

Safety Innovations

Simple Solutions for Improving Patient Safety In Cardiac Monitoring— Eight Critical Elements to Monitor Alarm Competency

**University of Pittsburgh Medical Center (UPMC);
Presbyterian Hospital**

UPMC is a large multi-hospital system. Through pilot programs and trial and error, it has sought to find commonalities in alarm management between different units.

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About the Healthcare Technology Safety Institute (HTSI)

Founded within the AAMI Foundation, the 501(c) (3) charitable arm of AAMI, the HTSI is a community of leaders throughout the healthcare system that are dedicated to one common vision, "No patient will be harmed by medical technology." HTSI's mission is "To engage the entire healthcare community in multi-disciplinary safety initiatives that strengthen the development, management, and use of medical technology for improved patient outcomes." HTSI engages the healthcare community in research, education, consensus, and partnerships related to the challenges facing healthcare technology industries, regulatory and accrediting bodies, clinicians, caregivers, and patients.

ALARM CONDITION

State of the ALARM SYSTEM when it has determined that a potential or actual HAZARD exists

NOTE 1 An ALARM CONDITION can be invalid, i.e. a FALSE POSITIVE ALARM CONDITION.

NOTE 2 An ALARM CONDITION can be missed, i.e. a FALSE NEGATIVE ALARM CONDITION.

ALARM SIGNAL

Type of signal generated by the ALARM SYSTEM to indicate the presence (or occurrence) of an ALARM CONDITION

From IEC 60601-1-8:2006, Medical electrical equipment – Part 1-8: General requirements for basic safety and essential performance – Collateral Standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems

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Simple Solutions for Improving Patient Safety in Cardiac Monitoring—Eight Critical Elements to Monitor Alarm Competency

At a Glance

- Subject:** University of Pittsburgh Medical Center (UPMC); Presbyterian Hospital
- Location:** Pittsburgh, PA
- Description:** UPMC Presbyterian hospital is a 737-bed hospital known for organ transplantation, cardiology, cardiovascular surgery, critical care medicine, neurosurgery, and trauma services.

Introduction

UPMC officials consider alarm system management a critical issue and the complex safety issues alarm noise presents in the care environment is one of the top technological hazards the Center faces. While alarm signals are meant to alert clinicians to potential threats to patient safety, such as cardiac dysrhythmias, the overabundance of these signals create “alarm fatigue,” leading to a far greater patient safety concern than nearly any other clinical issue in the Center’s hospitals.

Alarm system management has been first and foremost on the minds of UPMC Presbyterian Hospital officials in the cardiology unit. UPMC has come to realize that improving the utilization and management of non-life threatening arrhythmia alarm conditions could reduce alarm fatigue and preserve patient safety. With this in mind, UPMC Presbyterian launched pilot projects that would result in: decreasing alarm ring time, improving staff response to cardiac monitor alarm signals, and decreasing alarm noise within hospital units that contain a high volume of monitoring equipment.

UPMC’s top three pilot project priorities were:

- Accountability – how to ensure that an alarm signal is responded to in a timely fashion by a member of the health care team and interpreted appropriately for action.
- Action versus Non-Action – how the health team responsible for monitoring alarm conditions can identify alarm signals that require immediate patient response.
- Identifying Low Priorities – how the health team can effectively manage alarm conditions that do not require an immediate clinician response but cannot otherwise be ignored (e.g., telemetry pack battery warnings).

Alarm Fatigue

Alarm fatigue is the desensitization that staff experience from continuous exposure to frequent, often non-actionable alarms.

Alarm System Challenge

Headquartered in Pittsburgh, PA, UPMC is a large multi-hospital system that operates more than 20 academic, community, and specialty hospitals and 400 outpatient sites. What works best for one part of the hospital system in addressing the high volume of hospital alarm signals is not necessarily what works best for all parts. However, through pilot programs and trial and error, the hospital system sought to find commonalities in alarm system management. Over the years, different hospitals and units within UPMC developed their own mechanisms and processes for managing alarm systems. As a result, processes vary based on the individual(s) responsible for monitoring patient alarm conditions (nurses or medical technicians) and operational designs. For example, some other UPMC hospitals utilize “war rooms” staffed by medical technicians. The technicians monitor alarm signals that alert nurses and

physicians of alarm notifications. Other hospitals in the UPMC system use digital monitors at the bedside or through remote monitors in the hallways at strategically located positions or midway points (e.g., central station, mid-hallway, or end of the hallway). These monitors are accessible for nurses so they can take action or respond to patients’ needs by viewing the monitors at these points.

The figure (Figure 1) below indicates UPMC’s process for responding to alarm signals.

Kate Hileman, RN, MSN, knows all too well the reality behind the role alarm management plays in patient care delivery having worked as a staff nurse at UPMC’s Presbyterian Hospital, a hospital known for organ transplantation, cardiology care, cardiovascular surgery, critical care medicine, neurosurgery, and trauma services. “I was the unit director for a medical cardiology unit at UPMC’s Presbyterian hospital from 2003 to 2011. In 2006, following a

Food for Thought

Does your facility have a written protocol outlining alarm management responsibilities?

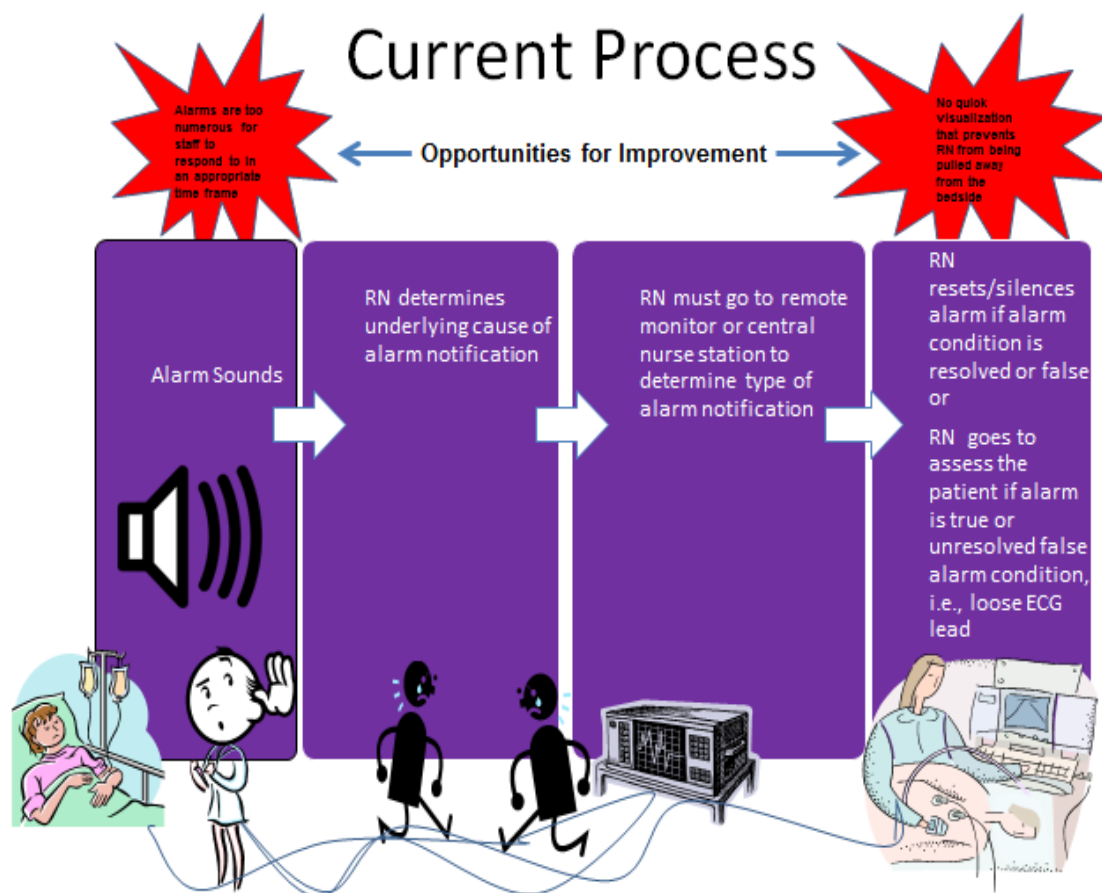


Figure 1.

particularly difficult shift, I met with the staff nurses for a debriefing. We began discussing some of the challenges they were facing on a daily basis, and we made a list of the things they saw as barriers to providing consistent quality nursing care. It was then that the issue of excessive alarm noise came up,” said Kate. The nurses, particularly on the night shift, acknowledged that alarm noise consistently pulled them away from direct patient care and that often alarm signals were too numerous for them to be able to respond in a timely fashion.

Kate and a team of nurses immediately began work on a pilot project that examined the number and types of alarm signals that were occurring. They began by doing direct observations on the unit by shadowing nurses as they worked, tracking the number of alarm conditions and related signals, and their responses to them. One observer was stationed at the central monitor station and recorded all the alarm signals and corresponding conditions which occurred during an eight hour shift. They also analyzed data from the main central monitoring station to determine the number of life-threatening and non-life-threatening alarm conditions. Non-life threatening alarm conditions included mid-level “informational” arrhythmia alarms, i.e. premature ventricular contractions (PVC’s). The team also reviewed data regarding the number of low level or “technical” alarm conditions such as “leads off” or low battery strength. Kate and the nurses she collaborated with also looked at any medical interventions that were taken resulting from alarm signals. “The results were eye opening,” says Kate, “the mid-level, non-life-threatening arrhythmia alarm conditions accounted for the majority of all alarm signals during an initial ten-day observation period and ranged anywhere from 247 to 1565 signals per day on an 18 bed medical cardiology unit. The overall average for the total observation period was 871 non-life threatening/non-actionable alarm signals per day.”

Kate and her nursing, physician, and clinical engineering colleagues then began to take a close look at other types of conditions that created alarm signals. What they

Technical Alarm Condition

An alarm condition arising from a monitored equipment-related or alarm system-related variable

EXAMPLE 1 An electrical, mechanical or other failure.

EXAMPLE 2 A failure of a sensor or component (unsafe voltage, high impedance, signal impedance, artifact, noisy signal, disconnection, calibration error, tubing obstruction, etc.).

EXAMPLE 3 An algorithm that cannot classify or resolve the available data.

realized was that most alarm signals were either “false positive” or “true positive” but had no significant health consequences.

These alarm signals had become background noise for nurses and other hospital staff members who have become desensitized to alarm sounds.

Launching Pilot Projects

Kate and her colleagues focused initially on reducing alarm signals in two of UPMC’s Presbyterian hospital units – a medical cardiology unit and a progressive care unit. Review of the data collected by the nursing team from cardiac monitors on these two units showed that non-life threatening arrhythmia alarm conditions were at a volume of 83 alarm signal per patient per day, averaging one alarm signal every 96 seconds. The nurses reviewed 10 days of all non-life threatening alarm conditions signaled by cardiac monitors. The problems were clear: alarm signals were too numerous for nurses to differentiate between them (life threatening or non-life threatening/nuisance) and too frequent to respond

Food for Thought

Have you measured the time that your nurses are responding to alarm signals and away from direct patient care?

Nuisance alarms are either false alarms or technical alarm conditions that have no significant patient health consequence and are non-actionable, requiring a response albeit not in relation to a life threatening event.

Food for Thought

Has your facility developed ways to identify and control nuisance alarms?

Food for Thought

What are some of the ways your facility can customize alarm parameters based on individual patient conditions?

to all of them on a timely basis. In addition, workflow was interrupted and inefficient due to the time and attention that nurses had to spend responding to alarm signals.

Given the frequency and number of alarm signals on these two units, the nursing team's first priority was to decrease the overall number of non-life threatening alarm conditions. Non-life threatening informational alarms were set to "OFF," permitting only heart rate parameters and life-threatening arrhythmias to produce an alarm signal. Nurses were then taught how to customize individual alarm signals based on a patient's clinical conditions.

Recognizing the challenge in customizing alarm signals for individual patients due to

the lack of standardized protocols that exist today, UPMC established its own protocol consisting of "Eight Critical Elements," and an annual nursing competency review. The elements focused on simple questions to complex issues that affect alarm management (e.g., How do you change the heart rate alarm parameters? How do you find pacemaker placement?) As a result of these efforts, overall alarm signal time was reduced by approximately 80 percent. Since this protocol was put in place, there has been no increase in adverse patient events related to the reduction of alarm signals on non-life threatening cardiac arrhythmias. See section on Finding Commonalities for details on the Eight Critical Elements.

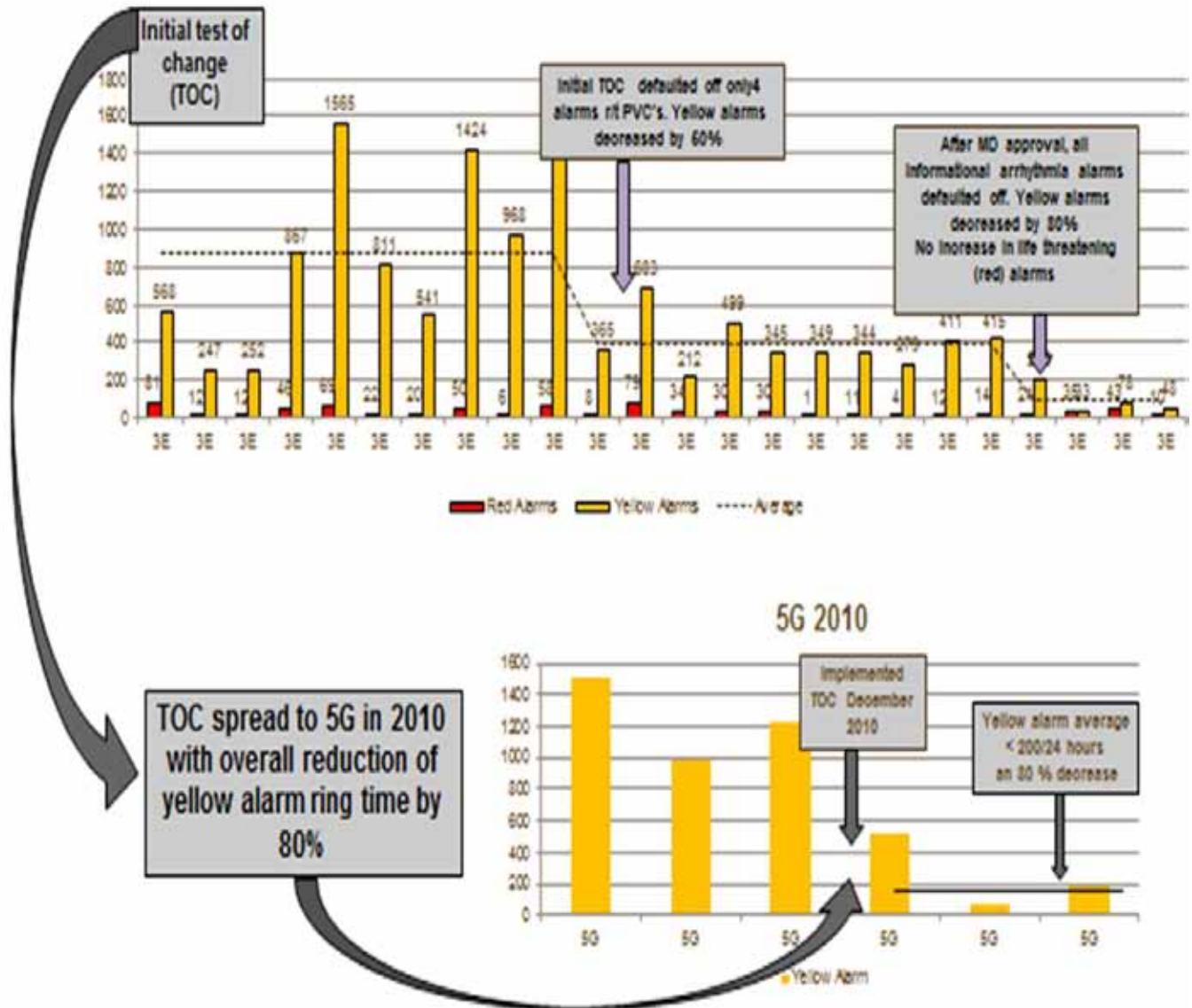


Figure 2.

The figure (Figure 2) shows the results of changes that were made to alarm parameters in both the medical cardiology unit and the progressive care unit. The yellow bars or “yellow alarm signals” represent the non-life threatening informational signals and the “red alarm signals” represent the life-threatening signals.

2. How to communicate changes in a patient’s alarm parameters from one nursing shift to another. UPMC implemented a process for a face-to-face information handoff between shift nurses that occurs at the patient’s bedside and includes a review of the patient’s alarm parameters.

Recommendations:

1. Measure the time that your nurses are spending on responding to alarm signals.
2. Determine a measure that will determine the number of signals your nurses are responding to, e.g., signals per unit - per bed - per day. Then, collect, document, and analyze the data.
3. Prioritize conditions that require an alarm signal and determine those that are non-actionable, non-life threatening and/or nuisance.
4. Re-set your alarm parameters according to your priorities.
5. Determine who on your staff has authority to set or re-set alarm parameters, e.g., nursing staff.

UPMC also held Nursing Grand Rounds on how to address alarm fatigue and improve alarm recognition and awareness. As nursing staff in units where pilot testing occurred became more comfortable and more in control of the new process, interest among the entire hospital nursing staff and the hospital leadership grew. “Hospital units facing similar challenges balancing life-saving and nuisance alarm signals, including the neurology unit, wanted to know more,” says Anne Ward, RN, MS, Presbyterian Hospital Unit Director for Neurology. “I got together with Kate in order to figure out how to systematically begin to silence nuisance alarm signals. Like the cardiac unit, neurology needed to understand how to identify the alarm conditions and corresponding signals that are most important in day-to-day care delivery.”

As word of the pilot protocol began to spread across the UPMC hospital system, the interest in developing solutions to every-day alarm problems began to grow. “What is interesting is that alarm manage-

Nursing staff education and awareness about the new process for alarm system management in relation to patient care needs was essential to the successful implementation of the pilot.

The Solution – Finding Commonalities

Education

Essential to the successful implementation of the pilot project was nursing staff education and awareness about the new process for setting alarm parameters in relation to patient care needs. “Alarm competency classes” were created with a curriculum focused on:

1. How alarm signals can be appropriately adjusted based on a patient’s condition.

“Even if a health system throws a million dollars in time, expertise or software at the problems associated with alarm management, there is no easy fix or one-size-fits-all solution.”

— Anne Ward, RN, MS, Presbyterian Hospital Unit Director for Neurology

ment is probably easily acknowledged to be a top, possibly the number one challenge a hospital faces in relation to medical device concerns and technology hazards, yet there is no one solution. Even if a health system throws a million dollars in time, expertise or software at the problems associated with alarm management, there is no easy fix or one-size-fits-all solution,” said Anne. “Even when a specific division or hospital unit has a minimal number of technology vendors – in the cardiac unit, we only have two – the problems persist,” remarked Kate.

Eight Critical Elements

Kate and Anne realized that if they could implement change with positive results in the medical cardiology and progressive care units, then certainly, their efforts could be replicated across other hospital units within the UPMC health system. They began to search for commonalities across departments. The result: an evaluation tool known as “Eight Critical Elements to Monitor Alarm Competency.” The tool adopts lessons learned from the pilot projects while emphasizing the importance of continual staff training and awareness. The tool is used to assess staff competency in identifying and responding to what are viewed at UPMC as essential elements in alarm systems management. The UPMC health system’s leadership has adopted this tool, now considering these elements as universal and standard across all hospital divisions and departments throughout the multi-hospital system. With so many types of monitors (e.g., three monitor vendor companies within just one hospital), the “Elements” had to be simple and allow for nurses to apply them to each type of alarm system regardless of the brand of monitor.

Nurses and medical technicians through-

UPMC’s Eight Critical Elements to Monitor Alarm Competency require hospital staff to demonstrate how to:

1. Admit a patient in the cardiac monitoring system
2. Discharge a patient from the cardiac monitoring system
3. Review alarm settings
4. Customize alarm settings and document these settings in the electronic health record
5. Properly place leads on a monitored patient
6. Correctly load ECG paper in the machines
7. Appropriately put patient monitors in stand-by mode versus alarm signal suspend mode
8. Set monitors to correctly identify a pacemaker implanted in a patient

out UPMC are required to undergo an annual competency review of each of the eight critical elements, which includes a written exam, and for the clinical team responsible for managing patients, a hands-on observation exam.

For those staff members that do not pass the written or hands-on tests of the eight critical elements, they must be re-tested within a short period of time. UPMC provides coaching to staff to help them through the test preparations, recognizing the importance of investing in the team’s success in order to ensure patient safety and well-being.

“At UPMC Presbyterian, each hospital unit has a champion who is assigned to meet with each staff member who will undergo an examination and observe how they are doing with daily alarm system management,” says Ms. Anne Ward.

Recommendations:

1. Conduct “alarm competency classes” with a curriculum focused on how alarm signals can be customized.
2. Hold Nursing Grand Rounds on how to address alarm fatigue and improve alarm recognition and awareness.
3. Look for commonalities across units and departments.
4. Establish an evaluation protocol of your own or adopt UPMC’s “Eight Critical Elements to Monitor Alarm Competency.”

The Results:

Prior to implementation of a hospital-wide competency training at UPMC Presbyterian, 33% of hospital nurses rated themselves “not confident” in one or more aspects of monitor functionality, and less than half of the hospital units had a unit-based monitor competency process. Common essential elements required for competency in proper monitor management were identified by a monitoring task force within the hospital. A nursing representative from each hospital unit was sent to two educational sessions on alarm monitor management. The nursing representatives developed a unit-based competency process, which incorporated the eight identified essential elements. Every monitored unit reviewed the competency process with staff and incorporated it into their annual unit-based competency process. Post survey results of nurses at the

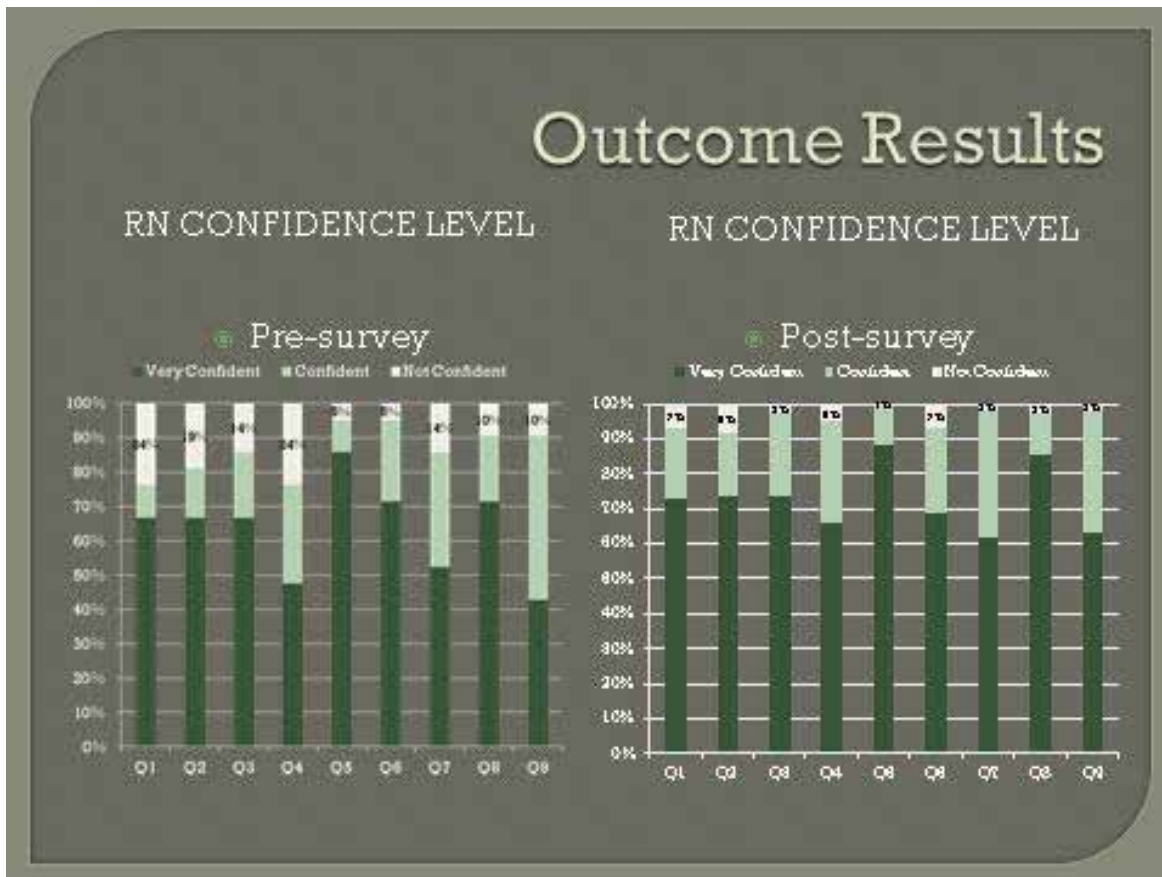


Figure 3.

Note: Please see Appendix A for list of questions, represented in Figure 3 by Q1-Q9.

hospital showed a 13% decrease in the number of nurses who rated themselves “not confident” in one or more aspects of monitor functionality.

Ongoing Management

Of course, there were challenges throughout this project such as; variations in the alarm monitoring systems across the hospital, staff turnover, and time constraints for training and education. These challenges exist in every hospital but it is important to address alarm noise not only for the sake of nursing staff but also for the patient. Alarm management at UPMC is viewed as a team effort with bedside and clinical care nurses, clinical engineers, clinical directors, unit directors, and risk management personnel all having a stake in the success of initiatives that seek to improve patient safety through alarm management. UPMC Presbyterian has set up two specific task forces—a *Monitor Task Force Group* and a *Patient Safety Group* to continue to improve upon alarm safety and to review negative patient events as they relate to alarm systems and identify

Benchmarks for Success:

Overall, program success in relation to alarm system management at UPMC is evaluated based on two benchmarks:

1. Improved rates of managing cardiac arrest
2. Improved rates of managing a critical patient care event

improved outcomes going forward. In addition, a *Monitoring Alarm Communications Committee* has been created to address issues that arise across the entire UPMC system.

“A dream goal is to make all care providers that work in a hospital aware of alarm conditions and patient behavior that could affect alarm signals. But, UPMC, like most health systems, is still struggling to ensure

the primary patient care providers, specifically nurses, are aware. This is very much a work in progress,” says Kate.

Kate and her team of nurses also found that changing electrodes daily and batteries in telemetry packs every 24 hours led to a reduction in alarm noise. They also strongly recommend that no alarm signal should be silenced without first checking on the patient or addressing the situation that triggered the signal.

Lessons Learned at UPMC

- Turning off the non-life threatening arrhythmia alarms did not negatively impact patient care.
- On-going reinforcement and education for nursing staff on customizing heart rate alarm settings specific to a patient’s baseline is crucial for reducing the frequency of alarm signals.
- Defaulting non-life threatening alarms to “OFF” can have a positive effect on unit noise level.

Recommendations:

Key Steps to Address Alarm Fatigue and Help Patients

- Change the patients’ ECG electrodes daily
- Change batteries in telemetry packs every 24 hours
- Ensure staff competency on monitor functionality
- Decrease the overall number of alarm signals related to a patient’s HR and SPO2 levels by setting the signals specific to that patient’s baseline
- Do not silence the alarm signal without first checking on the patient or addressing the problem

Alarm management at UPMC is viewed as a team effort with bedside and clinical care nurses, clinical engineers, clinical directors, unit directors, and risk management personnel all having a stake in the success of initiatives that seek to improve patient safety through alarm management.

APPENDIX A

List of questions from Figure 3 corresponding to Q1-Q9 on the horizontal axis

Monitor Competency and Training Survey

1. How confident are you at admitting a patient to the central monitoring station?
Very Confident Confident Not Confident
2. How confident are you at discharging a patient from the central monitoring station?
Very Confident Confident Not Confident
3. How confident are you at reviewing alarm settings?
Very Confident Confident Not Confident
4. How confident are you at customizing patient alarms?
Very Confident Confident Not Confident
5. How confident are you at proper lead placement?
Very Confident Confident Not Confident
6. How confident are you at properly loading ECG paper at the central monitoring station?
Very Confident Confident Not Confident
7. How confident are you that the education you received on monitors was adequate for you to be competent at your job?
Very Confident Confident Not Confident
8. How confident are you in determining when to place the patient in stand-by mode vs. alarm suspend mode?
Very Confident Confident Not Confident
9. Do you think that the education you received on monitors was adequate for you to be competent at your job?
Very Confident Confident Not Confident
10. Check all that apply: In what ways did you receive your monitor education?
 - a. Formal education
 - b. Vendor Education
 - c. Orientation
 - d. On-the-job training

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