Mini Review
Published: 26 Jan, 2018

Journal of Pediatric and Womens Healthcare

The Tiniest Patients Make the Biggest Noise

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Abstract

Women & Infants Hospital of Rhode Island (W&I) is one of the nation's leading specialty hospitals for women and newborns. It is a major teaching affiliate of The Warren Alpert Medical School of Brown University for activities that are unique to women and newborns. The hospital is the eleventh largest, stand-alone obstetrical service in the country with approximately 8,400 deliveries annually.

Women & Infants has been designated as a Baby-Friendly USA Hospital, published in the U.S. News & World Report 2014-15 as the Best Children's Hospital in Neonatology, and in 2014 identified as a Leapfrog Top Hospital.

In 2009, Women & Infants opened what was at the time the country's largest, single-family room neonatal intensive care unit (NICU). The NICU is well known for their ongoing research efforts and for providing the best evidence-based care. The unit this past year has focused on a quality improvement project to decrease alarm fatigue within their family-centered environment.

Background

In 2013, the Joint Commission announced National Patient Safety Goal (NPSG.06.01.01) in order to improve the safety of clinical alarm systems in hospitals. This NPSG requires that hospitals establish alarm management as an organizational priority, identify the most important alarms to manage, and create policies or procedures for managing those alarms identified. The goal sought to combat alarm fatigue. Alarm fatigue is the result of poor alarm management. Clinicians become desensitized to alarms if they occur in overwhelming quantities. There are two main causes of alarm fatigue: false alarms and nuisance alarms. False alarms generate a notification despite no true clinical event, often due to poor lead placement, patient movement, or monitor alarm detection algorithms. Nuisance alarms, in contrast, are the result of a true event, but do not require clinical intervention. In these cases, a patient may violate an alarm limit, but self-correct before any intervention is required by staff. Non-clinically actionable alarms contribute to alarm fatigue because they do not require clinical intervention but still generate a notification to the caregiver and add to the myriad of noises clinicians endure daily (Morano, 2014).

In an effort to address this NPSG and create a safer environment for its patients, Women & Infants Hospital assembled a multidisciplinary committee with members from nursing, education, quality management, clinical engineering, and respiratory care. The committee reviewed departmental processes and received staff input on alarm fatigue. The neonatal intensive care unit (NICU) staff provided the most feedback on alarm fatigue and the overwhelming quantity of alarms that disrupted patient care.

The neonatal intensive care unit (NICU) at W&I is the most monitored unit with 80 beds. This unit has no central station, but uses a secondary alarm notification system in the form of hospital-provided phones.

Failure Modes and Effects Analysis

The multidisciplinary committee worked with staff to outline steps taken to address patient alarms and performed a Failure Mode Effects Analysis (FMEA) for the NICU. A FMEA is a team-based, systematic, and proactive approach for identifying the ways that a process or design can fail, why it might fail, and how it can be made better and/or safer. Its purpose is to find whatever might go wrong and fix it before it does. Through this process, the committee identified opportunities for improvement for the NICU's alarm processes. W&I followed the work plan detailed in "A Work Plan for The Joint Commission Alarm National Patient Safety Goal" (Hyman, 2014).

Workflow Overview

The multidisciplinary team worked with nursing staff to outline the clinical alarm process in the

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Received Date: *02 Nov 2017*
Accepted Date: *15 Jan 2018*
Published Date: *26 Jan 2018*

Citation: *Henry D, Herold S, Kusiak M. The Tiniest Patients Make the Biggest Noise. J Pediatr Womens Healthcare. 2018; 1(1): 1002.*

ISSN 2643-797X

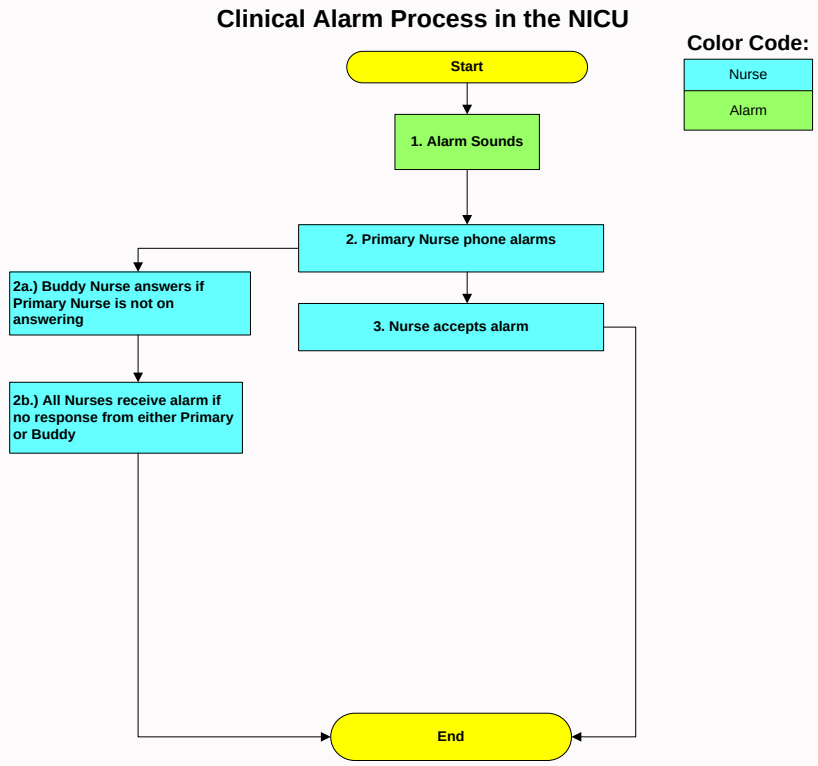

Figure 1: NICU Alarm Workflow.

NICU. When certain alarm limits are violated, an alarm is generated at the bedside monitor. The alarm then escalates by sending a message to the primary nurses' phone. The nurse can either accept or decline the alarm. If the nurse accepts the alarm, the alarm will not escalate. If the nurse declines the alarm, the alarm message is sent to the Primary nurse's "buddy". If that nurse does not accept the alarm, in 30 seconds all nurses in the neighborhood receive the alarm message. This process is outlined in Figure 1.

FMEA committee members reviewed the clinical alarm process and brainstormed failure modes. Each failure mode was assigned a risk score. Risk scores were calculated by determining the likelihood of the failure mode occurring, the severity if it occurred, and the failure mode's detectability (Sheff, 2002).

Risk Score = Frequency x Severity x Discoverability

The failure mode that yielded the highest risk score was that the primary nurse was multitasking and either did not hear the alarm or was unable to get to the phone to acknowledge and accept the alarm. This could lead to a missed critical alarm. Staff commented that the alarms sent to the phones occur in overwhelming quantities and usually stem from a specific patient population, "swooners". "Swooners" are defined by NICU staff as neonates that frequently, but briefly, breach the alarm limits and return within normal limits without any clinical intervention. In other words, "swooners" generated overwhelming quantities of nuisance alarms which can contribute to alarm fatigue. This FMEA provided the foundation of the quality improvement project.

Action Plan

The objective of this quality improvement project was to reduce overall noise and prevent alarm desensitization by reducing nuisance, or non-clinically actionable alarms, sent to nurses' phones.

Initial Data

The committee relied on clinical engineering and nursing to obtain initial alarm data. Due to limitations and licensing of the monitoring system, primary alarm data was not obtainable directly from the bedside monitor. Moreover, the feedback from NICU staff revealed that alarm fatigue was caused by non-clinically actionable alarms sent to the secondary alarm phone system. Nurses would often be in one room feeding a patient and receive an alarm notification on his/her phone. These alarm notifications would interrupt patient care because the nurse would have to put the bottle down, adjust the patient, and look at the phone message. The nurse, or the "buddy" nurse, would check on the patient and discover that he/she had already self-corrected without any need for clinical intervention.

Twenty-four hours of secondary alarm data were extracted from the server supporting the secondary alarm system and analyzed for the NICU. On this day, there were 76 patients being monitored, sending alarms to 28 hospital-provided phones. These patients generated 7,999 alarms to the nurses' phones. Of these, 6,929 alarms were related to SPO2 alarm limit violations. Clinical engineering analyzed the SPO2 data. With the primary alarm delay already set to the maximum time as allowable by the monitor, clinical engineering looked at widening alarm parameters. The team discovered that 2,256 SPO2 alarm notifications were within + 1% of the alarm limits and 3,315 SPO2 alarm notifications were within + 2% of the alarm limits. Nursing concluded that these alarms were indeed generated by the "Swooner" population and were non-clinically actionable.

This data provided the foundation for the alarm quality improvement project. Physician buy-in was a critical piece because the hospital policy for SPO2 alarm parameters was mandated by

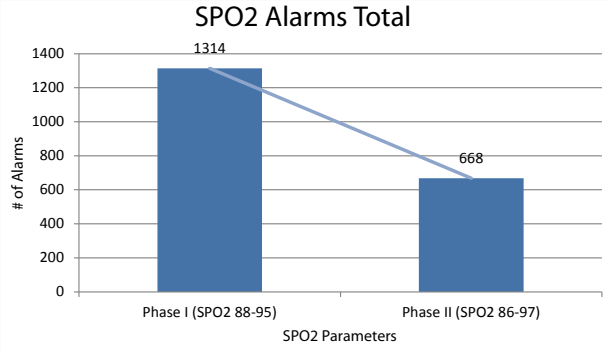

Figure 2: Total SPO2 alarms generated for Phase I and Phase II (Total monitored hours = 56.5, total number of patients = 5).

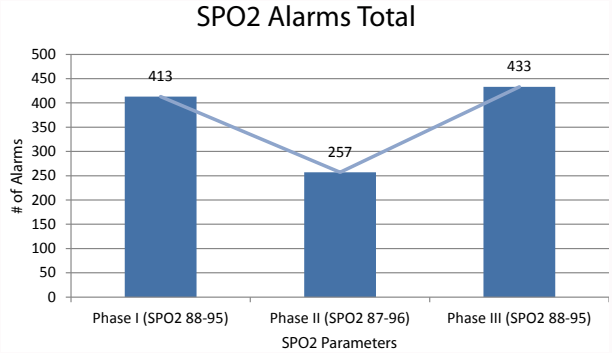

Figure 3: Total SPO2 alarms generated for Phase I, Phase II, and Phase III (Total monitored hours = 20, total number of patients = 5).

physicians based on results from a research study (Carlo et al., 2010). The above collected data was presented to the physician group, and they acknowledged the overwhelming alarm quantities, especially those generated from SPO2 alarms. Consent was given to allow widened parameters on "Swooner" patients on a trial basis.

Nursing staff would identify "Swooner" patients for this project. For a predetermined amount of time, the alarm parameters would be set per hospital policy. Then, nursing staff would widen the alarm parameters by + 2% for an equal amount of time. This meant that the upper limit for SPO2 would increase by 2% and the lower alarm limit for SPO2 would decrease by 2%. Clinical engineering would retrospectively analyze secondary alarm notification system data and compare the amount of alarms generated during both time periods.

Data Collection and Results

Per physician request, dual SPO2 monitoring was completed. A standalone SPO2 monitor was utilized to measure the percent time patients spent in a designated SPO2 range and see if the alarm parameters had any correlation to where patients were sitting with regards to SPO2. The bedside patient monitor was used to primarily monitor the SPO2 and it is from here that secondary phone alarms would be generated.

Five patients were identified as "swooner" patients. Alarm parameters were set per hospital policy for 56.5 hours (Phase I). During this time, these five patients generated 1,384 alarms to the phones; 1,314 of these alarms were SPO2. After the alarm limits were widened by +2% (Phase II), total alarms sent to the phones dropped to 710, with 668 SPO2 alarms. This data can be seen in Figure 2.

Table 1: Average percent time spent in designated SPO2 range for Phase I and Phase II.

% of Time in Each Range (x+std)	**<70%**	70-79%	80-87%	**88-95%**	96-100%	91-94% (Represents target range)
Phase I (min 88, max 95)	0.6+0.0 -	2.5+0.1 -	12.2+0.9 -	58.3+2.2 -	26.4+2.8 -	34.3+0.9 -
Phase II (min 86, max 97)	0.4+0.0 -	1.6+0.1 -	9.4+0.6 -	64.4+3.3 -	24.4+2.8 -	40.5+2.0 -

Table 2: Average percent time spent in designated SPO2 range for Phase I, Phase II, and Phase III.

% of Time in Each Range (x+std)	<70%	70-79%	80-87%	88-95%	96-100%	91-94% (Represents target range)
Phase I (min 88, max 95)	0.0+0.0 -	1.1+0.1 -	10.6+0.9 -	58.9+3.2 -	29.5+5.6 -	33.0+2.1 -
Phase II (min 86, max 97)	0.1+0.0 -	1.3+0.1 -	10.6+0.9 -	64.5+3.0 -	23.5+3.5 -	39.2+21.6 -
Phase III (min 88, max 95)	0.3+0.0 -	1.2+0.1 -	10.2+0.9 -	67.6+2.5 -	20.4+2.3 -	40.8+1.2 -

Additionally, longitudinal SPO2 data was downloaded from the standalone pulse oximeters. This data is a frequency histogram which annotates the percentage time each patient resides at selected oxygen saturations. This allowed us to see where the patients were sitting during testing with each alarm setting. These results are shown below in Table 1.

Acknowledging that some clinical interventions may have occurred between the two phases, nursing and clinical engineering decided to analyze secondary alarm notification data for an equal amount of time after Phase 2, thus introducing a Phase 3 where SPO2 alarm parameters were set back per hospital policy. Five different patients were identified as "swooner" patients. Alarm parameters were set per hospital policy for 20 hours (Phase I). SPO2 parameters were then widened by +2% for an additional 20 hours (Phase II). During Phase III, the alarm parameters were set back to reflect hospital policy and data was collected for an additional 20 hours. The five "swooner" patients generated 422 alarms during Phase I, of which 413 were SPO2 alarms. With widened SPO2 parameters, the five "swooner" patients generated 273 total alarms, of which 257 were SPO2 alarms. When the SPO2 alarm parameters were set back to reflect hospital policy during Phase III, 445 total alarms were generated, of which 433 were SPO2 alarms. These results can be seen in Figure 3.

Again, SPO2 data was downloaded from the standalone pulse oximeters to see where the patients were sitting during testing. These results are shown below in Table 2.

Conclusion

The reduction in the number of alarms generated, and thus the reduction in noise and care interruptions, prompted nursing staff to take action. The assistant nurse manager drafted a guideline for nurses to follow. The data was presented to NICU faculty for feedback and guidance regarding the proposed guideline. Currently, clinicians are unable to make a correlation, if any, between alarm parameters and their effect on where patients were sitting with regard to SPO2 levels.

A more in-depth data collection and analysis will be performed

comparing the current alarm limits and the proposed alarm limits and the effects on alarm reduction and patient SPO2 levels. Additionally, nursing staff will work with physicians to better define "swooner" criteria for the proposed guideline.

The quality improvement project also highlighted the limitations of the current monitoring system. A committee will be formed to investigate patient monitoring and available technology for combating alarm fatigue. Such technology may include longer alarm delays and tiered alarm capabilities.

Acknowledgements

Beth Taub, MSN, RN, Sarah Lillie, Jillyan Morano, MHA, and Mike Quinn.

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