# EVALUATION OF THE EARLY WARNING SYSTEM AT BANNER DESERT MEDICAL CENTER

by

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As members of the DNP Project Committee, we certify that we have read the DNP Project prepared by Kristina Denise Bardwell entitled Evaluation of the Early Warning System at Banner Desert Medical Center and recommend that it be accepted as fulfilling the DNP Project requirement for the Degree of Doctor of Nursing Practice.

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# DEDICATION

I would like to dedicate this project to the three most important people in my life. First to my husband Edmond, without your consistent motivation and support throughout this journey, I am not sure I would have made it to the finish line. You have been my biggest cheerleader and for that, I love you dearly. Second, to my mother for instilling in me the drive and motivation to follow my dreams from a young age. I did it MOM!!! And last, to my father, you are not with me in body, Dad, but your spirit has helped guide me through this process. I know you are cheering me on from heaven, yelling, “I knew you could do it pumpkin!”

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## ABSTRACT

*Purpose*: The aim of this project was to evaluate data from a survey sent to nurses in regards to the current practices and workflow of the Early Warning System (EWS) currently in use at Banner Health.

*Methods*: A descriptive cross-sectional design was used to collect feedback from Registered Nurses. The survey was open between February and March of 2016. Likert style and open-ended questions demonstrate evidence supporting the following study questions: 1) What are the barriers to documentation that triggers the EWS? 2) To what extent is the EWS useful and usable? 3) What were the features of the EWS implementation? Data was collected from nurses surveyed (n=65) working on Medical Surgical Units and Progressive Care Units.

*Results*: Findings of this DNP project demonstrated three barriers associated with EWS protocol compliance to include increased workload (78%), previous negative responses from providers (62%), and alert fatigue (48%). Provider responsiveness to notification of the Early Warning Score was shown to be effective "most of the time" and "about half of the time" at 71%, with 12% indicating "sometimes' and "never." Deployment of the Rapid Response Team (RRT) when indicated by EWS algorithm showed only 9 (14%) of nurses always call the RRT, 7 (11%) call about half the time, and 16% indicated they never use the RRT. "Real time" charting occurred 50-75% or less than 50% of the time for 96% of respondents. Open ended questions support recommendations for future practice to include: implementation of a pop up alert for easy recognition of changes in EWS, tailoring parameters based on individual patient characteristics, automatic direct paging to medical providers, and elimination of the level of consciousness parameter or allow nursing assistants to input information to support timely firing. A validated

usability survey provided data with a mean response rate (n=58). Nurses (84%) agree the EWS is useful and usable. Ease of use, efficiency, and comfort with EWS software showed 90% agree. System interface responses demonstrate 23% dislike using the interface, and 21% felt the system interface was unpleasant.

*Conclusions*: Findings from this DNP project demonstrate EWS system usability and usefulness. Recommendations for improvement include implementation of a “pop up” alert for easy recognition of changes in the Early Warning Score and/or automatic direct paging to medical providers and nursing will increase effective use. Barriers to EWS protocol documentation include increased workload, previous negative response from providers, and alert fatigue. “Real time” documentation of physiological parameters is essential to successful triggering of an Early Warning Score.

# INTRODUCTION

## Background Knowledge

Registered Nurses (RN) are often the first line of defense in the recognition of a deteriorating patient (Watson, Skipper, Steury, Walsh, & Levin, 2014). A marked change in vital signs and level of consciousness often precedes a serious adverse event. These subtle changes can go unrecognized by healthcare professionals. Lack of recognition of physiological changes can lead to increased length of hospital stay (LOS); delay in care, and in some cases, even death (Mapp, Davis, & Krowchuk, 2013). Numerous hospitals use clinical decision support systems (CDS) as part of the electronic health record (EHR) to assist the RN to recognize and intervene when a patient deteriorates clinically.

Since the implementation of the "Save 100,000 lives campaign" in 2006, the Institute for Healthcare Improvement (IHI) challenged hospitals across the country to reduce the number of serious adverse events. Rapid Response Teams (RRT) assist in the reduction of cardiac arrests, unintended ICU admissions, and decrease length of stay (IHI, 2015). RRT activation is generated by evaluating only a single parameter vital sign to include; heart rate, respiratory rate, level of consciousness, or temperature. The Early Warning System (EWS) was designed as a multiparameter system incorporating all vital signs as well as level of consciousness to assist in detecting clinical deterioration. While EWS and RRT evolved separately when used together, they create an added layer of support for nurses in identification and early intervention.

According to earlier works from Silber in the 1990s and Needleman et al. (2002) summarized patient outcomes associated with higher rates of "failure to rescue" (FTR) defined as "the death of a patient from pneumonia, shock, cardiac arrest, upper GI bleeding, sepsis, or

deep vein thrombosis, for which early identification and early intervention by nurses can influence the risk of death" (Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002, p. 1717). "Failure to rescue" offers a measure of the degree to which healthcare providers respond to adverse events that occur during hospitalization. It can reflect the quality of monitoring, or the efficiency of actions taken once identification of complications has been identified (Agency for Healthcare Research and Quality, n.d.). Rapid recognition and early aggressive interventions may prevent complications leading to death (Agency for Healthcare Research and Quality [AHRQ], 2011). "Failure to rescue" has now emerged as a quality indicator for hospitals. The Agency for Healthcare Research and Quality (AHRQ) incorporated "failure to rescue" as one of its patient safety indicators under complications of care. Similarly, Medicare reports "failure to rescue" rates on Hospital Compare (Wakeam, Asafu-Adjei, Ashley, Cooper, & Weissman, 2014 p. 931). This project used a descriptive cross-sectional design to collect feedback from RNs at Banner Desert Medical Center about the EWS. Questions from this project used Likert style scaling to inquire about current practices, usability, and workflow of the EWS scoring tool.

According to the National Healthcare Quality Report (NHQR) in 2011, from 2004 to 2008, the rate of deaths following complications of care declined from 138 to 122 per 1,000 admissions of adults ages 18-89 (AHRQ, 2011). This may be attributed to the implementation of RRTs and various Early Warning Systems utilized in the acute care setting. A significant decrease in FTR was also seen among all income groups during the same period (AHRQ, 2011; Hammer, Jones, & Brown, 2012). In 2013, the NHQR presented safety measures in alignment with healthcare systems that must measure, recognize, and improve patient safety to include various "hospital acquired conditions (HAC)." Conditions in this report include postoperative

sepsis, catheter-associated urinary tract infections, surgical site infections (SSI), adverse events related to central venous catheters, central line-associated bloodstream infections (CLABSI), and overall hospital-acquired conditions. In 2011, the national overall HAC rate was 142 per 1,000 hospital discharges. In comparison, the rate was 145 per 1,000 hospital discharges in 2010 (AHRQ, 2013). In 2013, the overall rate of hospital-acquired conditions declined to 121 per 1,000 hospital discharges (AHRQ, 2014). This identifies progress made in regards to effects of aggressive treatment interventions, prevention, and broad interventions to improve patient safety. Consistent with these efforts, use of a multi-parameter EWS in conjunction with existing RRT deployment holds promise to significantly reduce hospital acquired conditions rates in the future.

For over two decades in an effort to improve patient safety, researchers have studied physiological markers that precede cardiac arrest in hospitalized patients (Mapp, Davis, & Krowchuk, 2013). Early studies from tertiary facilities found that patients exhibited physiological changes up to eight hours prior to a serious adverse event (Albert & Huesman, 2011). Further, approximately 80% of hospitalized patients have vital signs outside of normal ranges up to 24 hours prior to ICU admission and approximately 75% of these patients have at least one potentially life-threatening incident eight hours before ICU admission (Tarassenko, Hann, & Young, 2006).

The EWS was developed and published in the late 1990's by researchers in the United Kingdom (UK) (Kyriacos, Jelsma, & Jordan, 2011). In an annual report on patient safety in 2007, the National Patient Safety Agency analyzed 425 deaths in the United States. Of these 425 deaths, 15% (n=64) were related to unrecognized patient deterioration (Albert & Huesman, 2011; Mapp, Davis, & Krowchuk, 2013). In light of this report, the IHI implemented the *5 Million*

*Lives Campaign* to promote the use of EWS to assist in identifying deteriorating patients (Albert & Huesman, 2001; Mapp, Davis & Krowchuk, 2013). The idea of the EWS is fairly new to the United States; however, in the United Kingdom this concept is being used successfully in many hospitals. The Acute Medicine Task Force of the Royal College of Physicians (RCP) recommended a National Early Warning Score (NEWS) to be standardized and used in all hospital units to replace the numerous systems used in the UK and Scotland (Patterson et al., 2011). To date, the NEWS is the largest national effort thus far; however, the system is not without its problems due to its lack of universal implementation for all patient populations (Smith, Prytherch, Schmidt, & Featherstone, 2013).

Clinical decision support systems (CDS) are a complex health IT component of the electronic health record. CDS assist physicians, nurses, and other staff with "knowledge and person-specific information, intelligently filtered or presented at appropriate times, to enhance health and health care" (HealthIT.gov, 2013).

The EWS CDS is a computerized alert embedded in the electronic health record (EHR) to assist nurses with identification of subtle changes in physiological parameters. The Early Warning System tool is used to assess basic physiological parameters to identify at risk patient's sooner. Evidence supports risk prediction of intensive care admission, death, and length of stay with specific parameters (Patterson et al., 2011). A score is assigned to each single parameter with a total sum score, when threshold numbers are met more frequent monitoring, clinician notification, or RRT notification must occur.

The target for this project was Banner Desert Medical Center in Mesa, Arizona. Banner Health is comprised of 29 facilities located in Arizona, Colorado, Wyoming, Northern California

and Alaska. I chose to focus this DNP project at Banner Desert Medical Center, as I have been an employee at Banner Desert Medical Center since 1993. I have been an integral member of the Rapid Response Team since its inception in 2005, and assisted with the implementation of the EWS in 2012. Banner Health's Mission, Vision, and Values include "*making a difference in people's lives through excellent patient care"* focusing everyone in the organization on a single purpose. The long-term vision of Banner Health includes, *"We will be a national leader recognized for clinical excellent and innovation, preferred for a highly coordinated patient experience and distinguished by the quality of our people"* (Banner Health, 2015a). Innovation is critical to the long-term success of Banner Health. Identification and deployment of strategies using evidence-based practice to "*ensure an extraordinary patient experience which is safe, efficient and effective"* supports the use of evidence-based guidelines, models, and tools developed to enhance the care for our patients. The EWS aligns with the current and future strategic planning for the organization. Use of evidence based tools to assist in providing safe, efficient, and effective care is a fundamental component of becoming an industry leader. Table 1 illustrates the EWS currently used in practice at Banner Health based on Patterson et al., 2011. Table 2 illustrates the escalation algorithm.

TABLE 1. *The Early Warning Score Tool. (Patterson et al., 2011)*

| | Score | | | | | | |
|---|---|---|---|---|---|---|---|
| **Variable** | **3** | **2** | **1** | **0** | **1** | **2** | **3** |
| ***Heart Rate*** | | ≤40 | 41-50 | 51-100 | 101-110 | 111-129 | ≥130 |
| ***Systolic Blood Pressure*** | ≤70 | 71-80 | 81-100 | 101-199 | | ≥200 | |
| ***Respiratory Rate*** | ≤8 | | 9-12 | 13-18 | 19-24 | 25-29 | ≥30 |
| ***Temperature (C°)*** | | <35° | | 35°-38.4° | | ≥38.5° | |
| ***Level of Consciousness*** | | | | Alert | Responds to voice: New Confusion or agitation | Responds to pain | Unresponsive |

TABLE 2. *Escalation Algorithm for EWS.*

| Score 3 | Score 4 | Score 5 | Score > 6 |
|---|---|---|---|
| Increase vital signs and level of consciousness (LOC) frequency to Q2 hrs x 3 and include oxygen saturation | Increase vital signs and level of consciousness (LOC) frequency to Q2 hrs x 3 and include oxygen saturation | Increase vital signs and level of consciousness (LOC) frequency to Q1 hrs x 3 and include oxygen saturation | Verify vital signs and level of consciousness (LOC) and increase to q 15 minutes |
| Perform focused assessment | Perform focused assessment | Perform focused assessment | Perform focused assessment |
| Review Chart for Severe Sepsis alert/mPage | Review Chart for Severe Sepsis alert/mPage | Review Chart for Severe Sepsis alert/mPage | Review Chart for Severe Sepsis alert/mPage |
| Inform RN Manager or designee | Inform RN Manager or designee | Inform RN Manager or designee | Inform RN Manager or designee |
| | Notify Provider when appropriate | Inform Provider | Inform Provider |
| | Document Strict Intake and Output and Notify Provider if urine output <0.5ml/kg/hr x 4 hrs | Document Strict Intake and Output and Notify Provider if urine output <0.5ml/kg/hr x 4 hrs | Recommend transfer to higher level of care |
| | | If patient remain ‘5’ for three consecutive readings, request order for possible transfer to higher level of care | Call Rapid Response Team when condition warrants |
| | | Call Rapid Response Team when condition warrants | |

## Local Problem

Banner Desert Medical Center implemented the EWS in October of 2012. The target population includes adults 18 and greater, medical surgical level of care (MS), Progressive Care level of care (PCU), and observations status patients that were either MS or PCU status. Current policy states, adult patients in the medical surgical and progressive care units will have "routine early warning system screening and interventions based on changes in blood pressure, heart rate, respiratory rate, temperature, pulse oximetry and level of consciousness using evidence based EWS screening tool administered on admission, at change of shift and with changes in patient condition. The EWS score will be calculated and interventions based on the score may include increased vital sign frequency, strict intake and output, notification of rapid response team, notification of charge nurse and physician, and possible transfer to higher level of care, resulting in decrease in mortality, hospital length of stay, and code blue calls" (Cadaret, 2012).

Throughout my eight-year tenure in leadership at Banner Health, I have identified inconsistencies related to the current EWS practice. As part of the RRT and Code Team I was being called to evaluate patients who had exceeded threshold EWS scores hours prior to nurses calling for assistance. The nursing staff are educated each year during annual skills training events, and given reminders throughout the year of the importance of following practice protocols related to the EWS and RRT deployment.

Banner provides a dashboard trending data monthly regarding EWS timeliness of response to alert, EWS RN notification form compliance and EWS provider notification compliance. Each measurement target for the organization is 85%. Most current data demonstrates timeliness to alert at 59.49%, notification form compliance at 78.22%, and provider

notification at 75.86% (Banner Health, 2015b). This statistical data implies reach and impact could be greater if barriers to use are identified and mitigated.

## Intended Improvement

The purpose of this project was to obtain and interpret data related to current practice and workflow of nurses' use of the Early Warning Score (EWS) tool currently in place at Banner Health. Potential barriers of use among end-users places the patient at risk for "failure to rescue" during the early stages of clinical deterioration. The approach for exploring current practice and nursing workflow was to survey nurses, the major stakeholders and users of EWS, within the Banner Health System. The aim was to obtain and evaluate survey data in relation to current EWS workflow and practice. Findings from this DNP project demonstrates opportunities to enhance workflow and use for the end-user.

## Purpose Statement

The aim of this project was to evaluate data from a survey sent to nurses in regards to the current practices and workflow of the EWS system currently in use at Banner Health. Potential workflow flaws including but not limited to documentation compliance, education, usefulness and usability of the system may be significant barriers of use in facilitating early interventions for patients experiencing clinical deterioration.

## Study Questions

The study questions answered in this project include: 1) What are the barriers to documentation that triggers the EWS? 2) To what extent is the EWS useful and usable? and, 3) What were the features of the EWS implementation?

## Literature Review

A search of the literature was conducted using the Cumulative Index of Nursing, Allied Health Literature (CINAHL), PubMed, and Cochrane Library in October 2015. Combinations of keywords were used in an effort to glean best results. Medical subject headings (MeSH) terms included: rapid response teams, early warning score, modified early warning score, electronic medical record, electronic health record, clinical decision support system, workflow, practice, nurse and practice. This search yielded 683 articles. Articles were excluded if they were written prior to 2010, not written in the English language, and not research driven. Articles lacking quality outcome data related to my research interest were also excluded. The majority of the literature focused on outcomes associated with mortality and morbidity, unplanned ICU admissions, and code arrests. However, of the 15-20 studies reviewed, the articles most relevant to the purpose of this project (i.e., to evaluate data from a survey sent to nurses in regards to the current practices and workflow of the EWS system currently in use at Banner Health) are described in detail below. Seven articles demonstrate evidence to support my study question in regards to usefulness, usability, and barriers of use of the EWS protocol.

A retrospective study of 65 unplanned ICU admissions at a tertiary facility in Iceland aimed to ascertain if insufficient documentation of the Modified Early Warning Score MEWS, monitoring of patients, and responses to altered physiological parameters prior to adverse events (AEs), affected the number of unplanned ICU admissions. MEWS in this study incorporated six parameters to include; temperature, heart rate, blood pressure, oxygen saturation, level of consciousness, and urine output. The EWS in current practice at Banner Health uses five parameters with the exclusion of urine output. The study demonstrated that insufficient

documentation occurred in three of the six MEWS physiological parameters including respiratory rate (14%), oxygen saturation (20%), and temperature (69%). Inadequate documentation of physiological parameters made it impossible to adequately calculate a MEWS score. Respiratory failure was the most common precursor for unplanned ICU admissions, and respiratory rate was the predominant undocumented parameter (Jonsson, Jonsdottir, Moller, & Baldursdottir, 2011). The authors deduced the possibility that greater measures had been taken to prevent clinical deterioration than documentation revealed (Appendix B).

A pilot study conducted in one university teaching hospital in the UK aimed to incorporate an alert system to measure EWS protocol compliance, length of stay (LOS), cardiac arrest incidence, unplanned ICU admissions, and hospital mortality. Patientrack, an intelligent alert response system, was developed to track clinical response. If alerts were inappropriate, unsuccessful, or absent, a predefined set of alerts were repeated indefinitely until the clinical situation was resolved (Jones et al., 2011).

The study had three phases. The first phase included baseline data capture. The second phase entailed implementation of an electronic observation capture and EWS calculation. Bedside observations were manually obtained and entered in a personal digital assistant (PDA). The PDA had wireless connectivity and results were presented as a "whole of ward view." The "whole ward view" displayed time and date of observations for each patient, the EWS score, and the time set for the next set of observations to occur. In this phase, traditional channels (i.e., Nurse call, operator to page providers, or personal notification) alerted providers. The third phase was the alert phase. All electronic observation data captured was sent as an automated electronic alert to medical providers. In the baseline phase, all medical records were checked manually each

day by a single investigator. During the alert phase, all data were collected using the Patientrack system. For patients that triggered and EWS alert retrospective chart review was performed. In the baseline and alert phase, there was no significant increase of observation in time to recheck patients for EWS of 3, 4, or 5 within one hour. Both groups maintained noncompliance (9% & 10%) up to four hours later. However, documentation of clinical response for EWS score 3, 4, and 5, increased significantly in the alert phase from 29% (baseline) to 78% (during alert phase) due to incorporation of the automated alert system and automatic escalation to physicians via paging. This study demonstrates the importance of communication via technology to enhance timely attendance, clinical response, and appropriate intervention of the "at risk" patient (Jones et al., 2011) (Appendix B).

In a service improvement project performed at the Nottingham University Hospitals in the UK (2015), a EWS Commissioning for Quality and Innovation Project (EWS CQUIN) team was introduced to assist in improving compliance rates of EWS protocols among nursing staff where compliance was poor. Six wards were chosen as part of this project. Five targets were established to enhance performance of nursing staff. Target 1 involved at least 75% of patients with observations completed every four hours. Target 2 involved over 95% compliance for EWS correctly scored and added. Target 3 measured where frequency of observations should have increased (i.e., correct in at least 35% of patients). Target 4 measured mandated nursing escalation interventions (e.g., fluid balance actions, notification of charge nurse, alerting medical staff, informing critical care outreach team) carried out with a target of at least 35%. Target 5 measured mandated medical escalation. This refers to timely review of the patient, involvement of senior medical staff if no immediate improvement is seen, and proper documentation of a

management plan. The CQUIN team felt it critical to define the culture surrounding the care of the acutely ill patient to assist in identifying latent failures in the EWS escalation pathway. To determine the "culture" the EWS CQUIN team held regular meetings with major stakeholders. CQUIN team members worked one shift a week in the clinical setting side by side with colleagues to better understand the issues present in the current workflow. Finally, the team sent out a questionnaire to frontline staff with the aim of determining reasons for non-adherence to protocols. Themes established from the questionnaire postulate rationale for decreased compliance. The first theme involved the lack of equipment available to meet EWS protocol standards (ratio of blood pressure machines and pulse oximeter to patients equated to 1:9 and 1:11 on poor compliance units vs. 1:4 and 1:6 on better performance units). The first theme demonstrates a clear association between lack of equipment and reduced targets, particularly targets 1 and 3. The second theme identified was perceived low staffing ratios and increased workload across all wards. The last theme involved hierarchy of care and previous negative responses when escalation occurred. The third theme remained consistent among all wards. Nurses expressed a lack of empowerment when their clinical decisions were over-ruled. This was identified as the primary reason for not escalating to the charge nurse, medical providers, or the Critical Care Outreach Team (Wood et al., 2015).

The EWS CQUIN team worked within the identified culture to educate through mandatory training, unit based in-services, and real time feedback provided to nursing staff in relation to EWS protocol compliance. By the fourth quarter of the study, each target was met and exceeded with the largest performance increase in mandated nursing escalation interventions. Obtaining staff engagement and identifying change champions during all phases of the project

contributed to increased compliance. Defining unit culture was also a valuable process (Wood et al., 2015). This study demonstrates a direct relationship between education, training, and understanding ward culture to the increased compliance of the EWS protocol (Appendix B).

The pre and post intervention study conducted by Mitchell et al. (2010), aimed to determine if the introduction of a multifaceted intervention to detect clinical deterioration in patients would decrease the rate of unplanned ICU admissions, increase the frequency of vital sign measurements, and increase the incidence of documented communication and medical review following clinical deterioration. The intervention involved redesign of ward observation charts, a track and trigger system, and an education program named COMPASS. Participation in the intervention period required at least 50% of the nursing staff and as many nursing assistants and physicians as practical be trained using the COMPASS program. The program involved both an online learning bundle and one three-hour face-to-face simulation training. The program aimed to promote a detailed understanding of physiological parameters, rationale for measurement and derangement, and create a forum for concise communication and initial resuscitation (Mitchell et al., 2010).

As a result of this study, a reduction in unplanned ICU admissions (1.8% vs. 0.5%) was determined during the intervention period (Mitchell et al., 2010). Also, a significant increase in the number of patients receiving a Medical Emergency Team review (2.2% vs. 3.8%), and daily frequency of vital sign documentation significantly increased ($p=0.001$), including respiratory rate ($p<0.001$) (Mitchell et al., 2010). This study shows a reduction in serious adverse events is attributed to increased frequency and accurate documentation of all vital signs of the acutely ill patient (Appendix B).

In the study by Bellomo et al. (2012), electronic automated advisory vital signs monitors were deployed to assist in the procurement of vital signs and the calculation of early warning scores. The monitors electronically display and transfer patient temperature, blood pressure, heart rate, and pulse oximetry. The monitor then requests the nurse manually input respiratory rate and level of consciousness. The EWS values were displayed as "safe range" in white, "observe range" in yellow, "warning range" in orange, and "urgent range" in red (Bellomo et al., 2012). For all ranges, advisory messages were displayed from supportive messages stating no further action required or recommendations for increased frequency of measurements when patients triggered the warning ranges.

Measures involved in this study include; RRT calls, immediate survival post RRT, 90-day survival post discharge, time required to record a set of vital signs, and Length of Stay (LOS) (Bellomo et al., 2012). While this study specifically measures adverse events, it also supports previous literature in regards to the importance of complete documentation of vital signs, including respiratory rate, which is often poorly documented among acutely ill patients (Bellomo et al., 2012; Mitchell et al., 2010; Jonsson et al., 2011). Deployment of electronic automated advisory monitors was associated with an improvement in RRT calls triggered by respiratory criteria, increased survival for those patients receiving RRT review, and a decreased time required to record vital sign measurement as evidenced in the evaluation table (Bellomo et al., 2012) (Appendix B).

A mixed methods study aimed to discover if the implementation of the Modified Early Warning Score (MEWS) increased the frequency of Rapid Response Team (RRT) calls among non-monitored patients on medical surgical units, as well as nurse led focus groups to identify

RN perceptions of barriers and facilitators to using the MEWS tool (Stewart, Carman, Spegman, & Sabol, 2014). A before and after design was used with retrospective chart review. Outcomes measured included frequency of RRT calls and the number of cardiac arrests. While primary and secondary outcomes were statistically not significant (RRT calls increased from 39 calls before and 55 after, P=0.288; cardiac arrest decreased from 14 to 11, P=0.878), this study highlights positive patient outcomes in reducing adverse events supported by the Institute for Healthcare Improvement (Stewart et al., 2014).

Five focus groups sessions each with 1 - 4 attendees were conducted for 11 RN's. A semi structured interview process explored how nurses use the MEWS at the bedside and how they communicate information to healthcare providers. Analysis of focus group transcripts identified three broad categories with seven themes. The broad categories include; "MEWS as a framework to support decision making at the bedside, the effect of the MEWS on interdisciplinary communication, and the influence of administrative support" (Stewart et al., 2014, p 226). Several themes emerged during focus group participation. Regarding decision-making, nurses acknowledged the increased patient acuity on medical surgical units and agreed that the MEWS scores aid in triaging, and prioritizing assignments. They also agreed MEWS scores alert them to changes in patient's conditions. Participants agreed across all groups that an elevated MEWS was not used to activate the RRT without assessing the patient first. Lastly, participants agreed that the MEWS score was not the principal reason to activate or not activate the RRT (Stewart et al., 2014). Regarding communication, nurses stated the MEWS was not typically communicated during shift report unless the score was elevated. Nurses also felt when communicating with physicians the MEWS score was useful as it assisted in creating a sense of urgency about the

clinical situation. Finally, nurses felt the MEWS played a significant role when obtaining information from nursing assistants, as they primarily document, report vital signs, and MEWS scores to the nurse. The group felt this information was important and kept them aware of subtle changes that may be occurring with the patient (Stewart et al., 2014). Regarding administrative support, confidence was felt among all groups in activating the RRT when necessary without fear of being ridiculed by physicians or other healthcare providers. Participants among all groups expressed this level of support was a major factor in their decision making process to activate a RRT when necessary (Stewart et al., 2014). Last, regarding perceived barriers to utilization, staff were asked how to improve the current MEWS. Participants agreed that a custom preset "normal vital sign" might be significant as many times what is "normal" for the patient, triggers MEWS criteria and interventions, which increases the nurses' workload. They also expressed the system was only as accurate as the data entered. Manual entry of vital sign data in the EHR to obtain a MEWS score was a significant barrier to effective system use. Errors or absent data could calculate an inaccurate MEWS score with no mechanism to alert nurses to this missing data (Stewart et al., 2014) (Appendix B).

While not broadly focused on early warning system parameters, a related study that electronically implemented an early recognition alert for adults with sepsis was also considered. McRee and associates evaluated the effects of an electronic medical record (EMR) sepsis surveillance alert in a retrospective chart review pre and post implementation. Pre-implementation, 75 patient charts were evaluated and post implementation 96 patient charts were evaluated. Patients admitted with a diagnosis of sepsis, severe sepsis and septic shock were targeted and the alert was triggered if two or more criteria of a systemic inflammatory response

were identified. These criteria included temperature r >38°C or <36°C, heart rate > 90 bpm, respiratory rate >20 breaths/minute, leukocytosis >12/L, or leukopenia < 4/L (McRee, Thanavaro, Moore, Goldsmith, & Pasvogel, 2014). If the patient met criteria and triggered an alert, nursing staff notified the nurse leader on the unit or "the patient in trouble crew" for further interventions. The physician was immediately notified for mean arterial blood pressure less than 60 mm hg. This sepsis surveillance alert demonstrated a decrease in hospital mortality (1.0% vs. 9.3% $p<.05$), and significantly improved home discharges (49% vs. 25.3%). While there was no statistical difference in length of hospital stay for the overall group, the post implementation group who triggered an alert had a decreased length of stay compared to pre implementation group ($7.2 \pm 4.2$ vs. $11.6 \pm 9.4$ days, $p<.05$) (McRee et al., 2014). While this study targets a specific diagnosis using different parameters compared to that of EWS, the concept of implementing an alert system in the EMR to aid in early identification and treatment of clinical deterioration relates to the overall purpose of the Banner Health EWS (Appendix B).

In a systematic review conducted by Bright et al. (2012), 148 RCTs evaluated the effect of CDSs on clinical outcomes, health care processes, workload and efficiency, patient satisfaction, cost, and provider use and implementation. Some 55 studies related to use and implementation outcomes demonstrated low to insufficient evidence supporting acceptance of the CDSs, health provider use, and how CDSs affected implementation in practice.

## Strengths and Limitations of the Evidence

Overall, current literature demonstrates positive effects of implementation of the Early Warning System (EWS) to assist in identification of clinical deterioration, reduction of unexpected ICU admissions, cardiac arrests, and reductions in hospital mortality. However, there

is a lack of research that has evaluated EWS once implemented and explored issues of usability, usefulness, and clinical adaptation to fit nursing workflow. Among the small number of studies identified in a review of the literature evidence demonstrates insufficient documentation of vital signs, and lack of compliance with EWS protocols, placing the patient at risk for "failure to rescue." Barriers identified include; lack of necessary equipment to remain compliant with EWS protocols, lack of knowledge about the significance in changes of physiological parameters, and provider responses when reporting changes based on Early warning scores (Wood et al., 2015; Jonsson et al., 2011; Jones et al., 2011; Mitchell, 2010).

Similarities across studies include the significance of complete documentation of vital signs to calculate an accurate EWS score. It was demonstrated in 4 of the 6 studies that respiratory rate is the most common poorly documented vital sign (Bellomo et al., 2012; Mitchell et al., 2010; Jonsson et al., 2011; Wood et al., 2015). At Banner Desert, a complete set of vital signs must manually be entered in the EHR to trigger and EWS. Missed data or errors in data can potentially produce inaccurate EWS calculation. Education remains a key factor in improving patient outcomes. Wood et al. (2015), and Mitchell et al. (2010), describe the use of a formal education training program to improve EWS protocol adherence. Currently at Banner Desert Medical Center, yearly competencies do not include formal training of significance of physiological parameters, rationale for measurement and derangement, or communication strategies that can be applied when speaking with other healthcare providers. EWS training is administered upon hire to the organization. Formal education may potentially improve outcomes in the future.

Differences between 2 of the 6 studies include escalation of care. Wood et al. (2015), describes a barrier to use as negative communication from providers when informing about EWS scores, while Stewart et al. (2014), demonstrates positive administrative support during focus group interviews. Care escalation algorithms in both studies are similar to those currently in place at Banner Desert Medical Center. Differences among studies necessitates further evaluation of current escalation practices.

Results among all studies indicate ongoing education programs, automated alert systems sent to providers and/or nurses, necessary equipment on each unit, and staffing ratios/workload, play an integral role in reducing barriers to use (Bellomo et al., 2012; Jones et al., 2011; Jonsson et al., 2011; Mitchell et al., 2010; Stewart et al., 2014; Wood et al., 2015). A systematic evaluation of the extent to which the EWS implementation has matched the evidence about effective CDS is unavailable and could support more effective use and reach.

## Weaknesses and Gaps

There are multiple adaptations of the EWS used in the US and UK, each with significant degrees of variants among scoring and threshold triggers that require specific responses. Despite obvious advantages of standardization to include transferability across organizations, and decreased confusion during use, there is a lack of uniformity in the choice of EWS used in the UK and the US (Smith, Prytherch, Meredith, Schmidt, & Featherstone, 2013). In response to these variances the United Kingdom's Acute Medicine Task Force of the Royal College of Physicians, London proposed the use of a standardized scoring system, the National Early Warning Score (NEWS) to be used throughout the UK (Smith et al., 2013). A number of different early warning models are available demonstrating different levels of prediction and

complexity. Even more challenging, is the fact that individual hospitals may be developing tools on their own and deploying them without adequate predictive testing. Finally, because these tools are embedded in Electronic Health Record (EHR) systems, the alerting that happens occurs in the context of already busy, time pressured, and highly interruptive work environments. The term alert fatigue describes how busy healthcare professionals become desensitized to safety alerts, resulting in failure to respond appropriately to such warnings. This phenomenon occurs due to the sheer number of alerts (AHRQ, 2015). It is likely that alert fatigue affects nurses working with EWS similar to the alert fatigue that occurs in computerized provider order entry systems with ordering clinicians. To date there remains no national standardized version of the EWS in the US, making it difficult to adequately ascertain and compare data among different populations and settings.

Finally, "usability" in the context of software design represents an approach that puts the user, instead of the system, at the forefront. Usability testing supports ease in which users perform particular tasks (Microsoft Corporation, 2000). While there is substantial amount of evidence supporting EWS use in reducing outcomes to include cardiac arrest, mortality and morbidity, length of stay, and unintended ICU admissions. There is a significant lack of evidence addressing the usability of the EWS at an interface level.

## METHODS

### Theoretical Underpinning

Change is inevitable in healthcare but evidence based practice (EBP) projects can catalyze or block adoption and successful change in the acute care setting (Manchester et al., 2014; Stange & Glasgow, 2013). In the acute care setting, there is a significant need to focus on

early planning prior to implementation of EBPs (Manchester et al., 2014). Use of a strong theoretical framework relevant to the intended change is essential for successful adoption and standardization within an organization. Havelock's Change Theory was used to evaluate the current EWS at Banner Desert Medical Center. Findings from this DNP project identified current workflow and practice trends. Proposed recommendations based on the results of this DNP project could enhance the current EWS in place using evidence based practice. The six-step process allows for an interdisciplinary approach involving key stakeholders (nurses) during the early planning phases.

Havelock's Change Theory is an adaptation of Lewin's Theory (e.g., including the concepts of unfreezing, moving, and refreezing) expanded to six elements (Swansburg, 1995). Havelock's model emphasizes the planning stage to understand why people and organizations resist change. Havelock's phases begin with *Building a Relationship*. Building relationships within an organization in need of change is critical to understanding the current state of practice and workflow of the organization. New practices cause interruptions to "the status quo" of an organization (Manchester et al., 2014, p. 4). Creating early buy-in from end-users is a driving force in sustaining change. The second phase includes *Diagnosing the Problem*. The Early Warning System has been utilized within the Banner organization for approximately four years. Significant flaws in workflow and practice have been identified requiring possible changes to be made to the current tool. The third phase of Havelock's theory involves *Acquiring Resources for Change*. At this stage, the need for change is implicit. The process for discovering solutions starts by gathering information. The survey gathered quantitative data relevant to current practice and workflow of the Early Warning Score tool in use at Banner Health. Barriers to use including

but not limited to lack of standardization, compliance with protocols, and education among end-users may potentially place the patient at risk for "failure to rescue" during the early stages of clinical deterioration warranting an evaluation and modification of current practice. The last three phases of Havelock's Theory include *Selecting a Pathway for Change*, *Establishing and Acceptance of the Change*, and *Maintenance and Separation* (Tyson, 2010). The three latter phases could be implemented should the Banner organization choose to move forward with proposed changes.

## Design and Setting

This project used a descriptive cross-sectional design to collect feedback from RNs at Banner Desert Medical Center about the EWS. Questions were asked using Likert style scaling to inquire about current practices, usability, and workflow of the EWS scoring tool. The setting for this project was a single 600-bed acute care hospital within a large hospital network. Banner Desert Medical Center in Mesa, Arizona is one of 29 facilities within the Banner Health System. Registered Nurses comprise 1,021 health care professionals employed at Banner Desert Medical Center. The EWS was introduced in October of 2012 and has been fully implemented on the Medical Surgical, Observation, and Progressive Care units (n=10). Currently the Intensive Care, Labor and Delivery (L&D), and the Emergency Departments (EDs) do not use the EWS. Nurses from Cardon Children's Medical Center, a close affiliate and part of Banner Desert, were excluded from this survey, as they do not currently utilize the EWS tool.

Registered Nurses working at Banner Desert Medical Center were invited to participate in a survey sent via email, using an anonymous survey link available through Qualtrics. Registered Nurses were chosen as the target for this survey as they work closely with the EWS in

everyday practice. The survey consisted of Likert Style questions with three open-ended questions. The survey also included the Post Study-System Usability Questionnaire (PSSUQ) (Lewis, 1995). The PSSUQ is a 19-item Likert scale questionnaire developed to assess users' perceived satisfaction with computer systems. The original version stemmed from an internal IBM project called System Usability MetricS (SUMS) (Lewis, 2002). The reliability and validity of this survey has been tested in several different domains for various products. Reliability was estimated using Cronbach's alpha coefficient. Coefficient alpha ranges from 0 = no reliability to 1 = perfect reliability (Lewis, 2002). Initial assessments of the PSSUQ scale from five years of lab data produced good inter-item reliability with Cronbach's alpha exceeding 0.85 consistently (Lewis, 2002). The development of the Computer System Usability Questionnaire (CSUQ) followed the development of the PSSUQ. "The items are identical to those in the PSSUQ except the wording was made appropriate for field and survey settings rather than just scenario based usability evaluation" (Lewis, 2002, p. 464). Both the PSSUQ and CSUQ are essentially the same questionnaire. Validity of the questionnaire was assessed with the Pearson correlation coefficient. Previous validity assessment of the PSSUQ compared to the CSUQ showed a significant correlation (r=.80) (Lewis, 2002). This measure is well suited for research and explores users' satisfaction with current computer systems, ease of use, efficiency of use, and comfort with their ability to interface with the system.

## Data Collection and Analysis

Following IRB approval from University of Arizona the survey was sent to all RNs working on medical surgical units, progressive care units, and post anesthesia care units at Banner Desert Medical Center using the anonymous survey link available through Qualtrics.

This link allowed for complete anonymity of participants. No identifying information was required or collected. Qualtrics option to deactivate collection of IP addresses was also implemented prior to being sent to potential participants. This survey did not require consent and responses were voluntary. The Director of Professional Practice, Melitta Modesti-Auclair via Banner Health email, sent out this survey link. All RN's working in previous stated departments were invited to respond, including direct caregivers as well as members of the leadership team.

RNs were selected as participants because they work closely with the EWS system during everyday practice. The survey consisted of Likert Style questions with three open ended questions and will take 15-20 minutes to complete. The survey remained open from February 9, 2016 to March 26, 2016. Exclusion criteria included any "No" responses to the first two questions in the survey. Demographic data in the survey included employee length of service, highest academic degree earned, and current position within the hospital (Appendix A). The survey also examined the mode in which nurses apply and perceive the usefulness of EWS tool during everyday practice, and how the tool influences communication with the healthcare team.

Banner Desert Medical Center employs approximately 1,021 Registered Nurses. The survey was sent to 405 nurses. It is feasible to expect at response rate of approximately 10%. The actual response rate equated to 6.2%. Qualtrics was used to capture descriptive statistics results. The principal investigator (PI) analyzed and coordinated data with assistance from my committee. The quantitative portion of the survey was analyzed using descriptive statistics to describe workflow and current practices. The principal investigator analyzed the qualitative portion of the survey. The investigator read and reread survey feedback to become immersed in the information then identified categories for individual statements, and establish themes from

the data. Qualitative comments were analyzed for themes until saturation was achieved. Committee co-chairs, Drs. Gephart and Baldwin, guided the analysis and verified the approach to categorizing and deriving themes from the data.

## Ethical Considerations and Resources

The survey did not require additional resources for effective evaluation of findings nor were there be any monetary costs involved during preparation, implementation, or analysis of data. The current process in place for all DNP projects at Banner Health involves committee approval led by The Director of Professional Practice to evaluate all proposals for feasibility and transferability of intended projects. This process requires a three-page written proposal for Evidence-based practice/Process improvement projects. The committee related to feasibility and transferability at Banner Desert Medical Center then evaluated the proposal. I worked closely with the Director of Professional Practice Melitta Modesti-Auclair RN, MSN, SPHR, at Banner Desert Medical Center to ensure that this survey aligned with current system initiatives and makes good use of Banner Health resources as well as to assure the project would not add undue burden to Registered Nurses. A letter of support was secured from Ms. Modesti-Auclair for this DNP project. IRB approval was obtained through the University of Arizona prior to implementation of the survey. The survey was anonymous. Nurses could freely answer questions without concern for retribution. Consent from participants was not necessary. The survey was voluntary.

# RESULTS

Evaluation of the EWS in use at Banner Desert Medical Center took place during the months of February and March 2016. The evaluation is significant in understanding current EWS

practice, barriers to adherence of protocols, and usability and usefulness from a nursing perspective. The EWS has been implemented and used since October of 2012 without an evaluation from the nursing perspective. A formal evaluation could improve the process of early recognition using the EWS and nursing perspectives could offer solutions of benefit to patient care.

## Sample and Setting

The target audience for this survey was nurses who work in Medical Surgical Units, Post Anesthesia Care Unit, Outpatient areas, Resource Team, and Progressive Care Units. There was also an option for "Other" should the respondent not fit in one of the listed categories. The survey was sent via email to 405 nurses at Banner Desert Medical Center located in Mesa, Arizona. Implementation of the survey began on February 9, 2016. A reminder email was sent February 26, 2016, with a final reminder email sent March 18, 2016. The survey was then closed on March 26, 2016. Of those invited, 72 nurses responded with 65 complete surveys. One non-nurse respondent was excluded from the survey based on the answer to the first question. Longevity as a nurse revealed that: 6 (9%) were nurses less than one year, 9 (14%) were nurses with 1-3 years in practice, 18 (28%) had 3-5 years in practice, 6 (9%) had 5-7 years in practice, 10 (15%) had 7-10 years in practice, and 16 (25%) had greater than 10 years of nursing practice.

Years of service at Banner Desert Medical Center from respondents include 11 (17%) having less than one year working at Banner Desert Medical Center, 23 (35%) with 1-3 years of service, 8 (12%) with 3-5 years of service, 5 (8%) with 5-7 years of service, 8 (12%) with 7-10 years of service, and 10 (15%) with greater than 10 years of service. The highest academic

degree earned by respondents: 16 (25%) held an associate's degree, 46 (71%) held a bachelor's degree, 2 (3%) held a Master's degree, and 1 (2%) held a doctorate degree.

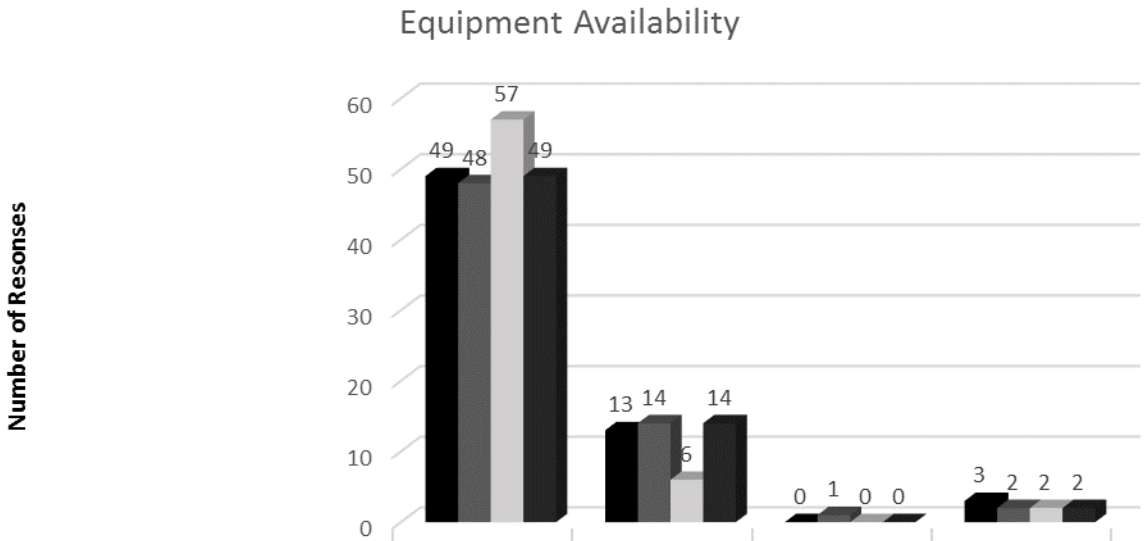
TABLE 3. *Demographics of Nurses Surveyed.*

| **Demographics** | | **n(%)** |
|---|---|---|
| Total Respondents (n=73) | Registered Nurse | 72 (99%) |
| | Non-Registered Nurse | 1 (1%) |
| Years as Nurse (n=65) | < 1 yr | 6(9%) |
| | 1-3 years | 9(14%) |
| | 3-5 years | 18(28%) |
| | 5-7 years | 6(9%) |
| | 7-10 years | 10(15%) |
| | > 10 years | 16(25%) |
| Years of Service at BDMC (n=65) | < 1 yr | 11(17%) |
| | 1-3 years | 23(35%) |
| | 3-5 years | 8(12%) |
| | 5-7 years | 5(8%) |
| | 7-10 years | 8(12%) |
| | > 10 years | 10(15%) |
| Highest Academic Degree (n=65) | Associate | 16(25%) |
| | Bachelor's | 46(71%) |
| | Master's | 2(3%) |
| | Doctorate | 1(2%) |
| Work Area (n=65) | Medical Surgical | 25(37%) |
| | Progressive Care | 36(54%) |
| | Resource Team | 0(0%) |
| | Outpatient | 1(1%) |
| | PACU | 5(7% |
| | Other | |
| Working Knowledge of EWS (n=65) | < 6 months | 3(5%) |
| | > 6 months | 62(95%) |

Of the total number of nurses 25 (37%) were from medical surgical units, 36 (54%) were from progressive care units, 1 (1%) from PACU, and 5 (7%) from other. Results from "other" included oncology and Clinical Care Operations staff. Respondents were asked about their exposure to the EWS system. Most respondents 62 (95%) have worked with the EWS system for greater than six months, while only 3 (5%) have had less than six-months exposure to the EWS system.

## Equipment Availability to Carry Out the EWS Protocol

Nurses were asked to indicate if they had the necessary equipment to carry out the EWS protocol. When asked about blood pressure cuff availability, 49 (75%) nurses indicated they always have a blood pressure cuff, 13 (20%) said they have a blood pressure cuff most of the time, and only 3 (5%) stated they sometimes have a blood pressure cuff available to carry out the EWS protocol. No respondent felt they never have this piece of equipment available. Regarding availability of a thermometer, 48 (74%) respondents felt they always have a thermometer available, while 14 (22%) felt they have a thermometer most of the time, and only 1 (2%) felt a thermometer was available half of the time with 2 (3%) indicating they sometimes have the equipment available. There were no "never" responses. Regarding a device to measure heart rate responses include: 57 (88%) always have a device available, 6 (9%) felt they have this equipment available most of the time, and 2 (3%) felt they sometimes have equipment to measure heart rate available. There were no about half of the time or never responses. Responses for oxygen saturation monitor include; 49 (75%) always have this available, 14 (22%) have it available most of the time, and 2 (3%) have it available sometimes. There were no about half the time or never responses.




| | Always | Most of the time | About half the time | Sometimes |
|---|---|---|---|---|
| Sum of Blood Presure Cuff | 49 | 13 | 0 | 3 |
| Sum of thermometer | 48 | 14 | 1 | 2 |
| Sum of heart rate device | 57 | 6 | 0 | 2 |
| Sum of oxygen saturation monitor | 49 | 14 | 0 | 2 |

*FIGURE 1*. Equipment Availability (n=65)

**Barriers and Responsiveness of Providers When Using EWS Protocol**

Respondents were asked to select from three choices that deterred individuals from following the EWS protocol. High workload topped the list with 49 (78%) responses. Previous negative responses from ordering clinicians when called in regard to EWS notification was common at 39 (62%) responses. Alert fatigue was a barrier for 30 (48%). Fewer cited barriers because they preferred to use their clinical judgement 8 (13%) or lacked knowledge of the EWS protocol 5 (8%).

TABLE 4. *Barriers to Following EWS Protocol (n=63)*

| **Barriers to Following EWS Protocol** | **n(%)** |
|---|---|
| Increased workload | 49(78%) |
| Alert Fatigue (different systems send prompts, alerts, and alarms that you no long pay attention to) | 30(48%) |
| Previous negative responses from ordering clinicians (Physicians, PA's, NP's) when you call to notify them of the patients score | 39(62%) |
| Lack of Knowledge of the EWS protocol | 5(8%) |
| Prefer using your own clinical judgment | 8(13%) |

*Note*: Respondents selected top three choices

Respondents were asked how often providers are responsive to notification based on the Early warning score, 29 (46%) indicated "most of the time," 16 (25%) indicated "about half of the time," 11 (17%) indicated "sometimes," while 6 (10%) felt responsiveness of providers "always" occurred, and 1 (2%) specified "never."

TABLE 5. *Responsiveness of Providers (n=63)*

| **Answer** | **Response** | **%** |
|---|---|---|
| Always | 6 | 10% |
| Most of the time | 29 | 46% |
| About half the time | 16 | 25% |
| Sometimes | 11 | 17% |
| Never | 1 | 2% |

Respondents were asked how often they utilize the Rapid Response Team when the Early Warning Score indicates a sum of 5 or greater. Of the 63 responses to this question 26 (41%) indicated they call the RRT sometimes. While 11 (17%) specified they call the RRT most of the time, and only 9 (14%) specified they always call the RRT when the EWS algorithm indicates to do so, 7 (11%) indicated they call the RRT about half the time, and 10 (16%) nurses indicated they never call the RRT for an EWS of 5 or greater.

TABLE 6. *Use of RRT When EWS Indicates a Score of 5 or Greater (n=63)*

| **Answer** | **n(%)** |
|---|---|
| Always | 9(14%) |
| Most of the time | 11(17%) |
| About half of the time | 7(11%) |
| Sometimes | 26(41%) |
| Never | 10(16%) |

## Charting in the Electronic Health Record and EWS Alert

Nurses were asked how often they were able to chart "real time." Of the 65 responses, 42 (65%) nurses indicated they were able to chart real time 50-75% of the time. Charting "real time" less than 50% of the time was common among nurses at 20(31%), only 1 (2%) indicated they were able to chart in "real time" all of the time, with 2 (3%) indicating they are never able to chart "real time."

Nurses were then asked if they were unable to chart "real time" does the EHR provide an Early Warning Score to assist in detecting clinical deterioration. Of the 63 responses to this survey question, 29 (49%) nurses indicated the EHR provides an Early Warning Score most of the time. A moderate number of 12 (19%) nurses indicated an Early Warning Score is always generated, while 10 (16%) nurses indicated an Early Warning Score appears about half of the time as well as sometimes, and only 2 (3%) specified the Early Warning Score never appears.

TABLE 7. *Charting and Evidence of EWS Alert (n=63)*

| **Question** | | **N(%)** |
|---|---|---|
| How often are you able to chart "real time"? | All of the time | 1(2%) |
| | 50-75% of the time | 42(65%) |
| | Less than 50% of the time | 20(31%) |
| | Never | 2(3%) |
| If unable to chart "real time" does the EHR provide you with an EWS? | Always | 12(19%) |
| | Most of the time | 29(46%) |
| | About half the time | 10(16%) |
| | Sometimes | 10(16%) |
| | Never | 2(3%) |
| How often do you call the RRT when EWS is indicated in the EHR? | Always | 9(14%) |
| | Most of the tine | 11(17%) |
| | About half the time | 7(11%) |
| | Sometimes | 26(41%) |
| | Never | 10(16%) |

## Potential Changes to the Early Warning System

Nurses were asked an open-ended question in regards to what changes could be made to make the system more usable to the bedside nurse. Of the 28 responses to this question one major theme of technical changes with several possible recommendations to improve the system emerged. The first recommendation was to generate a pop up alert much like the current allergy pop up or smart alert for sepsis. This was specified as a possible enhancement that would benefit end user's effective use of the EWS tool. Nurses described inconsistent firing of the EWS, leaving the nurse to search for it within the task list or vital signs screen. The second recommendation was to tailor parameters based on individual patient characteristics. Nurses specified several subsets of patients have vital signs, according to the EWS, that are characterized as abnormal. However, the vital signs are normal for the patient (e.g., if in atrial fibrillation or diagnosed tachycardia). If the system could be tailored to the particular patients' needs, this would be helpful in decreasing already heavy workloads for nursing and ancillary staff due to increased tasking of vital sign measurements and subsequent charting. A third

possible opportunity for change involved automatic direct paging to the attending physician and nurse for EWS alerts of 5 or greater. Last, it was proposed to omit the level of consciousness (LOC) parameter from the EWS. Ancillary staff do a majority of the vital signs charting and the alert will not fire until nursing inputs the LOC. More than 50% of responses identified delays in "real time" charting resulted in delay of EWS alert generation.

The second open-ended question asked nurses if there was anything else they would like to share in regards to the Early Warning System process. Of the 17 responses, the technical theme re-emerged in regards to the necessity for a "pop up" alert for easier recognition of changing parameters of the EWS. One nurse stated, "I don't like the fact that the EWS doesn't pop up on the screen when it "fires," it can be missed easily. The biggest thing is coordinating with the aide when they are charting vitals and clicking that the patient is alert within the hour." Nurses agree the EWS is a valuable tool however; improvements to the current system would enhance effective use. Nurses must continually check the EHR to see if an Early Warning Score has fired. A second response from the survey stated, "I wish it would come up like an allergy alert or a flu vaccine notification, or something like that." Increased workload was noted as a deterrent to effective use of the EWS tool. One nurse participant stated, "I think it is a valuable tool that can prevent negative patient outcomes however, at times workloads prevent it from being used as effectively as it could be." A final response involved responsiveness of providers, the nurse conveyed," MD's need to be more responsive and not just brush off the EWS."

### Early Warning System Process Perspective

A final open-ended question asked respondents to recall specifics about the implementation process of the Early Warning System. Of the 24 responses, the most common

theme specified the system was implemented prior to their arrival to the Banner System. Several responses demonstrated the roll out as confusing in regards to EWS alerts and subsequent charting required. Lack of education prior to implementation emerged as the next largest response, with a perceived lack of continuing education to support system usefulness.

Respondents were asked if their perspective was sought in regards to the implementation of the Early Warning system. Of the 63 responses, an overwhelming number 52 (83%) nurses indicated "no" their perspective was not sought in regards to the EWS implementation, while only 11 (17%) felt they had some involvement in the implementation process.

TABLE 8. *EWS Perspective Pursued by Nurses Prior to Implementation (n=63).*

| **Response** | **n (%)** |
|---|---|
| Yes | 11(17%) |
| No | 52(83%) |

## Usability of the Early Warning System Software

Finally, the last portion of the survey, questions 22 thru 40, asked nurses to evaluate their perceived satisfaction with the computer software system. The Post Study-System Usability Questionnaire (PSSUQ) is a 19-item Likert scale questionnaire, using four responses ranging from strongly agree to strongly disagree, which has shown to be valid and reliable (Lewis, 1995). The mean number of complete responses to this portion of the survey included 58 responses. Overall, survey results confirmed satisfaction with the Early Warning System. Seventy-six percent of nurses "agree" the EWS software application is usable, while 8% of nurses "strongly agree" to the application's usability. Of the total responses, 14% of nurses were not satisfied with the EWS system and a mere 2% "strongly disagree" that the EWS software is not usable. Questions 22 thru 28 asked nurses about ease of use, efficiency of use, and comfort with the

EWS software. Overall responses were positive in this regard with 90% of nurses either agree or strongly agree. Nurses were asked if they felt they were able to be productive quickly with the EWS. Positive responses from nurses at 44 (75%) either strongly agree or agree. Results demonstrate 15 (25%) of nurses disagree. There was continued disunion of results throughout the remainder of the survey. Nurses were asked about, "The system's ability to give error messages that clearly tell me how to fix problems," 57% indicated they agree or strongly agree, while 44% indicated they disagree or strongly disagree. The next question asked, "When mistakes are made using the EWS were they able to recover easily and quickly?" Nurses indicated they disagree or strongly disagree at 14 (23%) with 45 (76%) either strongly agree or agree. Of the 59 responses, nurses were then asked if information such as on screen messages and other documentation provided in the EWS was clear and 13 (22%) disagree, while 46 (78%) of nurses agree or strongly agree. Similar results were demonstrated when nurses were asked about the system interface, 12 (21%) indicated they disagree, while 45 (79%) agreed or strongly agreed the system interface was pleasant. Nurses were then asked if they liked using the interface of the EWS. Responses from 56 nurses identified 13 (23%) disagree while 43 (77%) agree or strongly agree.

The following four questions focused on ease of finding information, understanding the information, organization of the information, and effectiveness of the information in completing tasks and scenarios associated with the EWS. In regards to ease of finding information 13 (22%) disagree and 46 (78%) of the 59 responses agree or strongly agree. When nurses were asked if the information provided for the EWS was easy to understand 9 (15%) disagree and 50 (84%) of the 59 responses agree or strongly agree. Other important findings from this survey demonstrated that among the 58 responses, 10 (17%) of nurses disagree when they were asked if the

information was effective in helping complete tasks and scenarios, while 48 (83%) agree or strongly agree the information was effective in completing tasks and scenarios. Of the 58 responses 11 (19%) disagree when asked if the organization of information on the EWS screen was clear and 47 (81%) agree or strongly agree. Last, nurses were asked if the system had all of the functions and capabilities they expected it to have. Of the 58 response, 11 (19%) disagree and 47 (81%) strongly agree or agree with the systems functions and capabilities.

TABLE 9. *Post Study - System Usability Survey; Mean Response (n=58)*

| **Question** | **Response** | **n(%)** |
|---|---|---|
| 22. Overall, I am satisfied with how easy the EWS system is. | Strongly Agree | 10(17%) |
| | Agree | 42(71%) |
| | Disagree | 7(12%) |
| | Strongly Disagree | 0(0%) |
| | **Total** | **59** |
| 23. It is simple to use the system | Strongly Agree | 10(17%) |
| | Agree | 43(74%) |
| | Disagree | 5(9%) |
| | Strongly Disagree | 0 |
| | **Total** | **58** |
| 24. I can effectively complete my work using this system | Strongly Agree | 9(15%) |
| | Agree | 46(78%) |
| | Disagree | 4(7%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |
| 25. I am able to complete my work quickly using this (EWS) system | Strongly Agree | 7(12%) |
| | Agree | 45(76%) |
| | Disagree | 5(8%) |
| | Strongly Disagree | 2(3%) |
| | **Total** | **59** |
| 26. I am able to efficiently complete my working using this (EWS) system | Strongly Agree | 7(12%) |
| | Agree | 43(73%) |
| | Disagree | 9(15%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |
| 27. I feel comfortable using this (EWS) system | Strongly Agree | 15(25%) |
| | Agree | 40(68%) |
| | Disagree | 4(7%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |

TABLE 9. – *Continued.*

| **Question** | **Response** | **n(%)** |
|---|---|---|
| 28. It is easy to learn to use this (EWS) system | Strongly Agree | 15(26%) |
| | Agree | 39(67%) |
| | Disagree | 4(7%) |
| | Strongly Disagree | 0 |
| | **Total** | **58** |
| 29. I believe I became productive quickly using the (EWS) system | Strongly Agree | 7(12%) |
| | Agree | 37(63%) |
| | Disagree | 15(25%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |
| 30. The system gives error messages that clearly tell me how to fix problems | Strongly Agree | 6(11%) |
| | Agree | 26(46%) |
| | Disagree | 23(40%) |
| | Strongly Disagree | 2(4%) |
| | **Total** | **57** |
| 31. Whenever I make a mistake using the (EWS) system, I recover easily and quickly | Strongly Agree | 6(10%) |
| | Agree | 39(66%) |
| | Disagree | 12(20%) |
| | Strongly Disagree | 2(3%) |
| | **Total** | **59** |
| 32. The information provided with the (EWS) system is clear | Strongly Agree | 7(12%) |
| | Agree | 39(66%) |
| | Disagree | 13(22%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |
| 33. It is easy to find the information I need | Strongly Agree | 6(10%) |
| | Agree | 40(68%) |
| | Disagree | 13(22%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |
| 34. The information provided for the (EWS) system is easy to understand | Strongly Agree | 5(8%) |
| | Agree | 45(76%) |
| | Disagree | 9(15%) |
| | Strongly Disagree | 0 |
| | **Total** | **59** |
| 35. The information is effective in helping me complete the tasks and scenarios | Strongly Agree | 7(12%) |
| | Agree | 41(71%) |
| | Disagree | 10(17%) |
| | Strongly Disagree | 0 |
| | **Total** | **58** |
| 36. The organization of the information on the (EWS) system screen is clear | Strongly Agree | 7(12%) |
| | Agree | 40(69%) |
| | Disagree | 11(19%) |
| | Strongly Disagree | 0 |
| | **Total** | **58** |

TABLE 9. - *Continued*

| Question | Response | n(%) |
|---|---|---|
| 37. The interface of this (EWS) system is pleasant. (i.e., Screen display) | Strongly Agree | 5(9%) |
| | Agree | 40(70%) |
| | Disagree | 12(21%) |
| | Strongly Disagree | 0 |
| | **Total** | **57** |
| 38. I like using the interface of this (EWS) system | Strongly Agree | 6(11%) |
| | Agree | 37(66%) |
| | Disagree | 13(23%) |
| | Strongly Disagree | 0 |
| | **Total** | **56** |
| 39. The (EWS) system has all of the functions and capabilities I expect to have | Strongly Agree | 5(9%) |
| | Agree | 42(72%) |
| | Disagree | 11(19%) |
| | Strongly Disagree | 0 |
| | **Total** | 58 |
| 40. Overall, I am satisfied with the (EWS) system | Strongly Agree | 5(8%) |
| | Agree | 45(76%) |
| | Disagree | 8(14%) |
| | Strongly Disagree | 1(2%) |
| | **Total** | **59** |

## Summary of Results

Of the 65 responses from nurses working at Banner Desert Medical Center, it was determined the majority of nurses surveyed work on Medical Surgical units and Progressive Care units. Equipment availability was not a barrier to completing the EWS protocol. When asked about possible barriers to following the EWS protocol, nurses felt increased workload topped the list of barriers at 78%. The second most common barrier at 62% was previous negative responses by providers. The third most common barrier to following EWS protocols by nurses surveyed was alert fatigue at 48%. However, when asked about responsiveness of providers 81% of nurses felt providers were responsive, all of the time, most of time or half of the time. While only 19% of nurses felt providers were responsive sometimes, or never. Inability to consistently chart real time was identified as a potential barrier to following EWS protocol, as the EWS score is not

always generated due to charting delays. Respondents recommended removing the LOC parameter from the EWS to overcome this barrier. Overall, respondents felt the system is usable and useful. Two themes associated with possible changes to increase end user usability and usefulness include: a "pop up" to alert nurses of increased EWS and the ability to tailor parameters based on the patient's current normal trend of vital signs. The previously validated usability survey produced interesting results. Overall, usability and usefulness of the EWS showed positive results.

## DISCUSSION

The Early Warning System has been in place at Banner Desert Medical Center since 2012 and this project was the first evaluation of its usefulness and usability from a nursing perspective. Results of this survey, showed delays occur in timely documentation, which resulted in delayed Early Warning Score trigger. A significant number of nurses (96%) indicated charting occurred in "real time" 50-75% of the time or less than 50% of the time. It was also indicated lack of timely charting provided the end user with an EWS score most of time (46%), leaving missed opportunities to detect clinical deterioration through subtle changes in vital signs. Interestingly, 13% of nurses felt they had the necessary clinical ability to care for an acutely ill patient without the need to call the Rapid Response Team, in spite of this being part of the EWS protocol. This supports previous literature examining protocol compliance related to rapid response team initiation (Driscoll et al., 2012; Jonsson et al., 2011; Shearer et al., 2012)

The survey highlighted other barriers to following the EWS protocol including increased workload, previous negative responses from medical providers, and alert fatigue, which is consistent with other recent studies (Wood et al., 2015; Mitchell et al., 2010). Communication

remains a critical significant factor when monitoring clinically unstable patients. Provider responsiveness was identified as the second most common cause preventing compliance of EWS protocols. Results of the survey demonstrated a lack of consistent responsiveness from providers among those surveyed. Dissimilar to previous literature, equipment availability was not indicated as a significant deterrent to following the EWS protocol (Wood et al., 2015).

Nurses proposed several recommendations to improve the current system for the end user. The most common responses specified the need for a "pop up" to alert the end-user of changes in the EWS. Other perceived opportunities for improvement include automatic paging to the physician and nurse to assist in decreasing nursing workload, enhance timely documentation, and initiation of appropriate interventions based on Early Warning Score criteria, which showed positive outcomes in previous literature (Jones et al., 2011). Finally, ongoing education was identified as a barrier prior to implementation of the EWS tool. Education is a key component to sustain successful use of the EWS. As veteran nurses move away from the bedside, new graduates fill open positions, continuing education, and training to maintain EWS protocol compliance is critical in the delivery of safe, effective, evidence based care.

The results of the previously validated usability survey demonstrated overall satisfaction with EWS software. A significant number of nurses (84%) either strongly agree or agree the EWS is useful and usable. Questions 22 thru 28 of the usability survey asked nurses about ease of use, efficiency of use, and comfort with the EWS software. Overall responses were positive in this regard with 90% of nursing either agree or strongly agree. However, there was considerable disunion of results pertaining to "the system's ability to give error messages that clearly tell me how to fix problems" with 57% either indicating they agree or strongly agree, while 44%

indicated they disagree or strongly disagree. Results demonstrated that 20% of nurses disagree when asked; if mistakes were made in the EWS, recovery was easy and quick. Similarly, 25% of nurses responded negatively indicating they disagree when asked if they became productive quickly using the EWS. Four questions focused on ease of finding information, understanding the information, organization of the information, and effectiveness of the information in completing tasks and scenarios associated with the EWS. Results showed 19% of respondents disagree or strongly disagree about ease, organization, and effectiveness of the information provided by the EWS. Nurses were asked if the system interface was pleasant (i.e., Screen display) and if they liked using the system. Nurses disagree 13 (23%) that they did not like using the interface of the EWS, and 12 (21%) of nurses did not feel the system interface was pleasant.

## Key Challenges

The biggest challenge was timing and education of nurses about the survey due to the timing of when it was delivered. Banner Desert Medical Center is busy tertiary care facility. This project was implemented between February and March of 2016, the busiest season of the year. Historically volume and patient acuity is increased between November and April due to flu season in Arizona. Due to the increased volume, nurses have less time to check email, which was the selected mode of implementation of this project. Perhaps implementation during the summer months would have yielded a better response rate of the 405 nurses surveyed.

## Strengths and Limitations

This DNP project provides evidence that barriers exist to meeting the current EWS protocols. The findings highlight increased workload, previous negative responses from providers, and alert fatigue as predominant factors associated with protocol noncompliance. This

DNP Project demonstrates positive results with regard to overall usefulness and usability of the Early Warning System. A strength of this project involved the continual support of the nursing research committee and administration in rolling out the project. An additional strength of this DNP project involved collecting data from the nursing perspective. Nurses contribute a wealth of knowledge and expertise in managing critically ill patients. It was significant for nurses to provide feedback as they use the tool in everyday practice. Finally, the use of open-ended questions provided greater breadth and depth of current workflow and practices offering practical solutions to improve the system from an end-user perspective. There are limitations to this DNP project. The survey was distributed to nurses in a single facility, although many facilities use the EWS within Banner Health. Banner is a large network of acute care facilities varying in size, distributing the survey to multiple sites may have yielded diverse results. Second, the DNP project was implemented in what is historically considered peak season of acutely ill patients, limiting the number of responses.

## Recommendations for Future Practice

The findings of this DNP project have implications for future practice and might consider augmenting the current EHR to reflect a visible alert within the software that allows nurses to easily distinguish changes of the Early Warning Score. Opportunities to detect subtle changes in vital signs is dependent upon recording a full set of vital signs including level of consciousness. It may be prudent to change the current workflow to reflect the elimination of the level of consciousness parameter or allow nursing assistants to input this information for timely firing of an Early Warning Score as they input the vast majority of vital signs in the EHR. Continued education with regard to importance and meaning of derangement in physiological parameters is

critical in developing expert skill in managing the at risk patient. Last, implementation of this survey in multiple Banner facilities may provide insight as to what other facilities are doing well or lacking, gleaning more robust results to improve the current system.

## Conclusion

The aim of this DNP project was to evaluate the current Early Warning System from a nursing perspective, to ascertain if there were opportunities to improve the current system and provide continued safe and appropriate care for patients. Nurses contribute a wealth of knowledge and clinical expertise in managing critically ill patients. These findings suggest the EWS tool is a useful and usable system. However, barriers to effective use persist. Implementation of proposed recommendations for the EWS tool will assist end-user recognition of subtle changes in vital signs allowing for timely documentation and initiation of appropriate interventions to promote continued patient safety. Further research is warranted to identify potential barriers, and quantify patient outcomes related to nurses' use of the EWS.

# APPENDIX A:

# NURSING SURVEY

1. **Are you a Registered Nurse?**
   Yes
   No
   [If no - will be removed from the survey]
2. **In your current practice are you aware of the clinical decision support system embedded in the Electronic Health Record, that triggers a score once per shift (or if pt condition changes) in determining subtle changes in vital signs called the EWS?**
   Yes
   No
   [If no - will be removed from the survey]
3. **How long have you been a nurse employed at Banner Desert Medical Center?**
   - <1 year
   - 1-3 yrs
   - 3-5 yrs
   - 5-7 yrs
   - 7- 10yrs
   - >10 years
4. **How long have you been a Registered Nurse?**
   - < 1 year
   - 1-3 years
   - 3-5 years
   - 5-7 years
   - 7-10 years
   - > 10 years
5. **What is the highest academic degree you have earned?**
   Associates
   Bachelors
   Masters
   Doctorate
6. **Where do you currently work in the hospital? (Check all that Apply)**
   Medical Surgical Unit
   Progressive Care Units
   Resource Team Nurse
   PACU (Post Anesthesia Care Unit)
   Outpatient unit to include; Endoscopy, Cath Lab, OPTC, Radiology,
   Other _____
7. **On a typical day how many patients are you assigned to care for as the primary nurse?**
   1-2
   3-5
   6-7
8. **How long have you worked with or been exposed to Banner's Early Warning System?**
   < 6 months
   > 6 months
9. **Do you have a blood pressure cuff available to carry out the EWS protocol?**
   Always
   Usually
   Sometimes
   Rarely

Never

10. **Do you have a thermometer available to carry out the EWS protocol?**
    Always
    Usually
    Sometimes
    Rarely
    Never
11. **Do you have a device to measure Heart Rate to carry out the EWS protocol?**
    Always
    Usually
    Sometimes
    Rarely
    Never
12. **Do you have an oxygen saturation monitor to carry out the EWS protocol?**
    Always
    Usually
    Sometimes
    Rarely
    Never
13. **What barriers do you encounter most often that keeps you from following and documenting the EWS protocol? Select the top 3**
    Increased workload
    Alert fatigue (different systems send prompts, alerts, and alarms that you no longer pay attention to)
    Previous negative responses from Ordering Clinicians (Physicians, NPs, PAs) when you call them to notify about the score
    Lack of knowledge of the EWS protocol
    Prefer using your own clinical judgment
14. **During a typical shift, how often are you able to chart "real time" (as you accomplish tasks and assessments) on every patient?**
    All of the time
    50-75% of the time
    Less than 50% of the time
    Never
15. **If you are unable to chart "real time" on each patient, does the EHR provide you with an EWS to assist in detecting clinical deterioration of the patient?**
    Always
    Usually
    Sometimes
    Rarely
    Never
16. **How often are providers (Physicians, PA's, NP's) responsive to your notification based on the Early Warning Score?**
    Always
    Usually
    Sometimes
    Rarely
    Never

17. **In your current practice how often do you utilize the Rapid Response Team (calling 16666) when the EWS indicates patient deterioration (EWS of 5 or greater)?**
    Always
    Usually
    Sometimes
    Rarely
    Never
18. **Was your perspective sought in regards to the implementation of the Early Warning System?**
    Yes
    No

**What would you change to make the Early Warning System more usable for the bedside nurse?**

_____

_____

**What do you recall about the implementation process for the Early Warning System?**

_____

_____

**Is there anything else you want to share about the Early Warning System process?**

_____

_____

**Is there anything else you want to share about the Early Warning System process?**

_____

_____

***The second portion of this survey strictly asks questions about the Early Warning System interface, screen display, and ease of use.***

**Usability Satisfaction Questionnaire (Lewis, 1998)**

1. **Overall, I am satisfied with how easy it is to use(EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
2. **It is simple to use this (EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
3. **I can effectively complete my work using this (EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree

4. **I am able to complete my work quickly using this (EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
5. **I am able to efficiently complete my work using this (EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
6. **I feel comfortable using this (EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
7. **It was easy to learn to use this (EWS) system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
8. **I believe I became productive quickly using this (EWS)system**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
9. **The system gives error messages that clearly tell me how to fix problems**
   Strongly agree
   Agree
   Disagree
   Strongly disagree
10. **Whenever I make a mistake using the (EWS) system, I recover easily and quickly**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
11. **The information (such as online help, on-screen messages, and other documentation) provided with this (EWS) system is clear**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
12. **It is easy to find the information I needed**
    Strongly agree
    Agree
    Disagree
    Strongly disagree

13. **The information provided for the (EWS) system is easy to understand**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
14. **The information is effective in helping me complete the tasks and scenarios**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
15. **The organization of information on the (EWS) system screen is clear**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
16. **The interface of this (EWS) system is pleasant (i.e., screen display)**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
17. **I like using the interface (i.e., screen display) of this (EWS) system**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
18. **This (EWS) system has all the functions and capabilities I expect it to have**
    Strongly agree
    Agree
    Disagree
    Strongly disagree
19. **Overall, I am satisfied with this (EWS) system**
    Strongly agree
    Agree
    Disagree
    Strongly disagree

# APPENDIX B:

# SYNTHESIS OF EVIDENCE

| Reference | Study Design | Sample | Intervention | Outcome Measure | Results |
|---|---|---|---|---|---|
| Bellomo et al. (2012) | Before and after Controlled Trial | Sample<br>Before = 9,617<br>After= 8,688<br>Setting<br><br>Total 349 beds, in 12 general wards involving 10 hospitals in the US, Europe, and Australia | Experimental Group<br>8,688 patients<br>Deployment of automated advisory vital sign monitors<br><br>Control Group<br>9,617 patients normal operating procedure | Chart Review<br>Prevalence of predefined Serious Adverse Events, RRT calls, and Pt outcomes, time to record complete set of vital signs 3 months before intervention and 3 months post intervention | RRT calls: increased calls secondary to abn resps (21% to 31%)CI 9.9[0.1-18.5] p=.029<br>Total calls increased 52% after intervention<br><br>RRT activation and process in care 6.3% increase p=0.04<br>Survival Post RRT, and 90 day<br>86% to 92%<br>CI 6.3[0.0-12.6] p=0.04<br>Decreased Median LOS (unadjusted p=<.0001; adjusted p=.09<br>Time to record complete set of vs<br>Decreased<br>4.1±1.3 mins without to 2.5±0.5 with monitor<br>CI1.6[1.4-1.8]p<.0001 |
| Mitchell et al. (2010) | Prospective controlled before and after intervention | Sample<br>Before 1157<br>After= 985<br><br>Setting<br>2 hospitals in Australia<br>4 medical and surgical wards | Control<br>4 month period normal operating conditions<br><br>Education Phase<br>8 month prep and education new charting, new policy for VS measurement<br><br>Experimental<br>4 month period<br>Measures studied under new operating conditions | # Unplanned admissions to ICU<br><br>Medical Emergency Team reviews and unexpected deaths<br><br>VS documentation and frequency,<br><br>incidence of medical review following clinical deterioration | Unplanned admits to ICU (21/1157[1.8%] vs. 5/985 [.5%] p=0.006<br><br>Unexpected death 11/1157[1.0%] vs. 2/985 [0.2%], p=0.03<br><br>MET review for clinical deterioration<br>58/133[ 43.6%] vs. 55/79 [69.6%]p<.001<br><br>Number of MET review increased 2.2% vs. 3.9% p=.03<br>Frequency of VS increased 3.4 [SE0.22] vs. 4.5 [SE0.17], |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | p=.001 |
| Jones et al., (2011) | Observational study over 85 consecutive days | 1481 consecutive pts between baseline and intervention.<br><br>Baseline= 705pts with 7820 observations<br><br>Alert Phase= 776 pts with 5848 observations<br><br>Total 13,668 observation sets<br><br>Setting<br><br>One university hospital in the UK. | Implementation of Patient Track, (mgt of EWS scores and alerts) | Hospital LOS<br><br>Compliance with EWS protocol,<br><br>Cardiac arrest incidence<br><br>Critical Care utilization<br><br>Hospital mortality | Reduction in LOS between baseline and alert phase (9.7 days vs. 6.9 days, P<0.001)<br><br>EWS accuracy improved from 81% to 100% with electronic calculation of EWS<br><br>Attendance for EWS 3,4,5 increased from 29% to 78% with automated alert (P<0.001)<br><br>Attendance for EWS >5= increased from 67% to 96% with alerts (P<0.001)<br><br>Cardiac arrest and mortality = no statistical significance<br><br>Critical care utilization= P=0.04 |
| Jonsson et al., (2011) | Retrospective and descriptive study | 65 Unplanned ICU admissions from in-patient units<br><br>Setting:<br>Landspitali University Hospital, Reykjavik, Iceland | Retrospective chart review of nursing documentation prior to emergency ICU admission from in-patient units over 3 month period | Unplanned ICU admissions<br><br>Most common diagnosis for ICU admission<br><br>Vital sign parameters with documentation hx | 65 unplanned ICU admissions from medical and surgical wards<br><br>Most common dx Respiratory Failure<br><br>Documentation<br>Respiratory Rate 14% (n=9)<br><br>Temperature 69% (n=45)<br>Oxygen sat 80% (n=52)<br>Heart Rate 85% (n=55)<br>Blood Pressure 88% (n=57) |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Pre ICU admission SpO2 of <90% documented for 20% (n=13)<br><br>Range of Respiratory Rate from 10-40 (mean=30) |
| Wood et al. (2014) | Service improvement project initiated hospital wide to improve compliance with EWS protocol | Six main admission wards of one hospital in the UK.<br>All nursing staff (no hard numbers given)<br><br>Setting:<br><br>Nottingham University Hospital Trust | Implementation of a Service improvement team to increase presence, educate, and give real time feedback to staff of importance of EWS protocol follow through | **5 Target measures**<br><br>1. 75% pts have VS done hourly<br><br>2. EWS correctly scored in over 95% of patients<br><br>3. If frequency of VS needed to be increased, done correctly in 35% of pts<br><br>4. Mandated Nursing escalation interventions complete in at least 35% pts.<br><br>5. Medical escalation complete in at least 35% of pts | 4th Quarter measurement<br><br>Target 1.<br>**96%**<br><br>Target 2<br>93%<br><br>Target 3<br>**50%**<br><br>**Target 4**<br>**57%**<br><br>Target 5<br>37% |
| Stewart et al., (2014) | Mixed methods<br>Before and after<br>Focus groups | Med record review of 3 medical surgical units pre and post MEWS implementation (no specific *n* size given)<br><br>Focus group<br>11 nurses all female<br>6 ADN<br>4 BSN<br>1 MSN | MEWS implementation<br><br>Focus Groups | RRT calls pre and post<br><br>Cardiac Arrests pre and post<br><br>Themes: Focus Groups<br>1. Decision Making<br>2. communication<br>3. Administrative support<br>4. Perceived barriers | Before= 39 RRT calls<br>After 55 RRT calls<br>No statistical significance<br>P=0.288<br><br>Cardiac arrests<br>P=0.878<br><br>Focus Group Themes<br>1. MEWS not a single factor in activating RRT, pt assessment and clinical judgment is important<br>2. MEWS important during |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | physician communication to stress urgency of situation<br>3. Expressed confidence in admin support to call RRT<br>4. Customized preset "normal v/s values" for patients who v/s are always outside of MEWS range, to decrease workload |
| McRee et al., (2014) | Before and After design.<br>Retrospective chart review | Sample<br>6 mos pre and 6 mos post<br>Pre-implementation (n=75)<br>Post-implementation (n=96) | EMR surveillance alert system | Hospital Mortality<br>Length of hospital stay<br>Discharge location | Hospital Mortality<br><br>Survived to d/c<br>Pre = 68 Post =95<br>Died<br>Pre =7 Post = 1<br><br>Discharge location<br>Home Pre=19 Post 47<br>Other Pre=49 Post=48<br>Death Pre=7 Post =1<br><br>LOS<br>Pre 8.5±6<br>Post 8.7 ± 6 |
| LEGEND OF ABBREVIATIONS: RRT= Rapid Response Team; MEWS= Modified Early Warning Score; EWS= Early Warning Score; LOS= Length of Stay; MET= Medical Emergency Team, D/C = discharge, MOS= months | | | | | |

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