Advanced technology leads to earlier intervention for clinical deterioration on medical/surgical units

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ABSTRACT

Objective: To determine if enhancements developed to support the use of an electronic Early Warning System (EWS) resulted in quicker stabilization of clinical deterioration.
Background: Early Warning Systems are effective for alerting nurses to patient deterioration, but have not demonstrated positive clinical impact. An EWS embedded within an electronic medical record (EMR) was enhanced with tools to support nurses' ability to recognize and intervene in a timely manner for signs of deterioration.
Methods: A comparative design using retrospective EMR review evaluated time patients spent with higher risk EWS scores and time to reassessment after an EWS alert pre-and post-implementation of an enhanced EWS.
Results: There was a significant ($p < .001$) decrease in time patients spent with higher risk EWS scores and time to reassessment following an EWS alert after implementing an enhanced EWS.
Conclusion: Technology can be leveraged to support nursing practice and clinical decision making around management of clinical deterioration.

1. Introduction

Nurses working on busy medical/surgical units are responsible for monitoring multiple patients for change in condition. However, with increased patient acuity and competing priorities, it is possible for one patient's condition to change while the nurse is busy with another patient. Early recognition of clinical deterioration is the key to early intervention, and early intervention leads to improved patient outcomes (Massey, Chaboyer, & Anderson, 2017). There is some evidence in the literature which demonstrates that when an early warning system (EWS) is embedded in the electronic medical record (EMR), nurses recognize clinical changes earlier (Bailey et al., 2013; Umscheid et al., 2015). Unfortunately, early recognition does not always lead to timely or appropriate intervention (Bailey et al., 2013). Nurse leaders have the opportunity to equip nurses with tools that will support not only early detection of clinical deterioration, but also timely intervention (Swartz, 2013). The purpose of this paper is to share the results of a study conducted to determine if tools developed to support the use of an EWS

resulted in quicker stabilization for early signs of clinical deterioration on medical/surgical nursing units.

1.1. Early Warning Systems

Early Warning Systems (EWS) have demonstrated a high predictive value for determining risk of clinical deterioration (Churpek et al., 2012; Umscheid et al., 2015). While most EWSs include basic physiologic parameters such as systolic blood pressure, heart rate, and respiratory rate, they may differ with the inclusion of additional parameters and/or weighting assigned to each parameter. Using an algorithm, EWSs score physiological data (e.g. vital signs) to determine a patient's relative risk for clinical deterioration and trigger an alert for increased risk. Early Warning Systems are often accompanied by a protocol designed to ensure alerts are addressed by nurses in a timely manner. Unfortunately, appropriate clinical response is often lacking (Jones et al., 2011) and outcomes historically reported for EWSs demonstrate mixed results (Alam et al., 2014).

2. Review of the literature

While the literature does seem to support the idea that an EWS algorithm is useful in identifying patients at risk for clinical deterioration, results vary on the impact of EWSs on patient outcomes. Historically, EWS studies have evaluated patient outcomes related to ICU transfers, hospital length of stay, mortality, and the occurrence of serious adverse events with mixed results (Alam et al., 2014; Smith et al., 2014). This may be because patient outcomes often depend on the nurses' understanding of the clinical significance of patient observations and the decision of the nurse to intervene (Kyriacos, Jelsma, & Jordan, 2011).

Recognition and management of deteriorating patients is complex, particularly on busy medical/surgical units where nurses are faced with competing priorities. Despite the effectiveness of EWS identification and alert for at-risk patients on non-ICU units, it has been difficult to demonstrate positive clinical impact. For this reason, providing an alert alone may be insufficient to prevent an untoward event and must be coupled with a mechanism to trigger a nursing action (Bailey et al., 2013) that includes assessment, communication with the provider, and initiation of appropriate clinical care (Jones et al., 2011; Stewart, Carman, Spegman, & Sabol, 2014). System enhancements to an EWS may support the nurses' ability to both recognize and respond to patient deterioration in a timely and appropriate manner (Massey et al., 2017).

It is unknown whether enhancements made to support the use of an EWS will improve nurse response and timely intervention for signs of clinical deterioration, resulting in quicker stabilization of vital signs and a decreased length of time spent with at-risk EWSs scores. To address this gap in knowledge, we investigated the time patients spent with at-risk EWS scores pre- and post-implementation of an EWS embedded within an EMR and enhanced with tools to support nurse critical thinking, clinical decision making, and accountability. The enhanced EWS included: an automated EWS that provides real-time, color-coded visual alerts; quick documentation templates; a single report that collates key data, trends, focused nursing assessment and interventions onto a screen shared by all caregivers; timers and review tab to ensure alerts are acted upon; and a screensaver that continuously displays EWS scores for all patients on the nursing unit. Nurses attended a 90 min training session that focused on how to use the enhanced EWS to support critical thinking and clinical decision making, and unlicensed nursing staff attended a 30 min training session that discussed their role in the enhanced EWS and reviewed the importance of timely, accurate vital sign measurement.

3. Methods

3.1. Design

A comparative design using data collected from a retrospective review of EMRs was used to address our specific aims. Study approval was obtained through the hospital's Institutional Review Board.

3.2. Study aims

1. To determine if there is a difference in time (hours) patients spend with at-risk EWS scores post-implementation of an EMR-enhanced EWS when compared to pre-implementation.
2. To determine if there is a difference in time (minutes) until reassessment of vital signs following a EWS risk alert post-implementation of an EMR-enhanced EWS when compared to pre-implementation.

3.3. Setting

This study was conducted from February 2014 through January 2016 at a 157-bed community hospital in Northeast Ohio.

3.4. Sample

Study units included three medical/surgical units and one cardiac telemetry unit. Data from all adult patients (age 18 or older) admitted to the four study units during the study period and who did not have a "do not resuscitate, comfort care" (DNR CC) order, were included in this analysis.

3.5. Data collection

Demographic patient data (age, gender, race, length of stay (LOS), and adjusted case mix index) was collected from the EMR for patients included in the sample. Data on nurse educational makeup, turnover rate, and attendance at pre-implementation training was also collected.

A basic EWS scoring tool using the parameters (systolic blood pressure, pulse, respiratory rate, and oxygen saturation) and weighting described by Jones (2013) was applied to the vital sign data extracted from the EMR of patients admitted in the pre and post EWS phases. Each of the four parameters were scored individually using the automated system within the EMR, with zero points assigned for measurements falling within a defined "normal" range. Parameters that fell outside of "normal" values received weighted point values (1 or 2 points) based on degree of deviation. The total EWS score was calculated by adding the score of each of the four parameters. Total scores ranged from 0 to 8 with scores of 3 and 4 indicating moderate risk for deterioration and scores of 5 to 8 indicating high risk for deterioration.

The number of hours patients spent with moderate and high risk scores were calculated pre- and post-implementation as well as the time (minutes) from a moderate or high risk alert to the time vital signs were assessed. Pre-implementation data represents the EWS scores applied retrospectively for patients admitted from February 2014 through January 2015. Post-implementation data represents actual EWS scores for patients admitted February 2015–January 2016.

3.6. Analysis

Descriptive statistics and measures of central tendency appropriate to the level of data were used to describe the sample and major variables. An Independent *t*-test was used to determine if there was a significant difference in hours patients spent at moderate and high risk EWS levels (score 3–8) pre-versus post-implementation of the enhanced EWS and if there was a significant difference in minutes to reassessment of vital signs following a moderate or high risk EWS alert.

4. Findings

Analysis of patient demographic data for the two groups showed the groups were similar in age, gender mix, and race. While patient diagnoses were not tracked, study units included an orthopedic unit, general medical unit, general surgical unit, and cardiac telemetry unit. Including patients from four different types of units offered a diverse sample of patients with different diagnoses. More patients were admitted during the post-implementation group with an increase in adjusted case mix index (CMI) while the length of stay decreased (see Table 1).

During the study periods, the educational makeup of clinical nurses remained fairly stable with 53% Associate Degree/Diploma prepared nurses, 42% Bachelor's Degree prepared nurses, 4.6% Licensed Practical Nurses, and 1.4% Master's Degree prepared nurses on the study units. The average length of nurse employment was 5.7 years with a turnover rate of 14.9% for the pre-implementation timeframe and 5.9 years length of employment and 24.9% turnover for the post-implementation timeframe.

Prior to implementation, nurses attended a 90 min class that demonstrated the enhanced EWS but focused on hands-on application and scenario-based learning to demonstrate how the system supports nurse

Table 1
Patient demographic data.

	Patients n	Age			Gender		Race	Length of stay	Adjusted Case Mix Index (CMI)
		Mean	Median	Range	Female	Male			
Pre-implementation group admitted February 2014 through January 2015	4731	68	63	18–102	55% (n = 2592)	45% (n = 2139)	98% Caucasian	4.1 days	2.75
Post-implementation group admitted February 2015 through January 2015	5080	68	63	18–101	55% (n = 2793)	45% (n = 2287)	99% Caucasian	4.0 days	2.82

critical thinking and decision making. Unlicensed nursing staff attended a 30 min class that recognized them for the key role they play in supporting early recognition of signs of deterioration and reinforced the taking of accurate vital sign measurements and timely recording of vital signs in the EMR. In order to motivate and enhance engagement, every class began with the telling of an actual patient deterioration story and discussion of the impact an enhanced EWS could have had on the patient's outcome. 92% (n = 138) of nurses attended the training and 93% (n = 54) of unlicensed nursing staff attended the training. One-on-one training was provided for those unable to attend the scheduled classes. For new nurses orientating post-implementation, a 45 min class was added to orientation focused on scenario-based learning and how to use the system to support critical thinking and decision making. Preceptors worked 1:1 with new orientees to provide the hands-on training.

Total patient hours for the 12 months post-implementation (February 2015–January 2016) was 7% higher than the total patient hours during the pre-implementation time period (February 2014–January 2015). Despite an increase in total patient hours post-implementation, the use of the enhanced EWS led to a decrease in the number of hours patients spent at moderate or high risk EWS levels. Patients scoring in the moderate risk EWS level (score of 3–4) showed an average decrease of 1065 h per month, from 4933 h pre-implementation to 3868 h post-implementation (p < .001). For patients scoring in the high risk EWS level (score of 5-8), the number of patient hours decreased by an average of 48 h per month, from 82 h pre-implementation to 34 h post-implementation (p < .001) (Table 2).

Decreases were also noted in the time it took to reassess vital signs following a moderate or high risk EWS alert. At the moderate risk EWS level, the length of time between the first indication of possible patient deterioration (score change to 3–4) until reassessment of vital signs decreased from a pre-implementation average of 134 min to 100 min post-implementation (p < .001). For the high risk EWS level, the length of time between first indication of patient deterioration (score change to 5–8) until reassessment of vital signs decreased from a pre-implementation average of 76 min to 45 min post-implementation (p < .001) (Table 3).

5. Discussion

This study demonstrated a significant decrease in the time patients spent with moderate or high risk EWS scores and the time to reassessment following a moderate or high risk alert after implementation of an enhanced EWS within the EMR. This decrease was noted despite an increase in total patient hours and adjusted case mix index. While investigators have demonstrated the effectiveness of EWSs for alerting

nurses to signs of clinical deterioration (Bailey et al., 2013; Umscheid et al., 2015), they suggest that the mixed patient outcomes found in previous studies may be related to the need for an associated, timely response by the bedside nurse (Bailey et al., 2013; Stewart et al., 2014).

This study demonstrates the benefits of creating innovative tools to enhance and support nurses' use of an EWS (Massey et al., 2017; Stewart et al., 2014) by measuring the impact of nursing response through patient time spent at higher EWS risk levels. Time patients spend with higher EWS risk scores and time to reassessment following an EWS risk alert are driven by nurse intervention and reassessment. To impact these times, nurses must recognize the alert, assess the patient, identify the significance of the clinical changes, determine and initiate the appropriate intervention, and reassess the patient for improvement (Jones et al., 2011). Entering a new set of vital signs into the EMR with rescoring by the EWS demonstrates if the patient's risk level has decreased. Significant decreases in time at higher risk and time to reassessment suggest that nurses are intervening in a timelier manner and reassessing sooner to ensure clinical improvement and no additional need for intervention.

Use of the enhanced EWS by nurses may provide additional benefits not previously cited in the literature. Early warning systems were developed to improve identification of clinical deterioration (Bailey et al., 2013). Changes in EWS risk scores, particularly at the moderate risk level, could indicate early signs of clinical deterioration, requiring stabilizing interventions. They could also be an indicator of issues unrelated to deterioration, such as pain or anxiety. With the tools created to support the use of an EWS, nurses are better equipped to critically evaluate the significance of a change in patient condition and intervene appropriately when their assessment does not indicate clinical deterioration. Research is recommended to determine the impact of an enhanced EWS on nurse response and intervention for management of alerts unrelated to acute deterioration.

All code blue and rapid response cases were reviewed for the study period to further understand the impact of the enhanced EWS. When the number of code blue and rapid response events were compared, it was found that the code rate decreased from 0.737 codes/1000 patient days pre-implementation to 0.543 codes/1000 patient days post implementation. Rapid Response Team (RRT) calls were the opposite with RRT rates increasing from 2.672 RRTs/1000 patient days to 5.545 RRTs/1000 patient days. These finding suggests that nurses may have recognized signs of deterioration earlier (before the patient coded) and/or called for RRT assistance sooner when signs of deterioration were identified post-implementation.

While reviewing code blue data post-implementation, some delays in nurse identification of respiratory compromise were noted in patients with orders for oxygen titration to maintain a certain oxygen saturation level. In these cases, nurses increased the amount of oxygen delivered to improve patient saturation levels, which in turn improved the EWS score. These findings suggest that oxygen saturation levels alone are not a reliable indicator of clinical deterioration when data about oxygen delivery is excluded from the EWS algorithm. Factoring oxygen supplementation into the EWS scoring tool may be a more valid indicator of patients experiencing clinical deterioration. Additional research is needed to determine what other parameters may be important predictors of early clinical deterioration.

Table 2
Total hours spent/month at higher EWS acuity/risk levels.

	Group	Mean	Std. deviation	t	df	p
Total hours at moderate risk (scores 3–4)	Pre	4932.75	735.24	3.71	22	< 0.001
	Post	3867.58	669.31			
Total hours at high risk (scores 5–8)	Pre	81.75	38.55	4.05	22	< 0.001
	Post	33.83	13.89			

Table 3
Minutes from alert to reassessment.

	Group	Mean	Std. deviation	t	df	p
Time (minutes) to reassessment after moderate risk (score 3–4)	Pre	134.08	2.78	3.71	22	< .001
	Post	100.08	1.35			
Time (minutes) to reassessment after high risk alert (score 5–8)	Pre	76.25	3.57	4.05	22	< .001
	Post	44.83	4.05			

5.1. Study limitations

This is the first study to evaluate time as the major variable in identifying, intervening, and reassessing clinical deterioration. Use of a single site, a community hospital setting and patient population that is primarily Caucasian may limit the generalizability of our findings. Four different types of nursing units were included in the study to provide diversity in patient diagnoses but specific patient diagnoses and co-morbidities were not tracked. It is possible that differences in patient diagnoses and/or co-morbidities could account for a delay in patient response to interventions, impacting time spent at moderate or high risk levels. However, this study included a large sample and basic demographic data for the two groups were similar. Nurse turnover rate could have influenced outcomes as nurses with different experience levels left and started employment at the hospital, though the nurse length of employment was similar for both timeframes. Additionally, class time and hands-on training with preceptors on use of the enhanced EWS was incorporated into orientation for all new nurses.

6. Conclusion

Identification of early signs of clinical deterioration must be accompanied by nursing assessment and action to positively impact patient outcomes. Enhancing an EWS with tools to support nurse critical evaluation and decision to intervene for clinical deterioration led to a decrease in time patients spent with moderate and high risk EWS scores as well as a decrease in time to reassessment following an alert. With technological advances, it is important that nurse leaders explore ways to leverage this technology to improve patient care and outcomes and support nursing practice.

Declaration of Competing Interest

Cleveland Clinic has registered VitalScout^{SM} with a Service Mark. No other declarations.

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