Southern California CSU DNP Consortium

California State University, Fullerton
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EARLY WARNING AND RESPONSE SYSTEM: IMPLEMENTATION AND EVALUATION

A DOCTORAL PROJECT

Submitted in Partial Fulfillment of the Requirements

For the degree of

DOCTOR OF NURSING PRACTICE

By

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ABSTRACT

It is estimated that there are over 200,000 in-hospital cardiac arrests each year in the United States. Clinical deterioration in inpatient units often goes undetected, or if detected, it is ignored until a significant event occurs. Literature reports that with early identification and treatment, this deterioration may be prevented, decreasing the need to transfer a patient to the intensive care unit. Early warning systems (EWS) have been shown to identify patients who may experience a negative outcome as early as 20 hours before the event. A review of EWSs is included describing the three phases (early recognition, triggering a response, and appropriate response). The National Early Warning Score 2 is explored in greater detail.

The purpose of this quality improvement project was to develop a guide to assist an organization in implementing an EWS. The guide includes a sample detailed project plan and evidence-based training materials. The overall framework for this project was Donabedian's Model of Structure, Process, and Outcome. The actual implementation plan was based on Royce's system development lifecycle. Important aspects of each of the six steps (requirement gathering, design, build, testing, deployment, and maintenance/evolution) were explored. The proposed process was used to guide the initial phases of an implementation at a 207-bed medical center. It is essential to follow a structured implementation plan when deploying an EWS. By fully understanding the requirements

of a proposed solution, unnecessary time and expense in an aborted implementation can be avoided.

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ACKNOWLEDGMENTS

I want to thank all of the great clinicians that I have worked with over my career, starting with my first clinical nursing instructor, Joy Tecca. Her famous question of "why" has stuck with me and often comes to mind whenever I encounter a new experience. I would not have completed this program without the encouragement and direction from Drs. Penny Weismuller, Manal Alatrash, and Ruby Gill. Also, I would like to thank Martial and Jeremy Besse for their support and understanding of the demands required to complete this program.

BACKGROUND

Cardiac disease was the number one cause of death in 2015, and sudden cardiac death is responsible for 13.5% of all deaths (Benjamin et al., 2018). Using data from the national registry, it is estimated that over 200,000 in-hospital cardiac arrests (IHCA) occur each year in the United States (American Heart Association [AHA], 2018).

Short-term survival rates post-cardiac arrest (CA) have been reported at 25% to 39%, however, only 14% to 26% of those that arrest were discharged from the hospital (AHA, 2016; AHA, 2018; Benjamin et al., 2018; Girotra et al., 2012; McGrath, 1987; Syue, Huang, Cheng, Kung, & Li, 2016). Franklin and Mathew (1995) reported that of those that arrested, only 4.7% return to their baseline functional status. Poor outcomes continue to be an area of concern as data from 2006 to 2012 revealed the rate of return to baseline functional status to be only 9.1% (Fendler et al., 2015). Based on work completed in 2009, researchers also found that 28.1% of survivors were discharged with a clinically significant disability (Girotra et al., 2012).

Starting in the mid-nineties, researchers noted that there were often signs of deterioration (i.e., blood pressure, respiratory, or level of consciousness changes), documented in the medical record prior to an IHCA; however, the staff did not address the decline in status (Franklin & Mathew, 1995; Institute for Healthcare Improvement [IHI], 2017; Morgan, Williams, & Wright, 1997). These abnormal findings may display as early as 20 hours prior to the actual IHCA (Kirkland et al., 2013; Oh, Lee, & Seo, 2016; Zografakis-Sfakianakis et al., 2018). Substantial changes were noticed between five and eight hours before significant adverse events (SAE), then were again observed within two hours before the SAE (Kirkland et al., 2013; Oh et al., 2016; Zografakis-

Sfakianakis et al., 2018). Addressing conditions that could lead to further deterioration should occur as soon as possible since it has been reported that up to 46% of intensive care unit transfers (ICUT) could be avoided by providing interventions earlier (AHA, 2016; McQuillan et al., 1998; van Galen et al., 2016b).

Early warning and response systems (EWRS) were developed to alert clinicians that their patients may have a negative outcome (IHI, 2017; Jensen, Skår, & Tveit, 2019). The Acute Physiology and Chronic Health Evaluation (APACHE) (1979), one of the original scoring systems, was used to determine the severity of illness and predict the intensity of required therapy (Knaus, Zimmerman, Wagner, Draper, & Lawrence, 1981). The APACHE tool was adapted into the Rapid Acute Physiology Score (RAPS) in the late eighties to predict the success of emergency transports (Rhee, Fisher, & Willitis, 1987). Since then, additional EWRS were developed or modified to improve the predictive capability (Churpek et al., 2017; Qin, Xia, & Cao, 2017; Smith, Prytherch, Meredith, Schmidt, & Featherstone, 2013; Yu et al., 2014).

The three components of an EWRS, early detection, timely response, and competent response, were found to improve outcomes (Royal College of Physicians [RCP], 2012). Researchers have revealed that with a specific score derived from an EWRS, staff are more likely to request additional assistance, or activate a rapid response team (RRT) to stop patients' deterioration (IHI, 2017).

This project focused on a Magnet® recognized hospital, part of an integrated managed care consortium, in the Southwestern United States. There is a total of 207 beds, with 132 general medical/surgical (MS) and 20 critical care. The organization has Joint Commission accredited stroke and joint replacement programs; additionally, there are busy obstetric and cardiac catheterization services. No EWRS was in use in inpatient units.

Perman et al. (2016) reported a nationwide IHCA incidence rate of 0.580/1,000 patient days, with 59% occurring in the intensive care unit (ICU). Internal facility data (calendar year 2018) reported an IHCA rate of 0.771/1,000 patient days, and only 46% of these occurred in the ICU. Other baseline data includes 1.79 RRTs/1,000 patient days and 3.68/1,000 patient days unplanned transfers to either the ICU or the stepdown unit.

Purpose Statement

The purpose of this Doctor of Nursing Practice (DNP) project was to plan for and implement an EWRS on MS units and assess its effectiveness in decreasing the mortality rate, the number of IHCAs, and transfers to a higher level of care.

Supporting Framework

Donabedian's Model of Structure, Process, and Outcome (SPO) was used to guide this DNP project. The underlining principle of this model is that there is a one-way linear process that relates the triad of SPO (Donabedian, 2003). Having a solid structure increases the probability of successfully implementing the procedures which are needed to produce quality outcomes (see Figure 1).

Structure

Structure refers to the stable characteristics of an organization, including physical plant, resources to support staff, number, and qualifications of staff (Donabedian, 1966, 1985). There are three critical structural aspects of this project, availability of staff, the design/display of the EWRS, and training approach/requirements for staff.

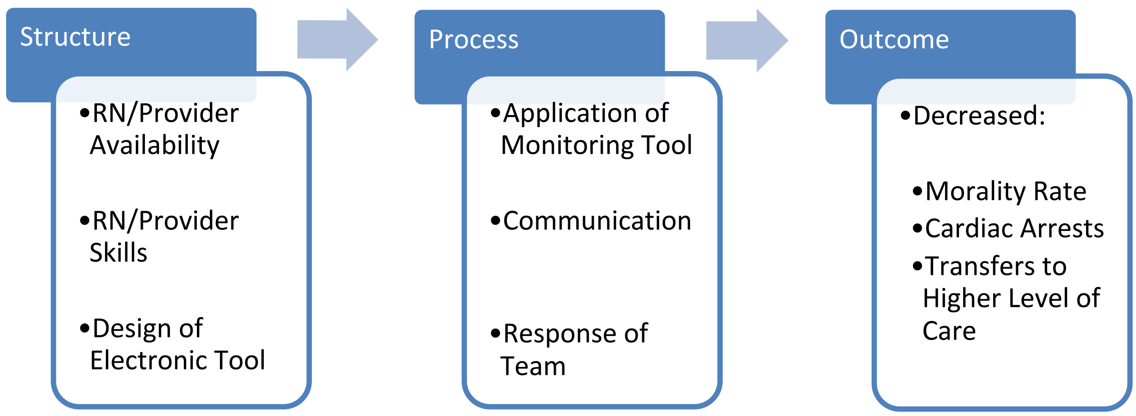


Figure 1. Modified Donabedian's conceptual framework.

Process

Components of the process include the application of the tools needed to deliver care (Donabedian, 1966, 1985, 2003). Stewart, Carman, Spegman, and Sabol (2014) stressed that the processes are complex and should be the main focus for the successful implementation of an EWRS. The core components of this project were focused on developing protocols for the application of the tool, including recognition of conditions, escalation of clinical concerns, and appropriate team response.

After the staff has been trained, the tools will go live. The process measures will be observed for staff compliance and the effectiveness of identifying the appropriateness of ratings. Communication between the nursing and provider staff is a critical component that will be closely monitored, and any opportunities to improve this aspect will be addressed.

Outcome

Outcomes are defined as changes in health status (Donabedian, 1966, 1985, 2003). The following indicators will be monitored to assess the success of this implementation: mortalities, IHCA, and transfers to a higher level of care. These measures and all other current hospital performance matrixes will be assessed for any unexpected impacts.

REVIEW OF LITERATURE

Overview

A literature search for English-language studies on EWRS using One Search was performed. Key words included “early warning systems,” “modified early warning systems,” “national early warning systems,” and “Rothman Index.” The initial search was conducted in 2018 with the date range of 2013 to 2018 and was limited to adult patients. The following topics were excluded, either electronically or manually, due to a large number of possible terms: “emergency,” “obstetrics,” and all disease-specific conditions, such as “sepsis”, “hematology”. A review of the initial references was conducted to identify additional relevant content, for a total of 73 sources of evidence. Topics in this literature search included: tool comparison (complexity, the design of tools, and feasibility), workflows, education/rollout, and outcomes. Abbreviations are summarized in a glossary (Appendix A).

This exhaustive search showed that early warning systems (EWS) have been implemented and studied around the world. Seventeen main tools (including variations) were identified. Modified Early Warning Score (MEWS) was reviewed in 18 studies, followed by the National Early Warning Score (NEWS) with 17 studies and EWS with 10 studies. The other 14 studies were listed between one and three times.

Forty-one studies compared specific tools’ performance, the majority of these studies (n = 32, 78.0%) were related to one system and their variations. Greater than one system was compared in nine studies, and one study compared nine tools, one examined five, and the others were four or fewer.

Additional Review

An interim search was completed in May of 2019 (see Table 1). A final literature review was completed in late 2019, and the last search was confirmatory of the results from the previous searches.

Table 1

Additional Search Strategy

Topic Search Terms	PubMed # Found	CINAHL # Found
Early Warning System	46 ~27 new	60
National Early Warning System	27 ~12 new	71
Modified Early Warning System	14 ~7 new	26
Rothman Index	3 ~1 new	9
Academic Detailing	20 3 potential (Included nursing, excluded home and physician)	9 1 potential (Included quality improvement)
Adult Learning Theory	204 4 potential	33 3 potential
Early Warning System Nurse Training	8 1 new	32 4 new

Early Warning Systems

History

The IHI (2017) reported that 40% of staff knew something was not right before an SAE. Early warning systems helped identify these issues with objective data that supported staff escalating their concern, providing interventions to prevent further deterioration, and avoiding the transfer to the ICU (Hart, Spiva, Dolly, Lang-Coleman, & Prince-Williams, 2016). Early identification and treatment may prevent further deterioration, decrease the need for ICUT, and reduce the number of in-hospital deaths

(Boniatti et al., 2014; Gagne & Fetzer, 2018; Mapp, Davis, & Krowchuck, 2013). Tillmann et al. (2018) reported that without early activation, greater than 60 minutes before an event, the probability of being transferred to the ICU is 22% more likely, and there is a 30% increase in the likelihood of death.

Vital signs are a better predictor for hospital deaths, while labs are a better predictor of 30-day post-discharge death (Kellett & Murray, 2016). Within four hours of an SAE, 60% of patients experienced abnormal vital signs (VS), but of all patients, only 13.4% were severely abnormal (Andersen et al., 2016). A review of a single trigger tool reported that the majority (59%) of identification of cases is related to their systolic blood pressure (SBP), followed by heart rate (HR) (27%), and respiratory rate (RR) (14%) (Smith & Aitken, 2016). A review of a multi-trigger system reported that hypotension was the trigger in 55% of patients, and the RR was a significant indicator triggering an alert in 42% of patients; findings related to HR were not reported (So, Ong, Wong, Chung, & Graham, 2015).

It has also been shown that an increase in the frequency of VS and additional comments documented in a chart predicts an increase in the likelihood of experiencing an SAE (Collins et al., 2013). Increasing the VS measurement to every five minutes was shown to increase the number of RRTs and decrease IHM in medical patients, there were no statistically significant (SS) differences noted in surgical patients (Evans et al., 2015). Just taking more frequent vitals may increase early identification of potential issues (Ludikhuize et al., 2013). There were no significant changes noted when VS were assessed every eight or 12 hours (Petersen, Antonsen, & Rasmussen, 2016).

It is important to follow policies regarding VS; Cardona-Morrell et al. (2016) reported that only 6–21% of patients had all five required VS, and only 89% had the VS at the correct times. An additional study reported that 40–50% of all necessary VS/documentation were missing (Odell, 2015; van Galen et al., 2016b). Another issue was when VS were taken by assistive personnel; the registered nurse (RN) staff may not be validating them or even aware of the results (Watson, Skipper, Steury, Walsh, & Levin, 2014).

Performance

The results of the EWS performance have been mixed. An early study showed that 36% of 33 different studies were reasonably successful at predicting survivors during a hospital stay (Smith, Prytherch, Schmidt, & Featherstone, 2008). Alam et al. (2014) reported that there was a positive trend in improving survival, but not decreasing the number of SAEs. In one systematic review of 13 EWS studies, eight had a substantial predictive value; however, one controlled study showed no difference in IHM, ICUTs, or length of stay (LOS) (Smith et al., 2014). Elevated scores have been an indicator of who should be moved to a higher level of care (Hart et al., 2016).

A MEWS system deployed in an emergency department did not significantly enhance performance; however, it may be of value for novice nurses (So et al., 2015). Stewart et al. (2014) did not show a SS change in CAs or the number of RRTs in an inpatient setting. Another study reported no difference in outcomes; however, they reported poor compliance of staff in following the appropriate protocols (Bedoya et al., 2018).

Dummett et al. (2016) reported an 11% decrease in ICUTs and a nine percent decrease in IHMs after the implementation of an EWS. While Parrish, Hravnak, Dudjak, and Guttendorf (2017) reported a 2.5% decrease in CA and no change in the post-arrest survival rate after their MEWS implementation.

The literature indicated that those individuals with a medium score (4–6) were three to four times more likely to die, and if they had a higher score (≥ 7), they were 10 times more likely (Roberts & Djärv, 2017; Spångfors, Bunkenborg, Molt, & Samuelsson, 2019). Similar results were reported by Spagnolli et al. (2017), where patients with scores > 4 were three times more likely to expire and twice as likely to be transferred to the ICU; for every point increase on the NEWS scale the odds ratio (OR) increased by 1.3.

Some studies investigated the appropriateness of alerts, which is another important performance factor. In a survey of 405 alerts, 74% were classified as accurate, with 43% of an urgent nature, and the remaining 57% were less urgent (Borgert, Goossens, Adams, Binnekade, & Dongelmans, 2015). In one survey of 232 clinicians, it was noted that while most triggers were for stable patients, almost half resulted in a change in the care of the patient; close to 40% of providers and 50% of nurses felt the alarm provided new information, and 54% of providers and 65% of nurses thought that the timing was appropriate (Guidi et al., 2015).

Tools—Design Principles

There are three aspects of an EWS, the first is monitoring the score, second is a triggering a response, known as the afferent arm, and third the efferent arm or the actual response (Petersen, Rasmussen, & Rydahl-Hansen, 2017; RCP, 2012). The tools were designed to pick up on subtle changes that may go unnoticed by staff, including borderline VS changes, mentation, oxygen requirements (Braaten, 2015). In a study of 17 tools, the number of assessed measurements ranged from four to 16, with eight tools (47%) having seven measures (Smith et al., 2014). The typical measurements include respiratory rate (RR), heart rate (HR), blood pressure (primarily systolic blood pressure [SBP], however, some use diastolic [DBP]), level of consciousness, temperature, and oxygenation (Pedersen et al., 2018; Smith et al., 2014). Oh et al. (2016) found no difference in the predictive value of the SBP and DBP. Other measures included lab results, cardiac rhythm, nursing system assessments, nursing intuition/worry, age, and urinary output (Boniatti et al., 2014; Nishijima et al., 2016; Pedersen et al., 2018; Smith et al., 2014; Wengerter, Pei, Asuzu, & Davis, 2018). Not all of the tools scored the parameters similarly, i.e., lower/higher ranges, or a higher rating for any abnormal level of consciousness versus a progressively higher score based on different responses (Boniatti et al., 2014; Braaten, 2015; Douw, Huisman-de Waal, van Zanten, van der Hoeven, & Schoonhoven, 2017; Kolic, Crane, Mccartney, Perkins, & Taylor, 2015; Nishijima et al., 2016; Pedersen et al., 2018; RCP, 2012; van Galen, Dijkstra, Ludikhuize, Kramer, & Nanayakkara, 2016a).

The Dutch-Early-Nurse-Worry-Indicator-Score (DENWIS), created after a review of 18 studies, is a subjective tool that reviews 37 different signs and symptoms combined into 10 indicators; when combining DENWIS with other tools, the predictive value was increased (Douw et al., 2015; Douw et al., 2017). One study by Rojas et al. (2017) reported the median clinical intuition was more accurate at predicting ICU readmissions than MEWS; the area under the curve for all clinicians was 0.71, and MEWS was 0.62.

Fellows' results were 0.72, nurses 0.69, attendings 0.63, and house staff was equal to the MEWS.

Other tools have included additional measures or design features. The Rothman Index (RI) uses 26 measures, including nursing assessments (Wengerter et al., 2018). One tool, the Advanced Alert Monitor (AAM), also included the *COmorbidity* Point score and a combined lab calculation (Dummett et al., 2016). Some tools looked at trends while others looked at individual scores; research reported that trended information had fewer false alarms and was more predictive of SAEs (Churpek, Adhikari, & Edelson, 2016).

National Early Warning Score/National Early Warning Score 2

Specifics

The National Early Warning Score Development and Implementation Group (NEWSDIG), a working group of the RCP, was formed in 2009 with the goal of a standardize EWS, the NEWS was released in 2012 (Jones, 2012). The NEWSDIG's goal was to identify patients who may be at risk and augment their care on the general care unit to avoid a transfer to the ICU.

The NEWS2 (Figure 2) was released in 2017, and this revision included a second oxygen saturation scale to help increase the sensitivity for hypercapnic respiratory failure (Pimentel et al., 2019; RCP, 2017). Along with the original baseline for oxygen saturation ≥ 96%, a new scale ≥ 93% when on air or if on oxygen 88% to 92%, was created (RCP, 2012; RCP, 2017). The authors stressed that NEWS2 is a supplemental tool and not a substitute for competent clinicians (Grant, 2019; RCP, 2017).

The RCP (2017) encouraged the use of this non-copyrighted tool; however, the tool may not be changed, including the display of the measurements in the EHR or on paper versions. One study compared the recommended NEWS with two variations 1) NEWS without temperature, and 2) NEWS without temperature and SBP; it was reported that the results were similar (Luís & Nunes, 2017). The authors suggested that if the temperature is not a required item, compliance may increase.

Physiological parameter	Score						
	3	2	1	0	1	2	3
Respiration rate (per minute)	≤8		9–11	12–20		21–24	≥25
SpO_2 Scale 1 (%)	≤91	92–93	94–95	≥96			
SpO_2 Scale 2 (%)	≤83	84–85	86–87	88–92 ≥93 on air	93–94 on oxygen	95–96 on oxygen	≥97 on oxygen
Air or oxygen?		Oxygen		Air			
Systolic blood pressure (mmHg)	≤90	91–100	101–110	111–219			≥220
Pulse (per minute)	≤40		41–50	51–90	91–110	111–130	≥131
Consciousness				Alert			CVPU
Temperature (°C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	

Figure 2. National Early Warning Score 2.

Reproduced from: Royal College of Physicians. *National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*. Updated report of a working party. London: RCP, 2017.

Hodgson, Congleton, Venn, Forni, and Roderick (2018) examined NEWS2 scores from 62 expirations and found that 44% of the patients were classified as low risk (≤ 4). Using the original NEWS tool, these patients were classified as high risk (≥ 7). The authors go onto suggest that additional validation is needed prior to the widespread use of the new tool, since too many situations would not be reported, and this would result in unnecessary deaths. An additional study with over 250,000 admissions, NEWS2 showed less sensitivity in identifying IHM, and the authors suggested that additional research should be completed before the widespread use of the new version (Pimentel et al., 2019).

Threshold and Response

Each tool has specific definitions for different thresholds and appropriate responses. These responses include frequency of monitoring, escalating within unit, protocols for notifying providers, and alerting the emergency response team (Boniatti, 2014; Braaten, 2015; Hart et al., 2016; Niegsch, Fabritius, & Anhøj, 2013; van Galen et al., 2016a). The NEWS2 scores are classified into four risks (low [0-4], low-medium [any single measure at the high end of assessment scale], medium [5-6], and high [7 or more]) (Figure 3) (RCP, 2017).

NEW score	Clinical risk	Response
Aggregate score 0–4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low–medium	Urgent ward-based response*
Aggregate score 5–6	Medium	Key threshold for urgent response*
Aggregate score 7 or more	High	Urgent or emergency response**

* Response by a clinician or team with competence in the assessment and treatment of acutely ill patients and in recognising when the escalation of care to a critical care team is appropriate.
**The response team must also include staff with critical care skills, including airway management.

Figure 3. National Early Warning Score thresholds and triggers.

Reproduced from: Royal College of Physicians. *National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS***.** Updated report of a working party. London: RCP, 2017.

The following lists the RCP (2017) clinical responses and are summarized in Figure 4. Scores of zero require a minimum of 12-hour monitoring. Any score above zero requires an RN assessment. Scores of one to four the patient should be monitored at least every four to six hours. The medical team should be notified when a patient has a rating of five or more (classified as urgent) or a single parameter at the top score; the monitoring should occur at a minimum of every hour. Clinicians with critical care skills should evaluate patients with a score of seven or more.

Early EWS were often paper-based, with the spread of EHRs and the addition of the EWS in the EHR, it was noticed that automated systems identified potential SAEs over ten hours earlier, 15.9 hours as compared to 5.7 hours when documented on paper (Alvarez et al., 2013; Pedersen et al., 2018). Even with this earlier identification, Romero-Brufau et al. (2014) suggested that additional work is done prior to actually automatically triggering an RRT; the clinical interpretation of the results by staff is needed to prevent false alarms.

Education

Mandatory training with an interdisciplinary approach will help ensure consistent application (Bedoya et al., 2018; Connell et al., 2016; McGaughey, O'Halloran, Porter, & Blackwood, 2017; RCP, 2017; Saab et al., 2017). A systematic review of 23 studies reported that the average training was eight hours, and 87% of the programs included simulations (Connell et al., 2016). Even with training, Niegsch et al. (2013) reported that 58% of all cases were observed and managed correctly, with only 77% of all MEWS elements included, and 68% had incorrect escalations. A robust training program is essential to improve compliance.

Each of the three phases, monitoring/detection, escalation, and appropriate response, of an EWS, need to be covered in the education plan for rollout. Information provided in training should include basic assessment skills, appropriate triggers, and a recommended response for each trigger level (Hart et al., 2016). Communication is key to successful implementation with the goal that everyone speaks the same language in a non-judgmental way; with consistent training, there should be a decrease in monitoring and response variability resulting in higher quality (Dummett, 2019; Hart et al., 2016).

NEW score	Frequency of monitoring	Clinical response
0	Minimum 12 hourly	• Continue routine NEWS monitoring
Total 1–4	Minimum 4–6 hourly	• Inform registered nurse, who must assess the patient • Registered nurse decides whether increased frequency of monitoring and/or escalation of care is required
3 in single parameter	Minimum 1 hourly	• Registered nurse to inform medical team caring for the patient, who will review and decide whether escalation of care is necessary
Total 5 or more Urgent response threshold	Minimum 1 hourly	• Registered nurse to immediately inform the medical team caring for the patient • Registered nurse to request urgent assessment by a clinician or team with core competencies in the care of acutely ill patients • Provide clinical care in an environment with monitoring facilities
Total 7 or more Emergency response threshold	Continuous monitoring of vital signs	• Registered nurse to immediately inform the medical team caring for the patient – this should be at least at specialist registrar level • Emergency assessment by a team with critical care competencies, including practitioner(s) with advanced airway management skills • Consider transfer of care to a level 2 or 3 clinical care facility, ie higher-dependency unit or ICU • Clinical care in an environment with monitoring facilities

Figure 4. Clinical Response to NEWS trigger thresholds.

Reproduced from: Royal College of Physicians. *National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*. Updated report of a working party. London: RCP, 2017.

Upon evaluation of a guided clinical reasoning training program, short-term improvements in the quality of documentation were discovered; these gains were present at the one-year mark, however by the fifth year, the performance was lower when compared to the results after the initial rollout (Bruylands, Paans, Hediger, & Müller-Staub, 2013). There was no difference in the accuracy of documentation; the authors acknowledged that the performance might have decreased because of many factors, staff turnover, changes in the organization's priorities, and less focus on critical thinking (Bruylands et al., 2013). These findings suggest the need for frequent reinforcement of the need for critical thinking skills, correct documentation reinforcement, and ongoing assessment for any potential barriers.

Provider

Provider issues included lack of engagement and a decreased response to calls by staff (Dalton, Harrison, Malin, & Leavey, 2018; Downey, Tahir, Randell, Brown, & Jayne, 2017; Fox & Elliott, 2015; Mathukia, Fan, Vadyak, Biege, & Krishnamurthy, 2015; Petersen, Mackel, Antonsen, & Rasmussen, 2014). McGaughey, O'Halloran, Porter, and Blackwood (2017) reported that the provider/nurse hierarchy might contribute to a negative culture. Cherry and Jones (2015) reported that providers tend to dismiss concerns from less senior staff.

Nursing

Several themes were identified as roadblocks or opportunities for improvement related to nursing. Of particular concern is the number of studies that report that staff ignores the alerts (Fletcher, Aaronson, White, & Julka, 2018; Jensen, Skår, & Tveit, 2018; Mathukia et al., 2015; Petersen, Mackel et al., 2014; Zografakis-Sfakianakis et al., 2018).

Staff reported negative interactions with the RRT, including feelings of being intimidated, talked down to, and need to convince the team to come to evaluate the patient, resulting in fewer calls for assistance (Petersen et al., 2017). These barriers resulted in fewer opportunities for more experienced staff to share learnings with the less experienced team members (Gagne & Fetzer, 2018).

Communication was one of the most identified issues (Burns et al., 2018; Mushta, Rush, & Andersen, 2018; Cherry & Jones, 2015; Stafseth, Grønbeck, Lien, Randen, & Lerdal, 2016). A standardized situation-background-assessment-recommendation (SBAR) approach should be encouraged (Burger, Jordan, & Kyriacos, 2017). Other limiting factors of successful implementation include acuity, workload, and appropriate skill mix (McGaughey et al., 2017; Petersen et al., 2017; Smith & Aitken, 2016). Experienced staff with strong assessment skills, including knowing if abnormal values are typical for a particular patient, are imperative (Chua et al., 2019; Massey, Chaboyer, & Anderson, 2017).

Additional Considerations

Proactive rounds on floor patients conducted by a dedicated team of experienced RNs are a best practice, ICUT without these preventive steps was 1.4 more likely to occur; the RRT rate increased by 40% which added to the staff's workload (Danesh et al., 2019). Proactive rounding will add additional costs as well but could be recouped if ICU admissions are prevented (Gagne & Fetzer, 2018). One hospital reported that there were 300 unplanned admissions to their ICU and upon review, it was estimated that 167 (59%) could have been prevented; by avoiding just one ICU day for each of these patients would result in almost $400,000 cost avoidance (Heasley & Pollner, 2019).

However, Escobar and Dellinger (2016) reported that with earlier recognition, ICU utilization might increase, requiring additional nursing staff and increase operational costs. Other costs related to staff expenses need to be taken into consideration as triggers are defined; one study showed that by lowering a trigger score from five to either a three or four would increase the workload for providers by 40% (Jarvis et al., 2015).

Critical concepts in developing an EWS is to ensure that the medical and nursing staff have input into the design and implementation of the program and leadership is supportive (Escobar et al., 2016; Dummett et al., 2016). As leadership plans for rolling out this project, proposals should include consistent 24-hour coverage; it was reported that deterioration during weekends and nighttime hours have a less than optimal response and poorer outcomes (Kolic et al., 2015; Odell, 2015).

The large number of available EWSs may lead to confusion for staff who work in more than one facility; therefore, it is recommended that hospitals use the same scoring system (“Hospitals Urged,” 2018). Using the same tool will ensure that patients receive the appropriate care when staff are well versed in consistent triggers and expected responses.

Summary

There is mixed evidence that an EWS decreases unexpected death by early identification and treatment of potential SAEs. There are studies with impressive results, and there are also many studies that identify issues that prevent success. With careful development, training, implementation, and support, EWRSs are a possible addition to patient care that may improve health outcomes.

METHODS

The purpose of this DNP project was to plan for and implement an EWRS on MS units and assess its effectiveness in decreasing the mortality rate, the number of IHCA, and transfers to a higher level of care. This section will describe the setting, design, training, implementation, and ongoing monitoring for this project.

Setting

The setting for this DNP project was a 207-bed Magnet®-recognized Southwestern U.S. hospital, which is part of an integrated managed care consortium. There were 20 dedicated critical care beds, five 24 bed MS units, and one 12 bed flex unit. There were 75 RNs in the critical care area and 289 in the MS units. Seventy-six percent of the nurses had a minimum of a bachelor's degree in nursing. There was an informatics workgroup that includes six MS and critical care staff RNs who will be used as superusers and peer-to-peer coaches during the implementation of this project.

Sample

The focus of this project was the six non-critical care units. The tool will be applied to all adult non-obstetric patients in these units.

Measures

Outcome measures for this project include 1) IHMs, 2) IHCAs, and 3) transfers to a higher level of care.

Project Procedure

The project was guided by Donabedian's Structure, Process, and Outcome model. Working with the nurses, providers, and the build team, appropriate tools for communication of patients' scores was designed along with the recommended response workflows. Upon completion of the design and build, prior to implementation, the superusers will be oriented to the final procedures, the charge nurses will be the next targeted audience, staff on the units will then be introduced to the tool via shift change huddles, electronic huddle communication, including both video and written content, and after the tool is implemented peer-to-peer coaching will be conducted with the subject matter experts. New staff will receive information in their onboarding process, and the content will be covered in the annual staff education review.

A main focus of this project will be the process components. It is imperative that staff are monitoring patients per policy and documenting their assessments in an accurate and timely manner. Other factors include the appropriate application of the tool, communication with other team members, and their response. This information will be obtained by working closely with the superusers, unit leaders, and the staff.

Ethical Issues

Human subject review was not necessary since there were no humans involved in this initial project planning.

Analysis and Evaluation Plan

Data will be analyzed using Statistical Package Social Sciences (SPSS) version 24. Paired *t*-tests (*t*-statistic and *p*-value) will be used to evaluate the pre- and post-implementation rates. These metrics will be assessed on a monthly basis and reported either monthly or quarterly to hospital leadership, including administration, nursing, physicians, and quality. For this project, the post-implementation evaluation will occur three months after the go-live.

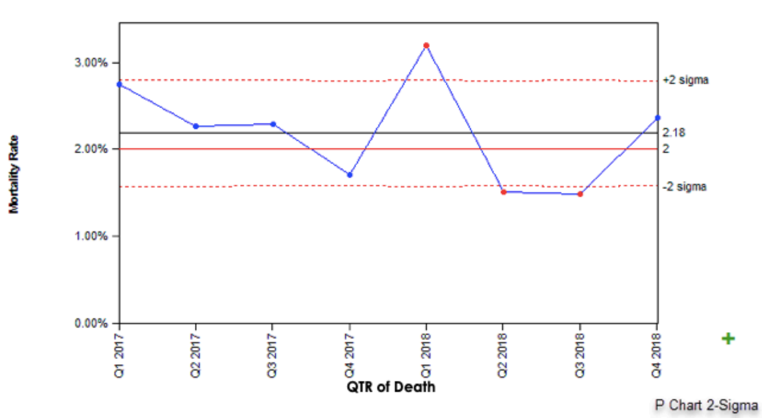
The organization uses Statit software to monitor quality improvement activities. Current metrics related to this project include the rate of IHM/inpatient discharge, the rate of IHCA/inpatient discharge, and the percent of RRTs that remain on the unit. The information is displayed in P-Charts (see figures 5 to 7). Shewhart rules will be used to monitor outcomes. The dark centerline is the mean score during the reporting period. The upper and lower control limits are set at two sigmas (standard deviations). Any data points outside of these limits signify that there may be something other than random variation affecting the performance. Baseline rates from 2018 include IHM/inpatient discharge 2.13 or 2.13% of patients expired during the hospital stay (see figure 5), IHCA/inpatient discharge 0.33 or the number of cardiac arrests (excluding patients with "Do Not Resuscitation" orders based on inpatient discharges (see figure 6), and 42.4% of the RRTs were not transferred to a highlighter level of care (see figure 7).

Metric 1. Rate of IHM/Inpatient Discharge (2018 Rate = 2.13)

Numerator = Total Expirations

Denominator = Number of Inpatient Discharges

IHM/Inpatient Discharge



*The red line is the existing goal of 2.0

Figure 5. IHM/inpatient discharge.

Metric 2. IHCA/Inpatient Discharge (2018 Rate = 0.33)

Numerator = Total Number of IHCAs

Denominator = Number of Inpatient Discharges

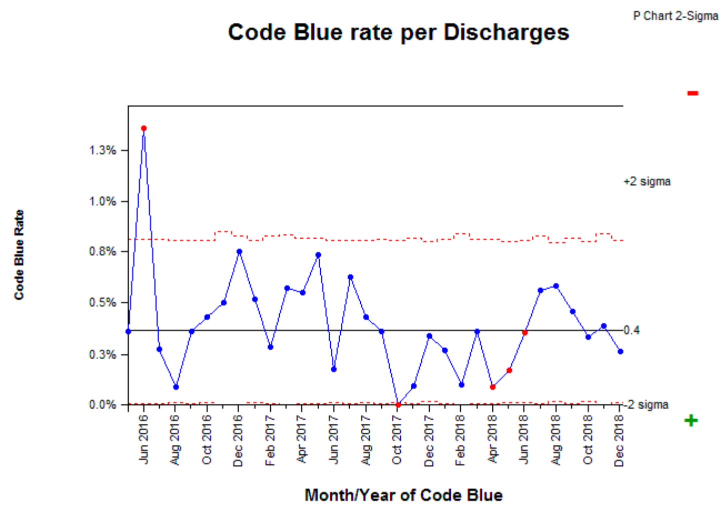


Figure 6. Code blue rate per discharges.

Metric 3. Rate RRT without ICUT (2018 Rate = 42.4%)

Numerator = Number of RRTs without a Transfer to a Higher Level of Care

Denominator = Total Number of RRTs

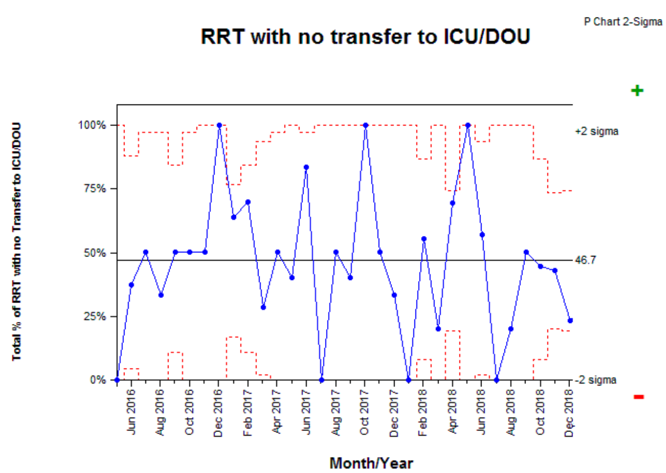


Figure 7. RRT with no transfers to ICU/DOU.

IMPLEMENTATION PLAN

A modified version of Royce's (1987) system development lifecycle, also known as the waterfall model, was used to create this plan (Figure 8). His original work was limited to five steps: requirements, design, implementation, verification, and maintenance. Since the initial version, there have been a variety of versions combining or breaking out different stages. The steps are defined in the following sections.

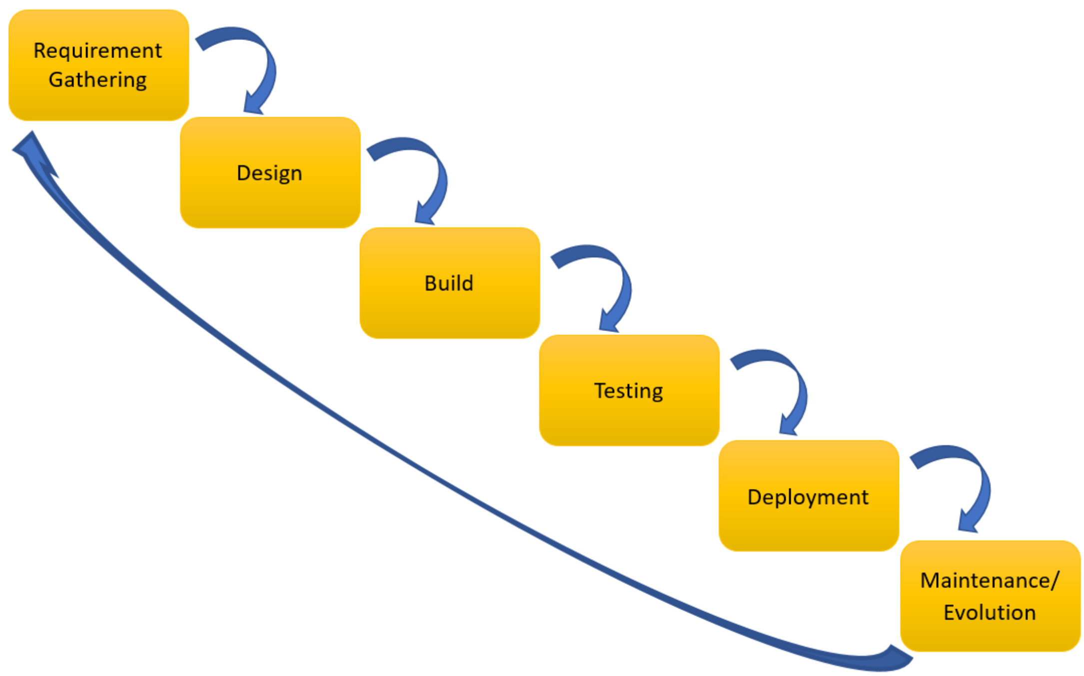


Figure 8. Modified Royce's system development lifecycle.

Requirement Gathering

After the leadership team approves the project concept, the initial step of software projects includes gathering requirements. What is the overall goal? What are the specific needs of the business owners and the organization? Are there resources available to execute this project?

A project plan needs to be created to ensure the project stays on track (see Figure 9). The project team then develops a more detailed plan, including each individuals' responsibility.

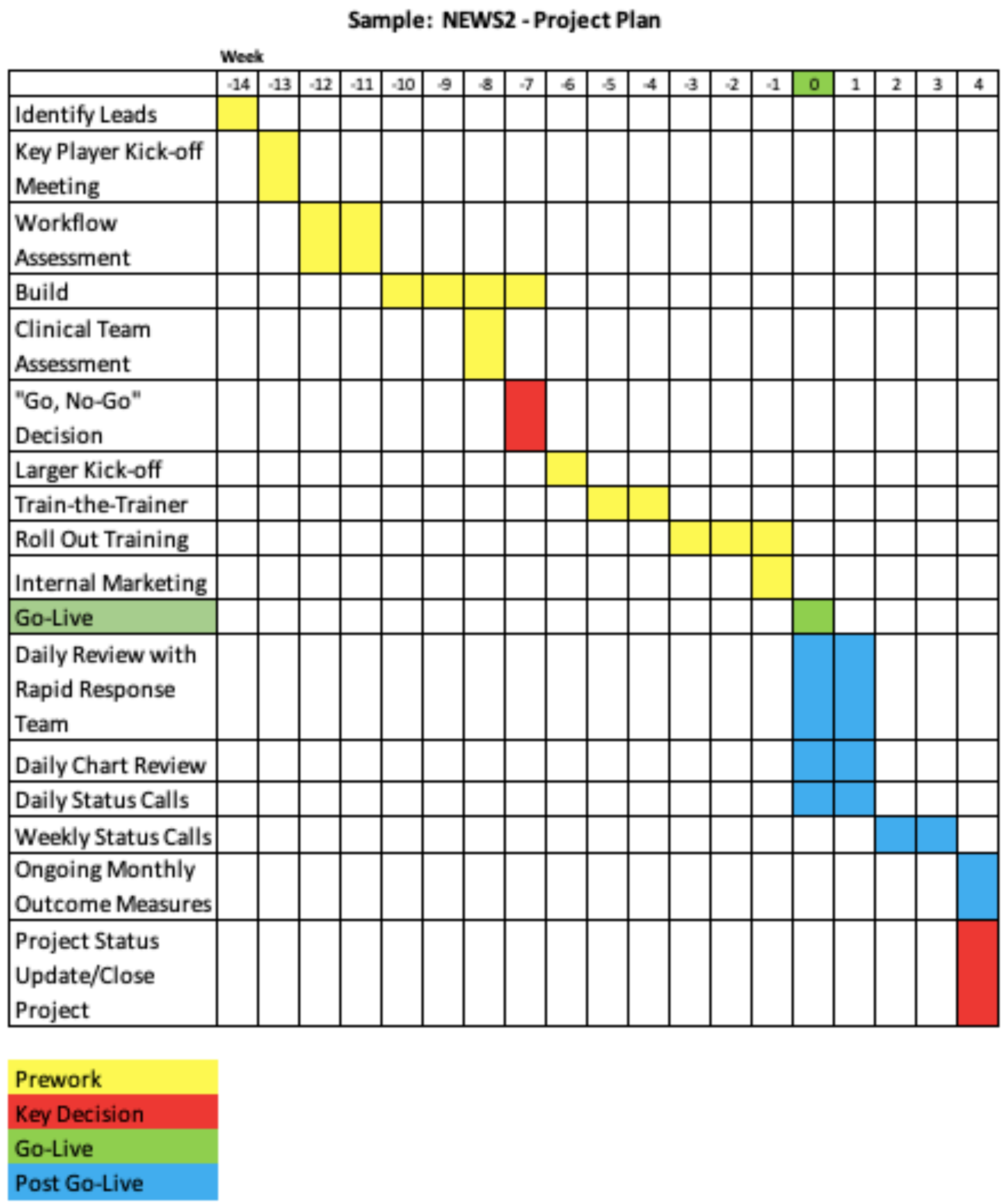


Figure 9. Sample project plan.

Design

After the requirements are assessed, the team reviews available tools. If tools are available (i.e., NEWS, NEWS2, Rothman Index, etc.), do they meet the proposed needs? Are the tools proprietary? Is funding available? One of the most important aspects of selecting a tool is identifying an instrument with high sensitivity (Epic, 2016), ensuring that true positives are not missed in the screening.

Once a solution is recommended, the specific workflows should be evaluated (see Figure 10), and the system designed to meet the particular needs. Critical decisions include the timeframe for creating a new score (i.e., every hour, every six hours, etc.)? How will information be displayed? Will the information be pushed to the end-users (i.e., sent to a phone, pager, presented as an alert in the EHR, etc.)? Will users need to retrieve information from a patient list or some report manually? Additional decision points include documentation standards and reporting needs. After the workflows have been finalized, they should be documented in a policy or procedure (Epic, 2016).

A key component of designing an application is to receive feedback from the end-users (Dummett, 2019). Often EHR tools are referred to as "working as designed," however, if the right people are not at the table, the design can be flawed and not meet the needs of the organization (Dummett, 2019).

Response

One crucial decision is who will be responding to the alerts. Many organizations have RRTs in place. A key consideration is the staffing model of this team. The response could be either an individual with other responsibilities (i.e., ICU staff or charge nurse) or dedicated staff without other responsibilities, known as an out-of-staff model.

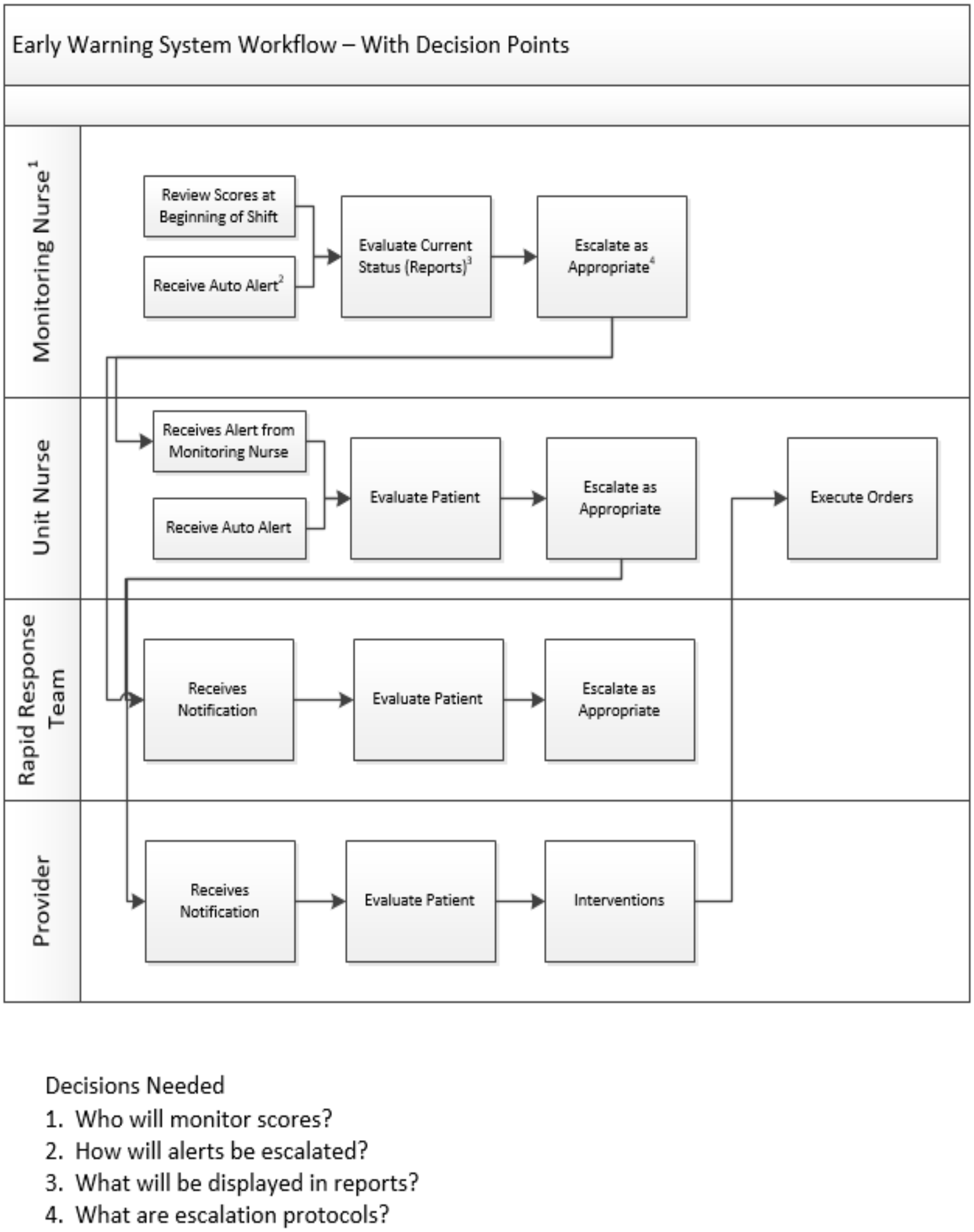


Figure 10. Sample early warning system workflow—with decision points.

There are many advantages to out-of-staff models. The team would be free to make pro-active rounds and act as a resource to the floors. Danesh et al. (2019) reported that these preventive steps decrease ICUTs. The team could be available to follow up on post-RRT calls within two hours of the initial event. A more significant presence on the floors could lead to stronger relationships and additional learning opportunities for staff.

Full-time RRTs will add staff costs, including an additional 4.5 full-time equivalents, 1.4 for each shift with a time off replacement factor of 0.3. Some of the costs could be recouped if there are decreases in ICU admissions (Gagne & Fetzer, 2018). However, Escobar and Dellinger (2016) reported that with earlier recognition, ICU utilization might increase requiring, additional nursing staff and increase operational costs. Other benefits not quantified in this discussion may include the missed work that would be completed by a minimum of five employees (hospitalist, two RNs, one respiratory therapist, and one pharmacist) for an estimated one hour each for each cardiac arrest. Roll-out plans should include consistent 24-hour coverage since researchers have found patients who arrest in the middle of the night have poorer outcomes secondary to a longer time to identify and treat their deterioration (Kolic et al., 2015; Odell, 2015; Syue et al., 2016).

Standard work agreements should be developed for all provider service lines (Dummett, 2019). These agreements will detail expectations of when verbal consults are appropriate or when an in-room visit needs to occur, along with structured documentation, which has been shown to improve communication, regarding the assessment and plan (Dummett, 2019). Dummett (2019) recommended a revised subjective-objective-assessment-plan (SOAP) format assessment-plan-subjective-objective (APSO). The pertinent information is at the top of the note, along with two plans, one for the most likely course and a backup plan.

The design phase of the cycle is estimated to take approximately four weeks. In this sample plan, these activities should be started 14 weeks before the projected go-live.

Build

A build plan needs to be created and approved. The build team will then complete the appropriate coding. Ideally, a clinical person will be available as a resource for nursing/medical questions. Frequent contact with clinicians will help ensure that the design and build meet the needs of the clinical team (Dummett, 2019; Fulop & Ramsay, 2019). A project manager or lead should be identified to monitor progress and provide additional resources if needed to make the deadlines.

Testing

Once the build is completed, the functionality should be tested by the technical team. It is imperative that there is a solid build, and the build supports the original intention; without this critical step, the product may fail (Karabašević, Maksimović, Stanujkić, Jocić, & Rajčević, 2018). If the build team needs to make changes to correct errors, they may unintentionally break other aspects of the build (Karabašević et al., 2018). These functionality tasks are completed by running test scripts. The scripts need to test the accuracy of the different components of the build (i.e., calculations, display, notification, and reports) see Figure 11.

Upon completion of the testing by the technical team, user acceptance testing should be completed by the end-users. All of the build issues need to be addressed before making the tools available for the entire hospital; if problems are discovered after go-live, the acceptance by the clinical team may be compromised (Karabašević et al., 2018).

Sample: NEWS2 Test Script (Scale 1)

Step	Action		Pass/Fail
	Patient: News2, Test		
	VS Flowsheet (Enter 12 Hours Earlier)	**Enter**	
1	Temp	98.7 f	
2	Pulse	88	
3	BP	120 80	
4	Resp	14	
5	O2 (LPM)	0	
6	SpO2 98	98	
	Shift Flowsheet (Enter 12 Hours Earlier)		
	Neuro Assessment Group		
7	Consciousness Level	Awake, Alert	
	Go to Patient List		
8	Add Patient List Column "NEWS"		
9	Add Patient List Column "NEWS Delta"		
10	Add Patient to List		
11	NEWS Score Displays 0		
	VS Flowsheet (Enter 6 Hours Earlier)		
12	Temp	98.7 f	
13	Pulse	88	
14	BP	120 80	
15	Resp	10	
16	O2 (LPM)	2	
17	SpO2 98	98	
	Shift Flowsheet (Enter 6 Hours Earlier)		
	Neuro Assessment Group		
18	Consciousness Level	Stuporous	
	Go to Patient List		
19	BPA fires "NEWS2 = 6, +6"		
20	"NEWS" Displays "6"		
21	"NEWS Delta" Displays "+6"		
	Page		
22	Pager displays "News2, Test, room 828 NEWS 6, +6"		
	VS Flowsheet (Enter 3 Hours Earlier)		
23	Temp	100.4 f	
24	Pulse	100	
25	BP	106 72	
26	Resp	28	
27	O2 (LPM)	6	
28	SpO2 98	96	
	Shift Flowsheet (Enter 3 Hours Earlier)		
	Neuro Assessment Group		
26	Consciousness Level	Obtunded	
	Go to Patient List		
27	BPA fires "NEWS2 = 10, +4"		
28	"NEWS" Displays "10"		
29	"NEWS Delta" Displays "+4"		
	Page		
30	Pager displays "News2, Test, room 828 NEWS 10, +4"		
	Open Patient List Report "NEWS2"		
31	Graph Displays Scores of "0, 6, 10"		

Figure 11. Sample: NEWS2 test script.

Deployment

Part of the deployment phase is providing training for all end users. After a predetermined completion rate (i.e., 80% of staff trained), the tools should be implemented.

Education Planning

A comprehensive training plan needs to be developed, including method of delivery, content (history, tool, response, team member communication, interaction skills with patient/family, and outcome monitoring), and length of training (see Table 2). The ADDIE model (analysis of content, design, development, implementation, and evaluation) was used to design this proposed education plan (Allen, 2006). The curriculum design could be done concurrently with the build phase, as long as there are no expected changes to the build.

There are three different groups that need to be trained (charge nurses/RRT nurses/charge respiratory therapists, floor staff nurses, and hospitalists). Each group will have different needs and, therefore will have job-specific training content. A standard message through all training should be that we "treat the patient, not the score" (Epic, 2016). A sample training program for the charge nurses and RRT team is found in Appendix B. One consideration for training is if continuing education credits will be provided.

Live in-person train-the-trainer sessions, done by a project expert/trainer, should be conducted for the RRT, charge nurses, respiratory therapists, and physician leads. Interdisciplinary approaches have been shown to increase successful implementations of EWSs (Merriel et al., 2016). It is recommended that these live sessions include case studies for student engagement and opportunities to assess student comprehension (Kennedy, 2017; Li, Ye, & Chen, 2019).

Table 2

Education Plan

Specialty	Timing	Method	Duration
-RRT Nurses -Charge Nurses -Charge Respiratory Therapists -Physician Leads	5 weeks out	Classroom	2 hours
-Floor Nurses -Respiratory Therapist	3 weeks out	Staff Meeting Daily Huddles e-Huddles e-Modules Peer-to-Peer Conversations	45 minutes
Hospitalists	3 weeks out	Lunch and Learns	30 minutes

Clinical simulations in a lab have been shown as a valuable training option (Cooper et al., 2017; Lee et al., 2019; Liaw et al., 2017). Providing a variety of learning opportunities allow staff to choose which method is most appropriate for their preferred mode of learning and has been shown to give a better mastery of knowledge and skills (Chaghari, Saffari, Ebadi, & Ameryoun, 2017). Based on the sample plan, these live sessions should occur between four and five weeks before the go-live.

Training hours are a significant budgeting concern, other possible training methods for the majority of the floor staff may include daily huddles, e-huddles, in-person staff meetings, video sessions, at-the-elbow peer-to-peer sessions, lunch and learns (Epic, 2016). Just-in-time training starts three weeks before the implementation. It is also recommended that there is an annual review for staff (Epic, 2016).

Peer coaching/learning is an effective method of initial training, ongoing reinforcement of learnings, and improving teamwork (Badowski, 2019; McQuiston & Hanna, 2015; Nelwati, Abdullah, & Chan, 2019). The training plan for this project will rely heavily on peer coaching.

Go-live

Once the system is turned on, the superusers should be available for questions/concerns. Having superusers available and daily status updates for the first two weeks is a good practice. Some type of quick reference may be helpful (see Appendix C), quick response codes linking to available references have been shown to improve the application of learnings (Park, Lee, & Yun, 2019).

Maintenance/Evolution

After the deployment, the final stage of maintenance/evolution begins. During this terminal phase, maintaining a status quo is the goal. However, as the needs of an organization change, the system may need to be revised. If it is identified that a change needs to occur, the cycle starts back at the requirement gathering phase (Royce, 1987).

Evaluation

In the short term, it may be useful to assess the response for each alert critically. One method is split team members into opposing teams, team one would defend the actual process, while the second team plans a devil's advocate attempting to find issues with the first plan (Dummett, 2019).

Both process and outcome measures need to be created and monitored. SMART goals should be considered. What processes need to be put in place to gather additional information in the future? Are there limitations in the EHR? Are there existing tracking/reporting systems? Potential measures are listed in Table 3. The graphic display of the information in control charts may be helpful. The performance needs to be reported to appropriate leadership and staff (i.e., hospital, nursing, medical, and performance improvement).

The impact of the project should be monitored. Paired *t*-tests (*t*-statistic and *p*-value) are tests that can be used to compare the pre- and post-implementation rates. Data could be analyzed using a statistical program, such as Statistical Package Social Sciences (SPSS) version 24. These metrics should be evaluated every month and reported either monthly or quarterly to hospital leadership, including administration, nursing, physicians, and performance improvement. For this project, the post-implementation evaluation will occur three months after the go-live.

In conclusion, this draft roadmap (Appendix D) was created using the systems life cycle and could be used to help guide the implementation of an EWS. Once there is a commitment to move forward, this 14-week plan should provide adequate time to implement the system. It is essential to note this is to be used as a potential guide. It should be modified to meet your organization's particular needs.

Table 3.

Potential Process/Outcome Measures

Measure	Numerator	Denominator	Baseline Rate
Process			
Appropriate Response/Patients with Score >5	# of Patients with Appropriate Response	# of Patients with a Score >5	TBD[1]
Appropriate Documentation/RRTs	# of Patients with Appropriate Documentation	Total Number of RRTs	TBD[1]
Follow Up Assessment for RRTs that Remained in a non-ICU	# of Patients with a follow up documentation within 2 hours of RRT	# of RRT patients that did not transfer to an ICU	TBD[1]
Outcome			
Deaths/Discharge	Total Expirations	# of Inpatient Discharges	2.13
Cardiac Arrest/Discharge	# of Cardiac Arrests	# of Inpatient Discharges	0.33
RRT/1,000 Patient Days	RRTs	# of Inpatient Discharges	1.79
RRT without ICU Transfer	# of RRTs without Transfer to Higher Level of Care	Total # of RRTs	42.4%
Percent of Cardiac Arrests on Floors	# of non-ICU codes	Total Codes	54.0%
ICU Average Daily Census	Sum of Census at Midnight	Time Period	7
ICU Length of Stay	Total Days	Number of Patients	5

TBD[1] Baseline will be determined based on experience during the first two weeks after go-live.

IMPLEMENTATION PROCESS

The goal of this project was to implement an EWS. EWSs have been shown to identify patients that may deteriorate within the next 20 hours and allow staff to provide appropriate interventions to prevent SAEs and transfers to a higher level of care (Boniatti et al., 2014; Gagne & Fetzer, 2018; Mapp et al., 2013). The study site was a medical center, which was part of a multi-hospital national health system. The systems development lifecycle was used as the guiding framework.

The initial steps of requirement gathering were completed. The organization's regional leadership expressed interest in implementing an EWS starting in 2017. Early in 2019, there was a commitment to implement a system later that year, most likely the NEWS2. In May, it was decided that the NEWS2 would be implemented.

A discussion occurred with the organization's IRB, and additional information was requested before approving this project. In the meantime, leadership decided that the AAM tool would be used as the EWS; however, the NEWS2 would be implemented for short-term use in identifying potential septic inpatients. This decision affected the implementation plan.

Since the NEWS2 tool is prescriptive and the design was straight forward, the tool was built in the EHR using decisions made by the regional team, which includes RNs who no longer work in clinical roles. There were local decisions that needed to be made before the build could be finalized.

In mid-August 2019, the tool was presented to the core medical center team. The tool was turned on in the system, and access was given to the core team members. This meeting was attended by a diverse group of 19 employees, including:

- Regional
    - Four technical team members (including three RNs)
    - Two quality department employees
    - The EHR physician lead
- Local
    - Three nursing directors
    - Two staff nurses
    - Two sepsis RN coordinators
    - Clinical nurse specialist
    - ICU educator
    - Sepsis physician lead
    - RN quality director
    - Clinical Informatics Specialist

Over four weeks, the tool was introduced to additional clinical staff, the feedback was gathered, and suggestions were submitted to the regional team. Suggestions included: adding the NEWS2 score and the change from the previous score into a patient list, adding a second graph to display the trend for the last 24 hours, sending a text page to the charge nurse on the unit where the patient is located once a high score is triggered, and only graphing new calculated scores. The regional team reported that many of the requests were updated in the system by mid-October.

One day after being notified that the changes were completed in the build environment, leadership decided to abort this project and to use the EHR vendor's tool. So as described in the systems lifecycle, it became necessary to return to the initial step of requirement gathering (Royce, 1987). As of this writing, there is no estimated go-live date.

However, efforts to familiarize hospital and physician leadership with the EWS has continued. The chief nurse has committed to a possible three-month pilot, using an out-of-staffing RRT nurse starting sometime after March 2020. The pilot may be able to make use of the vendor-specific tool, if implemented, or the existing NEWS2 tool could be used, if needed.

DISCUSSION

Donabedian's Structure, Process, and Outcome model was useful in directing this project. The structure components included the design of the tool and ensuring that the staff receives proper training before the implementation. The process steps are essential for the application of the instrument. When the appropriate structure is present to support the processes needed for accurate use of the tools, one would expect to see improved outcomes.

The systems lifecycle is a useful tool to guide software implementations and was used to guide this project. The complexity of this integrated delivery system, with a multi-layer managerial structure, was an obstacle in successfully implementing the NEWS2 tool. The roadmap appears to have been an appropriate process; however, since the tool was not implemented, the roadmap's usefulness has not been validated.

As previously reported, EWSs have been shown to potentially decrease IHM (9 to 30%) and the number of ICUTs (11 to 46%) (AHA, 2016; Dummett, 2016; McQuillan et al., 1998; Tilllman et al., 2018; van Galen et al., 2016b). The delay of this implementation could have resulted in unnecessary deaths and ICUTs.

The first step of the system's life cycle is requirement gathering and scope (Royce, 1987). Even though there was leadership approval of the initial plan, there were later decisions that the tool would not be completely implemented. There was a national goal that the entire health system would use the same EWS. Upon review of the AAM tool, it was determined that it was not feasible, due to the complexity of the design, to implement the tool in the organization's EHR. Therefore, regional leadership decided to proceed with the vendor's EWS. The organization is now developing an implementation plan for the new tool.

The decision to change tools resulted in a significant amount of wasted time and costs by both the build team and local operations. Information technology delays or failures are common; on-time implementation occurs only 40% of the time, and 18% of healthcare projects do not go live (Standish Group International, 2015). Of the projects that fail, 66% were related to inadequate system specifications in the design phase (Curtis Digitial, 2014). Konkel (2018) reported that the Department of Veterans Affairs had wasted close to two billion dollars on their three attempted updates to their EHR.

An issue that came up with the design of graphs was that the technical team created an hourly score using previously recorded values. Therefore, it was misleading to review charts with this incorrect information. This design flaw could have been prevented by having a staff nurse involved in the design earlier (Escobar et al., 2016; Dummett et al., 2016; Fulop & Ramsay, 2019; McGregor, Chohan, & O'Reilly, 2017). The build team agreed to address the issue by only documenting actual scores. This suggestion was not tested, since the changes were never moved into the production version of the EHR.

Interdisciplinary training is essential (Bedoya et al., 2018; Connell et al., 2016; McGaughey et al., 2017; RCP, 2017; Saab et al., 2017). Due to budget constraints, the proposed training program was limited to two hours without simulations for the core team. Even though many organizations provided simulations and an average of eight hours of training (Connell et al., 2016), there were not available resources to support additional training. A previous study reported poor protocol compliance, even with robust training programs (Niegsch et al., 2013). To help address the limited training, staff support will be supplemented with a robust peer-to-peer coaching plan during the implementation phase.

Process measures are critical to successful implementation (Bedoya et al., 2018; Stewart et al., 2014). Key processes included in the training were the importance of valid vital signs, timely assessments, appropriate escalations, and consistent follow-up.

The NEWS2 tool has prescriptive workflows (RCP, 2017); the implementation of any tool requires a comparison to existing workflows. For example, low-risk patients require VS every four to six hours (RCP, 2017), while the medical center's policy states once a shift for general medical/surgical patients. The practice varies between nurses, with most taking a second set at some point during the 12-hour shift. It is imperative that the policies support the implementation (Cardona-Morrell, 2016; Freathy, Smith, Schoonhoven, & Westwood, 2019; McGregor et al., 2017). The procedures should address the frequency of vital signs, when should the primary nurse be notified in real-time, escalation, and appropriate response.

Along with the timing of VS, they must be accurate (Grant, 2019; Watson et al., 2014). A study protocol is being proposed by van Velthoven et al. (2019) that will use programmable wearable devices to gather the necessary information at prescribed times. Depending on the results of the study, this may be a valuable addition to an implementation.

Other components that need to be addressed include intrateam communication and patient interactions. Grant (2019) reported that often nurses put complaint avoidance above patient safety and are reluctant to escalate concerns (Fletcher et al., 2018; Jensen et al., 2018; Mathukia et al., 2015; Petersen et al., 2014; Zografakis-Sfakianakis et al., 2018). Communication is one of the key initiatives that should be addressed in training. A detailed review of compliance and outcome measures is a crucial component of a successful implementation. These need to be monitored on an ongoing basis and addressed if needed.

Implications for Practice

There were two main lessons learned from this project. Most importantly, there needs to be a substantial commitment to the project from the top leadership. Of the 15 critical factors required for successful implementations, leadership is ranked at number nine (Ayesha, Yasir, Saif, & Sammandar, 2017). Based on 10 key considerations, there was not enough focus on considering the available options and choosing the best system at the onset of this project (Cresswell, Bates, & Sheikh, 2017). In the future, additional research needs to be completed before the project begins. Executive leadership needs to make this a bigger priority and continue to be involved throughout the project other than just at the kick-off (Curtis Digital, 2014).

The second learning is the importance of involving clinicians at the beginning of the project. There were design decisions (display on reports and notification of scores) that may have been improved if the tool was introduced to the clinicians earlier.

Recommendations for Further Study

Additional research opportunities to be considered after the system has been implemented include:

- Compare discharge LACE Index Score with the final EWS score.

- Compare final EWS score with admission score for those patients that are readmitted within seven and 30 days.
- Comprehensive assessment of the patients with an SAE that did not trigger a score of medium risk or higher.
- Did the implementation of an EWS have an impact on the number of patients receiving palliative care or a change in their code status?
- Does the use of standing orders/protocols, impact any of the measures?
- Compare and contrast the demographics, antecedent events, treatment, and after-care for SAEs.
- Evaluate false alarms.
- A survey of other facilities to assess tools used, main components of those tools, and suggestions for enhancements.

Conclusion

Early Warning Systems have been shown to decrease the number of patients who experience significant adverse events while they are hospitalized. This project was guided by Donabedian's Structure, Process, and Outcome model. The systems development life cycle was shown to be a valuable tool to guide the implementation of this EHR application. Each step of this cycle is essential. This process was documented in a playbook that can be used by other organizations. Also, a training plan with content was created. In this project, if additional work had been done in the requirement gathering phase, an EWS tool may have been implemented on time.

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Appendix A

Glossary

AHA: American Heart Association

AP: abnormal parameter

APACHE II: Acute Physiologic Assessment and Chronic Health Evaluation II

AUROC: area under the receiver operator characteristic curve

BPA: best practice advisory

CA: cardiac arrests

CART: Cardiac Arrest Risk Triage

CC: critical care

CCI: Charlson Comorbidity Index

CEWS: Christiana Early Warning System

DBP: diastolic blood pressure

DENWIS: Dutch-Early-Nurse-Worry-Indicator-Score

DX: diagnosis

EDI: Early Deterioration Indicator

EHR: electronic health record

EWRS: early warning and response system

EWS: Early Warning Score

GCS: Glasgow Coma Scale

GMEWS: Global Modified Early Warning Score

HOTEL: Hypotension, Oxygen saturation, Temperature, ECG abnormality, Loss of independence

HR: heart rate

ICU: intensive care unit

ICUT: intensive care unit transfer

IHCA: in-hospital cardiac arrest

IHI: Institute of Health Improvement

IHM: in-hospital mortality

IQR: interquartile range

IRR: incidence rate ratio

LOS: length of stay

LTC: long term care

MEDS: Mortality in Emergency Department Sepsis

MERIT: Medical Early Response Intervention and Therapy

MEWS: Modified Early Warning Score

MICN: mobile intensive care nurse

MS: medical/surgical

NEWS: National Early Warning Score

NEWSDIG: National Early Warning Score Development and Implementation Group

NPV: negative predictive value

NSA: Nurse Screening Assessment

OR: odds ration

PARS: Patient at Risk Score

PIRO: Predisposition/Infections/Response/Organ Dysfunction Score

PPV: positive predictive value

PRISMA: Prevention and Recovery Information System for Monitoring and Analysis

qNEWS: quick National Early Warning Score

qSOFA: quick Sepsis-related Organ Failure Assessment

RAPS: Rapid Acute Physiology Score

RCP: Royal College of Physicians

RCT: randomized control trial

REMS: Rapid Emergency Medicine Score

RI: Rothman Index

ROC: receiver operator characteristic curve

RN: registered nurse

RR: respiratory rate

RRT: rapid response team

SAE: serious adverse event

SAPS II: Simplified Acute Physiology Score II

SBP: systolic blood pressure

SCS: Simple Clinical Score

SEWS: Standardized Early Warning Score

SIRS: Systemic Inflammatory Response Syndrome

SOFA: Sepsis-related Organ Failure Assessment

SS: statistically significant

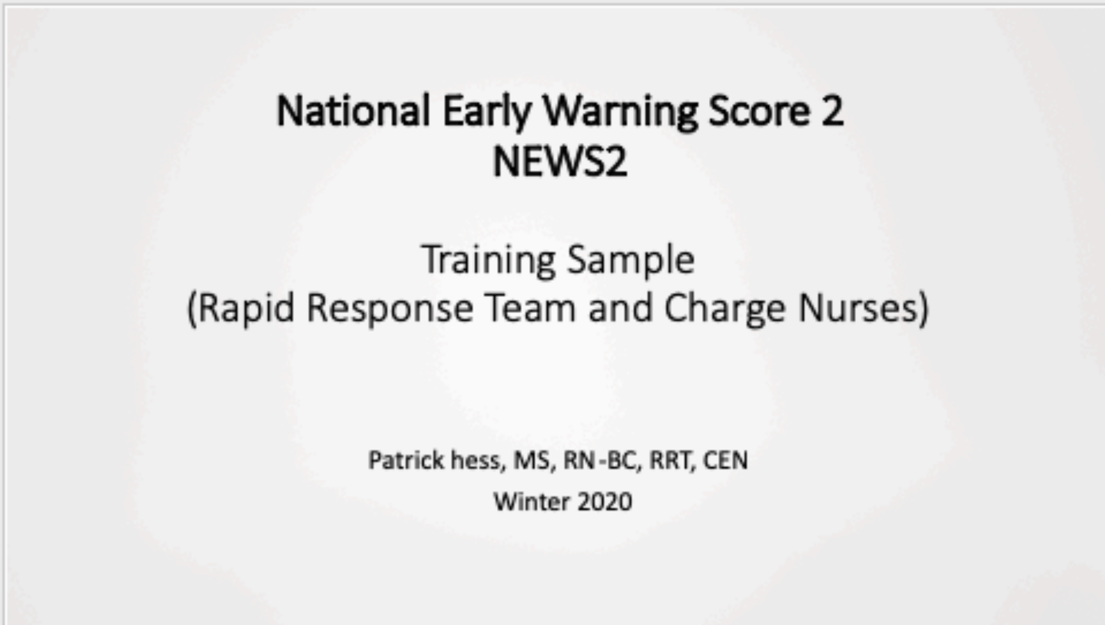
TOTAL: Tachypnoea, Oxygen saturation, Temperature, Alert, Loss of independence

ViEWS: VitalPAC Early Warning Score

VS: vital signs

APPENDIX B

SAMPLE EDUCATION TRAINING CONTENT



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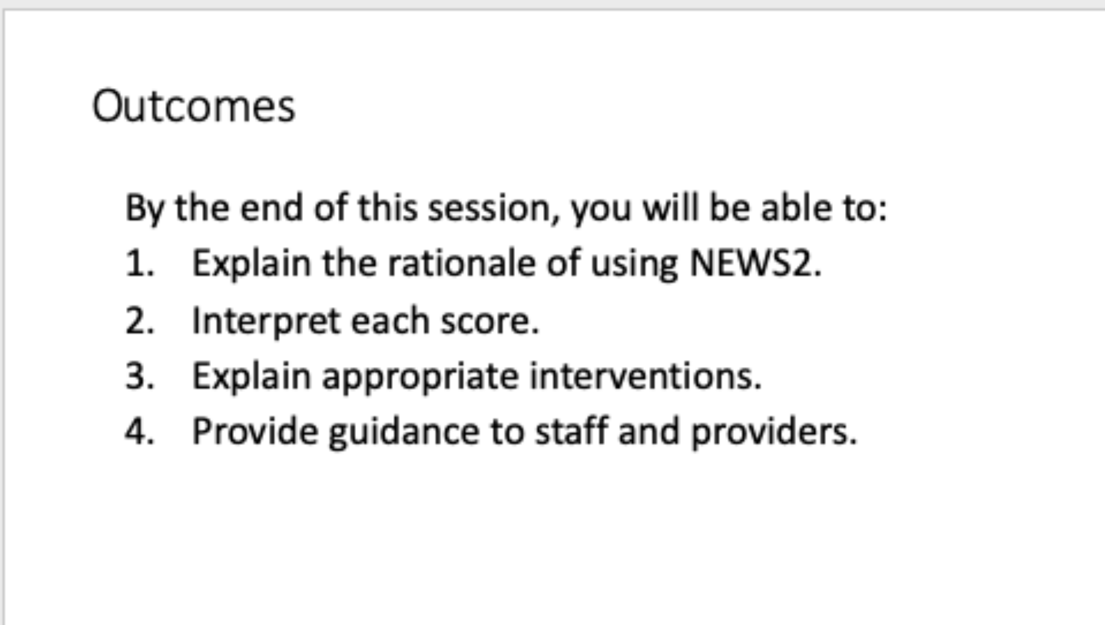

2

Outline

- Background
- Literature Review
- Goals
- Components
  - Early Recognition
  - Timely Response
  - Competent Response
- Implementation Training Plan
- Scenarios
- Summary

3

Background

- Sudden Cardiac Death – 14% (Benjamin et al., 2018)
- In-Hospital Cardiac Arrests – 200,000
  - Short-term Survival – 25 to 39%

(AHA, 2016; AHA, 2018b; Benjamin et al., 2018; Girotra et al., 2012; McGrath, 1987; Syue,Huang, Cheng, Kung, & Li, 2016)

  - Discharged – 14 to 26%
  - Baseline Function – 9% (Fendler et al., 2015)

4

Background (Cont.)

- Signs of Deterioration (Kirkland et al., 2013; Oh, Lee, & Seo,2016; Zografakis-Sfakianakis et al., 2018)
  - Early Signs 20 Hours
  - Increasing between 5 and 8 hours
  - Significant within 2 hours
- Early Treatment May Prevent Transfers to ICU (AHA, 2016; McQuillan et al., 1998; van Galen et al., 2016b)

5

Literature Review

- Staff Aware of Potential Issues - 40% (IHI, 2017)
  - Abnormal VS – 60%, only 13% Severely (Andersen et al., 2016)
  - With Objective Data More Likely to Escalate (Hart et al., 2016)
  - Early Identification ↓ (Tilmann et al., 2018)
    - ICUT – 22%
    - Dying – 30%

6

Clinical Intuition

- Median Clinical Intuition – Predicting ICU Readmission (Rojas et al., 2017)
  - AUC
    - Fellows 0.72
    - All Clinicians 0.71
    - Nurses 0.69
    - Attendings 0.63
    - MEWS/House Staff 0.62

7

Increased Length of Stay

- Medical errors
- Medication errors
- Skin Breakdown
- Infections
- Falls

8

Problem Statement/Significance

- IHCA Incident Rate 0.580/1,000 days, 59% in ICU (Perman et al., 2016)
- Facility (2018) 0.771/1,000 days,
  46% in ICU

(www.nursebuff.com/code-blue-in-hospital/)

9

Goals

- Decrease
  - Mortality Rate
  - Number of IHCA
  - Transfers to a Higher Level of Care

10

Components

- Early Detection
- Timely Response
- Competent Response

(RCP, 2013)

11

NEWS2 - Tool

Physiological parameter	Score 3	2	1	0	1	2	3
Respiration rate (per minute)	≤8		9–11	12–20		21–24	≥25
SpO_2 Scale 1 (%)	≤91	92–93	94–95	≥96			
SpO_2 Scale 2 (%)	≤83	84–85	86–87	88–92 ≥93 on air	93–94 on oxygen	95–96 on oxygen	≥97 on oxygen
Air or oxygen?		Oxygen		Air			
Systolic blood pressure (mmHg)	≤90	91–100	101–110	111–219			≥220
Pulse (per minute)	≤40		41–50	51–90	91–110	111–130	≥131
Consciousness				Alert			CVPU
Temperature (°C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	

Reproduced from: Royal College of Physicians. ***National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*** Updated report of a working party. London: RCP, 2017.

12

Vital Signs

- Importance
- Regular
- Review
- Validating

13

NEWS2 – Clinical Risk

NEW score	Clinical risk	Response
Aggregate score 0–4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low-medium	Urgent ward-based response*
Aggregate score 5–6	Medium	Key threshold for urgent response*
Aggregate score 7 or more	High	Urgent or emergency response**

*Response by a clinician or team with competence in the assessment and treatment of acutely ill patients and in recognising when the escalation of care to a critical care team is appropriate.

**The response team must also include staff with critical care skills, including airway management.

Reproduced from: Royal College of Physicians. ***National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*** Updated report of a working party. London: RCP, 2017.

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NEWS2 – Clinical Risk

4 - 6
3 to 4 X more likely to die

(Roberts & Djärv, 2017; Spagnolli et al., 2017; Spångfors, Bunkenborg, Molt, & Samuelson, 2018)

NEW score	Clinical risk	Response
Aggregate score 0–4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low–medium	Urgent ward-based response*
Aggregate score 5–6	Medium	Key threshold for urgent response*
Aggregate score 7 or more	High	Urgent or emergency response**

*Response by a clinician or team with competence in the assessment and treatment of acutely ill patients and in recognising when the escalation of care to a critical care team is appropriate.
**The response team must also include staff with critical care skills, including airway management.

Reproduced from: Royal College of Physicians. ***National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*** Updated report of a working party. London: RCP, 2017.

15

NEWS2 – Clinical Risk

≥ 7
10 X more likely to die

(Roberts & Djärv, 2017; Spagnolli et al., 2017; Spångfors et al., 2019)

NEW score	Clinical risk	Response
Aggregate score 0–4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low–medium	Urgent ward-based response*
Aggregate score 5–6	Medium	Key threshold for urgent response*
Aggregate score 7 or more	High	Urgent or emergency response**

*Response by a clinician or team with competence in the assessment and treatment of acutely ill patients and in recognising when the escalation of care to a critical care team is appropriate.
**The response team must also include staff with critical care skills, including airway management.

Reproduced from: Royal College of Physicians. ***National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*** Updated report of a working party. London: RCP, 2017.

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NEWS2 – Clinical Response

NEW score	Frequency of monitoring	Clinical response
0	Minimum 12 hourly	• Continue routine NEWS monitoring
Total 1–4	Minimum 4–6 hourly	• Inform registered nurse, who must assess the patient • Registered nurse decides whether increased frequency of monitoring and/or escalation of care is required
3 in single parameter	Minimum 1 hourly	• Registered nurse to inform medical team caring for the patient, who will review and decide whether escalation of care is necessary
Total 5 or more Urgent response threshold	Minimum 1 hourly	• Registered nurse to immediately inform the medical team caring for the patient • Registered nurse to request urgent assessment by a clinician or team with core competencies in the care of acutely ill patients • Provide clinical care in an environment with monitoring facilities
Total 7 or more Emergency response threshold	Continuous monitoring of vital signs	• Registered nurse to immediately inform the medical team caring for the patient – this should be at least at specialist registrar level • Emergency assessment by a team with critical care competencies, including practitioner(s) with advanced airway management skills • Consider transfer of care to a level 2 or 3 clinical care facility, ie higher dependency unit or ICU • Clinical care in an environment with monitoring facilities

Reproduced from: Royal College of Physicians. *National Early Warning Score (NEWS) 2: Standardising the assessment of acute-illness severity in the NHS*. Updated report of a working party. London: RCP, 2017.

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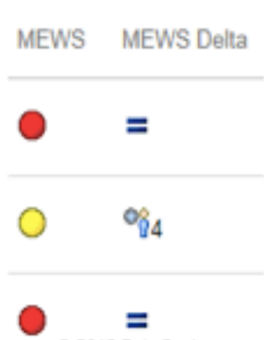

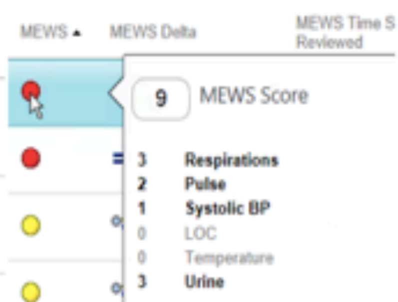

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18

TREAT PATIENT NOT SCORE!

19

RRT Responsibilities

- Review all non-ICU patient Scores at a minimum of four hours
- Respond to both System and Staff Initiated Pages
- Rounding
  - Non-Critical Care Patients with Score of 5 or Greater
  - Post-RRT Patients that remained on non-ICU Unit (2 hours)
  - ICU transfers out (24 hours)
- Peer-To-Peer Dialogues
  - Post RRTs
  - Post Code Blues

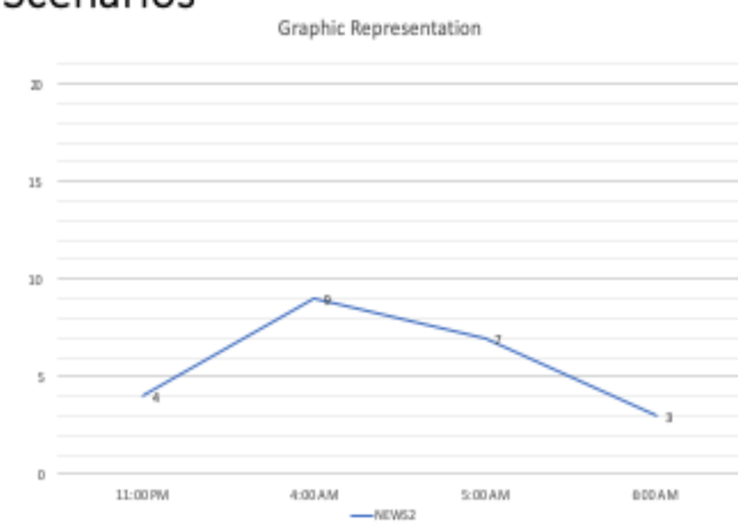
20

APSO Note

- Assessment
- Plans
  - A
  - B
- Subjective
- Objective

21

Clinical Scenarios



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Implementation Plan

- Change of Shift Huddles
- Electronic Huddles (Video and Written)
- Peer-to-Peer Coaching
- On-Boarding Process
- Annual Staff Education Review

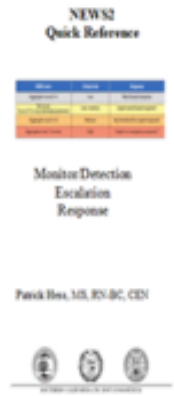
23

Communication

- Within team
- With families/patients (script)

24

Quick Reference



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Quick Reference

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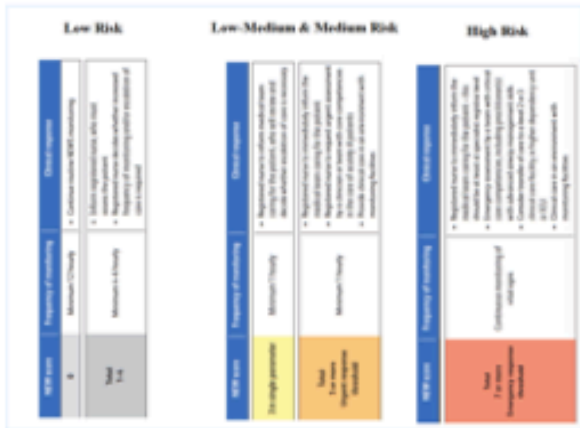

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Summary

- Implement the NEWS2
- Early Identification and Treatment of Potential Issues
- Improves Outcomes
  - ↓ Mortality Rate
  - ↓ Cardiac Arrest
  - ↓ Transfers to ICU

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Questions

(www.bayshore.ca)

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APPENDIX C

NEWS2 QUICK REFERENCE

NEWS2
Quick Reference

NEW score	Clinical risk	Response
Aggregate score 0-4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low-medium	Urgent ward-based response*
Aggregate score 5-6	Medium	Key threshold for urgent response*
Aggregate score 7 or more	High	Urgent or emergency response**

Monitor/Detection
Escalation
Response

Patrick Hess, MS, RN-BC, CEN

SOUTHERN CALIFORNIA CSU DNP CONSORTIUM

Go-Live May 15, 2020

Goals

1. **Decrease the number of expirations.**
2. **Decrease the number of cardiac arrests.**
3. **Decrease RRTs.**
4. **Decrease transfers to the ICU.**
5. **Decrease length of stay.**

Scoring Criteria

Physiological parameter	Score 3	2	1	0	1	2	3
Respiration rate (per minute)	≤8		9–11	12–20		21–24	≥25
SpO_2 Scale 1 (%)	≤91	92–93	94–95	≥96			
SpO_2 Scale 2 (%)	≤83	84–85	86–87	88–92 ≥93 on air	93–94 on oxygen	95–96 on oxygen	≥97 on oxygen
Air or oxygen?		Oxygen		Air			
Systolic blood pressure (mmHg)	≤90	91–100	101–110	111–219			≥220
Pulse (per minute)	≤40		41–50	51–90	91–110	111–130	≥131
Consciousness				Alert			CVPU
Temperature (°C)	≤35.0		35.1–36.0	36.1–38.0	38.1–39.0	≥39.1	

Workflows

Bedside Nurse - review score at start of shift and with vital signs. Escalate as appropriate.

RRT Nurse - Review at start of shift and every four hours.

-Assess all patients with a new score of 5 or higher, or 3 in any one area. Initial assessment will be done remotely.

-Provide on-unit post RRT assessment for all patients remaining in non-ICU units within two hours of event.

For additional information:

Link to Training Video (if URL is available)

Royal Collage of Physicians, NEWS2, 19 December 2017

NEWS2 Quick Reference

NEW score	Clinical risk	Response
Aggregate score 0–4	Low	Ward-based response
Red score Score of 3 in any individual parameter	Low–medium	Urgent ward-based response*
Aggregate score 5–6	Medium	Key threshold for urgent response*
Aggregate score 7 or more	High	Urgent or emergency response**

Monitor/Detection Escalation Response

Patrick Hess, MS, RN-BC, CEN

SOUTHERN CALIFORNIA CSU DNP CONSORTIUM

Low Risk

NEW score	Frequency of monitoring	Clinical response
0	Minimum 12 hourly	• Continue routine NEWS monitoring
Total 1–4	Minimum 4–6 hourly	• Inform registered nurse, who must assess the patient • Registered nurse decides whether increased frequency of monitoring and/or escalation of care is required

Low-Medium & Medium Risk

NEW score	Frequency of monitoring	Clinical response
3 in single parameter	Minimum 1 hourly	• Registered nurse to inform medical team caring for the patient, who will review and decide whether escalation of care is necessary
Total 5 or more Urgent response threshold	Minimum 1 hourly	• Registered nurse to immediately inform the medical team caring for the patient • Registered nurse to request urgent assessment by a clinician or team with core competencies in the care of acutely ill patients • Provide clinical care in an environment with monitoring facilities

High Risk

NEW score	Frequency of monitoring	Clinical response
Total 7 or more Emergency response threshold	Continuous monitoring of vital signs	• Registered nurse to immediately inform the medical team caring for the patient – this should be at least at specialist registrar level • Emergency assessment by a team with critical care competencies, including practitioner(s) with advanced airway management skills • Consider transfer of care to a level 2 or 3 clinical care facility, ie higher-dependency unit or ICU • Clinical care in an environment with monitoring facilities

APPENDIX D

EARLY WARNING SYSTEM
IMPLEMENTATION PLAYBOOK

Early Warning System Implementation Playbook

Patrick Hess, MS, RN-BC, RRT, CEN
January 2020

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Introduction

Patient deterioration in hospitals is a significant concern.[1, 2, 3, 4] Researchers noted that there were often signs of deterioration (i.e., blood pressure, respiratory, or level of consciousness changes), documented in the medical record prior a significant adverse event; however, the staff did not address the decline in status.[5]

These abnormal findings may display as early as 20 hours prior to the actual deterioration.[6, 7, 8]. Substantial changes were noticed between five and eight hours prior to significant adverse events.[6, 7, 8] Addressing conditions that could lead to further deterioration should occur as soon as possible since it has been reported that up to 46% of intensive care unit transfers (ICUT) could be avoided by providing interventions earlier.[1, 9]

Early warning and response systems (EWRS) were developed to alert clinicians that their patients may have a negative outcome in the future.[5] Since the initial scoring system reported in the early eighties, there have been more than thirty tools and variations available.[10, 11, 12, 13, 14]

The three components of an EWRS, early detection, timely response, and competent response, were found to improve outcomes.[15] Researchers have revealed that with an objective score derived from an EWRS, staff are more likely to request additional assistance, or activate a rapid response team (RRT) to stop patients' deterioration and prevent transferring to an ICU.[5, 16]

Reported Outcomes

- Delayed response within one hour of deterioration:
    - 22% increased probability of transferring to ICU[17]
    - 30% increased probability of death[17]
- After implementation of an EWRS:
    - 11% decrease of transfers to ICU[18]
    - 9% decrease in hospital mortality[18]
    - 2.5% decrease in cardiac arrests[19]
- Likelihood of expiring
    - Medium score three to four times more[20, 21, 22]
    - High scores 10 times more [20, 21]

Systems Life Cycle Steps

A modified version of Royce's[23] system development lifecycle will be used as a guide for this implementation plan.

Requirement Gathering

After the leadership team approves the project concept, the initial step of software deployment projects includes gathering requirements.

- Who will lead this project?
- Who will be part of the project leadership team?
- What is the overall goal?
    - Create specific SMART goal (s).
- What are the specific needs of
    - The business owners?
    - The organization?
    - End users?
- What projected resources are needed?
- Are there resources available?
- Define scope, will this be a pilot or house-wide implementation?

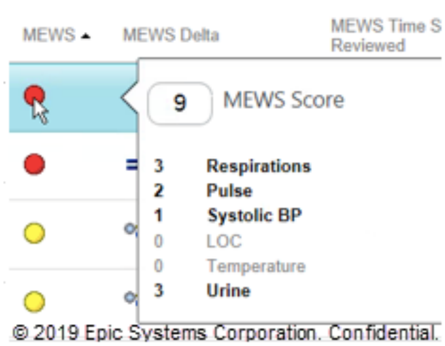
Design

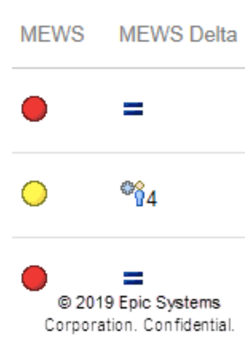
After the requirements are assessed,

- Is there an existing tool that meets the organization's needs (i.e., Advanced Alert Monitor, MEWS, NEWS, NEWS2, Rothman Index, specific EHR vendor, etc.)?
    - Has validity and reliability testing been completed?
        - A higher sensitivity and specificity are preferable.
    - Is there a system-wide standard?
    - Is there a standard in your community?

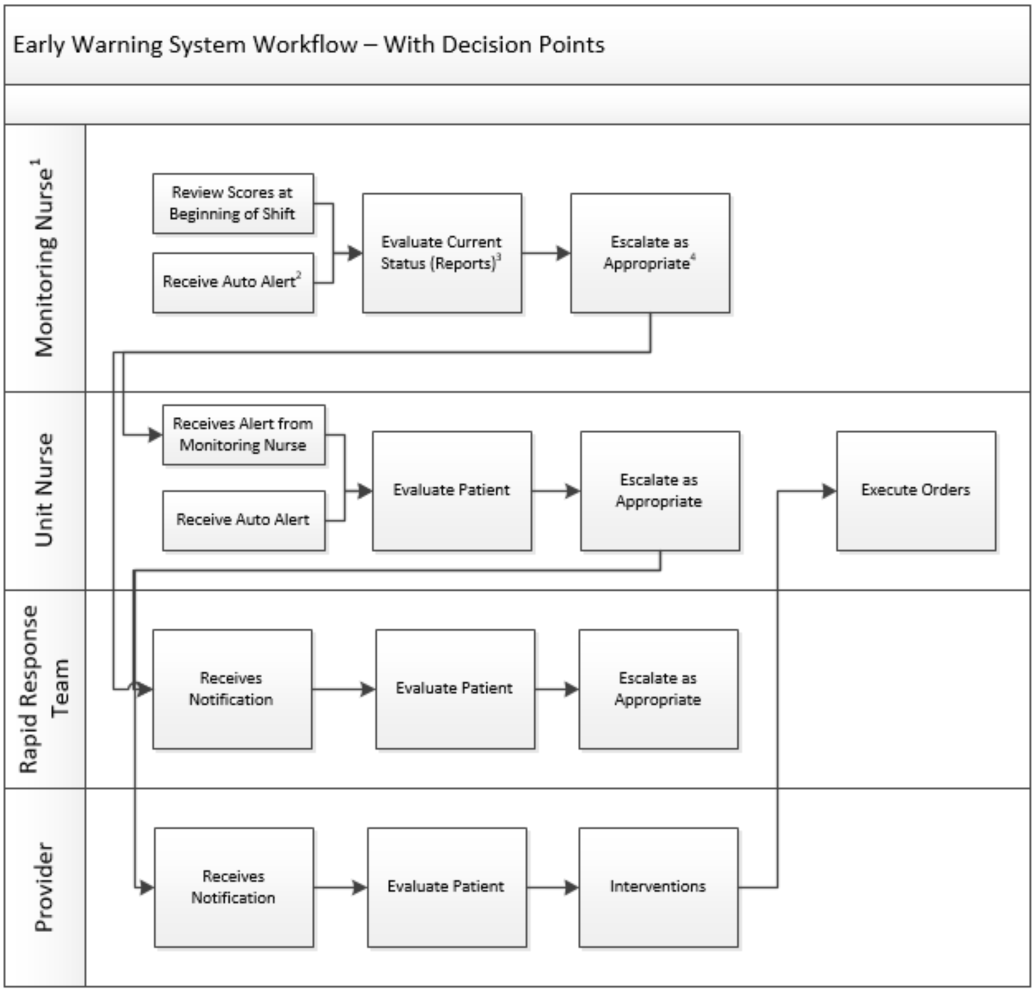
Once a solution is recommended,

- The specifics design questions and workflows should be created:
    - Include feedback from bedside clinicians.
    - What is the timeframe for calculating a score?
    - What is the time range to include recorded values for a particular score?
    - Where will the scores display (i.e., a report, patient list, banner, etc.)?



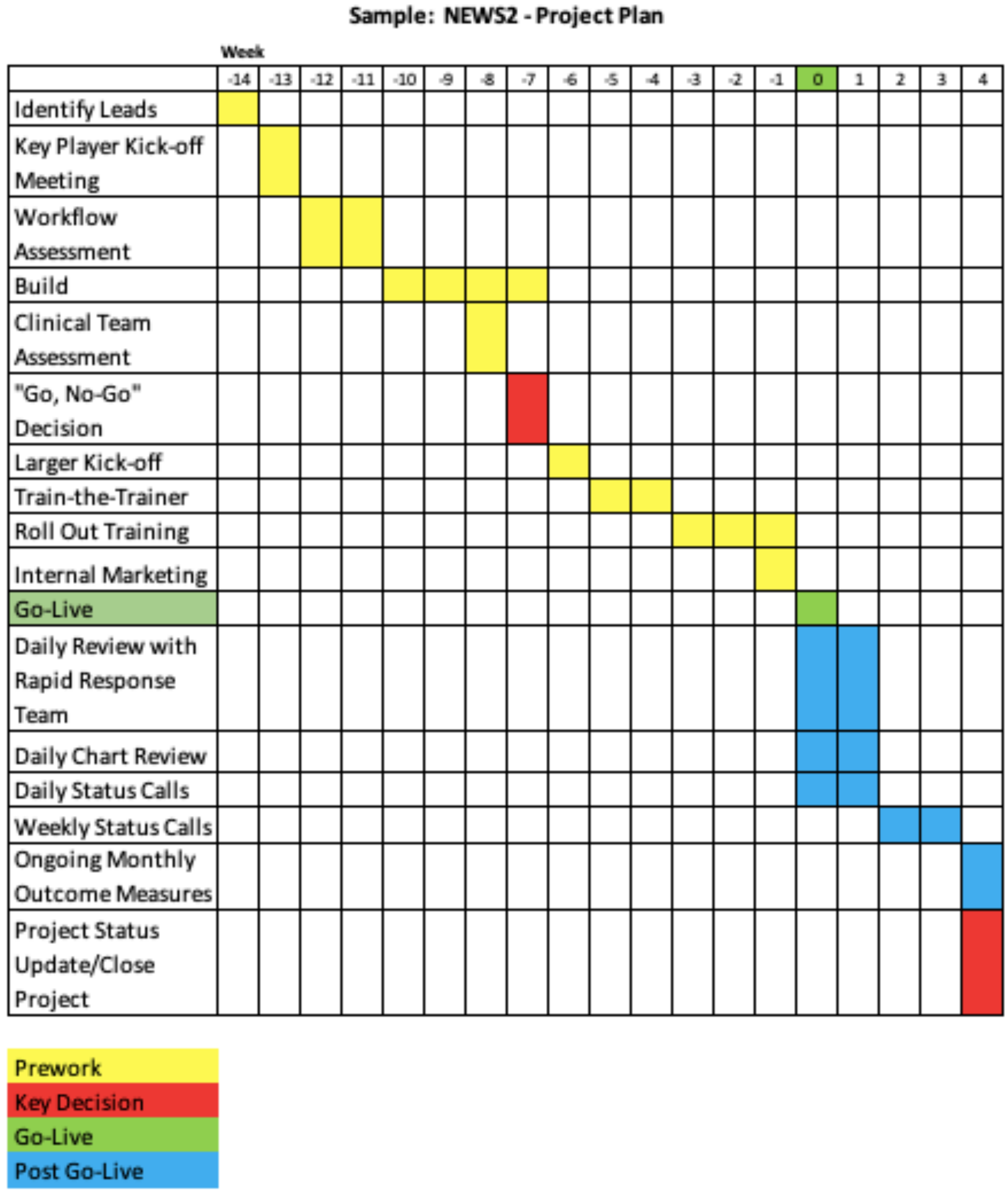


    - When will scores be escalated?
    - Who will be notified of out-of-range scores (i.e., unit charge nurse, rapid response team, provider, etc.)?
    - How will the staff be notified (i.e., passive alert in EHR, trigger an alert in the EHR, automated page, automated phone call, etc.)?
    - Define expected responses for each range of scores.
        - Proactive rounding
        - Reactive
    - Do the current documentation workflows meet the need for new documentation?
- Document the workflow (see example).
- Create a project plan, including estimated times for key milestones (see example).



Decisions Needed

1. Who will monitor scores?
2. How will alerts be escalated?
3. What will be displayed in reports?
4. What are escalation protocols?


Sample: NEWS2 - Project Plan
Week
-14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4
Identify Leads
Key Player Kick-off Meeting
Workflow Assessment
Build
Clinical Team Assessment
"Go, No-Go" Decision
Larger Kick-off
Train-the-Trainer
Roll Out Training
Internal Marketing
Go-Live
Daily Review with Rapid Response Team
Daily Chart Review
Daily Status Calls
Weekly Status Calls
Ongoing Monthly Outcome Measures
Project Status Update/Close Project
Prework
Key Decision
Go-Live
Post Go-Live

Build

- Project lead communicates build plan to team.
- Build team defines what build need to be completed.
- Start build.
- Project lead/manager monitors progress and adjust resources or timing if necessary.
- Escalate concerns to clinical experts, if needed.
- Create operational policy.
- Create a training plan (see sample below).
    - Are there preferred training methods in your organization?
    - Is there funding for classroom sessions?
    - Will a train-the-trainer model be used?
    - Determine desired completion rate.
    - Define content for sessions, at a minimum include detection, escalation, communication, and appropriate response.

Sample Education Plan

Specialty	Timing	Method	Duration
-RRT Nurses -Charge Nurses -Charge Respiratory Therapists -Physician Leads	5 weeks out	Classroom	2 hours
-Floor Nurses -Respiratory Therapists	3 weeks out	Staff Meeting Daily Huddles e-Huddles e-Modules Peer-to-Peer Conversations	45 minutes
-Hospitalists	3 weeks out	Lunch and Learns	30 minutes

Testing

- Create tests scripts to ensure key features are functioning correctly (i.e., calculation of scores, escalation of scores, display of scores in banners and reports, etc.) see sample below.
- Both technical and clinical users should run test scripts.
- Also, allow clinicians to explore the functions on their own.

Sample: NEWS2 Test Script (Scale 1)

Step	Action		Pass/Fail
	Patient: News2, Test		
	VS Flowsheet (Enter 12 Hours Earlier)	**Enter**	
1	Temp	98.7 f	
2	Pulse	88	
3	BP	120 80	
4	Resp	14	
5	O2 (LPM)	0	
6	SpO2 98	98	
	Shift Flowsheet (Enter 12 Hours Earlier)		
	Neuro Assessment Group		
7	Consciousness Level	Awake, Alert	
	Go to Patient List		
8	Add Patient List Column "NEWS"		
9	Add Patient List Column "NEWS Delta"		
10	Add Patient to List		
11	NEWS Score Displays 0		
	VS Flowsheet (Enter 6 Hours Earlier)		
12	Temp	98.7 f	
13	Pulse	88	
14	BP	120 80	
15	Resp	10	
16	O2 (LPM)	2	
17	SpO2 98	98	
	Shift Flowsheet (Enter 6 Hours Earlier)		
	Neuro Assessment Group		
18	Consciousness Level	Stuporous	
	Go to Patient List		
19	BPA fires "NEWS2 = 6, +6"		
20	"NEWS" Displays "6"		
21	"NEWS Delta" Displays "+6"		
	Page		
22	Pager displays "News2, Test, room 828 NEWS 6, +6"		
	VS Flowsheet (Enter 3 Hours Earlier)		
23	Temp	100.4 f	
24	Pulse	100	
25	BP	106 72	
26	Resp	28	
27	O2 (LPM)	6	
28	SpO2 98	96	
	Shift Flowsheet (Enter 3 Hours Earlier)		
	Neuro Assessment Group		
26	Consciousness Level	Obtunded	
	Go to Patient List		
27	BPA fires "NEWS2 = 10, +4"		
28	"NEWS" Displays "10"		
29	"NEWS Delta" Displays "+4"		
	Page		
30	Pager displays "News2, Test, room 828 NEWS 10, +4"		
	Open Patient List Report "NEWS2"		
31	Graph Displays Scores of "0, 6, 10"		

Deployment

- After the build has been tested and a decision has been made to go forward with the plan, implement training. Note that training could occur during the testing phase if needed.
- Provide internal marketing just prior to the go-live.
- After the completion of the training, turn on the tools for use.
- Provide go-live support
- At the elbow support?
- Command center?
- How long?
- Provide quick refence guide.
- Monitor compliance.

Maintenance/Evolution

- Any issues affecting performance should be addressed and treated as a break fix.
- If the system needs to be updated to new standards, start at the first step of the life cycle.
- Outcome monitoring should be ongoing (monthly) and shared with leadership and bedside staff (monthly or quarterly), see possible measures below.
- Consider publishing successes and failures.

Potential Process/Outcome Measures

Measure	Numerator	Denominator	Baseline Rate
Process			
Appropriate Response/Patients with Score >5	# of Patients with Appropriate Response	# of Patients with a Score >5	TBD[1]
Appropriate Documentation/RRTs	# of Patients with Appropriate Documentation	Total Number of RRTs	TBD[1]
Follow Up Assessment for RRTs that Remained in a non-ICU	# of Patients with a follow up documentation within 2 hours of RRT	# of RRT patients that did not transfer to an ICU	TBD[1]
Outcome			
Deaths/Discharge	Total Expirations	# of Inpatient Discharges	TBD[2]
Cardiac Arrest/Discharge	# of Cardiac Arrests	# of Inpatient Discharges	TBD[2]
RRT/1,000 Patient Days	RRTs	# of Inpatient Discharges	TBD[2]
RRT without ICU Transfer	# of RRTs without Transfer to Higher Level of Care	Total # of RRTs	TBD[2]
Percent of Cardiac Arrests on Floors	# of non-ICU codes	Total Codes	TBD[2]
ICU Average Daily Census	Sum of Census at Midnight	Time Period	TBD[2]
ICU Length of Stay	Total Days	Number of Patients	TBD[2]

TBD[1] Baseline should be determined based on experience during the first two weeks after go-live.
TBD[2] To account for seasonal variations, baseline should be based on a three-month period, starting 15 months prior to go-live.

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APPENDIX E

PERMISSION TO CONDUCT PROJECT FROM CHIEF NURSING EXECUTIVE

Patrick Hess
May 30, 2019 at 6:55 PM
PH
Request for Doctoral Project
Details
To: [redacted] Weismuller, Penny, Alatrash, Manal, **Bcc:** Patrick Hess

I am requesting permission to use the proposed implementation of the National Early Warning Score 2 (NEWS2) as my DNP project. After speaking with [redacted], it is my understanding that we will be rolling out this project in the 3rd or 4th quarter of this year.

Purpose Statement - Implement the NEWS2 on DOU1, 4th/5th floors, and 3rd floor overflow. Also, evaluate the implementation process and outcomes.

Aim - Decrease the mortality rate, number of cardiac arrests, and transfers to a higher level of care.

Donabedian's model of Structure, Process, and Outcome will be used to guide this work, with the major focus being on the processes: application of the tool, communication/escalation, and team response.

I will involve the staff from the informatics workgroup, rapid response team, and charge nurses in reviewing the proposed workflows prior to the implementation. Physician involvement will be sought as well.

The facility will not be identified any presentations or publications. Aggregated information from Statit will be used to assess the outcome measures listed above. Depending on the timing of the project, I would like to compare pre-implementation data to three months post-implementation.

Please let me know if you have any questions. Thank you for your consideration.

Patrick Hess, MS, RN-BC, RRT, CEN
DNP Student

[redacted]
June 1, 2019 at 1:25 PM
R
RE: Request for Doctoral Project
Details
To: Patrick Hess, **Cc:** Weismuller, Penny, Alatrash, Manal

Patrick, This is very exciting! I approve the NEWS2 implementation as your doctoral project. Please let me know if I can provide any additional support.

Thank you,
[redacted]

APPENDIX F

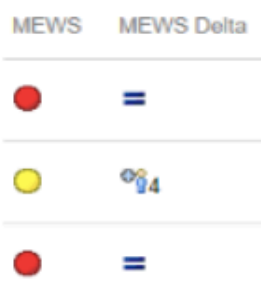
PERMISSION TO USE EPIC EHR IMAGES

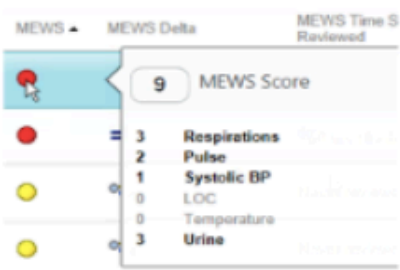
Patrick Hess November 17, 2019 at 9:14 AM

Request to Use Images in a DNP Project

To: consultantinquiries@epic.com

Hello, I am clinical informaticist at [redacted] and a doctor of nursing practice student. My doctoral project is on Early Warning Systems. May I include images from the UserWeb?





Thank you.

Patrick Hess

Megan Mundt Yesterday at 7:01 AM

RE: Request to Use Images in a DNP Project

To: Patrick Hess

Hi Patrick,

The screenshots have been approved for your doctoral project.

Thank you,
-Megan

From: Patrick Hess <patrickhess@csu.fullerton.edu>
Sent: Wednesday, November 20, 2019 5:42 PM
To: Megan Mundt <mmundt@epic.com>
Subject: Re: Request to Use Images in a DNP Project