of capnography and operation of the equipment, and patient refusal due to the cumbersome cannula used for monitoring. In order to address the barrier of lack of equipment, a group of nursing managers, supervisors, and educators took an inventory of all capnography monitoring equipment in the facility. Several different types of equipment were available in the facility, and ongoing work will be required to streamline the equipment used. Lack of staff knowledge on the benefit of

capnography and operation of the equipment was addressed by staff education. Staff education also addressed the barrier of patient refusal. Previously, staff members were unable to provide comprehensive patient education on the benefits of capnography, as they did not have a full understanding themselves. After staff members received a thorough education on the use of capnography, they were better able to explain the benefit to their patients, which decreased the rate of patient refusal.

Staff education was provided in several different formats to address the cognitive and psychomotor domains of learning. The author presented both the policy change and evidence for the use of capnography at two Surgical Unit staff meetings in May 2016. All Surgical Unit nurses were in attendance. Additionally, in May 2016, the information on capnography and the policy changes were presented at a meeting of Pain Resource Nurses. The Pain Resources Nurses are frontline staff members who have been identified as experts on pain management and monitoring. These nurses are a resource for their peers while caring for patients at the bedside.

Further education was provided at a two-day Medical-Surgical Nursing conference, held in October 2016. An expert on capnography monitoring presented evidence supporting the use of capnography in monitoring patients for respiratory depression. The objectives of the presentation were that the learner will understand the rationale for the use of capnography, the learner will demonstrate the use of capnography monitoring equipment, and the learner will recognize the effects capnography monitoring has on alarm fatigue. The information was presented in lecture format and included a discussion on the new policies related to capnography monitoring, a video highlighting

the time difference in detection of apnea between capnography and pulse oximetry, and a hands-on demonstration of the capnography equipment available in the organization. The hands-on demonstration included a demonstration and explanation of how to customize the alarm settings to decrease the number of false and non-actionable alarms. Ninety-one nurses from the Medical and Surgical Units were in attendance. Post-conference feedback was overwhelmingly positive. Written evaluations included comments such as, “I specifically will implement using the option of capnography for patients whom I have respiratory depression concerns”, “I previously did not know how to use this device and feel more comfortable with it now”, “I plan to use capnography more and explain it to my patients”, and “I feel better equipped with knowledge to try and work through the barriers with patients”. All written evaluations were collated into a summative evaluation (Appendix C).

Several methods of competency assessment were employed, addressing both the cognitive and psychomotor aspects of competence. An online educational course with subsequent test questions was developed by the Clinical Educators to address cognitive competence and will be required for all inpatient nursing staff in the organization by the end of 2016. All new employees of the units who utilize capnography are required to attend a training and competency validation session on the use of capnography upon hire, led by the author. The use of capnography, both cognitive and psychomotor components, will be included as a topic for the Organization-wide competency fair in 2017. Attendees will be required to demonstrate the use of capnography equipment as well as verbalize how the equipment works and the organization-wide policy requirements for monitoring.

In the fall of 2016, in order to sustain and stabilize the change, audits of the use of capnography on applicable patients on the Surgical Unit will be conducted. Real-time re-education of the nursing staff will be implemented as necessary. In addition to monitoring the use of capnography, the impact on patient safety will be monitored by assessing the frequency of opioid-induced respiratory depression in 2017, comparing the data to a retrospective review of data from 2015. Alarm fatigue will be reassessed by further direct observation on the frequency of false and non-actionable alarms after the use of capnography has been fully implemented.

DISCUSSION

Summary

After uncovering a gap in best practice and the need to improve alarm management, two policies were developed to include the use of capnography when monitoring patients post-operatively for opioid-induced respiratory depression. Education and competency validation of the staff included both online and in-person modalities.

Lewin's theory of change was used to guide the evidence-based practice project, which involved the phases of unfreezing, moving, and refreezing. In the unfreezing phase, a gap in best practice was found at the organization level. The current standard for monitoring patients receiving opioids post-operatively was pulse oximetry. Although the equipment to monitor patients using capnography was available, there was no policy in place to guide nursing practice.

In the moving phase, a policy was developed and staff education and competency validation were completed. Education of staff was multi-faceted and provided in several different formats. Education on the policy that guides the use of capnography and the cognitive and psychomotor components was provided in person at staff meetings and a two-day Medical-Surgical Nursing Conference. Additional cognitive education was provided in a web-based format to all inpatient nursing staff, with subsequent test questions to validate nursing competency. A plan to include competency validation on the use of capnography in the 2017 organization-wide nursing competency day was put in place.

The refreezing phase will take place in 2017 and will involve audits of the use of capnography, as well as the frequency of false and non-actionable alarms, and the instances of opioid-induced respiratory depression. Audits will be conducted to ensure capnography is being used as outlined in the nursing policy. After the use of capnography has been fully implemented according to the nursing policy, additional observations will be conducted to determine if the frequency of alarms related to pulse oximetry has decreased. Finally, a retrospective review of the instances of respiratory depression will be conducted, comparing data from 2015 to 2017.

Limitations

One limitation of this evidence-based practice project was the sample size. This project was limited to a 20-bed inpatient surgical unit at an 86 licensed-beds rural hospital. The data collected by direct observation of type and frequency of audible alarms was produced from a relatively small number of patients.

Another major limiting factor of this project was time. Direct observation of the type and frequency of audible alarms on the Surgical Unit was conducted in the fall of 2015 and the policy changes and organization-wide nursing education and competency assessment were completed in 2016. Although the foundation for the practice change has been built, follow-up to ensure full implementation will not be complete until 2017.

Finally, the complexity of patient care, specifically the aspect of patient refusal continues to be a significant barrier to the implementation of capnography monitoring equipment and the improvement in the frequency of false and non-actionable alarms.

Although there are policies in place and the nursing staff has a comprehensive understanding of the rationale for the use of capnography, many patients continue to refuse the application of the cumbersome monitoring equipment or remove the cannula during monitoring, causing an increase in the frequency of alarms. The improvement in patient education has enhanced patient compliance, however, patient refusal is still a limitation to the success of this project.

Conclusion

The phenomenon of alarm fatigue is a safety concern, especially with the rapid increase in available technology, allowing for an increased number of alarm systems to monitor when caring for patients in the hospital. As alarm systems generate many false and non-actionable alarms, nurses lose trust and respond to those alarms less frequently posing the risk of nurses not rescuing patients in distress. In order to decrease alarm fatigue and ensure patient safety, alarm systems must be specific for the patient condition they are intended for and cause minimal false and non-actionable alarms.

Pulse oximetry is commonly used to monitor for respiratory depression post-operatively, although the literature has shown that capnography is a superior method of detecting respiratory depression. After performing an observation on the type and frequency of alarms on a surgical unit at a rural community hospital, pulse oximetry was found to be in the top five most frequent audible alarm instances. In order to decrease alarm fatigue and improve patient safety, the use of capnography was implemented on a surgical unit at a rural community hospital.

This evidence-based practice project is a step towards improving patient safety on an inpatient surgical unit by recognizing opioid-induced respiratory events sooner.

Further, utilizing capnography as opposed to pulse oximetry will improve specificity for the patient condition that the monitor is intended to detect, decreasing the number of false and non-actionable alarms, and ultimately decreasing alarm fatigue among nursing staff.

Additional work will need to be done to ensure the success of this project.

Regularly auditing the use of capnography will be necessary to ensure staff compliance.

Continued education and competency assessment will be required to ensure all staff, including new hires, understands the rationale for the use of capnography and are competent in the use of the equipment. Monitoring the instances of respiratory depression among patients on the Surgical Unit will provide data to support the effect the project has had on patient safety.

Based on the scope of services for each hospital department and the similarities between patient population and conditions, it is recommended that the use of capnography to monitor for opioid-induced respiratory depression be implemented throughout the organization.

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APPENDICES

APPENDIX A

PATIENT-CONTROLLED ANALGESIA (PCA) – ADULTS

POLICY/PROCEDURE

TITLE	PATIENT-CONTROLLED ANALGESIA (PCA) – ADULTS		
APPLICABLE TO	Deaconess Hospital		
SECTION	Patient Care (Organizational)		
		CURRENT DATE	4/16
CONTRIBUTORS		REPLACES	PCA Procedure and Titration Protocol
APPROVED BY	CNO	REVIEWED	

POLICY: All patients have a right to adequate pain control.

PROCEDURE:

Lippincott Link: [Patient-controlled analgesia](#)

BHDH Policy Link: [Opioid Analgesics Monitoring](#)

1. Routine Monitoring:
 - a. At start of therapy or with each dose increase:
 - 1) Continuous electronic monitoring via pulse oximetry or capnography (EtCO₂) as ordered
 - a) If patient's oxygen demand increases, order End Tidal CO₂ monitoring and monitor closely for respiratory depression
 - 2) (Adults) Assess and document pain score, sedation level, and respiratory rate every 1 hour for 12 hours and then every 4 hours
2. Patient and Family Education:
 - a. Goal of PCA use
 - b. Medication name, type, and reason for use
 - c. How to administer medication, including process, time, frequency, route, and dose
 - 1) Use of control button (patient only, no family pain assessment for use of button)
 - 2) Safety feature explanation – lockout interval
 - d. Anticipated actions and potential side effects of the medication
 - e. Use of a pain scale to monitor the effects of the medication
 - f. Nurse demonstration of use of pump
 - g. If the nurse has concerns about the patient's ability to safely use the PCA pump, the ordering physician (or their designee) should be notified.
3. Documentation:
 - a. Baseline and continuing pain and vital sign assessment
 - b. Patient and family education
 - c. Patient response to medication, need for dose changes
 - d. Adverse effects, treatment, and response to treatment
 - e. Volume and dose of medication infused

APPENDIX B

OPIOID ANALGESICS MONITORING

POLICIES/PROCEDURES

TITLE:	OPIOID ANALGESICS MONITORING
SECTION:	Patient Care

APPLICABLE AREAS:		CURRENT DATE:	3/16
CONTRIBUTORS:	Quality, Educators, Pharmacy	REPLACES:	
APPROVED BY:	CNO	REVIEWED:	

POLICY: In order to safely and effectively administer opioid analgesics, patients will receive timely assessments and appropriate monitoring.

PROCEDURE:

- Routine monitoring will minimally include; vital signs, pain level, respiratory status and a comprehensive respiratory assessment and sedation scale. Richmond Agitation Sedation Scale (RASS) and/or the Pasero Opioid-induced Sedation Scale (POSS) will be used to assess for excessive sedation on *all* patients receiving opioid analgesics and documented in the medical record.
- Sedation level and respiratory status are to be monitored and documented prior to administration of medication and reassessed timely (within one hour of administration, if oral and within 30 minutes if IV). More frequent monitoring would be required if clinically indicated, (i.e., adverse change in sedation scores).
- **Patient Controlled Analgesia (PCA) Infusions:**
All patients on PCA pumps for pain control will be continuously, electronically monitored. See Adult and Pediatric PCA order-set/policy.
- **HIGH RISK PATIENTS:**
Patients at high risk for opioid induced respiratory depression will be continuously, electronically monitored using SPO2 (pulse oximetry), and/or ETCO2 (capnography) – physician order is required. If the patient's oxygen demand increases, order ETCO2 monitoring and monitor closely for respiratory depression. Sedation and respiratory assessment monitoring frequency for high risk patients will be every hour for the first 4 hours, then every four hours for 24 hours after initiation of opioid analgesics. Other vital signs may be obtained as required per physician order. More frequent monitoring would be required if clinically indicated i.e., adverse change in sedation score. Patients considered to be high risk may include but are not limited to:
 - Long length of time receiving general anesthesia during surgery
 - Patients with a history of snoring or obstructive sleep apnea
 - Obesity
 - Concurrent administration of other sedating medications such as benzodiazepines
 - Opioid naïve patients (patients not accustomed to taking opioids)
 - Opioid habituation or increased opioid dose requirements
 - Pre-existing pulmonary or cardiac disease
 - Smoking
 - Pediatric patients

APPENDIX C

ACTIVITY EVALUATION FORM COLLATED

**Continuing Nursing Education
Activity Evaluation Form**

**Medical/Surgical Nursing Conference
October 17-18, 2016**

Please describe how you plan to use information from this learning activity to strengthen your practice.

- Didn't realize how much more effective capnography is vs. oximetry.
- Using capnography for PCA use. Usually have only been using O₂ monitoring.
- Very helpful for monitoring our opioid heavy patients.
- Capnography was a great follow up to opioid talk.
- The presentation on this subject was great at showing how much more accurate this tool is when detecting over sedation.
- Utilize capnography more.
- Advocate for use of capnography.
- Need to utilize capnography on our narc/PCA patients.
- Better understand capnography and benefits, will use more often!
- Info on monitoring capnography very useful. Will definitely start using capnography.
- Will not hesitate to use capnography.
- Use capnography more!
- Consult coworkers on use of CO₂ monitor.
- Increased familiarity with capnography, increased level of comfort with these topics.
- I specifically will implement using the option of capnography for patients whom I have respiratory depression concerns. I previously did not know how to use this device and feel more comfortable with it now.
- Increase use of capnography.
- Incorporate capnography into practice.
- I feel better equipped with knowledge to try and work through the barriers with patients.
- I plan to use capnography more and explain it to my patients!
- Going to start using capnography vs. pulse oximetry.
- Use of capnography vs. pulse oximetry – knowing when to use on the floor and how to use.
- Will be a good tool to use with patients receiving opioids.
- Know when and how to use capnography.
- Work on using capnography for patients using high dose/PCA more often.
- Clarified the questions I had on capnography.
- Will use more capnography.
- I will consider using capnography earlier on patients.
- I think that capnography will be useful with opioids and also other patients with declining respiratory status.
- Will try and use capnography more often so can catch problems faster with my patients.
- More use of capnography – clearer instructions.