WHITEPAPER

Masimo Patient SafetyNet™

Improved outcomes and reduced costs with continuous monitoring of post-surgical patients on the general care floor

INTRODUCTION

A significant number of avoidable adverse and sentinel events occur on the general care floor, where nurse-to-patient ratios often preclude continuous direct patient observation. According to CMS data extracted from Medicare patient discharge records between 2005 through 2007, failure to rescue and respiratory failure were two of the three medical errors with the highest incident rates, accounting for 26% of the 97,755 reported deaths and over $1.82B in excess Medicare costs.[1]

More than 80% of patients who experience a cardiopulmonary arrest have evidence of deterioration within eight hours preceding the event. If they are on the general care floor, they often exhibit changes in respiratory function.[2] A retrospective multi-center study of 14,720 cardiopulmonary arrest cases showed that 44% were respiratory-related and more than 35% occurred on the general care floor.[3]

One of the major contributors to respiratory-related adverse events is the set of complications arising from opioid pain management, especially for patients with Obstructive Sleep Apnea (OSA). Unfortunately, only 21% of patients with OSA have been diagnosed.[4] The effects of opioids on OSA patients are not uniform. In some cases, patients with mild forms of undiagnosed OSA can experience profound episodes of central apnea and be at significant risk when given opioids for pain management.[5]

Hospitals have adopted Rapid Response Systems to make clinical expertise available to the bedside when a life-threatening change occurs. These systems rely on early warning indicators, including changes in oxygen saturation, pulse rate and respiratory rate.[6,7] How often these parameters are measured on the general care floor largely determines how soon an avoidable event can be detected. Delayed activation of a Rapid Response Team is the strongest predictor of patient mortality.[8]

Clinical practice organisations now recommend that post-operative patients receiving pain management be continuously monitored with at least SpO_2 and that notifications of critical changes in patient condition be sent directly to clinicians who can act on the reported changes.[9,10]

MASIMO PATIENT SAFETYNET

Masimo Patient SafetyNet (PSN) is designed specifically to address the unique requirements of the general care floor, where nurse-to-patient ratios preclude continuous patient observations and nursing stations are often not staffed during some shifts. Patient SafetyNet has a flexible configuration allowing continuous monitoring to fluidly integrate with current clinical work flows. The result is continuous surveillance monitoring for patients when a clinician is not at the bedside.

The key elements of Patient SafetyNet are Masimo SET measure-through motion pulse oximetry and RadNet™ remote monitoring and notification system. RadNet includes robust, bidirectional communications (wired or wireless), a low cost server that can be hosted in the IT data center, a PC based assignment and viewing station and remote alarm annunciation options that link patient data to the assigned nurse.

Hospitals can choose how clinicians are notified: at the nursing station, by pager, or both. The system can utilize the existing IT infrastructure, thereby avoiding costs found in proprietary systems.

Alarm Management

ECRI Institute has identified high rates of alarms as the number one health hazard for patient safety.[11] Too many alarms desensitise clinicians to the point where life threatening alarms are ignored, resulting in sentinel events often called a "dead in bed" incident. An essential feature of Patient SafetyNet is a configurable alarm management capability that assists in reducing alarms to only those events requiring clinical intervention. Masimo SET measure-through motion oximetry removes most false alarms common due to motion. Without Masimo SET, any general floor monitoring solution would be inundated with alarms.

A true alarm is further separated between actionable and non-actionable alarms through configurable audio alarm delays at both the bedside and before the alarm is sent to the assigned clinician's pager. When an alarm occurs, the bedside unit annunciates the visual indicator but holds off the audio for up to 15 seconds. This feature keeps the bedside environment quiet for short duration events and thereby improves the environment of care for the patient.

If an alarm persists, the first action is for the bedside unit to audibly annunciate allowing a clinician in close proximity to respond followed by a paged alarm if the alarm persists beyond the delay configured within Patient SafetyNet. The settings of alarm thresholds and delays can significantly reduce non-actionable audio alarms.

CLINICAL VALIDATION

A team of clinicians at Dartmouth Hitchcock Medical Center in New Hampshire realised the need for an early warning patient surveillance system that could be applied to every patient admitted to the post-surgical general care floor. They partnered with Masimo in the deployment of Masimo Patient SafetyNet. An 11-month clinical study was conducted to measure system performance, nursing acceptance, and patient outcomes.[12]

Methods

The clinical team selected a 36-bed, post-surgical general care ward at Dartmouth Hitchcock as the study unit. The unit cared for post-surgical orthopedic, trauma, and plastic surgery patients. Patients were frequently on high dose opioids to manage post-surgical pain. Each bedside was equipped with a bedside pulse oximeter (Masimo Radical-7) connected to a Masimo RadNet system via wireless radios.

The RadNet system was integrated into the hospital IT network with the RadNet server installed in the IT data center remote to the study floor. The wireless infrastructure shared the RadNet application with other non-medical device applications.

Masimo RadNet provides alarm annunciation directly to the nurse assigned to each patient via a pager. Alarm settings were: Low SpO_2=80, Low Pulse Rate (PR)=50 and High PR=140. An alarm delay of 15 seconds was set at the bedside with an additional 15 seconds before paging annunciation. A standing-order policy was instituted to continuously monitor all patients admitted to the unit regardless of admission diagnosis. System data were captured for uptime reliability, alarm annunciation, and alarm profiles.

Patient outcome data were captured for Rapid Response activations, ICU transfers, ICU length of stay, morphine equivalents per day and overall unit length of stay. Rapid Response activation data included Rapid Response, Stat Airways and Cardiopulmonary Arrest activations. No changes were implemented in trigger points to activate these specialty teams. Nursing satisfaction surveys based on a scale from 1-6 (with 6 being most favorable) were conducted to assess system usability and acceptance.

Data were compared to an equivalent period of time on the same patient care unit as well as similar post-surgical general care units during the study period.

Results

Data collected covered 19,070 monitored days from 5,959 patients over an 11 month period. Average patient age was 56.7, with an equal mix of males and females.

Patient Outcomes Data

Table 1 - Outcomes improvements comparisons pre and post implementation

Outcomes Improvements Comparisons				
	Before PSN	**After PSN**	**Statistical Significance**	**% improvement**
Rescue calls per month	3.4	1.2	p = 0.01	65%
ICU transfers per month	5.0	2.6	p = 0.02	48%
Morphine equivalents per 1000 patient days	25.8	19.3	p = 0.02	26%

Rescue calls include all activations of rapid response, emergency intubation and cardiopulmonary arrests. The improvement in rescue activations equate to an annualised reduction from 37 activations in the pre-implementation period to 11 activations. The reduction in ICU transfers equated to an annualised savings of 163 ICU days during the study period from this single 36-bed, post-surgical unit.

Morphine equivalents per 1000 patient days were calculated to normalise differences in dose administration between surgical units such that meaningful comparisons between units could be assessed. Reduction in morphine equivalents per 1000 patient days was statistically significant suggesting reliable real time monitoring allowed tighter control over analgesia management.

Patient satisfaction scores collected during pre- and post-implementation showed no statistical change. Comparisons of these metrics during post implementation to similar post-surgical units showed no statistically significant changes, indicating improvements in outcomes were related to the implementation of Masimo Patient SafetyNet.

Nursing Satisfaction Surveys

Nursing acceptance surveys were collected to assess overall end user acceptance. All staff nurses assigned to the study unit participated in the survey.

"The ability to provide surveillance on my patients has added benefit for me to provide safe care to my patients."	*Score 5.2 out of 6*
"If a relative or close friend needed the type of inpatient care that is provided on the PSN unit, would you want them to come that unit?"	*Score 5.4 out of 6*
"Should we keep using the system?"	*Score 5.5 out of 6*

Overall positive nursing satisfaction results were associated with acceptable level of alarm frequency and overall ease of use with the system. Considering this unit went from no continuous monitoring to a policy of continuously monitoring all patients supports the design goal to improve patient care with minimum impact on current work flow processes.

Financials

Reduction in rescue activations, ICU transfers and Morphine administration has a positive impact on overall financial value. Less rescue activations frees clinical personnel for other patient care activities. Reduction in ICU transfers and the resulting avoidable ICU days opens these beds for additional admissions or increased surgical procedures. Reduction in drug consumption reduces associated direct and indirect costs. Direct cost savings for two representative DRGs are summarised in Tables 2 and 3.

Table 2 - Direct cost savings from two representative DRGs

Direct Cost Savings			
	Average direct costs when rapid response was activated	**Average direct costs with no rapid response activation**	**% improvement**
Bilateral joint replacement (DRG 471)	$49,602	$19,987	60%
Single joint replacement (DRG 544)	$19,765	$13,648	31%

Table 3 - Length of stay comparison of two representative DRGs

Length of Stay (days)			
	Average LOS when rapid response was activated	**Average LOS with no rapid response activation**	**% improvement**
Bilateral joint replacement (DRG 471)	12.3	3.9	68%
Single joint replacement (DRG 544)	5.8	3.6	31%

Lower direct cost has financial benefit in a capitated environment and will become more significant if the pattern of non-recoverable reimbursement for avoidable adverse events continues. More importantly, overall reductions in length of stay improves hospital patient flow and capacity resulting in improvement in operational effectiveness by expanding hospital capacity to admit more patients without adding overhead costs.

System Data

Uptime reliability was 99.995%, which equates to 26.5 minutes of system unavailability per year. One system configuration change accounted for the downtime; otherwise, the system was continuously available for the entire study period.

Alarm Effectiveness

Nuisance alarms have historically compromised the effectiveness of continuous monitoring. Too many alarms result in alarm fatigue causing clinicians to ignore true clinically actionable alarms when they occur. Average alarms per patient per day is an indicator of the frequency in which clinical personnel are called to bedside to assess patient condition.

This is especially important when nurse to patient ratios are 1:5 and greater. An average of 29 patients were monitored during the study period, reflecting a pattern of lower census at the beginning and end of the week with peaks mid-week due to surgical scheduling. The average alarms per patient per day were 4.1, with a minimum of 3 and a maximum of 11. Table 4 summarises the distribution of the types of alarms.

Table 4 - Distribution of paged alarms

Alarm Summary			
Sensor Alerts	**High SpO_2**	**High PR**	**Low PR**
26%	44%	14%	16%

Sensor alerts accounted for 26% of all alarms primarily due to intentional sensor disconnect for physical therapy, ambulation and patient hand washing. In some cases sensor alerts warned nurses a patient was attempting to get out of bed unassisted. Alarm annunciations were escalated 23% of the time to the nursing supervisor, the majority of which were associated with sensor alerts.

Several cardiac arrhythmias were identified and verified with subsequent bedside ECGs including bradycardia, tachycardia and irregular rhythms. Clinicians felt RadNet was effective in annunciating actionable alarms requiring intervention at the bedside or activation of the rapid response team.

CONCLUSIONS

The impact of the Masimo Patient SafetyNet System (Masimo Rainbow SET and Masimo RadNet), coupled with a high degree of nursing acceptance, has resulted in improved patient safety outcomes and positive financial impact.

The addition of continuous monitoring tools to the general care environment allowed a more timely response to patient care needs. The real-time surveillance has allowed nurses to more effectively manage pain medication, resulting in a lower overall use of opioids without compromising patient satisfaction scores. The identification of new cardiac diagnoses from changes in pulse rate is a positive but unanticipated outcome that further supports continuous pulse oximetry monitoring in the general care setting.

Nurse satisfaction scores overwhelmingly tip the benefit-versus-burden choices in favor of sustaining the system and expanding RadNet to additional post-surgical areas. The low incidence of alarms and the direct assignment to the nurses caring for patients improved the ability of clinicians to respond and intervene to patient needs, contributing to the high acceptability of the system.

The robust reliability of the system on the hospital's existing IT wireless network and backbone demonstrates that IT networks can accommodate this medical device application at a reliability level equivalent to more costly and proprietary solutions, as found in Intensive Care settings.

The financial benefits due to early detection and intervention reduced the cost of care for two dominant DRGs in the study unit. Although cumulative costs savings have not been analysed, the representative sampling plus the increased access to the ICU are positive indicators of the financial benefit realised by implementing Patient SafetyNet. Lower overall direct costs, improved outcomes metrics and patient throughput will help make the hospital more competitive and profitable in a climate of increased financial constraints.

The real impact of Masimo Patient SafetyNet is realised in the overall improvement in patient safety and the resulting number of patient lives saved through the reliable identification and response to actionable alarms. The implementation of Masimo Patient SafetyNet on this post-surgical general care floor created a new clinical tool set that resulted in measureable improvements in patient care. Nursing personnel realised these new tools assisted them in delivering better patient care, which led to unanticipated benefits.

One anecdotal observation was that the bedside monitor was used to provide positive reinforcement for patients on incentive spirometry. Nurses became more aware when patients fell out of compliance and used the tool as a positive feedback mechanism for the patient. Nurses also began noticing subtle changes in physiologic parameters requiring further patient assessments which accelerated interventional care. On at least one occasion, an actionable alarm at the bedside led a nurse to immediately resuscitate a patient who would have otherwise gone unnoticed, possibly resulting in an undesirable outcome. These anecdotes are not represented in the measured outcomes but raise the bar of quality patient care and strengthen the overall safety environment.

Results from this data has set a new internal benchmark within Dartmouth Hitchcock Hospital, resulting in the expansion of Masimo Patient SafetyNet to all post-surgical and medical service beds where continuous monitoring has not been previously available.

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