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The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Assistant Dean for MSN and DNP Studies, on behalf of the program; we verify that this is the final, approved version of the student's DNP Project including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Beth A. Meade, Student

Dr. Debra Anderson, Advisor

Final Practice Inquiry Project

Introduction of a Comprehensive Modified Early Warning Scoring System in a Large Rural Hospital

Beth A. Meade, MSN, RN

University of Kentucky

College of Nursing

Fall 2017

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Dedication

First and foremost, I would like to thank God for giving me the strength and the determination to achieve my goals. As I struggled, most notably at the end, I drew much comfort from this verse in the Book of Joshua: “Have I not commanded you? Be strong and courageous. Do not be afraid; do not be discouraged, for the Lord your God will be with you wherever you go” (Joshua 1:9, New International Version).

It is most fitting that I dedicate this final project to my family and friends who have been by my side from the very beginning of this endeavor that began seven years ago. First, I would like to thank my husband Barry for his unwavering love and support, without which I surely would not have succeeded! He was always there to hear my troubles and carry some of the burden. His favorite phrase was, “Just get it done!” Secondly, my son Chad was someone I leaned on frequently for support and encouragement. He was my number one cheerleader! Chad was also instrumental in helping me understand some basic concepts about finance and policy. He regularly stated, “Momma, you can do this!” Next, I would like to thank my daughter Blake who took the tough-love approach that helped propel me to the finish line. She would not tolerate thoughts of quitting or giving up in any form or fashion and for that I am extremely grateful! She would often say, “It does not have to be perfect, Momma!” To my friend Tonya, I would like to thank her for always being willing to listen to my woes, for believing in me when I did not believe in myself, and for being a true friend! She would frequently add words of encouragement such as, “It will all work out!” It is pretty safe to say that when I graduate, we all graduate!

I would be remiss if I did not mention Harley Davidson and Zoe Beans, my most special dogs! They have spent the last seven years walking – literally. When I was stressed, they gladly walked. When I was tired of sitting at the computer, they gladly walked. When I needed a study break, they gladly walked. No matter what time of day, they gladly walked. Now, as they have gotten up in age, they still gladly walk, albeit at a much slower pace. I am forever grateful for their unconditional love and affection and I will always remember our walks!.

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Practice Inquiry Project Introduction

Beth A. Meade
University of Kentucky

Introduction

In 1999, the Institute of Medicine (IOM) revealed a healthcare system plagued by preventable medical errors in a seminal report on patient safety titled To Err is Human: Building a Safer Health System. They advanced the conversation in Crossing the Quality Chasm: A New Health System for the 21st Century (Institute of Medicine [IOM], 1999; IOM, 2001). In this report, the IOM (2001) provided a comprehensive plan for improving patient safety and quality of care in U.S. hospitals with the intent of making healthcare "safe, effective, patient-centered, timely, efficient, and equitable" (p. 3). In 2004, the Institute for Healthcare Improvement (IHI) and the Robert Wood Johnson Foundation (RWJF) joined forces to achieve similar goals in an effort known as Transforming Care at the Bedside. However, this initiative provided a framework for transforming care specifically on medical-surgical units (Institute for Healthcare Improvement [IHI], 2004).

Previously, researchers had uncovered a mountain of evidence indicating hospitalized patients were particularly vulnerable to clinical deterioration leading to severe adverse events (SAEs) such as cardiac arrest and/or death (IOM, 1999, 2001, 2011; Kohn, Corrigan, & Donaldson, 2000; Mapp, Davis, & Krowchuk, 2013; National Patient Safety Agency [NPSA], 2007a, 2007b). For example, researchers in one study estimated nearly 40% of unexpected in-hospital deaths occurred on medical-surgical units (IHI, 2004). In other studies, researchers contended that approximately 25% of SAEs in hospitalized patients were preventable (Al-Qahtani & Al-Dorzi, 2010; Kohn et al., 2000; Winters et al., 2007). In many instances, clinical deterioration was not recognized, communicated, and/or treated appropriately; hence, contributing to the well documented problems of failure to rescue and suboptimal care (Al-Qahtani & Al-Dorzi, 2010; McQuillan et al., 1998; Mei, Ying, & Fai, 2009; National Confidential Enquiry into Patient Outcome and Death [NCEPOD], 2005; Patient Safety First [PSF], 2008; Subbe & Welch, 2013).

First introduced in 1992, the term "failure to rescue" was simply defined as "hospital deaths after adverse events" (Silber, Williams, Krakauer, & Schwarz, 1992; Taenzer, Pyke, & McGrath, 2011, p. 421). Subbe and Welch (2013) later described the phenomenon as "the inadequate or delayed response to clinical deterioration in hospitalized patients" (p. 6). In several studies, researchers reported that patients exhibited warning signs (i.e., changes in vital signs and/or level of consciousness) in the hours leading up to an SAE (Garvey, 2015; NCEPOD, 2005; Schein, Hazday, Pena, Ruben, & Sprung, 1990; Subbe & Welch, 2013). These warning signs were often missed or mismanaged by nursing staff. In addition, care provided during this timeframe was often deemed suboptimal (Al-Qahtani & Al-Dorzi, 2010; McQuillan et al., 1998; Mei et al., 2009; NCEPOD, 2005; PSF, 2008; Subbe & Welch, 2013). Reasons for failure to rescue events and suboptimal care were described as numerous and complex. One study pointed to the following causal factors: "communication factors; working conditions and environmental factors; task factors; education and training factors; patient factors; team and social factors; organizational factors; equipment and resource factors; and individual factors" (NPSA, 2007a, p. 12-13).

As a result of the 2001 IOM report, failure to rescue events became a patient safety indicator in many hospitals (Shever, 2011; Taenzer et al., 2011). In addition, the IHI introduced a quality improvement initiative in December 2004 called the 100,000 Lives Campaign. The purpose of the campaign was to save 100,000 lives from unnecessary death in U.S. hospitals over an 18-month period by "encouraging and helping hospitals to adopt six

evidence based interventions" (McCannon, Schall, Calkins, & Nazem, 2006, p. 1328). The first intervention, deployment of rapid response teams (RRTs), relied on early recognition of clinical deterioration coupled with a rapid response by expert clinicians (Al-Qahtani & Al-Dorzi, 2010). However, researchers noted RRTs were often activated when a patient's condition was already critical; this strategy was judged to be a reactionary response to clinical deterioration versus a preventative one (Jones, 2013; Mathukia, Fan, Vadyak, Beige, & Krishnamurthy, 2015; Page, Blaber, & Snowden, 2008). Consequently, early warning scoring (EWS) systems were developed and implemented "based on the premise that a decline in a patient's condition can be detected early through assessment of an aggregate set of critical physiologic variables" (Jones, 2013, p. 36). The combination of an EWS system with a RRT was an upgraded strategy to avert failure to rescue events and suboptimal care.

In 1997, the original EWS system was introduced in the United Kingdom consisting of five physiologic parameters: "heart rate, respiratory rate, systolic blood pressure, temperature, and consciousness level" (Mathukia et al., 2015, p. 2). By using this simple bedside scoring system, researchers believed that subtle changes in two or more parameters would enhance early recognition of clinical deterioration. Eventually, EWS system evolved and became known as modified early warning scoring (MEWS) systems as different physiologic parameters (i.e., oxygen saturation, urine output, and nursing concern) were added to the tool to enhance effectiveness (Mapp et al., 2013; Mathukia et al., 2015; Page et al., 2008; Smith, Prytherch, Schmidt, & Featherstone, 2008). The most ideal scoring system has yet to be determined or agreed upon (Gao et al., 2007).

This practice inquiry project includes three manuscripts that explore different aspects pertaining to development, implementation, and evaluation of a comprehensive MEWS system for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky. The first manuscript presents a review of the literature on effectiveness of MEWS systems in predicting clinical deterioration and improving patient outcomes in acutely ill adult patients on medical-surgical units. The second manuscript puts forward a review of the literature on educational strategies and programs to improve early recognition and management of clinical deterioration by nursing staff. Findings from both reviews provide the foundation for the development, implementation, and evaluation of a comprehensive MEWS system for this particular hospital. The third and final manuscript details the results related to the development and testing of a comprehensive MEWS system on two medical-surgical-telemetry units; education and training of nursing staff in utilization of a new MEWS system and early identification and management of clinical deterioration; and nursing satisfaction regarding education, training, and use of a new MEWS system. Although the scope of this project is limited, findings will serve as a foundation for the broader initiative. Recommendations for future studies are offered.

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Manuscript 1:

Effectiveness of Modified Early Warning Scoring Systems: An Integrative Review

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Abstract

Despite considerable emphasis on patient safety and high-quality care in U.S. hospitals for the past two decades, significant challenges remain in the early detection and treatment of clinical deterioration in adult medical-surgical patients contributing to poor patient outcomes, increased resource utilization, and increased costs. Modified early warning scoring (MEWS) systems have been used to identify patients at risk of deterioration. The aim of this study was to examine the effectiveness of MEWS systems in predicting clinical deterioration and improving patient outcomes. An integrative review of studies identified from electronic databases yielded 22 studies that met inclusion criteria: English-language only; peer-reviewed journals; date of publications between 2001 and 2016; full text only articles; quantitative and qualitative research designs; adult medical-surgical patient population; and study emphasis on the effectiveness of MEWS systems. Of the 22 studies, 8 studies were systematic reviews and 14 studies were independent investigations. Seven major themes emerged: measurement and documentation of observations; escalation of care; rapid response systems; communication; organizational supports; education and training; and evaluation, audit, and feedback. The majority of studies deemed MEWS systems beneficial and worthy of implementation despite the lack of high-level evidence to support them. Further research is needed to provide rigorous evidence in support of the validity, reliability, and utility of MEWS systems.

Keywords: early warning scoring system, EWSS, modified early warning system, MEWS, and deteriorating patient

Effectiveness of Modified Early Warning Scoring Systems: An Integrative Review

Despite considerable emphasis on patient safety and high-quality care in U.S. hospitals for the past two decades, significant challenges remain in the early detection and treatment of clinical deterioration in adult medical-surgical patients contributing to poor patient outcomes, increased resource utilization, and increased costs (Institute of Medicine [IOM], 1999, 2001, 2011; Kohn, Corrigan, & Donaldson, 2000; Mapp, Davis, & Krowchuk, 2013; National Patient Safety Agency [NPSA], 2007a, 2007b). The term "failure to rescue" has been coined to describe "the inadequate or delayed response to clinical deterioration in hospitalized patients" often resulting in avoidable disability or unexpected death (Mapp et al., 2013; Subbe & Welch, 2013, p. 6; Taenzer, Pyke, & McGrath, 2011). Patients in acute care settings are particularly vulnerable to clinical deterioration leading to medical emergencies. An estimated 10% of hospitalized patients suffer a severe adverse event with 25% of these deemed preventable (Al-Qahtani & Al-Dorzi, 2010; Kohn et al., 2000; Winters et al., 2007). In addition, failure to rescue events are estimated to cost between "$17 and $29 billion annually" (Kyriacos, Jelsma, & Jordan, 2011, p. 312).

Warning signs of subtle changes in a patient's physiologic condition may be present as early as 72 hours prior to a severe adverse event (Garvey, 2015; National Confidential Enquiry into Patient Outcome and Death [NCEPOD], 2005; Subbe & Welch, 2013). Patients regularly exhibit changes in vital signs and/or acute changes in level of consciousness (Schein, Hazday, Pena, Ruben, & Sprung, 1990). Yet these signs and symptoms go unrecognized and/or untreated. Concurrently, patient care in the hours preceding a severe adverse event is often judged to be suboptimal (Al-Qahtani & Al-Dorzi, 2010; McQuillan et al., 1998; Mei, Ying, & Fai, 2009; NCEPOD, 2005; Patient Safety First [PSF], 2008; Subbe & Welch, 2013).

Reasons for failure to rescue and suboptimal care are complex. Findings from one study pointed to the following causal factors: "communication factors; working conditions and environmental factors; task factors; education and training factors; patient factors; team and social factors; organizational factors; equipment and resource factors; and individual factors" (NPSA, 2007a, p. 12-13). In another study, researchers discovered four broad themes to describe nursing practice surrounding the issue of clinical deterioration: "recognition; recording and reviewing; reporting; and responding and rescuing" (Odell, Victor, & Oliver, 2009, p. 2000). They acknowledged that the nurse at the bedside is in an ideal position to recognize early clinical deterioration, record and analyze vital signs, complete thorough physical assessments, properly communicate and escalate concerns, and initiate corrective measures and treatments (Moldenhauer, Sabel, Chu, & Mehler, 2009; Odell et al., 2009; Shever, 2011; Subbe & Welch, 2013). A breakdown in any one area negatively impacts patient outcomes and contributes to failure to rescue events and suboptimal care.

Implementation of rapid response systems (RRSs) was one of the first strategies employed to assist in the stabilization of a deteriorating ward patient (Mathukia, Fan, Vadyak, Biege, & Krishnamurthy, 2015; McCannon, Schall, Calkins, & Nazem, 2006). RRSs, also referred to as critical care response teams (CCRTs), critical care outreach teams (CCOTs), medical emergency teams (METs), or rapid response teams (RRTs), consist of expert clinicians skilled in assessing and managing the deteriorating patient (Moon, Cosgrove, Lea, Fairs, & Cressey, 2011; NPSA, 2007b; Robb & Seddon, 2010). RRSs are typically activated for a single, drastic change in a patient's

condition such as complaints of acute dyspnea or changes in level of consciousness (Al-Qahtani & Al-Dorzi, 2010; Duncan, McMullan, & Mills, 2012; Mathukia et al., 2015; McCannon, Hackbarth, & Griffin, 2007; Winters et al., 2007). By the time the RRS is activated, a patient's condition is likely critical, necessitating emergency intervention. This process is more reactionary and less preventive, hence, negating the goals of early identification and prompt treatment of clinical deterioration (Mathukia et al., 2015; Page, Blaber, & Snowden, 2008).

In an effort to improve processes and patient outcomes, early warning scoring (EWS) systems, also known as track and trigger systems, were developed to augment pre-established RRSs (Bunkenborg, Poulsen, Samuelson, Ladelund, & Akeson, 2016; Gao et al., 2007; Jones, 2013; Mathukia et al., 2015). "EWS systems are based on the premise that a decline in a patient's condition can be detected early through the assessment of an aggregate set of critical physiologic variables" (Jones, 2013, p. 36). The primary purpose of EWS systems is to alert the nurse to patients at high-risk for clinical deterioration; secondary goals include reducing severe adverse events such as cardiopulmonary arrest and death. The original EWS system was introduced in 1997 as a multi-parameter assessment tool consisting of five physiologic parameters: "heart rate, respiratory rate, systolic blood pressure, temperature, and consciousness level" (Mathukia et al., 2015, p. 2). Eventually, EWS systems evolved and became known as modified early warning scoring (MEWS) systems as different parameters (e.g., oxygen saturation, urine output, and nursing concern) were added to the tool to improve its predictability of patient outcomes (Mapp et al., 2013; Mathukia et al., 2015; Page et al., 2008; Smith, Prytherch, Schmidt, & Featherstone, 2008).

A key feature of MEWS systems is the routine collection of data, the physiologic parameters, from patients during the course of their hospitalization. Nurses are accustomed to obtaining vital signs and completing physical assessments (Gao et al., 2007; Mapp et al., 2013; Maupin, 2010). A MEWS tool helps to quantify the physiologic variables by assigning a score to each variable in a weighted manner. A score of zero is given to normal values (Mapp et al., 2013). A higher MEWS alerts the nurse to deviations in vital parameters, thus prompting early recognition and management of clinical deterioration (Mapp et al., 2013; Roney et al., 2015). A MEWS tool is often coupled with an algorithm that outlines appropriate nursing action based on the score. For example, a MEWS protocol may indicate that the nurse needs to reassess the patient, monitor vital signs more frequently, or activate the RRS. The urgency of the response depends on the score and predetermined call-out algorithm (Drower, McKeany, Jogia, & Jull, 2013; Jones, 2013; Nishijima et al., 2016; PSF, 2008; Royal College of Physicians [RCP], 2012).

Failure to rescue events and suboptimal care are well documented in the literature (IOM, 1999, 2001, 2011; Kohn et al., 2000; Mapp et al., 2013; NPSA, 2007a, 2007b; Subbe & Welch, 2013; Taenzer et al., 2011). MEWS tools may help to prevent these phenomena and improve patient outcomes (Bunkenborg et al., 2016; Gao et al., 2007; Jones, 2013; Mathukia et al., 2015; McCannon et al., 2006). This integrative review will examine the effectiveness of MEWS systems in predicting clinical deterioration and improving patient outcomes in acutely ill adult patients on medical-surgical units. Findings will guide the development, implementation, and evaluation of a comprehensive MEWS system for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky. In the continued effort to improve patient safety and quality of care, future research may be directed towards the standardization of MEWS systems.

Scope of the Review

An integrative review of published literature was conducted to study the effectiveness of MEWS systems in predicting clinical deterioration and improving patient outcomes in acutely ill adult patients on medical-surgical units. The review was not limited by research design or literature type (empirical or theoretical). Instead, this integrative review was broad and focused on methodology (experimental and non-experimental), theory, and results in order to enhance understanding of complex nursing concepts such as failure to rescue and suboptimal care (Whittemore & Knafl, 2005). The literature related to the effectiveness of MEWS systems was examined and summarized using the original framework and an updated methodology for conducting integrative reviews (Cooper, 1982; Whittemore & Knafl, 2005).

Problem Formulation

The leading question for this integrative review was "How effective were MEWS systems in predicting clinical deterioration and improving patient outcomes?" A secondary question was "How did MEWS systems impact resource utilization such as RRS activation and unexpected transfers to the intensive care unit (ICU)?" Studies were selected based on the following inclusion criteria: English-language only articles from peer-reviewed journals; date of publications between 2001 and 2016 (15 years); full text only articles; quantitative and qualitative research designs; adult medical-surgical patient population; and study emphasis on the effectiveness of MEWS systems. Exclusion criteria included studies that focused on the following: specific patient populations (e.g., pediatric, obstetric, and psychiatric patient populations); patients located in areas outside of medical-surgical units (e.g., emergency departments, ICUs, same day surgical units, outpatient areas, and community locations); disease specific MEWS systems (e.g., sepsis, heart failure, and pulmonary disease scoring systems); participants other than nursing staff on medical-surgical units (e.g., undergraduate nursing students and consumers); and specific topics without mention of MEWS system effectiveness (e.g., educational strategies and compliance).

Data Search

Data sources for available literature pertaining to the effectiveness of MEWS systems included a search of the following electronic databases: The Cochrane Library, PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and MEDLINE. Additional articles and resources were retrieved from the Institute for Healthcare Improvement (IHI) and from a hand search of all review article reference lists. The following key words and abbreviations were used: early warning scoring system, EWSS, modified early warning system, MEWS, and deteriorating patient. Twenty-two articles met criteria for this integrative review providing a comprehensive representation of research on this subject.

Data Evaluation

The author conducted an initial data evaluation by systematically reviewing all article titles and abstracts. Articles meeting inclusion criteria were then read in full and extensively examined. Each study was analyzed for study design, sample, purpose, findings, limitations/comments, and level of evidence (see Table 1 for an overview of studies and Table 2 for a rating system for the hierarchy of evidence). Questionable studies were reevaluated by the

author. An overwhelming majority of studies selected for this integrative review was observational studies; the number of randomized controlled trials (RCTs) was limited.

Data Analyses and Interpretation

Data from twenty-two studies were extracted and transferred to an evidence table. The content was studied and comparisons were made in terms of the following: specific study aims and objectives; research designs; sample characteristics to include inclusion and exclusion criteria; outcome measures; quantitative findings; limitations; overarching themes; subthemes; barriers and facilitators; impact; conclusions; and direction of future research. The information was categorized, data were conceptualized, broad themes emerged, and gaps were identified. Although this safety initiative has been greatly researched and promoted, the overall strength of the evidence supporting the effectiveness of MEWS systems was lacking.

Review Presentation

The evidence table displayed pertinent data from each study, facilitating the synthesis and summarization of study findings. Complexity of the nursing concepts of failure to rescue and suboptimal care were revealed, as were the proposed solutions of RRSs and MEWS systems. Seven broad themes emerged that helped to organize the findings and are presented here.

Findings

A total of twenty-two studies was identified and met the eligibility criteria for this integrative review. Eight studies were classified as systematic reviews (Gao et al., 2007; Johnstone, Rattray, & Myers, 2007; Kyriacos et al., 2011; Mapp et al., 2013; McArthur-Rouse, 2001; McGaughey et al., 2007; Roney et al., 2015; Smith et al., 2014) and fourteen studies were independent investigations (Drower et al., 2013; Duncan et al., 2012; Finlay, Rothman, & Smith, 2014; Huggan et al., 2015; Kim et al., 2015; Kyriacos, Jelsma, James, & Jordan, 2015; Kyriacos, Jelsma, & Jordan, 2014; Ludikhuize et al., 2014; Mathukia et al., 2015; Mitchell et al., 2010; Nishijima et al., 2016; Perera et al., 2011; Prytherch, Smith, Schmidt, & Featherstone, 2010; and Stewart, Carman, Spegman, & Sabol, 2014). Of the systematic reviews, three were categorized as meta-analyses (Level I evidence) and five were tagged as systematic reviews of descriptive studies (Level V evidence). A total of 144 studies was evaluated between the eight different systematic reviews. Remaining studies yielded the following: one randomized controlled trial (Level II evidence), one controlled trial without randomization (Level III evidence), eleven case control or cohort studies (Level IV evidence), and one expert opinion or consensus (Level VII evidence). No qualitative or descriptive studies (Level VI evidence), strictly speaking, were included. Of independent studies, seven were retrospective in nature (see Table 1).

Settings for various research studies included Australia, Japan, the Netherlands, New Zealand, South Africa, South Korea, Sri Lanka, the United Kingdom, and the United States. Medical and nursing disciplines contributed, both independently and collaboratively. Evaluation of research spanned fifteen years, providing an in-depth look at the effectiveness of MEWS systems over time. Studies described unique scoring systems such as the adult deterioration detection system (ADDS), EWS systems, MEWS systems, patient at-risk score (PARS), Rothman Index, track and trigger systems (TTs), and VitalPAC™ EWS (ViEWS). A majority of studies reported MEWS systems that included the original physiologic variables of four vital signs and one neurological assessment:

"heart rate, respiratory rate, systolic blood pressure, temperature, and level of consciousness" (Mathukia et al., 2015, p. 2). Many included additional physiologic parameters such as oxygen saturation, urine output, seizure activity, color change, pain, and biomarker results. The number of physiologic variables across all studies ranged from five to thirty-two parameters (see Table 3 for a list of each study's physiologic parameters). Nursing intuition was calculated in two MEWS systems under the heading of "nursing concern". Despite similarities across systems, scoring structures; trigger points; sensitivity and specificity; and call-out algorithms varied.

Objectives of each of the studies in this review were comparable. However, many studies incorporated unique aims (e.g., to discuss organizational impact or to evaluate the implementation of a specific protocol like mandatory MEWS documentation every eight hours). Several studies described the different MEWS systems and their development, implementation, and evaluation processes (Duncan et al., 2012; Gao et al., 2007; Kyriacos et al., 2011; Mathukia et al., 2015; Prytherch et al., 2010). A majority reviewed the existing evidence "on the reliability, validity, and utility of existing systems" (Gao et al., 2007, p. 667; Huggan et al., 2015; Kyriacos et al., 2011; Mapp et al., 2013; Perera et al., 2011; Roney et al., 2015). Gao et al. (2007) reported on the sensitivity, positive predictive value, specificity, and negative predictive value of different MEWS models, while Prytherch, Smith, Schmidt, and Featherstone (2010) validated an aggregate weighted track and trigger system (AWTTS) using 35,585 patient episodes. Many studies focused on the impact of MEWS systems in terms of certain patient outcomes (e.g., delays in care, in-hospital cardiac arrest, length of hospital stay, ICU transfer, and mortality). The methodology across all studies varied. Overall findings were summarized and seven broad themes emerged pertaining to the effectiveness of MEWS systems: measurement and documentation of observations; escalation of care; RRSs; communication; organizational supports; education and training; and evaluation, audit, and feedback (National Clinical Effectiveness Committee [NCEC], 2013).

Measurement and Documentation of Observations

Researchers agreed that accurate measurement and documentation of vital signs were critical for MEWS systems to be effective in signaling clinical deterioration (Gao et al., 2007; Kyriacos et al., 2015; Kyriacos et al., 2011, 2014; Mapp et al., 2013; Mitchell et al., 2010; Smith et al., 2014). Abnormalities in physiologic parameters had a strong predictive ability in terms of patient outcomes such as cardiac arrest and in-hospital mortality (Gao et al., 2007; Huggan et al., 2015; Kim et al., 2015; Kyriacos et al., 2011; Nishijima et al., 2016; Perera et al., 2011; Roney et al., 2015; Smith et al., 2014). One study reported a lack of vital sign observations and documentation in the eight hours leading up to severe adverse events (Mapp et al., 2013). Kyriacos, Jelsma, and Jordan (2014) described similar results whereby, "No patients' records contained recordings for all seven parameters displayed on the MEWS" (p. 1). Hence, no observations meant no MEWS to assist in alerting the nurse to patients at-risk for clinical deterioration. Other studies determined respiratory rate to be the most sensitive physiologic parameter in predicting clinical deterioration; respiratory rate was also the most poorly assessed vital sign (Kim et al., 2015; Kyriacos et al., 2011, 2014). Others stressed the importance of electronic medical record (EMR) utilization for real-time input of vital signs. They argued that automatic MEWS calculations incorporated into EMRs would potentially reduce human calculation errors, allow for automatic alerts, and improve clinical response times (Duncan et al., 2012; Finlay et al., 2014; Kyriacos et al., 2015; Ludikhuize et al., 2014; Mapp et al., 2013; Smith et al., 2014). Key factors

to patient safety and MEWS tool effectiveness were directly linked to accurate measurement, documentation, and trending of patient observations by nursing staff on general wards (Gao et al., 2007; Kyriacos et al., 2015; Kyriacos et al., 2011, 2014; Mapp et al., 2013; Mitchell et al., 2010; Smith et al., 2014).

Escalation of Care

Effectiveness of MEWS tools was directly related to organizations that had incorporated protocols for the escalation of care as part of their plan for managing clinical deterioration. Essentially, these protocols "allow for a graded response commensurate with the level of abnormal physiological measurements, changes in physiological measurements, or other identified deterioration" and may include frequent vital sign monitoring, specific nursing interventions, activation of the RRS, or transfer of the patient to ICU (NCEC, 2013, p. 9). Several studies in this integrative review provided examples of clear escalation protocols, also referred to as call-out algorithms (Duncan et al., 2012; Gao et al., 2007; Kyriacos et al., 2011; Mathukia et al., 2015; Nishijima et al., 2016; Smith et al., 2014). Others declared their vital role in MEWS system effectiveness (Kyriacos et al., 2015; Kyriacos et al., 2011; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015). An escalation protocol was seen as critical in care of the deteriorating patient (NCEC, 2013).

Rapid Response Systems

The Institute for Healthcare Improvement (IHI) was one of the first organizations to strongly advocate for the adoption and implementation of RRTs across the U.S.; they sought to make an immediate impact on safety for general ward patients with this strategy (Duncan et al., 2012). Despite a lack of robust evidence demonstrating their effectiveness, RRTs were widely endorsed and implemented (Duncan et al., 2012; Winters et al., 2007). In this integrative review, a majority of studies made reference to RRSs in the various escalation protocols (Drower et al., 2013; Duncan et al., 2012; Gao et al., 2007; Huggan et al., 2015; Johnstone et al, 2007; Kyriacos et al., 2011; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; McArthur-Rouse, 2001; Mitchell et al., 2010; Nishijima et al., 2016; Roney et al., 2015; Smith et al., 2014; Stewart et al., 2014). In evaluating MEWS tool effectiveness, some studies measured RRS utilization as an outcome (Johnstone et al., 2007; Kyriacos et al., 2011; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; Mitchell et al., 2010; Roney et al., 2015; Smith et al., 2014; Stewart et al., 2014). One research study reported the number of RRT calls was doubled post-MEWS implementation. This was seen as a positive outcome as increased RRT utilization was associated with a decline in severe adverse events (Ludikhuize et al., 2014). Mitchell et al. (2010) experienced similar results post-intervention as medical emergency team (MET) utilization increased, while transfers to ICU and in-hospital deaths decreased. In another study, Nishijima et al. (2016) described a MEWS system that did not have an official RRS due to a lack of human resources. However, their call-out algorithm included a response by an attending physician and an ICU nurse (Nishijima et al., 2016). Overall, researchers acknowledged the link between MEWS tool effectiveness and RRSs. The nurse's recognition of clinical deterioration was considered essential, however; the response and rescue aspects of the protocol were believed to be equally critical in terms of improved patient outcomes (Drower et al., 2013; Duncan et al., 2012; Gao et al., 2007; Huggan et al., 2015; Johnstone et al, 2007; Kyriacos et al., 2011; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; McArthur-Rouse, 2001; Mitchell et al., 2010; Nishijima et al., 2016; Roney et al., 2015; Smith et al., 2014; Stewart et al., 2014).

Communication

Interdisciplinary communication and teamwork were cited as important factors impacting MEWS tool effectiveness (NCEC, 2013). Ability of the nurse to convey the appropriate level of concern for a patient's clinical deterioration was associated with patient outcomes (Classen, 2010; Endacott, Kidd, Chaboyer, & Edington, 2007; Subbe & Welch, 2013). In this integrative review, several studies identified poor communication as a significant factor contributing to failure to rescue events and suboptimal care (Drower et al., 2013; Duncan et al., 2012; Johnstone et al, 2007; Kyriacos et al., 2011; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; Mitchell et al., 2010; Stewart et al., 2014). Mitchell et al. (2010) explained that MEWS systems actually provided a framework to assist nursing staff in being able to effectively communicate patient concerns. Similarly, other studies reported improved interdisciplinary communication as MEWS tools provided sound evidence for the nurse to frame patient concerns (Mapp et al., 2013; Mathukia et al., 2015; Stewart et al., 2014). Utilization of a structured communication tool was seen as a key element for an effective MEWS system; ISBAR (Identify, Situation, Background, Assessment, and Recommendation) was identified as one such tool (NCEC, 2013).

Organizational Supports

MEWS system effectiveness was closely related to organizational supports (NCEC, 2013). Administrative leadership, hospital culture, strategic planning, committee involvement, protocol development, and information technology (IT), all had an influence on the reported success and sustainability of MEWS systems. A few of the studies in this integrative review addressed this directly, while others implied its significance by describing the process of developing, implementing, and evaluating a MEWS system (Drower et al., 2013; Duncan et al., 2012; Finlay et al., 2014; Johnstone et al, 2007; Kyriacos et al., 2015; Kyriacos et al., 2014; Ludikhuize et al., 2014; Mathukia et al., 2015; McArthur-Rouse, 2001; Mitchell et al., 2010; Nishijima et al., 2016; Roney et al., 2015; Stewart et al., 2014).

Education and Training

Education and training of nursing staff regarding recognition and management of clinical deterioration were determined to be fundamental to ensuring MEWS system effectiveness (NCEC, 2013). Researchers agreed that MEWS tools were simply adjunctive assessment tools and regarded nursing clinical judgment as essential (Gao et al., 2007; Johnstone et al., 2007; Kyriacos et al., 2015; Kyriacos et al., 2011; Ludikhuize et al., 2014; Smith et al., 2014). A number of studies reported formal educational programs as part of MEWS system implementation (Johnstone et al., 2007; Kyriacos et al., 2015; Ludikhuize et al., 2014; McArthur-Rouse, 2001; McGaughey et al., 2007; Mitchell et al., 2010). Others reported varied educational preparation in terms of the following: content (e.g., how to calculate a MEWS, how to assess clinical deterioration, and how to document a MEWS), course format (e.g., online, classroom, or hybrid), session timeframes (e.g., 30 minutes, two weeks, or six months), and targeted staff (e.g. physicians, medical-surgical nurses, and/or ICU nurses). Researchers noted that staff training, competency, and teamwork were essential for appropriate MEWS protocol implementation. Johnstone, Rattray, and Myers (2007) commented that EWS systems were not used to their fullest potential and stressed that education and training should be mandated as part of EWS system implementation.

Evaluation, Audit, and Feedback

Evaluation, audit, and feedback were deemed essential to the process of implementing MEWS systems. Monitoring compliance and measuring patient outcomes were often targeted as the outcomes/impacts to help define MEWS system effectiveness (NCEC, 2013). All studies in this integrative review defined individual study outcomes and described methods utilized to examine and evaluate the results. Although similarities existed between studies, each study varied in some aspect of the evaluation process. For example, Kyriacos, Jelsma, James, and Jordan (2015) evaluated the implementation of a MEWS system. They concluded that more education and training were needed to enhance protocol compliance; the lack of compliance was perceived to diminish MEWS system effectiveness. The primary focus of another study was the impact of a MEWS system on the incidence of in-hospital cardiac arrests (Drower et al., 2013). This very specific outcome was used to determine MEWS system utility in one hospital. Of twenty-two studies, most concluded that MEWS systems were beneficial in assisting nursing personnel in early identification of clinical deterioration (Drower et al., 2013; Duncan et al., 2012; Huggan et al., 2015; Johnstone et al, 2007; Kim et al., 2015; Kyriacos et al., 2011, 2014; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; Mitchell et al., 2010; Nishijima et al., 2016; Perera et al., 2011; Prytherch et al., 2010; Smith et al., 2014; Stewart et al., 2014). Few studies provided detailed feedback from nursing and medical staff regarding MEWS system implementation and impact. Ongoing evaluation, audit, and feedback were considered central to determining MEWS system effectiveness (NCEC, 2013).

Discussion and Implications for Clinical Practice

In theory, the pairing of RRSs and MEWS systems creates a more effective process for identifying and managing early clinical deterioration in vulnerable ward patients (Jones, 2013). However, the validity, reliability, and utility of both RRSs and MEWS systems have been questioned (Gao et al., 2007; Johnstone et al., 2007; Kyriacos et al., 2011; McGaughey et al., 2007; Roney et al., 2015; Smith et al., 2014). In particular, MEWS systems have been widely promoted and adopted without clear evidence of benefit in terms of patient outcomes (Roney et al., 2015; Smith et al., 2014). More robust research is needed to evaluate the effectiveness of these systems: the current body of evidence is primarily derived from observational studies (Gao et al., 2007; Huggan et al., 2015; Johnstone et al., 2007; Kyriacos et al., 2011; McGaughey et al., 2007; Roney et al., 2015; Smith et al., 2014).

Determining the effectiveness of MEWS systems is a real challenge for many reasons. As mentioned, a lack of rigorous evidence exists (Gao et al., 2007; Johnstone et al., 2007; Kyriacos et al., 2011; McGaughey et al., 2007; Roney et al., 2015; Smith et al., 2014). Furthermore, a variety of MEWS systems have been developed and tailored to meet the needs of hospitals and their specific patient populations (Gao et al., 2007; Mapp et al., 2013). Whilst similar in many ways, MEWS systems often vary in the following: physiologic parameters; scoring structures; trigger points; sensitivity and specificity; and call-out algorithms (Kyriacos et al., 2011; Roney et al., 2015). Therefore, it is difficult to compare outcomes or generalize findings when significant heterogeneity is present (Jones, 2013). Additionally, effectiveness of MEWS systems is directly influenced by the same factors that contribute to failure to rescue events and suboptimal care such as “communication factors; working conditions and environmental factors; task factors; and education and training factors” (NPSA, 2007a, p. 12-13). A problem with one or more of these factors can diminish any advantage MEWS systems might lend in alerting the nurse to clinical

deterioration (Hogan, 2006; McArthur-Rouse, 2001; NPSA, 2007a; Odell, 2014; Odell et al., 2009). In summary, the task of determining the effectiveness of MEWS systems is complicated by the lack of robust research to support them, the diversity of MEWS systems in use, and the multiple factors that influence clinical outcomes.

Failure to rescue events and suboptimal care in acutely ill adult patients on medical-surgical units are well documented in the literature (IOM, 1999, 2001, 2011; Kohn et al., 2000; Mapp et al., 2013; NPSA, 2007a, 2007b; Subbe & Welch, 2013; Taenzer et al., 2011). The strategy to employ RRSs and MEWS systems to detect and manage clinical deterioration is logical (Bunkenborg et al., 2016; Gao et al., 2007; Jones, 2013; Mathukia et al., 2015; McCannon et al., 2006). Although not supported by high-level evidence, MEWS systems are deemed beneficial and worthy of implementation; findings from numerous observational studies regard the use of MEWS systems as feasible in terms of identifying patients at risk for severe adverse events (Cei, Bartolomei, & Mumoli, 2009; De Meester et al., 2012; Duncan et al., 2012; Gardner-Thorpe, Love, Wrightson, Walsh, & Keeling, 2006; Huggan et al., 2015; Kim et al., 2015; Kyriacos, Jelsma, & Jordan, 2014; Ludikhuize et al., 2014; Ludikhuize, Smorenburg, de Rooij, & de Jonge, 2012; Mapp et al., 2013; Mathukia et al., 2015; Odell, 2014; Perera et al., 2011; Subbe, Davies, Williams, Rutherford, & Gemmell, 2003).

Strengths and Limitations

A majority of studies in this integrative review reported positive patient outcomes related to adoption and implementation of a MEWS system. A reduction in delays in care, in-hospital cardiac arrests, lengths of hospital stay, ICU transfers, and/or mortality rates were observed in many of the studies (Drower et al., 2013; Duncan et al., 2012; Huggan et al., 2015; Johnstone et al, 2007; Kim et al., 2015; Kyriacos et al., 2011, 2014; Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; Mitchell et al., 2010; Nishijima et al., 2016; Perera et al., 2011; Prytherch et al., 2010; Smith et al., 2014; Stewart et al., 2014). Researchers emphasized the need to improve patient safety and identified MEWS systems as one way to support this initiative. MEWS systems continue to be widely adopted and studied.

Study design remained a major limitation in evaluation of the effectiveness of MEWS systems; a majority of studies in the systematic reviews and independent investigations were observational in nature. A lack of robust evidence existed to support “the reliability, validity, and utility” of MEWS systems (Gao et al., 2007, p. 667; Kim et al., 2015; McArthur-Rouse, 2001; Smith et al., 2014). Researchers acknowledged the great heterogeneity in MEWS systems from one hospital to the next, making it difficult to compare results and generalize findings. They also concluded that MEWS system effectiveness was dependent upon many factors to include nursing knowledge and skill, communication, and timeliness of response (Gao et al., 2007; Johnstone et al., 2007; Kyriacos et al., 2015; Kyriacos et al., 2011; Ludikhuize et al., 2014; Mapp et al., 2013; Smith et al., 2014; Stewart et al., 2014).

MEWS system effectiveness was also impacted by patients who regularly fell out of the normal physiologic ranges set forth by MEWS system protocol. For example, a patient with chronic obstructive pulmonary disease (COPD) may have a baseline oxygen saturation of 90% on two liters of oxygen and/or a respiratory rate of 22 breaths per minute. Likewise, the patient with atrial fibrillation may have a heart rate of 110 beats per minute, consistently. Researchers suggested MEWS system protocol needed to address such situations whereby a MEWS

alert occurred, but the patient was in stable condition (Gao et al., 2007; Perera et al., 2011; Roney et al., 2015). False alarms were noted to have potential to exhaust limited resources (Duncan et al., 2012; Mathukia et al., 2015).

Implications for Future Research

Further research is needed to provide rigorous evidence in support of the validity, reliability, and utility of MEWS systems. More specifically, research is needed to evaluate MEWS tool scoring structures, trigger points, sensitivity and specificity, and clinical pathways (Gao et al., 2007; Johnstone et al., 2007; Kyriacos et al., 2011; McGaughey et al., 2007; Roney et al., 2015; Smith et al., 2014). In addition, studies are needed to evaluate the accurate measurement and documentation of vital signs, education of ward staff, measurement of patient outcomes different from cardiac arrest, and measurement of patient outcomes across different patient populations (Ludikhuize et al., 2014; McArthur-Rouse, 2001; Roney et al., 2015; Smith et al., 2014; Stewart et al., 2014).

In an effort to address the questions about "the reliability, validity, and utility" of MEWS systems, Ireland and the United Kingdom developed and implemented their own national early warning scoring (NEWS) systems (Gao et al., 2007, p. 667; NCEC, 2013; RCP, 2012). NEWS systems offer standardization in assessment and management of clinical deterioration and inherently provide data that can be compared and evaluated across hospital systems. Education and training are considered key components to NEWS system effectiveness and sustainability (NCEC, 2013; RCP, 2012). Future studies on NEWS system effectiveness in terms of patient safety and improved patient outcomes are anticipated.

Conclusions

Knowledge gained from this integrative review can guide the development, implementation, and evaluation of a comprehensive MEWS system. Despite the need for more robust research, a majority of researchers regarded MEWS systems as beneficial and effective in detecting early clinical deterioration and predicting severe adverse events in their specific settings. MEWS systems were perceived to be valuable adjunctive assessment tools to enhance nursing knowledge and skill for greater goals of improved patient safety and improved patient outcomes.

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Table 1.1 Overview of Studies

Reference Information	Design	Sample	Purpose	Findings	Limitations and Comments	Level
Drower, D., McKeany, R., Jogia, P., & Jull, A. (2013). Evaluating the impact of implementing an early warning score system on incidence of in-hospital cardiac arrest. *Journal of the New Zealand Medical Association, 126*(1385), 26-34. Medical New Zealand	Retrospective, single center, pre-post cohort observational study	Before and after retrospective assessment of EWS system implementation focusing on patient outcome of in-hospital cardiac arrest. Data collection 12-months prior to and 12-months post-EWS implementation (April 1, 2009 through March 31, 2011).	Study impact of EWS implementation on the incidence of in-hospital cardiac arrest in adult patient population.	▪ Total of 621 emergency calls made in 24-month period with 324 occurring pre-EWS and 297 occurring post-EWS – no significant increase. ▪ Of 621 emergency calls, 168 were cardiac arrests, 199 deemed medical emergencies, and 254 had incomplete records. ▪ Cardiac arrests decreased from 8.5 arrests/month pre-EWS to 5.5 arrests/month post-EWS. ▪ Cardiac arrest incidence rate per 1000 admissions decreased from 4.67 pre-EWS to 2.91 post-EWS.	▪ Adult Deterioration Detection System (ADDS) included the following variables: level of consciousness, respiratory rate, oxygen flow rate, oxygen saturation, heart rate, systolic blood pressure, temperature, and 4-hour urine output. ▪ In-hospital cardiac response team already in place. ▪ Combination of EWS implementation plus in-hospital cardiac response team decreased cardiac arrest incidence. ▪ Single-center study with retrospective, observational design.	IV
Duncan, K. D., McMullan, C., & Mills, B. M. (2012). Early warning systems: The next level of rapid response. *Nursing 2012, 42*(2), 38-44. Nursing United States	Expert opinion	Not applicable.	Describe key points in the implementation of EWSS and provide an example of one hospital's experience with EWSS implementation.	▪ Rapid Response Teams (RRT) and EWSS improve patient outcomes in terms of decreased cardiac arrests and transfers to ICU. ▪ RRT calls were increased and Code Blue calls were decreased. ▪ Automatic notification of RRT director for patients with a MEWS $\geq$ 4 deemed valuable in early detection of deterioration and prevention of catastrophic event. ▪ Mortality and length of stay not impacted by RRT and	▪ RRT were identified as one strategy by the Institute for Healthcare Improvement (IHI) to improve patient outcomes, but typically triggered by one major change in a patient's condition. ▪ EWSS may help identify patients at risk of deterioration prior to a catastrophic event. ▪ Stony Brook University MEWS included respiratory rate, heart rate, systolic blood pressure, conscious	VII

				MEWS in early evaluations at Stony Brook University Hospital. ▪ Ongoing evaluation of MEWS continues with the belief that standardization of an acuity assessment and communication method increases reliability in the delivery of patient care.	level (AVPU), and temperature. ▪ Stony Brook University MEWS with treatment algorithm. ▪ Input of vital signs into EMR for real-time MEWS is not an easy task. ▪ Nursing staff still criticized for RRT calls.	
Finlay, G. D., Rothman, M. J., & Smith, R. A. (2014). Measuring the Modified Early Warning Score and the Rothman Index: Advantages of utilizing the electronic medical record in an early warning system. *Journal of Hospital Medicine, 9*(2), 116-119. Medical United States	Retrospective, single center, cohort observational study	Retrospective review of data from patient records from July 2009 through June 2010 (n=1,794,910). Inclusion criteria included patients ≥ 18 years of age and charts with adequate data to compute the Rothman Index (RI). Exclusion criteria included obstetric and psychiatric patients.	Compare the MEWS with the RI in terms of predictability of in-hospital death within 24 hours.	▪ RI with superior detection of 24-hour mortality versus MEWS. ▪ Early clinical deterioration may be overlooked by using the limited MEWS (4 vital signs and a neurological check). ▪ RI addresses changing acuity level of patient and incorporates additional assessment pieces that are already being recorded in the electronic medical record (EMR).	▪ RI included 26 variables that are routinely assessed and documented in the EMR to include vital signs, lab results, cardiac rhythms, and nursing assessments. ▪ MEWS included systolic blood pressure, temperature, respiratory rate, heart rate, and level of consciousness (AVPU score). ▪ Study limited by retrospective design, single-institution setting, and EMR condition. ▪ Automatic calculation of MEWS beneficial in reducing calculation errors and providing real-time scores.	IV
Gao, H., McDonnell, A., Harrison, D. A., Moore, T., Adam, S., Daly, K., . . . Harvey, S. (2007). Systematic review and evaluation of physiological track	Systematic review	Review of 36 papers from 1990 to 2007. Inclusion criteria included full text, English-only papers and adult inpatients on	Describe track and trigger warning systems (TTs); identify the reliability, validity, and effectiveness of TTs; and determine best TTs for early	▪ Measured outcomes varied from study to study to include the following: hospital mortality, ICU admission, 30-day mortality, ICU and HDU admission, CPR, 60-day mortality, or some combination of the above.	▪ Authors suggested that TTs be used as an adjunctive assessment tool to clinical judgment. ▪ With low sensitivity, chances greater that patients experiencing deterioration more likely to be missed.	I

and trigger warning systems for identifying at-risk patients on the ward. *Intensive Care Medicine*, *33*(4), 667-679. Medical United Kingdom		units outside of critical care areas (ward patients). Exclusion criteria included patients < 12 years old and studies with missing data or lack of patient outcome summary.	identification and treatment of the deteriorating ward patient.	▪ Validity of TTs in question due to lack of rigorous evidence to support. ▪ Sensitivity and positive predictive value of the different studies were low. ▪ Specificity and negative predictive value of the different studies were acceptable. ▪ Benefits of TTs rely upon accurate measurement and documentation of vital signs/physiological parameters. ▪ Hospitals developed individualized TTs to fit their specific hospital needs. ▪ The data does not support the determination of the best TTs.		
Huggan, P. J., Akram, F., Er, B. H., Christen, L. S., Weixian, L., Lim, V., . . . Merchant, R. A. (2015). Measures of acute physiology, comorbidity, and functional status to differentiate illness severity and length of stay among acute general medical admissions: A prospective cohort study. *Internal Medicine Journal*, *45*(7), 732-740. Medical	Prospective, single center, cohort observational study	Admissions to two general medical wards assessed over a 2-month period (n=398). Data collection included the following: demographics, diagnoses, co-morbid conditions, MEWS, transfers to ICU, length of hospital stay, and deaths.	Investigate whether or not common assessment tools can predict patient outcomes in terms of transfers to the ICU, length of hospital stay, and deaths.	▪ High MEWS ($\geq$ 5) associated with ICU transfers or death. ▪ Systolic blood pressure $\leq$ 100 mm Hg and respiratory rate > 20 breaths per minute independently linked to ICU transfers or death. ▪ Excess length of stay in-hospital was associated with functional status (referring to frail elderly that often present with both infection and delirium leading to impaired functional capacity) and level of consciousness – they were independent predictors of LOS in this study.	▪ Small prospective cohort sample from one hospital. ▪ Overall, the use of MEWS and similar assessment tools is feasible in the early identification of the deteriorating ward patient. ▪ Other strategies combined with MEWS may benefit early detection of the deteriorating ward patient. ▪ More research is needed in the evaluation of clinical pathways and MEWS in the deterioration of patients hospital-wide. ▪ More research and resources needed to identify the patient at risk for prolonged LOS.	IV

Singapore						
Johnstone, C. C., Rattray, J., & Myers, L. (2007). Physiological risk factors, early warning scoring systems, and organizational changes. *Nursing in Critical Care, 12*(5), 219-224. Nursing United Kingdom	Systematic review of descriptive studies	Review of 35 papers between 1997 and 2007. Search broadened to include both older and relevant papers.	Review literature to determine the risk factors associated with acute patient deterioration, to assess the use of track and trigger systems, and to determine the role of outreach teams.	▪ Track and trigger systems (EWS) not utilized to their full potential, therefore, impact of EWS systems is unknown. ▪ Studies suggest poor rigor in the development of both EWS systems and outreach teams. ▪ Must consider development of EWS and outreach teams in context of local requirements.	▪ Nursing clinical judgment remains paramount and cannot be replaced. ▪ EWS systems are decision-making tools to assist in the detection of the deteriorating patient. ▪ More research is needed to determine the effectiveness of EWS systems in terms of physiological variables that may trigger a response or referral.	V
Kim, W. Y., Shin, Y. J., Lee, J. M., Huh, J. W., Koh, Y., Lim, C., & Hong, S. B. (2015). Modified Early Warning Score changes prior to cardiac arrest in general wards. *PLOS ONE, 10*(6), e0130523. Medical South Korea	Retrospective, single center, cohort observational study	Retrospective review of data from patient records on a general ward between March 2009 and February 2013. Focus was MEWS calculated at 24-hours, 16-hours, and 8-hours leading up to in-hospital cardiac arrest (n=380). Inclusion criteria included adult patients > 18 years of age who	Determine whether or not MEWS was effective in identifying patients at risk for cardiac arrest by noting MEWS at 24-, 16-, and 8-hours prior to cardiac arrest and if mortality was associated with changes in MEWS.	▪ Average MEWS at 24-hours was 2.0. ▪ Average MEWS at 16-hours was 2.0. ▪ Average MEWS at 8-hours was 3.0. ▪ With cardiac arrests with MEWS (n=380), compared increasing MEWS group (n=178) to non-increasing MEWS group (n=202). ▪ Characteristics between the two groups were not significantly different in terms of age, gender, co-morbidities, etc. ▪ 46.8% of patients demonstrated an increased MEWS in the 24-hours leading up to cardiac arrest.	▪ Three MEWS risk groups were identified to include low: $\leq$ 2, intermediate: 3-4, and high: $\geq$ 5. ▪ MEWS included systolic blood pressure, heart rate, respiratory rate, temperature, and neurological (AVPU). ▪ MEWS is a simple and beneficial risk management tool in detecting the deteriorating patient on a ward. ▪ Because in-hospital mortality not associated with increasing MEWS, monitoring of MEWS alone may not be enough to predict in-hospital cardiac arrest. ▪ Single-center study with 24-hour medical emergency	IV

		were monitored and resuscitated. Exclusion criteria included incomplete records and Do Not Resuscitate orders.		▪ 45.3% still had low MEWS in the 8-hours leading up to cardiac arrest. ▪ In-hospital mortality not associated with increasing MEWS. ▪ In-hospital mortality is associated with MEWS itself in 24-hours prior to cardiac arrest.	team in academic hospital – not generalizable. ▪ Not able to analyze predictive power of MEWS for cardiac arrest – no control group. ▪ Respiratory rate poorly assessed in electronic medical records. ▪ Need to improve MEWS to identify patients at risk of cardiac arrest.	
Kyriacos, U., Jelsma, J., & Jordan, S. (2011). Monitoring vital signs using early warning scoring systems: A review of the literature. *Journal of Nursing Management, 19*(3), 311-330. Nursing South Africa	Literature review	Review of 14 data papers, 2 reviews, and 2 meta-analyses between 1998 and 2011. Focus on MEWS/EWS on adult inpatient general wards.	Review literature to determine the need for modified early warning scoring (MEWS/EWS) systems, to identify how the systems have been developed and validated, and to determine their clinical effectiveness.	▪ Little data exists in terms of MEWS/EWS validity, implementation, evaluation, and clinical testing. ▪ Patient safety dependent upon nursing clinical judgment of patient deterioration with vital signs being a part of the equation. ▪ Although no large scale randomized controlled clinical trials conducted on MEWS/EWS, the many observational studies indicate that these systems help in identifying the deteriorating patient. ▪ Much variability exists among MEWS/EWS systems in terms of the physiological parameters assessed, ranges of parameters, trigger scores, intervention responses, and sensitivity and specificity of the tool. ▪ Resources are needed to validate and evaluate	▪ For serious adverse events (SAEs), looked at mortality; prolonged current hospitalization; persistent or significant disability; avoidable in-hospital cardiac arrest; and/or urgent and unanticipated transfer to ICU. ▪ Costs of SAEs in US estimated at $29 billion annually. ▪ Need for MEWS/EWS systems to include nursing intuition – “something is just not right”. ▪ Nurses responsible for monitoring airway, breathing, circulation, oxygen therapy, and fluid balance as part of optimal care of patient and in early detection of the deteriorating patient. ▪ Factors leading to SAEs may include the following: lack of nursing knowledge, lack of supervision, failure of	I

				MEWS/EWS systems in context of a general ward. ▪ One study showed that increasing MEWS correlated with worse patient outcomes. ▪ One study noted the beneficial effects of intensive staff training before MEWS system implementation. ▪ Few MEWS/EWS measured temperature and oxygen saturation. ▪ Most sensitive indicator of patient deterioration is the respiratory rate, but this vital sign is poorly documented.	nurse to call for assistance, poor communication skills by nurse conveying seriousness of situation, and delays in response by healthcare team. ▪ Suggestion of organizational failures related to suboptimal care and SAEs.	
Kyriacos, U., Jelsma, J., & Jordan, S. (2014). Record review to explore the adequacy of post-operative vital signs monitoring using a local modified early warning score (MEWS) chart to evaluate outcomes. *PLOS ONE, 9*(1), e87320. Medical & Nursing South Africa	Retrospective, single center, cohort observational study	Retrospective review of data collected from patient records from May 1 to July 31, 2009 from 6 adult surgical wards. No MEWS/EWS systems in place on the wards during selected study period. Inclusion criteria included medical records of all surgical patients who were > 13 years of age (n=55; 11 patients who	Study vital signs, level of consciousness, and urine output in the first 8 hours post-operatively and record into MEWS chart format to determine if clinical deterioration is identifiable. Study recorded responses to clinical deterioration according to MEWS reporting algorithms from transfer from Recovery Room to ward and up to 7	▪ MEWS physiologic measures were not recorded in full for either the patients who died or the control group. ▪ Respiratory rate was not recorded in the 11 patients who died and only one had this measure recorded in the control group. ▪ Inter-rater reliability testing compared favorable to a seminal study with a sensitivity of 89%. ▪ 61% of triggers/physiological changes in the patients who died did not get documented in the chart by a single healthcare professional. ▪ Poor vital sign monitoring not sole reason for mortality – other variables played role.	▪ Cape Town MEWS chart included respiratory rate, heart rate, O_2 saturation, systolic blood pressure, temperature, pain, neurological status, and urine output. ▪ Also included on Cape Town MEWS chart but no score assigned: inspired O_2, diastolic pressure, pain medication, sweating, wound oozing, other, pedal pulses, blood glucose, finger prick hemoglobin, pupil assessment, IV therapy, and "looks well". ▪ Small sample size, short duration of study, and focus on single outcome of mortality considered limitations of this study. ▪ Overall, MEWS systems are useful tools in the early	IV

		died; 44 control patients).	days after the surgery.		identification of the deteriorating patient and in intervention guidance.	
Kyriacos, U., Jelsma, J., James, M., & Jordan, S. (2015). Early warning scoring systems versus standard observation charts for wards in South Africa: A cluster randomized controlled trial. *The Cochrane Central Register of Controlled Trials (CENTRAL), 16*(1), 1-15. Medical & Nursing South Africa	Prospective, parallel-group, cluster randomized trial with two arms	Six adult wards (general, vascular, and surgical) randomized to intervention group or control group (n=114 total records randomly selected; 19 from each ward). Three intervention wards (n=3 clusters) and three control wards (n=3 clusters). Inclusion criteria included patients $\geq$ 14 years old admitted between May 1 and July 31, 2010. Exclusion criteria included incomplete records, 'Do Not Resuscitate' patients, and patients transferred from	Examine the impact of a new MEWS plus MEWS protocol training on nursing response to clinical deterioration, documentation of physiological variables, and nursing knowledge of clinical deterioration.	▪ Significant differences in nursing knowledge, respiratory rate documentation, and MEWS parameters in first 8-hours post-operatively. ▪ Evidence lacking related to improved nursing response to critical MEWS in terms of following MEWS protocol – very concerning.	▪ MEWS included respiratory rate, heart rate, oxygen saturation, systolic blood pressure, temperature, level of consciousness, and urine output. ▪ First study of MEWS with randomized controlled trial design. ▪ Recommend further training for nursing staff on physiologic abnormalities and appropriate protocol implementation related to MEWS triggers. ▪ MEWS intervention approved for duration of study period only. ▪ Impact of study may have weakened by nurses working on wards not trained in new MEWS protocol. ▪ MEWS hand-calculated and prone to errors. ▪ In terms of safety initiatives, vital sign monitoring and trending should be central.	II

		operating room to ICU post-surgery.				
Ludikhuize, J., Borgert, M., Binnekade, J., Subbe, C., Dongelmans, D., & Goossens, A. (2014). Standardized measurement of the Modified Early Warning Score results in enhanced implementation of a Rapid Response System: A quasi-experimental study. *Resuscitation, 85*(5), 676-682. Medical The Netherlands	Quasi-experimental, single center, study	Group 1 made of 10 adult general wards with new MEWS protocol three times daily. Group 2 made of 8 adult general wards with usual care – MEWS calculation when clinically indicated. Study period from September 1 to November 31, 2011.	Determine effect of new MEWS protocol of obtaining MEWS three times daily versus standard of care on early identification of clinical deterioration and activation of RRT.	▪ Intervention group completed MEWS three times daily in 70% of patients. ▪ Control group completed MEWS as clinically indicated in 2% of patients. ▪ Intervention group compliant with new MEWS protocol in 68% of patients. ▪ Control group compliant with standard MEWS protocol in 4% of patients. ▪ In terms of resource utilization, nurses made 90 calls to physicians in the intervention group versus 9 calls in the control group. ▪ RRT calls were doubled per admission for intervention group versus control group.	▪ MEWS included heart rate, systolic blood pressure, respiratory rate, temperature, AVPU score, 'worried about patient's condition', urine output, and oxygen saturation. ▪ This study supports the utilization of vital signs, MEWS, and a standardized MEWS protocol in the early detection and treatment of clinical deterioration. ▪ Recommendation for use of electronic medical records to improve MEWS calculations.	III
Mapp, I. D., Davis, L. L., & Krowchuk, H. (2013). Prevention of unplanned Intensive Care Unit admissions and hospital mortality by early warning systems. *Dimensions of Critical Care Nursing, 32*(6), 300-309.	Systematic review of descriptive studies	Review of 9 studies published between 2007 and 2012. ▪ Review included the following 9 studies: Albert & Huesman (2011), Churpek et al. (2012), Keller et al. (2010), Kho et al.	Review of literature to determine effectiveness of early warning scoring systems (EWSS) in detection of deteriorating patients and prevention of poor outcomes i.e. ICU transfers and/or death.	▪ Patient outcomes improved by the use of EWSS and capacity to incorporate electronic medical records (EMRs), intervention algorithms, and first responders (rapid response teams [RRTs]). ▪ Patient outcomes measured by the increased RRT calls, decreased transfers to ICU, and decreased in-hospital mortality. ▪ EWSS implementation not associated with negative	▪ Original EWSS included systolic blood pressure, heart rate, consciousness level, respiratory rate, and temperature. ▪ EWSS tools used in each study for single institutions were adapted to their facility. ▪ Some MEWS included additional parameters to include age, urine output, oxygen saturation, body mass index, "feeling that	V

Nursing United States		(2007), Ludikhuize et al. (2014), Maupin (2009), Moon et al. (2011), Page et al. (2008), and Robb & Seddon (2010).		patient outcomes in the studies. ▪ MEWS helpful in identification of the deteriorating patient. ▪ Intervention algorithms and clinical support systems make MEWS more effective.	something was not right", labs, blood glucose, etc. ▪ All studies were descriptive designs, retrospective in nature and conducted in single institutions. ▪ Majority of studies limited to a 3- to 15-month study period. ▪ EWSS accuracy improved if done via EMR. ▪ Reasons cited for missed physiological changes up to 8- hours prior to cardiac arrest as follows: lack of observation, lack of documentation, inability to recognize deterioration, and communication problems between providers.	
Mathukia, C., Fan, W., Vadyak, K., Biege, C., & Krishnamurthy, M. (2015). Modified Early Warning System improves patient safety and clinical outcomes in an academic community hospital. *Journal of Community Hospital Internal Medicine Perspectives, 5*(2),1-6. Medical & Nursing	Retrospective, single center, cohort observational study	Retrospective review of data collected monthly from January 2010 to June 2014 from non-ICU wards. MEWS system protocol officially implemented June 2013. Data collection included the following parameters: the number of RRT calls per 100	Introduce a MEWS system and report on its impact in terms of patient outcomes.	▪ Post-MEWS implementation yielded increased RRT calls. ▪ Post-MEWS implementation yielded decreased Code Blue occurrences. ▪ Post-MEWS implementation yielded decreased RRT calls that progressed to a Code Blue occurrence. ▪ Supports the implementation of a MEWS system in the early identification of the deteriorating ward patient. ▪ MEWS were effective in assisting nursing staff in the early identification of significant changes in a patient's physiologic status.	▪ MEWS system included respiratory rate, heart rate, systolic blood pressure, conscious level (AVPU), and temperature. ▪ MEWS system is color-coded for severity (green 0-2, yellow 3, orange 4-5, and red $\geq$ 6). ▪ Intervention algorithm clearly defined in article. ▪ Noted the existence of over 100 different MEWS systems. ▪ Identified as a quality improvement project. ▪ Hard to prove the exact causality of decreased inpatient mortality, but trends of positive patient	IV

United States		patient-days, number of Code Blue calls per 100 patient-days, and RRT/Code Blue outcomes.			outcomes associated with MEWS implementation. ▪ Noted improved communication between nursing staff and physicians, possibly due to quantitative nature of MEWS tool. ▪ Adherence to MEWS systems imperative for improved patient outcomes. ▪ Noted MEWS led to fairly high false alarm rate. ▪ Anticipate new scoring systems to be tested and have improved accuracy for detecting deterioration.	
McArthur-Rouse, F. (2001). Critical care outreach services and early warning scoring systems: A review of the literature. *Journal of Advanced Nursing, 36*(5), 696-704. Nursing United Kingdom	Systematic review of descriptive studies	Review of 9 primary research articles over a 10-year period. Inclusion criteria included adult patients on general wards prior to cardiac arrest and/or admission to the ICU. Focus on suboptimal care, EWS systems, and outreach teams.	Review literature to determine relationship between the development of critical illness (deterioration), EWS systems, and critical care outreach teams.	▪ Effectiveness of EWS systems and critical care outreach teams remains unanswered. ▪ Further research is needed to determine and evaluate the validity and reliability of EWS systems and critical care outreach teams in terms of patient outcomes. ▪ Further research is needed in the education of ward staff in terms of identifying those patients at risk of deteriorating. ▪ Further research is needed in the decision-making process by ward nurses in summoning help from the healthcare provider or critical care outreach team.	▪ Defines suboptimal care. ▪ Suggests that EWS systems are too simplistic to effectively assess the complex issue of clinical deterioration.	V
McGaughey, J., Alderdice, F., Fowler, R., Kapila, A., Mayhew, A., &	Systematic review	Review of two-cluster-randomized control trials.	Determine effect of critical care outreach services on in-hospital	▪ Study 1 noted composite score for intervention group was slightly lower than control group.	▪ Overall, the two studies evaluated to determine the effectiveness of critical care outreach and EWS on	I

Moutray, M. (2007). Outreach and early warning systems (EWS) for the prevention of Intensive Care admission and death of critically ill adult patients on general hospital wards (review). *Cochrane Database of Systematic Reviews*, *3*(CD005529), 1-20. Nursing United Kingdom		Study 1 involved 23 hospitals with 2-month baseline period, 4-month implementation period, and 6-month evaluation period for both control and intervention hospitals. Study 2 involved 16 acute wards in one general hospital that received 4-week training periods for 32 weeks.	mortality rates, unplanned ICU transfers, length of hospital stay, and severe adverse events. Study 1 looked at incidence of cardiac arrests without a pre-existing not-for-resuscitation order (NFR), unplanned ICU admissions, and unexpected deaths in the form of a composite score (rate of incidence per 1000 admissions) and treated individually as secondary outcomes. Study 2 measured hospital mortality and length of stay.	▪ Study 1 noted the Simplified Acute Physiology Score (SAPS) II death probability slightly lower than control group. ▪ Study 1 noted no significant difference between intervention group and control for unplanned ICU admissions. ▪ Study 1 noted an increased incidence of unexpected cardiac arrests in the control group. ▪ Study 1 noted documentation of EWS 15 minutes before cardiac arrest event was significantly higher in control group versus intervention group with MET, but documentation not significantly different in unexpected ICU admissions or unexpected deaths. ▪ Study 2 showed outreach decreased in-hospital mortality but increased mean length of stay in intervention group versus control group.	reducing hospital mortality, unplanned ICU admissions and readmissions, length of hospital stay and adverse events were lacking. ▪ Limited in that only two RCTs met the inclusion criteria and they varied considerably in study design – thus, hard to compare and contrast. ▪ Further research is needed – high quality. ▪ Suggested that future studies be RCTs across different medical centers but that standardization of outcomes occurs so that results may be compared. ▪ In summary, one RCT with inconclusive evidence and the other noted a reduction in hospital mortality rates – no strong recommendation can be made with this evidence.	
Mitchell, I. A., McKay, H., Van Leuvan, C., Berry, R., McCutcheon, C., Avard, B., . . . Lamberth, P. (2010). A prospective controlled trial of the effect of a multi-faceted intervention on early recognition	Prospective, controlled, before-and-after, single center study	Consecutive admissions of patients to four medical and surgical wards during two 4-month study periods: pre-intervention (February to June 2006) and post-intervention	Study effectiveness of a new ward observation chart, a track and trigger system, and an educational program in terms of identifying early clinical deterioration, transfers to ICU,	▪ Baseline characteristics between pre-intervention group (n=1,157) and post-intervention group (n=985) were not statistically different. ▪ Unplanned transfers to ICU and deaths were significantly decreased post-intervention. ▪ Reviews of unstable patients by the Medical Emergency Team (MET) were	▪ MEWS included respiratory rate, oxygen saturation, temperature, heart rate, systolic blood pressure, sedation score, and urine output. ▪ Utilization of the observation chart for vital sign documentation and track and trigger system provided framework for nursing staff to	IV

and intervention in deteriorating hospital patients. *Resuscitation, 81*(6), 658-666. Medical & Nursing Australia		(February to June 2007). An 8-month intervention preparation and educational period occurred between June 2006 and January 2007. Exclusion criteria included patients < 18 years of age, readmissions during study periods, and palliative care patients.	and unexpected deaths.	significantly increased post-intervention. ▪ Documented communication between nurses and physicians did not increase post-intervention despite increase in MET reviews. ▪ Vital sign documentation increased significantly post-intervention.	communicate with physicians on clinical instability. ▪ First study to couple MET activation and reviews with decreased ICU transfers and deaths. ▪ Study design limited by absence of concurrent control group.	
Nishijima, I., Oyadomari, S., Maedomari, S., Toma, R., Igei, C., Kobata, S., . . . Iha, K. (2016). Use of a modified early warning score system to reduce the rate of in-hospital cardiac arrest. *Journal of Intensive Care, 4*(12), 1-6. Medical Japan	Prospective, controlled, before-and-after, single center study	Compared in-hospital cardiac arrest incidence over the course of 18-months prior to MEWS implementation and 18-months post-MEWS implementation. In-hospital cardiac arrest (n=79) pre-MEWS and (n=43) post-MEWS implementation.	Introduce a MEWS system and evaluate its effect on the occurrence of in-hospital cardiac arrest rates.	▪ In-hospital cardiac arrest rates were decreased significantly (from a rate of 5.21 per 1000 admission to 2.39). ▪ Higher MEWS were associated with acute deterioration. ▪ A MEWS of 6 = 0.18% in-hospital cardiac arrest. ▪ A MEWS of 7 = 1.40% in-hospital cardiac arrest. ▪ A MEWS of 8 = 1.75% in-hospital cardiac arrest. ▪ A MEWS greater than or equal to 9 = 3.57% in-hospital cardiac arrest. ▪ Characteristics of patients before and after MEWS implementation were not significantly different (age,	▪ MEWS system included systolic BP, heart rate, respiratory rate, temperature, conscious level, and "any concern about the patient's condition. ▪ Defined the "warning zone" as the score linked with deterioration (WZ $\geq$ 7). ▪ Callout algorithm designed for prompt intervention of the deteriorating patient. ▪ Note this hospital relied upon the ICU nurses and attending physicians for initial responses. ▪ No rapid response team due to lack of human resources.	IV

				gender, and admitting diagnoses).	▪ Study conducted in one institution and involved a small number of cases. ▪ Study conducted using a pre- and post-interventional design. ▪ More research is needed to evaluate the effectiveness of MEWS systems.	
Perera, Y., Ranasinghe, P., Adikari, A., Welivita, W., Perera, W., Wijesundara, W., . . . Constantine, G. (2011). The value of the modified early warning score and biochemical parameters as predictors of patient outcome in acute medical admissions: A prospective study. *Acute Medicine, 10*(3), 126-132. Medical Sri Lanka	Prospective, single center, cohort observational study	Follow-up study of consecutive medical emergency admissions to a specific unit over a 1-month period in June 2009 (n=250). Exclusion criteria included admissions to any of the critical care areas, patient declination, or incomplete records.	Evaluate the effectiveness of MEWS and biochemical markers in predicting patient outcomes on an acute medical unit. Patient outcomes defined as a High Dependency Unit (HDU) or ICU transfer, cardio-respiratory arrest/resuscitation, or death.	▪ MEWS determined to be helpful in the early detection and treatment of the deteriorating patient. ▪ MEWS is a simple and effective tool that can be easily implemented at the bedside. ▪ Combined adverse endpoints were reached by the elderly and patients with increased heart rates and respiratory rates on admission – labs were also telling. ▪ A MEWS of $\geq$ 5 more likely to be transferred to HDU/ICU, suffer cardiac arrest, require resuscitation, or die. ▪ Length of stay (LOS) and MEWS did not correlate, but LOS and biomarkers did. ▪ MEWS + biomarkers improved the sensitivity of detecting patient deterioration.	▪ Most common admitting diagnoses included sepsis (25.4%), acute chest pain (18.4%0, and airway disease (12.3%). ▪ MEWS system included systolic blood pressure, heart rate, respiratory rate, temperature, and level of consciousness. ▪ Suggest that integrating diagnosis into MEWS could render it less useful (e.g. respiratory disease, cardiac disease). ▪ Study limited by single-institution setting and small sample.	IV
Prytherch, D. R., Smith, G. B., Schmidt, P. E., & Featherstone, P. I. (2010). ViEWS – Towards a national early warning score for detecting adult	Retrospective, single center, cohort observational study	Physiologic parameters obtained from consecutive admissions to a Medical Assessment Unit between May	Develop an aggregate weighted track and trigger system (AWTTS) that was validated and paper-based as a potential template for a	▪ 35,585 patient episodes where patient either died in-hospital or stayed past midnight on the day of admission. ▪ AUROC = 0.888 (0.880-0.895) for ViEWS using in-hospital mortality within 24 hours of the observation set.	▪ Did not exclude patients with Do Not Attempt Resuscitation (DNAR) orders from study. ▪ Chose not to study cardiac arrest separate from death because in-hospital cardiac arrest = 83% morality.	IV

inpatient deterioration. *Resuscitation, 81*(8), 932-937. Medical & Nursing United Kingdom		2006 and June 2008. Inclusion criteria included patients ≥ 16 years of age. Exclusion criteria included patients discharged before midnight on the day of admission.	national early warning score (EWS) for the early identification of clinical deterioration. Patient outcome: death within *n* hours of a given vital signs measurement	▪ AUROC = 0.803 (0.792-0.815) to 0.850 (0.841-0.859) for 33 other AWTTS tested using the same outcome. ▪ ViEWS performed better in all outcomes compared to the other 33 AWTTS. ▪ Inclusion of age adds further complexity to AWTTS. ▪ Inclusion of age does increase AUROC to 0.892 (0.885-0.900) but adds little benefit.	▪ Achieved goal of developing a simple, paper-based AWTTS and determined that is was superior to other AWTTS in detecting patient deterioration. ▪ Tool provides the number of "triggers" generated and therefore comparisons of the workload created by the different AWTTS can be made.	
Roney, J. K., Whitley, B. E., Maples, J. C., Futrell, L. S., Stunkard, K. A., & Long, J. D. (2015). Modified early warning scoring (MEWS): Evaluating the evidence for tool inclusion of sepsis screening criteria and impact on mortality and failure to rescue. *Journal of Clinical Nursing, 24*(23-24), 3343-3354. Nursing United States	Systematic review of descriptive studies	Review of 18 articles through 2014. Inclusion criteria included patients ≥ 18 years of age; admission to medical-surgical/telemetry wards or transfer to ICU due to MEWS instrument; and studies to validate MEWS and assess impact on cardiac arrest, RRT use, and mortality. Exclusion criteria included disease specific focus and emergency department settings.	Review of literature to determine outcomes from MEWS utilization on adult medical-surgical/telemetry wards in early identification of the deteriorating patient.	▪ Articles ranged from Level I (systematic review) to Level VII (expert opinion). ▪ Articles included mortality predictive value or reduction, RRT utilization, and/or a combination of both. ▪ Validity, standardization, and reliability of MEWS measurement tools were lacking. ▪ Most articles were descriptive studies with a focus on MEWS tool implementation. ▪ Majority of articles did not address prevention of failure to rescue. ▪ No validated MEWS tools mentioned in literature review pertaining to all clinical diagnoses i.e. sepsis.	▪ More research is needed to validate and standardize MEWS tools with organizational-specific reliability testing. ▪ No randomized controlled clinical trials included. ▪ Validation of individual physiological assessment scores needed for MEWS tool development. ▪ Recommend multi-site MEWS testing trials. ▪ Suggest the need for all-cause screening tool development i.e. sepsis.	V

		Note one pediatric study included due to high relevance.				
Smith, M. E., Chiovaro, J. C., O'Neil, M., Kansagara, D., Quinones, A., Freeman, M., . . . Slatore, C. G. (2014). Early warning scoring systems: A systematic review. *Annals of the American Thoracic Society, 11*(9), 1454-1465. Medical United States	Systematic review of descriptive studies	Review of 17 studies to April 2013. Inclusion criteria included full text, English-only papers on adult patients admitted to medical or surgical wards. Exclusion criteria included non-systematic reviews, expert opinions, and case series.	Review literature to determine effectiveness of EWS in predicting patient deterioration and review impact of EWS treatment strategies on patient outcomes and resource utilization. Analytic framework used to ask the three key questions.	▪ All studies included the utilization of vital signs and clinical evaluation. ▪ Six studies with strong predictive ability for patient outcomes of death and cardiac arrest within 48 hours of data collection. ▪ Eleven studies described impact of EWS interventions but evidence insufficient to draw conclusions due to limitations related to process.	▪ Current EWS with positive predictive ability related to cardiac arrest and death within 48 hours. ▪ Current EWS impact on health outcomes and resources (length of hospital stay, transfer to ICU, utilization of RRT, and nursing) remains unclear. ▪ More research is needed to rigorously assess the implementation and effectiveness of EWS.	V
Stewart, J., Carman, M., Spegman, A., & Sabol, V. (2014). Evaluation of the effect of the Modified Early Warning System on the nurse-led activation of the Rapid Response System. *Journal of Nursing Care Quality, 29*(3), 223-229. Nursing	Mixed-methods, single center, retrospective, before-and-after study	Retrospective review of data from patient records 12 months pre-MEWS implementation and 12 months post-MEWS implementation who required Rapid Response System (RRS) activation or suffered cardiac arrest.	Evaluate the effectiveness of MEWS in identification of the deteriorating medical-surgical patient and utilization as a framework for intervention algorithms and RRS activation.	▪ Pre-MEWS: n=39 RRS activations and n=14 cardiopulmonary arrests. ▪ Post-MEWS: n=55 RRS activations and n=11 cardiopulmonary arrests. ▪ No significant characteristic difference in pre-MEWS group of patients versus post-MEWS. ▪ Note differences in groups did not reach statistical significance but positive patient outcomes were trended and suggest clinical significance in line with the	▪ Impact of MEWS should continue to be monitored in terms of RRS activation and incidence of cardiopulmonary arrest. ▪ First study to assess MEWS incorporation at the bedside from the RN perspective in terms of impact on their decision-making. ▪ Communication between physicians, RNs, nursing assistants, and nursing administrators key to effective RRS.	IV

United States		Focus groups of RNs to explore facilitators and barriers to use of MEWS bedside (n=11 RNs).		Institute for Healthcare Improvement. ▪ Three broad topics emerged from focus groups: decision-making at bedside with MEWS as triage support, MEWS as a powerful tool to communicate with interdisciplinary team, and importance of administrative support in activation of RRS.	▪ Included calculation of the Charlson Comorbidity Index (CCI) score. ▪ Study limited by single-institution setting and small sample sized for both record review and focus groups. ▪ More research needed to connect patient safety strategies like MEWS with positive patient outcomes.	

Table 1.2 Rating System for the Hierarchy of Evidence for Intervention Studies

Level I	Evidence from a systematic review or meta-analysis of all relevant RCTs
Level II	Evidence obtained from well-designed RCTs
Level III	Evidence obtained from well-designed controlled trials without randomization
Level IV	Evidence from well-designed case-control and cohort studies
Level V	Evidence from systematic reviews of descriptive or qualitative studies
Level VI	Evidence from single descriptive or qualitative studies
Level VII	Evidence from the opinion of authorities and/or reports of expert committees

Note. Referenced from *Evidence-based Practice in Nursing and Healthcare: A Guide to Best Practice* (2nd ed.), by B. M. Melnyk and E. Fineout-Overholt. Copyright 2011 by Lippincott, Williams & Wilkins.

Table 1.3 Physiologic Parameters in Each Study

#	Study	Year	Design	Level	Parameters	#	Other	System
1	Drower et al.	2013	Retrospective, single center, pre-post cohort observational study	IV	SBP, HR, T, RR, LOC, O_2 sat, UOP	8	Oxygen flow rate	ADDS (Adult Deterioration Detection System)
2	Duncan et al.	2012	Expert	VII	SBP, HR, T, RR, LOC	5	N/A	MEWS
3	Finlay et al.	2014	Retrospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC	5	N/A	MEWS, Rothman Index (RI)
4	Gao et al.	2007	Systematic review	I	Varied	5-32	Seizures, color change, biomarkers	Single parameter, multiple parameter, MEWS, PARS, etc.
5	Huggan et al.	2015	Prospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC	5	N/A	MEWS
6	Johnstone et al.	2007	Systematic review of descriptive studies	V	Varied	-	Many	EWSS
7	Kim et al.	2015	Retrospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC	5	N/A	MEWS
8	Kyriacos et al.	2011	Systematic review	I	Varied	-	Many	EWSS, MEWS
9	Kyriacos et al.	2014	Retrospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC, O_2 sat, UOP	7	Chart with additional parameters but no score assigned (e.g., pain and DBP)	MEWS
10	Kyriacos et al.	2015	Prospective, parallel-group, cluster randomized trial with two arms	II	SBP, HR, T, RR, LOC, O_2 sat, UOP	7	N/A	MEWS, single center
11	Ludikhuize et al.	2014	Quasi-experimental, single center, study	III	SBP, HR, T, RR, LOC, O_2 sat, UOP	8	Concern	MEWS
12	Mapp et al.	2013	Systematic review of descriptive studies	V	Varied	-	Many	EWSS, MEWS
13	Mathukia et al.	2015	Retrospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC	5	N/A	MEWS
14	McArthur-Rouse	2001	Systematic review of descriptive studies	V	SBP, HR, T, RR, LOC	5	Many	EWSS
15	McGaughey et al.	2007	Systematic review	I	Not described	-	Not described	EWSS, SAPS

16	Mitchell et al.	2010	Prospective, controlled, before-and-after, single center study	IV	SBP, HR, T, RR, O_2 sat, UOP	7	Sedation score	MEWS, Track and Trigger System
17	Nishijima et al.	2016	Prospective, controlled, before-and-after, single center study	IV	SBP, HR, T, RR, LOC	6	Concern	MEWS
18	Perera et al.	2011	Prospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC	5	N/A	MEWS
19	Prytherch et al.	2010	Retrospective, single center, cohort observational study	IV	SBP, HR, T, RR, LOC, O_2 sat	7	Inspired oxygen	ViEWS
20	Roney et al.	2015	Systematic review of descriptive studies	V	Varied	-	Many	MEWS
21	Smith et al.	2014	Systematic review of descriptive studies	V	Varied	-	Many	EWSS
22	Stewart et al.	2014	Mixed-methods, single center, retrospective, before-and-after study	IV	Not described	-	Not described	MEWS

Level I: Systematic review or meta-analysis	**Level II**: Randomized controlled trial	**Level III**: Controlled trial without randomization	**Level IV**: Case control or cohort study	**Level V**: Systematic review of qualitative or descriptive study	**Level VI**: Qualitative or descriptive study	**Level VII**: Expert opinion or consensus
3 studies: (4, 8, & 15)	1 study: (10)	1 study: (11)	11 studies: (1, 3, 5, 7, 9, 13, 16, 17,18, 19 & 22)	5 studies: (6, 12, 14, 20, & 21)	0 studies: (0)	1 study: (2)

Manuscript 2:

Review of Educational Strategies to Improve Early Recognition and Management of Clinical Deterioration

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Abstract

Medical-surgical nurses on the front lines of patient care can positively impact patient safety and patient outcomes through early recognition and management of clinical deterioration. Rapid response systems and modified early warning scoring systems have been implemented to combat problems of failure to rescue and suboptimal care; the effectiveness of these strategies is greatly dependent on the education and training of nursing staff. The aim of this study was to investigate educational strategies and/or educational programs developed to improve medical-surgical nurses' abilities to recognize and manage clinical deterioration. An integrative review of studies from Cumulative Index to Nursing and Allied Health Literature(CINAHL), MEDLINE, and PubMed resulted in 19 studies that met inclusion criteria: English-language only; peer-reviewed; date of publication between 2007 and 2017; full text only; quantitative, qualitative, and mixed-method designs; target population of nursing staff assigned to acute care wards; and study emphasis on education and training related to early recognition and management of clinical deterioration. Of 19 studies, four were classified as either a systematic review, a literature review, or an integrative review of descriptive studies; the remaining 15 studies were independent investigations or expert opinions. Three broad themes emerged: the organization, the patient, and the nurse. Organization-based strategies included the use of clinical decision-making models, standardized assessment tools, and standardized communication tools. Clinical process modification was also identified as an organizational strategy. Patient-based strategies concentrated on patient characteristics, conditions, and outcomes when designing educational strategies and/or programs. Nurse-based strategies focused on enhancing nursing knowledge, skills, and experiential learning specifically as it pertained to caring for deteriorating patients. The majority of studies agreed that educational interventions and programs that used a mixed method approach (e.g., incorporation of knowledge, technical skills, non-technical skills, and simulation in educational interventions) were more likely to result in sustained learning outcomes. However, future research is needed to measure the direct impact of education and training on patient outcomes for patients at risk for clinical deterioration.

Keywords: clinical deterioration, education, nursing assessment, and ward patient

Review of Educational Strategies to Improve Early Recognition and Management of Clinical Deterioration

Medical-surgical nurses on the front lines of patient care can positively impact patient safety and patient outcomes through early recognition and management of clinical deterioration (Chua, Mackey, & Liaw, 2013; Harvey, Echols, Clark, & Lee, 2014; Liaw, Scherpbier, Klainin-Yobas, & Rethans, 2011). Their acutely ill adult patients are particularly vulnerable to clinical deterioration; high acuity levels are associated with advanced age, complex medical conditions, advances in medical technology, and reduced critical care resources (Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; McDonnell et al., 2012). However, the literature highlights problems of failure to rescue events and suboptimal care in this population in which clinical deterioration is frequently missed or mismanaged by primary nursing staff (Al-Qahtani & Al-Dorzi, 2010; McQuillan et al., 1998; Mei, Ying, & Fai, 2009; National Confidential Enquiry into Patient Outcome and Death [NCEPOD], 2005; Subbe & Welch, 2013). Reasons for the breakdown in patient care are multi-factorial: "communication factors; working conditions and environmental factors; task factors; education and training factors; patient factors; team and social factors; organizational factors; equipment and resource factors; and individual factors" (Meade, 2017, p. 8; National Patient Safety Agency [NPSA], 2007a, p. 12-13).

In general, patients exhibit abnormal physiologic parameters (e.g., changes in vital signs and/or level of consciousness) in the hours leading up to severe adverse events such as cardiac arrest and/or death (Garvey, 2015; NCEPOD, 2005; Subbe & Welch, 2013). Rapid response systems (RRS) and modified early warning scoring (MEWS) systems have been implemented to assist nursing staff in early recognition and management of clinical deterioration (Bunkenborg, Poulsen, Samuelson, Ladelund, & Akeson, 2016; Gao et al., 2007; Jones, 2013; Mathukia, Fan, Vadyak, Biege, & Krishnamurthy, 2015; McCannon, Schall, Calkins, & Nazem, 2006). The effectiveness of these strategies has been extensively studied; education and training of nursing staff have been deemed critical to maximizing the benefits of RRSs and MEWS systems for the greater goals of improving patient safety and patient outcomes (Gao et al., 2007; Johnstone, Rattray, & Myers, 2007; Kyriacos, Jelsma, James, & Jordan, 2015; Ludikhuize et al., 2014; National Clinical Effectiveness Committee [NCEC], 2013). However, a wide variety of educational approaches and programs have been developed and implemented (Connell et al.,2016; Johnstone et al., 2007; Kyriacos et al., 2015; Ludikhuize et al., 2014; McArthur Rouse, 2001; McGaughey et al., 2007; Mitchell et al., 2010). This integrative review will investigate educational strategies and/or educational programs employed to improve medical-surgical nurses' abilities to recognize and manage clinical deterioration. Findings will guide the development, implementation, and evaluation of an educational strategy for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky (Meade, 2017).

Scope of the Review

An integrative review of current research was performed to evaluate the effectiveness of educational strategies to improve medical-surgical nurses' abilities to recognize and manage clinical deterioration in the adult patient population they serve. The review was broad and included studies of varied research designs and literature types. The literature was examined using an updated, modified framework for conducting integrative reviews; Cooper's (1982) original framework served as a foundation (Whittemore & Knafl, 2005).

Problem Formulation

The primary question addressed in this integrative review was "What educational strategies or programs have enhanced medical-surgical nurses' abilities to recognize and manage clinical deterioration in acutely ill adult patients?" Study articles met the following inclusion criteria: English-language only; peer-reviewed; date of publication between 2007 and 2017; full text only; quantitative, qualitative, and mixed-method designs; target population of nursing staff assigned to acute care wards; and study emphasis on education and training related to early recognition and management of clinical deterioration. Study articles were excluded based on the following criteria: target audience other than nursing staff assigned to acute care wards (e.g., undergraduate nursing students and intensive care unit nurses) and absence of discussion on educational strategies or programs related to early recognition and management of clinical deterioration (e.g., focus on barriers to assessment, vital sign monitoring practices, patient assessment frameworks, and activities of RRSs). Therefore, the objective of this integrative review was to identify those educational strategies or programs that improved nurses' abilities to identify and treat clinical deterioration.

Data Search

The literature search was focused specifically on educational strategies or programs geared towards early recognition and management of clinical deterioration. Search terms were added to broaden the discovery of pertinent references; keywords included clinical deterioration, education, nursing assessment, and ward patient. The following electronic databases were searched and yielded positive results: Cumulative Index to Nursing and Allied Health Literature (CINAHL), MEDLINE, and PubMed. The data search was narrowed from 526 original studies to 19 studies meeting inclusion criteria.

Data Evaluation

Data evaluation began with an organized review of all study titles and abstracts. This process led to a significant reduction in number of studies meeting inclusion criteria; for example, 16 studies were excluded because they targeted undergraduate nursing students. The remaining studies were read in full and evaluated according to "study design, sample, purpose, findings, limitations/comments, and level of evidence" (Meade, 2017, p. 10). Twenty-six studies underwent a second reading and evaluation before being excluded from the final review (see Table 2.1 for an overview of studies and Table 2.2 for a rating system for the hierarchy of evidence). Of 19 studies meeting inclusion criteria, only one was classified as a randomized controlled trial (RCT).

Data Analyses and Interpretation

To facilitate data analyses, an evidence table was created to extract data from 19 studies. Comparisons were made based on design: quantitative, qualitative, and mixed methods. In addition, each study was condensed to a one-page summary and analyzed for key points, barriers, gaps, themes, strategies, specific program content, final conclusions, and implications for future research. Data were organized according to emerging themes and conclusions were drawn.

Review Presentation

An evidence table presented study findings, limitations, and conclusions in a logical manner, allowing readers to draw their own conclusions from the evidence. Diverse educational strategies to improve nurses' abilities to identify and treat clinical deterioration were reasonably well-documented; information on specific educational programs was somewhat limited. While findings from several studies complemented one another, other studies supported new ideas and strategies. Findings were organized into three main themes and are presented here.

Findings

Nineteen studies were evaluated for this integrative review; most were quasi-experimental studies with an evidence rating of Level IV or below. Four studies with an evidence rating of Level V were classified as either a systematic review, a literature review, or an integrative review for descriptive studies; they added 52 unduplicated studies to the review (Connell et al., 2016; Liaw et al., 2011; Massey, Chaboyer, & Anderson, 2016; Odell, Victor, & Oliver, 2009). The remaining 15 studies were independent investigations or expert opinions (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Considine & Currey, 2015; Cooper et al., 2011; Fuhrmann, Perner, Klausen, Ostergaard, & Lippert, 2009; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Ozekcin, Tuite, Willner, & Hravnak, 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webbe-Janek, Lenzmeier, Lambden, Herrick, & Pliego, 2012). Independent studies included the following: one randomized controlled trial (Level II evidence), six case control or cohort studies (Level IV evidence), six descriptive or qualitative studies (Level VI evidence), and two expert opinions (Level VII evidence). Of 19 studies, four were mixed method studies, four were pre/post-interventional studies, and one was an interrupted time-series analysis (see Table 2.1).

Studies were conducted largely by combined medical and nursing disciplines in the following countries: Australia, Denmark, Greece, Ireland, Singapore, the United Kingdom, and the United States. One researcher from the University of Singapore led or participated in four studies (Chua et al., 2013; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016). This integrative review, which covered a 10-year timeframe, provided a comprehensive assessment of educational strategies and/or programs pertaining to early recognition and management of clinical deterioration in acutely ill adult patients. However, study designs, sample populations, specific aims or purposes, and outcome measures varied from study to study. Outcome measures could be categorized as organization-based, patient-based, and/or learner-based; learner-based outcome measures included nursing staff self-reports and/or actual performance or demonstration of confidence, knowledge, and skills following an educational intervention (Connell et al., 2016).

Eight studies focused on aspects of simulation: medium versus high fidelity simulation, lab setting versus in situ simulation, manikin-based versus web-enhanced simulation, and/or nursing staff only versus interprofessional staff simulation (Buckley & Gordon, 2010; Cooper et al., 2011; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2015; Liaw et al., 2016; Ozekcin et al., 2015; Webbe-Janek et al., 2012). Every study addressed at least one key facet of nursing practice related to clinical deterioration: "recognition; recording and reviewing; reporting; and responding and rescuing" (Odell et al., 2009, p. 2000). Specific educational programs were highlighted in a few of the studies: ACT NOW (Alert-Communicate-Treat-Nurses-Observing for-Warnings), ALERT (Acute Life-

threatening Events: Recognition and Treatment) course, e-RAPIDS (Rescuing a Patient in Deteriorating Situations), and FIRST^2 ACT (Feedback Incorporating Review and Simulation Techniques 2 Act on Clinical Trends). However, the majority of studies did not provide an in-depth evaluation of educational programs (Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2016; Massey et al., 2016; Pantazopoulos et al., 2012). Liaw, Scherpbier, Klainin-Yobas, and Rethans (2011) conducted the only study to review existing educational programs to include the following: ALERT, MPFS (Multi-professional Full-scale Simulation), AIM (Acute Illness Management), and COMPASS.

Findings from 19 studies were analyzed and summarized. Unique objectives, methods, and outcome measures of each study made this process complex. However, three broad themes were identified to present evidence for educational strategies and/or programs that improved nurses' abilities to recognize and manage clinical deterioration: the organization, the patient, and the nurse.

The Organization

In order for educational strategies and/or programs to positively impact nurses' abilities to recognize and manage clinical deterioration, researchers agreed that organizational supports played a key role. Under this umbrella, researchers identified clinical decision-making models, standardized assessment tools, and standardized communication tools as ways of fostering a culture of safety and improving patient outcomes through the provision of structured processes (Brier et al., 2015; Buckley & Gordon, 2010; Considine & Currey, 2015; Fuhrmann et al., 2009; Kinsman et al., 2012; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; Massey et al., 2016; McDonnell et al., 2012; Ozekcin et al., 2015; Pantazopoulos et al., 2012) . Examples of clinical decision-making models included RRS policies, track and trigger systems, MEWS systems, and other surveillance algorithms. In addition, a number of studies reported the need for a systematic approach to assessment, coupled with a clear communication process; versions of an ABCDE (Airway, Breathing, Circulation, Disability, and Expose/Examine) primary survey and an SBAR (Situation, Background, Assessment, and Recommendation) communication tool were mentioned in many studies (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Considine & Currey, 2015; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Ozekcin et al., 2015). Researchers in one study described clinical process modification as a strategy to enhance nurses' competencies in caring for deteriorating patients (Chua et al., 2013). For example, hospitals did not always have clear protocols regarding vital sign monitoring in terms of what to monitor, how often to monitor, or who was ultimately responsible for monitoring. In this instance, modifications to such protocols could improve clinical processes and ultimately impact patient outcomes (Kinsman et al., 2012; McDonnell et al., 2012; Pantazopoulos et al., 2012). Pantazopoulos et al. (2012) suggested that protocol-based or guideline-based education may be beneficial. Overall, researchers acknowledged the significance of organizational influence on educational strategies and programs geared to enhance nursing care of the deteriorating patient.

The Patient

Specific patient characteristics, conditions, and outcomes were described as important factors to consider in designing educational strategies and/or programs to improve nurses' competencies in caring for acutely ill adult patients. According to several studies in this review, patients on general wards had higher acuity levels and more complex medical problems than in years past, making them at greater risk for clinical deterioration (Chua et al.,

2013; Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2016). While studies reported differing rates of severe adverse events among their medical-surgical patient populations, researchers agreed that most were preventable and cited the need to educate nurses on the signs of clinical deterioration (Chua et al., 2013; Considine & Currey, 2015; Cooper et al., 2011; Fuhrmann et al., 2009; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2011; Massey et al., 2016; McDonnell et al., 2013; Ozekcin et al., 2015; Pantazopoulos et al., 2012). The didactic portion of an educational program in one study incorporated the assessment of "heart rate, respiratory rate, blood pressure, temperature, level of consciousness, oxygen saturation, urine output, metabolic acidosis, significant pain, or delayed capillary refill" as 10 key signs of clinical deterioration known as the *Ten Signs of Vitality* (Harvey et al., 2014, p. e59). An abnormality in two or more of these physiologic parameters warranted further action. Other studies emphasized the importance of providing education on common problematic conditions for general ward patients such as chest pain, hypoxia, pneumonia, sepsis, and shock (Buckley & Gordon, 2010; Ozekcin et al., 2015). One study revealed that bradycardia, atypical chest pain, airway obstruction, and bradypnea were the patient conditions of greatest concern for medical-surgical nurses (Pantazopoulos et al., 2012). Many studies addressed patient outcomes as a measure to determine if educational interventions were successful: length of hospital stays, RRT calls, unexpected transfers to the intensive care unit (ICU), and mortality rates (Connell et al., 2016; Cooper et al., 2011; Fuhrmann et al., 2009; Liaw et al., 2011; Liaw et al., 2015; Massey et al., 2016; McDonnell et al., 2012; Odell et al., 2009; Ozekcin et al., 2015). However, researchers found it difficult to link improved patient outcomes solely to educational strategies/programs due to many confounding variables associated with caring for acutely ill adult patients (Buckley & Gordon, 2010; Connell et al., 2016; Fuhrmann et al., 2009; Kinsman et al., 2012). In general, several studies in this review concentrated on patient characteristics, conditions, and outcomes for the development of educational strategies and/or programs.

The Nurse

Studies in this integrative review described educational strategies and programs that were developed specifically for general ward nurses caring for patients at risk for clinical deterioration. Learning objectives focused on the enhancement of knowledge, skills, and experiential learning (e.g., case studies, role play, guided inquiry, and simulation). A majority of studies used a mixed method educational approach by combining some aspect of lecture, hands-on technical skills, and simulation (Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Odell et al., 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010). A few studies incorporated self-directed learning methods (e.g., e-learning) and/or non-technical skills that focused on teamwork, leadership, communication, and situational awareness (Fuhrmann et al., 2009; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; Massey et al., 2016; Webbe-Janek et al., 2012).

In terms of knowledge, researchers agreed that general ward nurses needed to have a sound understanding of the following: physiology related to clinical deterioration; compensatory mechanisms of the body; subtle cues associated with deterioration; importance of accurate vital sign monitoring and analysis; proper use of equipment and tools; effective communication styles; and timely response and management of clinical deterioration (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Considine & Currey, 2015; Cooper et al., 2011; Fuhrmann et

al., 2009; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webbe-Janek et al., 2012). In addition, researchers emphasized the importance of educating nurses on advanced assessment and communication skills (Brier et al., 2015; Considine & Currey, 2015; Cooper et al., 2011; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Odell et al., 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010). Several studies referred to a primary survey in which a priority-based assessment put the most important clinical findings first and prompted nurses to respond accordingly (Considine & Currey, 2015; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Ozekcin et al., 2015). Considine and Currey (2015) argued, "if all nurses were to adopt the primary survey approach (assessment of airway, breathing, circulation, and disability) as the first element of patient assessment, they would be more focused on active detection of clinical deterioration rather than passive collection of patient data" (p. 300).

In terms of skills, researchers stressed the importance of promoting nursing competence by incorporating hands-on practice of technical skills such as airway assessment and management (Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webbe-Janek et al., 2012). Studies reported that nurses were more likely to retain knowledge and skills in a clinical environment if they had intentionally practiced those skills; nurses who had practiced basic life support (BLS) or advanced cardiovascular life support (ACLS) skills were more apt to respond to clinical deterioration in a timely manner (Cooper et al., 2011; Pantazopoulos et al., 2012). Skill competency included training in vital sign monitoring, advanced assessment, use of equipment, use of communication tools, and use of track and trigger systems (another name for early warning systems) or MEWS tools (Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webbe-Janek et al., 2012). In two studies, researchers described the use of expert nurses as consultants; their support and guidance enhanced knowledge, skills, and confidence of general ward nurses in recognizing and managing clinical deterioration (McDonnell et al., 2012; Ozekcin et al., 2015). Overall, researchers repeatedly emphasized the need for nurses to maintain skill competency and receive ongoing training related to clinical deterioration (Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Massey et al., 2016; Ozekcin et al., 2015).

Finally, researchers highlighted the use of experiential learning, particularly simulation, as an extremely effective strategy for achieving sustained learning by general ward nurses. Simulation was described as an educational strategy with potential to bring knowledge, technical skills, and non-technical skills together in a way to reduce the gap from classroom learning to clinical practice; simulation provided an opportunity for nurses to assimilate their learning (Buckley & Gordon, 2010; Cooper et al., 2011; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2015; Liaw et al., 2016; Ozekcin et al., 2015; Webbe-Janek et al., 2012). A couple of studies reported web-based simulations as an effective means of training large numbers of nursing staff; in situ simulations were considered ideal but presented unique challenges (Harvey et al., 2014; Liaw et al., 2015; Liaw et al., 2016). Some important aspects of simulation included an emphasis on teamwork, a culture of safety, and authentic situations to recreate an atmosphere of stress (Harvey et al., 2014; Ozekcin et al., 2015; Webbe-Janek et al., 2012). Simulation

provided an opportunity for nurses, especially novice nurses, to practice their leadership and assertiveness skills; debriefing was considered one of the most important features (Buckley & Gordon, 2010). Two studies emphasized the importance of creating simulations that involved interdisciplinary teams (Connell et al., 2016; Webbe-Janek et al., 2012). Generally, studies in this integrative review described educational strategies and programs that targeted the enhancement of general ward nurses' knowledge, skills, and experiential learning as it pertained to the recognition and management of clinical deterioration in their patient population.

Discussion and Implications for Clinical Practice

Although educational strategies and/or programs were themed organization-based, patient-based, and nurse-based, every study in this review addressed at least one of these aspects of patient care: recognition of clinical deterioration; recording and reviewing of observations (e.g., vital signs and assessment data); reporting of clinical deterioration; and/or responding and rescuing the patient from clinical deterioration (Odell et al., 2009). A majority of studies concluded that patient safety and patient outcomes were dependent upon general ward nurses' competencies regarding three key principles:

- having a fundamental understanding of the underlying causes of clinical deterioration;
- being able to recognize and manage clinical deterioration; and
- being able to communicate effectively (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Fuhrmann et al., 2009; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; Massey et al., 2016; Odell et al., 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webbe-Janek, 2012).

To achieve these principles, researchers agreed the best educational strategies and/or programs incorporated a mixed method educational approach: lecture, hands-on technical skills, non-technical skills, self-directed learning, and experiential learning (Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Fuhrmann et al., 2009; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; Massey et al., 2016; McDonnell et al., 2012; Odell et al., 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webb-Janek et al., 2012).

A number of studies evaluated nursing characteristics and their impact on patient care. For example, researchers described differences in the following: surveillance and discovery processes; reliance on experience and "knowing the patient"; patterns of assessment and recognition; reasons for failure to rescue and suboptimal care; and educational preparation and training (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Cooper et al., 2011; Massey et al., 2016; McDonnell et al., 2012; Odell et al., 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010). They acknowledged that nurses at the bedside played a critical role in recognizing and managing clinical deterioration; however, general ward nurses varied in their abilities and preparation to do so (Connell et al., 2016; Considine & Currey, 2015; Liaw et al., 2011). In a study by Odell, Victor, and Oliver (2009), researchers learned that nurses recognized clinical deterioration in one of three ways: concern expressed by the patient or family; concern or an uneasy feeling experienced by the nurse (e.g., nursing intuition); or care of the patient during routine monitoring. Experienced nurses often relied on intuition and "knowing the patient"; they were more likely to detect changes in a patient's condition based on pattern recognition and cues (Brier et al., 2015;

Massey et al., 2016; McDonnell et al. 2012; Odell et al., 2009). While Cooper et al. (2011) warned that relying on intuition alone could result in overlooking clinical deterioration; others argued that intuition and pattern recognition were invaluable to nursing judgment (Massey et al., 2016; McDonnell et al., 2012; Odell et al., 2009).

In terms of patterns of assessment and recognition, nurses were responsible for accurate vital sign monitoring, comprehensive assessments, correct interpretation of data, concise communication practices, and appropriate decision-making (Liaw et al., 2011; Odell et al., 2009; Preston & Flynn, 2010). A deficiency in any one of these actions could increase the likelihood of failure to rescue events and suboptimal care (Moldenhauer, Sabel, Chu, & Mehler, 2009; Odell et al., 2009; Shever, 2011; Subbe & Welch, 2013). Researchers identified the following as possible contributors to unrecognized or mismanaged clinical deterioration: missing data, inaccurate data, lack of knowledge and skills, lack of structured assessments or processes, poor communication skills, lack of teamwork, negative communication, lack of supervision, and heavy workloads (Chua et al., 2013; Considine & Currey, 2015; Cooper et al., 2011; Kinsman et al., 2012; Liaw et al., 2011; Odell et al., 2009;Ozekcin et al., 2015; Preston & Flynn, 2010; Webbe-Janek et al., 2012). Many studies reported the need for nurses to be trained in advanced assessment; researchers encouraged use of a structured primary survey (e.g., an ABCDE primary survey) to accomplish this goal (Brier et al., 2015; Buckley & Gordon, 2010; Connell et al., 2016; Considine & Currey, 2015; Liaw et al., 2011; Odell et al., 2009; Pantazopoulos et al., 2012). In particular, Considine and Currey (2015) argued:

> The primary survey approach as the first element in patient assessment has three major advantages: (1) data are collected according to clinical importance; (2) data are collected using the same framework as most organization's rapid response system activation criteria; and (3) the primary survey acts as a patient safety checklist, thereby decreasing the risk of failure to recognize and therefore respond to, deteriorating patients (p. 300).

A structured communication tool (e.g., an SBAR communication tool) was another strategy offered by researchers to enhance clear, concise communication when reporting clinical deterioration (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Considine & Currey, 2015; Liaw et al., 2011; McDonnell et al., 2012; Ozekcin et al., 2015). Researchers noted the importance of understanding nursing patterns of assessment and recognition in order to create effective educational strategies and programs.

Finally, several studies addressed educational preparation and training (Cooper et al., 2011; Liaw et al., 2011; Odell et al., 2009; Pantazopoulos et al., 2012; Webbe-Janek et al., 2012). For example, Pantazopoulos et al. (2012) reported differences between two-year and four-year prepared nurses regarding their abilities to recognize and manage clinical deterioration; four-year nurses demonstrated greater knowledge and skills in these critical situations. Researchers recommended that undergraduate nursing programs integrate clinical deterioration into their nursing curriculum; in this way, novice nurses would be better prepared to care for acutely ill adult patients (Liaw et al., 2011). Other studies reported positive outcomes when nurses received BLS and/or ACLS training (Cooper et al., 2011; Pantazopoulos et al., 2012; Webbe-Janek et al., 2012). In addition, researchers highlighted the importance of utilizing an interprofessional learning approach when developing educational strategies and programs; however, few studies did this (Connell et al., 2016; Massey et al., 2016; Webbe-Janek et al., 2012).

Strengths and Limitations

Studies in this integrative review were consistent in their message; educational strategies and/or programs needed to be developed and implemented to enhance general ward nurses' abilities to recognize and manage clinical deterioration. An overwhelming majority concluded that a mixed method educational approach was ideal to enhance knowledge, skills, and experiential learning (Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Odell et al., 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010).

Researchers repeated the need to improve ward nurses' competencies through active learning (Buckley & Gordon, 2010; Cooper et al., 2011; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2015; Liaw et al., 2016; Ozekcin et al., 2015; Webbe-Janek et al., 2012).

Study design was a limitation; studies were primarily quasi-experimental with an evidence rating of IV or below. Liaw et al. (2015) conducted the only RCT. Many studies had small sample sizes and self-reports by nurses of enhanced knowledge, skills, confidence, and motivation following an educational intervention (Brier et al., 2015; Buckley & Gordon, 2010; Chua et al., 2013; Cooper et al., 2011; Fuhrmann et al., 2009; Harvey et al., 2014; Kinsman et al., 2012; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Webbe-Janek et al., 2012). Researchers acknowledged difficulty in directly linking educational strategies and programs to patient outcomes (Buckley & Gordon, 2010; Chua et al., 2013; Webbe-Janek et al., 2012).

Studies reported several barriers associated with or impacting educational strategies and/or programs. For example, high-fidelity simulation was lauded as a great teaching strategy; however, high-fidelity manikins were resource intensive and limited in their ability to demonstrate subtle changes in skin temperature and color (Buckley & Gordon, 2010; Connell et al., 2016; Liaw et al., 2015). In addition, researchers described changing roles for general ward nurses; vital sign monitoring and assessments were frequently delegated to nursing assistants and/or nursing students (Liaw et al., 2011; McDonnell et al., 2012). Researchers even suggested that vital sign monitoring was considered a low priority task (McDonnell et al., 2012). Massey, Chaboyer, and Anderson (2016) added that nurses relied heavily on technology instead of performing thorough assessments contributing to delays in recognition and management of clinical deterioration. Researchers described communication barriers citing the following: nurses tended to use social versus medical language; nurses provided irrelevant information when giving report; nurses did not properly express the seriousness of a situation; nurses were frustrated when expressed concerns received no response; and nurses feared negative responses when conveying concerns (Brier et al., 2015; Liaw et al., 2011; Massey et al., 2016). Finally, researchers noted that general ward nurses often lacked confidence in their abilities to assess and manage clinical deterioration and had a tendency to underestimate the significance of physiologic abnormalities (Brier et al., 2015; Massey et al., 2016; Webbe-Janek et al., 2012). This review provided a clear understanding of various barriers associated with or impacting educational strategies and/or programs.

Implications for Future Research

Future research is needed in many areas regarding educational strategies and programs aimed at improving nurses' abilities to recognize and manage clinical deterioration. First, more rigorous research is needed to evaluate

the effectiveness of structured assessment tools and structured communication tools (Brier et al., 2015; Liaw et al., 2011; Odell et al., 2009). Second, educational programs need to be more extensively developed and evaluated, especially interprofessional educational programs (Connell et al., 2016; Massey et al., 2016; Webbe-Janek et al., 2012). Next, studies need to be designed to measure retention of knowledge and skills obtained in a classroom setting; finding ways to accelerate this process whereby nurses translate their knowledge and skills to clinical practice is critical (Brier et al., 2015; Connell et al., 2016; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016). Most importantly, future research is needed to link educational strategies and programs to improved patient safety and patient outcomes (Connell et al., 2016; Cooper et al., 2011; Fuhrmann et al., 2009; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; Pantazopoulos et al., 2012).

Conclusions

Studies in this integrative review reported a variety of educational strategies and programs geared to enhance nurses' abilities to care for the deteriorating patient. Researchers agreed that educational interventions and programs that used a mixed methods approach were more likely to sustain learning outcomes and positively impact patient safety and patient outcomes. Thus, knowledge gained from this review can guide the development, implementation, and evaluation of an educational strategy for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky.

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Table 2.1 Overview of Studies

Reference Information	Design	Sample	Purpose	Findings	Limitations and Comments	Level
Brier et al. (2015) Nursing United States	Mixed methods approach	Combination of retrospective chart reviews and semi-structured interviews (n=10 chart reviews; n=10 expert nurses interviews)	To develop an algorithm to enhance nurses' ability to recognize and manage clinical deterioration through systematic examination, assessment, response, and communication.	▪ Main theme – nurses emphasized significance of complete, methodical assessments. ▪ Theme – nurses used visual cues and recognition of patterns to identify clinical deterioration. ▪ Theme – nurses often sought validation of initial assessment with other healthcare professionals. ▪ Theme – nurses frustrated by lack of response when communicating concerns.	▪ Small sample size; retrospective recall; family member input not included in algorithm development. ▪ Clinical algorithm deemed beneficial but needs further study. ▪ Clinical algorithm developed to enhance nurses' ability to critically think by focusing on assessment, recognition, response, and communication.	IV
Buckley & Gordon (2010) Nursing Australia	Survey design	50 nurses received a mixed-methods education program that combined didactic and high fidelity simulation (n=38 nurses participated in follow-up survey)	To assess frequency nurses used recognition and response skills following training. To assess effect of training on nurses' ability to recognize and respond to clinical deterioration. To assess the most valuable aspects of simulation in improving recognition and response. To identify if a relationship exists	▪ Most improved skills following simulation included a systematic response approach, communication with emergency team, and airway management. ▪ Most common emergencies in follow-up timeframe included cardiac, respiratory, neurological, cardiac arrest, and electrolyte imbalance. ▪ Debriefing and assertiveness training reported as most beneficial aspects of simulation training. ▪ Less experienced nurses reported greater benefits from playing team leader role.	▪ Nurses perceived that teaching methodology of combining didactic content with immersive simulation positively impacted their ability to recognize and manage clinical deterioration. ▪ Nurses reported equal importance of practicing both technical and non-technical skills as both are relevant during situations of clinical deterioration. ▪ Hard to determine what aspect of teaching (classroom, workshop, or simulation) impacted perceived clinical skills.	VI

			between years of experience and simulation in improving recognition and response.			
Chua, Mackey, & Liaw (2013) Nursing Australia & Singapore	Qualitative exploratory descriptive study	15 nurses (n=15 enrolled nurses interviewed)	To investigate the experience of nurses who have cared for deteriorating patients and to determine educational strategies to improve their ability to recognize and manage them.	▪ Experiences related to caring for deteriorating patients revealed 3 themes: recognition, responding, and responsibility. ▪ Strategies to improve nurses' ability to identify and manage clinical deterioration revealed 2 themes: educational development (skills and knowledge; experiential learning) and clinical process modifications.	▪ Interviews collected retrospective data; nurses more likely to share positive experiences where sound clinical judgment used; and findings could not be generalized. ▪ Study underscored need to improve nurses' ability to identify and manage clinical deterioration through training and process modifications.	VI
Connell et al. (2016) Nursing Australia	Mixed methods systematic review of literature	23 studies (n=20 quantitative; n=2 mixed methods; n=1 qualitative)	To assess effectiveness of educational programs pertaining to early recognition and management of clinical deterioration. To determine outcome measures to evaluate educational effectiveness.	▪ Most educational programs positively impacted participants, patient outcomes, and organizational systems. ▪ Hard to directly credit educational programs to improved patient outcomes – a very complex relationship between social behaviors and organizational culture. ▪ 22 studies used blended teaching strategies; greater than 87% incorporated medium to high- fidelity simulation. ▪ Median program length was 8 hours; most effective educational program based on 40 minute simulation.	▪ Most studies were quasi-experimental; risk of publication bias due to 21 of 23 studies reported positive impact of educational programs; and potential lack of statistical reliability due to use of indirect outcome measures (e.g., reports of improved confidence post-intervention). ▪ Participant outcomes improved when incorporate medium to high-fidelity simulation. ▪ In situ simulation had sustained impact. ▪ Outcome measures included indirect and objective measures of knowledge and	V

					skills; and impact on RRS triggering and response. ▪ Quality of assessments and documentation of care can be used to measure educational effectiveness.	
Considine & Currey (2015) Nursing Australia	Discursive paper	N/A	To make a case for the use of the primary survey approach to assessment (airway, breathing, circulation, and disability-ABCD).	▪ An argument was made for use of primary survey approach to patient assessment versus the vital signs approach or the body systems approach. ▪ ABCD approach lends to data collection that is prioritized. ▪ ABCD approach is similar to most RRT activation criteria. ▪ ABCD approach provides a patient safety checklist that reduces potential to miss clinical deterioration.	▪ Vital sign approach does not give direction regarding order of collection – may miss clinical deterioration. ▪ Body systems approach often leaves the order and number of systems assessed to the discretion of the nurse – clinical deterioration could be missed. ▪ Primary survey approach is evidence-based and can be used in any clinical setting.	VII
Cooper et al. (2011) Nursing Australia	Exploratory quantitative performance review	85% of nurses from a medical-surgical ward (n=35) Scenario 1-AMI Scenario 2-COPD Both scenarios with subtle deterioration cues Scenario 1-had a high level of relevant information; low level of uncertainty	To describe nurses' ability to recognize and manage clinical deterioration in a simulated environment by using the following: knowledge test, situation awareness questionnaire, and standardized rating form for skill performance.	▪ Average knowledge score 67% with wide range of 27-91%. ▪ Nurses who recently completed BLS did better on knowledge score but their clinical skill performance was not better. ▪ RN knowledge not maintained as parallel study demonstrated third year RN students with higher knowledge scores. ▪ Situation awareness and skill performance poor for both scenarios at 50%. ▪ Many important assessments and responses to deterioration were missed. ▪ Respiratory rate and capillary refill time not completed most of time.	▪ Study single center and lacked cultural diversity. ▪ Findings support what literature reports – room for improvement regarding nurses' ability to recognize and manage deterioration. ▪ Study demonstrates need for training to ensure clinical skills are developed. ▪ Educational programs or models like FIRST^2 ACT offer training that can bridge the gap between knowledge and practice. ▪ Nurses have used pattern recognition and intuition to guide care of deteriorating patient versus more objective data from changes	VI

		Scenario 1 – low level of relevant information; high level of uncertainty		▪ Attributed high anxiety to poor clinical performance.	in physiologic parameters – this can be dangerous. ▪ Educational strategies should help link patient assessment with changes in physiologic parameters to identifying trends. ▪ Educational strategies should focus on providing high fidelity scenarios in situ with reflective feedback, improving situational awareness, and providing supervised clinical practice.	
Fuhrmann, Perner, Klausen, Ostergaard, & Lippert (2009) Medical Denmark	Prospective before-and-after study	Medical staff and nursing staff received 1-day multi-professional training (n=50% of medical staff; n=70% of nursing staff; approximately 220 participants) Vital signs measured for pre-intervention = 690 (n=129 abnormal) Vital signs measured for post-intervention = 873 (n=155 abnormal)	To assess the effect of a 1-day educational training program on mortality and staff awareness of patients at risk of clinical deterioration on general wards.	▪ Incidents of patients with abnormal vital signs from pre- and post-intervention not statistically significant. ▪ Staff awareness of clinical deterioration pre- and post-intervention not statistically significant. ▪ 30-day mortality pre- and post-intervention not statistically significant. ▪ 180-day mortality pre- and post-intervention not statistically significant. ▪ Length of hospital stay pre- and post-intervention not statistically significant.	▪ Lack of awareness of clinical deterioration pre- and post-intervention may be why no effect noted in mortality or LOS. ▪ Lack of recognition or understanding of abnormal vital signs may have contributed to no effect on mortality or LOS. ▪ Lack of recognition of clinical deterioration may be related to nurse to patient ratio; patients with more complex medical problems. ▪ In developing educational intervention, did not target organizational issues that impact how patients are cared for. ▪ Study possibly needs more time to see an impact.	IV
Harvey, Echols, Clark, & Lee (2014)	Quasi-experimental, two-group comparison,	39 nurses practicing on one of two medical-surgical PCUs	To evaluate the impact of an evidence-based training method	▪ Knowledge scores higher in both groups after education but not significant difference between the two.	▪ Both groups achieved increased knowledge and teamwork skills improvement.	IV

Medical & Nursing United States	pre/post intervention study	 Unit A received in situ simulation-based training (SBT) scenarios Unit B received case study reviews (CSR)	(SBT versus CSR) on nurses' knowledge, confidence, teamwork, and clinical skill performance in recognizing and managing clinical deterioration. Both incorporated TeamSTEPPS training, a standardized system for team building.	▪ Confidence scores high for both groups before education. ▪ Total confidence score related to teamwork and clinical skills did not increase post education for CSR group. ▪ Total confidence did increase post education for SBT group. ▪ SBT group with significant improvement in all areas of teamwork skills post education. ▪ SBT group with significant improvement in clinical skills.	▪ Only SBT group demonstrated improvement post education in confidence, teamwork, and clinical skill performance. ▪ Suggest need for ongoing training/refresher training to maintain current knowledge and competence. ▪ In situ simulation creates challenges but is beneficial. ▪ Small sample size; knowledge tool and skill measures lacked validity and reliability. ▪ Greatest education impact related to in situ SBT. ▪ Regardless, education programs that are well-developed can be beneficial and impact nursing knowledge, confidence, teamwork, and clinical performance.	
Kinsman et al. (2012) Nursing & Science Australia	Interrupted time-series analysis	The FIRST^2 ACT simulation program was the intervention 83% of eligible nurses participated (n=34) 258 records audited pre-intervention 242 records audited post-intervention	To appraise the impact of a new, 1.5-hour simulation program on nursing practice (vital sign monitoring, pain assessment, etc.) related to the early recognition and management of clinical deterioration.	▪ Two variables showed statistical improvement – frequency of nursing observations and assessment of pain. ▪ Oxygen therapy improved but was not statistically significant. ▪ No statistical change was noted pre- or post-intervention for the following variables: temperature, oxygen saturation, respiratory rate, blood pressure, and Glasgow Coma Scale.	▪ Improved patient safety and quality of care demonstrated by increased nursing clinical and pain assessments. ▪ This study followed a previous study of student nurses and midwives whereby participants of the simulation program demonstrated increased knowledge, confidence, and competence per participant feedback. ▪ This study adds to the research that educational programs can be useful and	IV

					translate to true clinical setting. ▪ Unable to measure exact impact of management of clinical deterioration due to study design.	
Liaw, Scherpbier, Klainin-Yobas, & Rethans (2011) Medical & Nursing Singapore	Literature review	26 studies (n=19 identified educational needs; n=7 focused on development and evaluation of training programs)	To determine educational needs and strategies for nurses to enhance their ability to recognize and manage deteriorating ward patients.	▪ Nurses need knowledge and skill to help them recognize, report, and respond to clinical deterioration. ▪ Existing educational programs provided valuable information related to course content and strategies to improve care of deteriorating ward patients.	▪ Review may be limited by search strategy, small number of eligible articles, and unpublished information about other educational courses. ▪ Strategies identified: use of clinical decision-making models; development of standardized tool for nursing assessment and treatment; integration of content into nursing education; provision of training related to vital signs for nursing assistants; and evaluation of educational programs via research.	V
Liaw et al. (2015) Medical & Nursing Singapore	Randomized controlled trial	67 registered nurses from general ward units (n=35 for experimental group; n=32 for control group)	To describe the design and development of a web-based simulation. To evaluate the web-based simulation in terms of nurses' competencies to care for acutely ill adult patients.	▪ Instructional strategies of web-based simulation included: animation videos, multimedia instructional materials, virtual patients, and online quizzes. ▪ Experimental group: pretest on simulation-based assessment + 3-hour web-based simulation + simulation evaluation questionnaire + post-test on simulation-based assessment. ▪ Control group: pretest on simulation-based assessment + post-test on simulation-based assessment.	▪ Experimental group reported great satisfaction with the intervention in terms of relevance to practice, teaching strategies, and opportunities to problem solve. ▪ Web-based simulation can positively impact nurses' competencies to care for acutely ill adult patients. ▪ Web-based simulation ideal for training large numbers of nurses in acute care settings and for keeping clinical competencies current.	II

				▪ Experimental group post-test clinical performance scores improved significantly from pre-test scores.		
Liaw et al. (2016) Medical & Nursing Singapore	Pre-and-post-intervention study	99 nurses (n=53 from surgical ward; n=46 from medical ward) for an 85% participation rate	To determine effectiveness of web-based simulation on nurses' abilities to recognize and manage clinical deterioration. Kirkpatrick's 4-level evaluation model used to measure the primary clinical outcome – trigger rates of clinical deterioration.	▪ Pre-intervention trigger rate for medical ward = 8.96%. ▪ Post-intervention trigger rate for medical ward = 14.58%. ▪ Pre-post intervention trigger rate for medical ward was significant. ▪ Pre-post intervention trigger rate for surgical ward not significant. ▪ Knowledge pretest and post-test scores showed significant improvement with e-RAPIDS training. ▪ Motivation of participants to learn content was measured using the Instructional Material Motivation Survey. ▪ Participants reported high motivation due to practical relevance, high satisfaction with program, and higher level of confidence.	▪ Evidence from medical ward demonstrated improved outcomes related to triggering data – e-RAPIDS effective in helping nurses' abilities to recognize and manage clinical deterioration. ▪ Nurses self-reported improved knowledge and transfer of that knowledge to bedside. ▪ Lack of significant evidence from surgical ward may be due to patient characteristics. ▪ Study limited by lack of a control group; short study period; and study of only the afferent limb of RRS.	IV
Massey, Chaboyer, & Anderson (2016) Medical & Nursing Australia	Integrative review of literature	17 studies (n=9 qualitative; n=6 quantitative; n=2 mixed methods)	To review and summarize studies that addressed early recognition and management of clinical deterioration. To review studies that described or evaluated ward nurses' practice of recognizing and	▪ Studies revealed 4 themes surrounding early recognition of clinical deterioration: assessment; knowing the patient; ongoing training and education; and environmental factors. ▪ Studies revealed 3 themes pertaining to management of clinical deterioration: skills related to effective leadership, teamwork, communication, and situational awareness;	▪ Thorough integrative review but may have missed some pertinent studies. ▪ Need to develop a culture of patient safety by employing strategies that promote positive teamwork and collaboration; reduce anxiety associated with clinical deterioration; and reduce negative emotional responses related to such events.	V

			managing clinical deterioration. To expose gaps in the literature.	consultation and support from medical and nursing colleagues; and potential negative emotional responses.	▪ Ongoing education identified as critical element in enabling nurses to recognize and manage clinical deterioration; noted ALERT course with use of simulation; noted educational model and use of early warning signs.	
McDonnell et al. (2012) Medical & Nursing United Kingdom	Single center, mixed methods before-and-after study	Surveys (n=213) Interviews of nursing staff (n=15)	To determine to what extent a new clinical model geared toward the recognition and management of clinical deterioration impacted nursing knowledge and confidence.	▪ Nurses reported improved knowledge and confidence in recognizing and managing clinical deterioration post-intervention. ▪ Clinical model included the use of a T&T tool, response algorithm, and observation charts. ▪ Training delivered face-to-face by expert nurses. ▪ Emphasized importance of use of clinical judgment and familiarity of patient patterns.	▪ Single center; omitted care of elderly wards; short time period for follow-up so potential questions about sustainability. ▪ Consider tailoring training packages related to experience of staff. ▪ Commented that hands-on assessment and talking with patient enhanced T&T tool – use of technology only a limitation.	VI
Odell, Victor, & Oliver (2009) Medical & Nursing United Kingdom	Systematic literature review	14 studies (n=9 qualitative; n=5 quantitative)	To investigate nursing practice related to recognition and management of deteriorating ward patients.	▪ Themes included recognition; recording and reviewing; reporting; and responding and rescuing. ▪ Nursing intuition helps to identify clinical deterioration and vital signs validate. ▪ Identification and management of clinical deterioration dependent upon many factors that include nursing experience and education.	▪ Study limited by single reviewer and review methodology. ▪ Recognition and response to clinical deterioration is a complex process dependent upon nursing skill, experience, and confidence. ▪ Education and support systems needed – e.g., nurses need training in advanced assessment skills.	V
Ozekcin, Tuite, Willner, & Hravnak (2015) Nursing	Pre-and-post-intervention study	Pretests (n=39 acute care nurses) Post-tests (n=39 acute care nurses)	To evaluate the effectiveness of a 2-phase education program that focuses on the	▪ Purpose of intervention was to provide acute care nurses with a standardized process and experience in recognizing and	▪ Important to develop education modules that focus on assessment cues and triggers of clinical deterioration.	IV

United States		Survey (n=31 acute care nurses) Simulation scenarios (n=35 acute care nurses)	early recognition of clinical deterioration and empowers nurses to communicate concerns using SBAR communication tool.	managing clinical deterioration. ▪ Nurses with years of experience did not have higher scores on pretest or post-test. ▪ Average pretest score 56.5%. ▪ Average post-test score 84.6%. ▪ Time to achieve first correct critical action in simulation improved from scenario 1 to scenario 2. ▪ Time to escalate care in simulation improved from scenario 1 to scenario 2.	▪ Important to develop simulation scenarios for acute care nurses to enhance their assessment skills and communication skills. ▪ Clinical nurse specialists in ideal position to advance the assessment skills, knowledge, and communication skills of acute care nurses. ▪ Simulation provides an opportunity for nurses to rehearse actions and empowers them to manage clinical deterioration.	
Pantazopoulos et al. (2012) Medical & Nursing Greece	Descriptive, quantitative design	Multiple choice questionnaire; response from medical-surgical nurses = 62% (n=94)	To consider relationship between nursing demographics and ability of nurses to recognize and manage clinical deterioration.	▪ Major difference between 4-yr RNs and 2-yr RNs in the early recognition and management of clinical deterioration – BSN graduates identified critical situations at a higher rate and scored higher on questions pertaining to deterioration. ▪ Nurses expressed greatest concern for bradycardia, chest pain, airway obstruction, and bradypnea. ▪ Critical nursing actions were accurately identified in a majority of cases for airway obstruction and chest pain. ▪ Education level and BLS/ACLS courses influenced activation of MET.	▪ Small study sample; answers to questions may reflect what nurses think should be done versus what is actually done in practice. ▪ Need for continuing education pertaining to recognition and management of clinical deterioration with provision of clear guidelines for assessment, recognition, management, and communication. ▪ Emphasis on accurate, timely vital signs; complete assessments; clear communication process; and timely response. ▪ BLS/ACLS courses should be prerequisite for caring for ward patients.	VI
Preston & Flynn (2010)	Expert opinion	N/A	To assess patient safety in the context of nurses'	▪ Nurses in acute care poorly assess respiratory rate – a	▪ Emphasized need to enhance more accurate nursing assessment skills via	VII

Nursing Ireland			knowledge, skill, and practice of recording vital signs (T, P, R, BP, O_2 sat), blood glucose levels, and neurological function. To identify nurses' needs related to understanding of physiologic compensatory mechanisms in deterioration.	sensitive indicator of clinical deterioration. ▪ Emphasized that accuracy of vital signs dependent upon knowledge, skill, and training of nurse. ▪ Both advantages and disadvantages of use of electronic equipment presented. ▪ Emphasized belief that for nurses to recognize, manage, and communicate clinical deterioration, nurse needs to not rely solely on intuition but should understand the physiology of deterioration.	planned course on early recognition and management of clinical deterioration (e.g., ALERT course) and use of clinical simulation. ▪ Emphasized need for nurses to be regularly updated on use of electronic equipment and early warning scoring system tools.	
Webbe-Janek, Lenzmeier, Lambden, Herrick, & Pliego (2012) Medical & Nursing United States	Mixed-methods study	360 medical-surgical nurses completed the 3-week simulation program (n=203 nurses completed the study survey)	To assess nurses' perspectives of an interprofessional simulation training program with a follow-up survey.	▪ Ten main themes generated: 1-opportunity for hands-on practice and experience 2-increased awareness and preparedness 3- role clarity 4-teamwork and interprofessional training 5-increased knowledge/skills 6-communication 7-increased confidence and comfort 8-simulation experience 9-debriefing and reflective learning 10-patient outcomes. ▪ Responses of strongly agree and agree were related to simulation increased familiarity with equipment; feedback sessions were beneficial; and simulation	▪ Nurses perceived improved knowledge, skill, awareness, and preparedness to recognize and manage clinical deterioration following simulation program training. ▪ Kolb's cycle of learning requires a variety of learning strategies and useful model in designing nursing related educational programs. ▪ Simulation is experiential, offers reflection and refining of prior concepts, and allows for testing of new knowledge. ▪ Study findings cannot be generalized; study survey voluntary; and focused only on nurses' perspectives although training was interprofessional.	VI

				increased familiarity with roles and responsibilities in codes.		

Table 2.2 Rating System for the Hierarchy of Evidence for Intervention Studies

Level I	Evidence from a systematic review or meta-analysis of all relevant RCTs
Level II	Evidence obtained from well-designed RCTs
Level III	Evidence obtained from well-designed controlled trials without randomization
Level IV	Evidence from well-designed case-control and cohort studies
Level V	Evidence from systematic reviews of descriptive or qualitative studies
Level VI	Evidence from single descriptive or qualitative studies
Level VII	Evidence from the opinion of authorities and/or reports of expert committees

Note. Referenced from *Evidence-based Practice in Nursing and Healthcare: A Guide to Best Practice* (2nd ed.), by B. M. Melnyk and E. Fineout-Overholt. Copyright 2011 by Lippincott, Williams & Wilkins.

Manuscript 3:

Evaluation of a Comprehensive Modified Early Warning Scoring System and an Educational Intervention

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Abstract

PURPOSE: To develop and test a comprehensive modified early warning scoring (MEWS) system for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky; to educate and train nursing staff in utilization of a new MEWS system and early identification and management of clinical deterioration; and to determine nursing satisfaction regarding education, training, and use of a new MEWS system.

BACKGROUND: Adult medical-surgical patients are at risk for clinical deterioration. Rapid response systems and MEWS systems are strategies that have been employed to assist nursing staff in early identification and management of clinical deterioration. Testing of a newly proposed comprehensive MEWS system and an educational intervention is an essential first step in determining interventional effectiveness.

STUDY DESIGN: A retrospective, single center, mixed methods observational study.

METHODS: In Phase I, retrospective chart reviews (RCRs) were conducted during a 6-month timeframe for patients meeting one of the following severe adverse event (SAE) criteria: in-hospital cardiac arrest, in-hospital death, unexpected transfer to the intensive care unit, and/or rapid response team utilization specifically pertaining to the medical-surgical-telemetry units of interest. Physiologic parameters (i.e., vital signs and level of consciousness) and nursing responses were recorded in the 24-hours leading up to SAEs; MEWS were retrospectively calculated at 24-hours ($MEWS_{24}$), 16-hours ($MEWS_{16}$), and 8-hours ($MEWS_{8}$) to gauge utility of the MEWS tool. In Phase II, a 3-hour education and training workshop designed for nursing staff was developed, implemented, and evaluated. A focus was placed on use of a new MEWS system and early identification and management of clinical deterioration.

RESULTS: In Phase I of RCRs, 81 patients met criteria during a study timeframe of September 2016 through February 2017. Demographic data yielded the following: 51.9% male, 76.5% sixty years of age or older, and 98.8% White. $MEWS_{24}$ (n = 62) had a mean of 3.0, standard deviation (SD) of 1.6, and range of 1.0 – 7.0; $MEWS_{16}$ (n = 76) had a mean of 3.3, SD of 1.3, and range of 1.0 – 7.0; and $MEWS_{8}$ (n = 81) had a mean of 5.0, SD of 2.3, and range of 1.0 – 10.0. In Phase II, nine nursing staff participated in one of eight education and training workshops. Participants reported increased confidence in recognizing deterioration, responding to deterioration, and communicating concerns following an educational intervention. Nursing staff consistently reported respiratory effort, level of consciousness, oxygen saturation, respiratory rate, blood pressure, and heart rate as the most influential parameters in a nursing assessment for determining clinical deterioration. Satisfaction was high regarding the education, training, and use of a new MEWS system.

CONCLUSION: RCRs indicated that a MEWS system would be feasible in identifying patients at risk for SAEs in this patient population. Introduction of a new comprehensive MEWS system with an educational intervention had a positive effect on nursing staff's self-reported confidence, knowledge, and skill in recognizing and managing clinical deterioration.

RELEVANCE TO CLINICAL PRACTICE: Before full implementation, a prospective study is recommended to test a comprehensive MEWS system for all admissions through discharge over a defined time period and provide a mandatory educational intervention for interdisciplinary staff on the two medical-surgical-telemetry units of interest. Great insight could be learned regarding tool utility, resource utilization, and staff preparedness.

Evaluation of a Comprehensive Modified Early Warning Scoring System and an Educational Intervention

Acutely ill adult medical-surgical patients are at increased risk for clinical deterioration; many are advanced in age with complex medical problems and numerous comorbidities (National Patient Safety Agency [NPSA], 2007a; NPSA, 2007b). These patients frequently exhibit changes in physiologic parameters (e.g., respiratory rate, heart rate, and/or level of consciousness) in the 24-hours leading up to a severe adverse event (SAE) such as cardiopulmonary arrest and/or death (Garvey, 2015; National Confidential Enquiry into Patient Outcome and Death [NCEPOD], 2005; Subbe & Welch, 2013). However, subtle signs of clinical deterioration often go unrecognized or mismanaged by primary nursing staff, contributing to the well documented problems of failure to rescue events and suboptimal care (Al-Qahtani & Al-Dorzi, 2010; McQuillan et al., 1998; Mei, Ying, & Fai, 2009; NCEPOD, 2005; Patient Safety First [PSF], 2008; Subbe & Welch, 2013). Supported by organizations like the National Patient Safety Agency (NPSA) and the Institute for Healthcare Improvement (IHI), rapid response systems (RRSs) and modified early warning scoring (MEWS) systems are strategies that have been employed to assist nursing staff in early identification and management of clinical deterioration (Duncan, McMullen, & Mills, 2012; NPSA, 2007a; NPSA, 2007b). Many observational studies reported favorably on the use of comprehensive MEWS systems; they identified both clinical processes (e.g., the incorporation of a MEWS tool, a response algorithm, a RRS, and a communication tool) and organizational needs (e.g., organizational buy-in, staff education and training, and ongoing evaluation) as essential to successful implementation. With the right resources and processes in place, researchers predicted nursing staff could potentially reduce the number of SAE occurrences and ultimately improve patient safety and patient outcomes (Cei, Bartolomei, & Mumoli, 2009; De Meester et al., 2012; Duncan et al., 2012; Gardner-Thorpe, Love, Wrightson, Walsh, & Keeling, 2006; Huggan et al., 2015; Kim et al., 2015; Kyriacos, Jelsma, & Jordan, 2014; Ludikhuize et al., 2014; Ludikhuize, Smorenburg, de Rooij, & de Jonge, 2012; Mapp, Davis, & Krowchuk, 2013; Mathukia, Fan, Vadyak, Biege, & Krishnamurthy, 2015; National Clinical Effectiveness Committee [NCEC], 2013; Odell, 2014; Perera et al., 2011; Subbe, Davies, Williams, Rutherford, & Gemmell, 2003). With these goals in mind, the purpose of this study was threefold:

1. To develop and test a comprehensive MEWS system for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky;
2. To educate and train nursing staff in utilization of a new MEWS system and early identification and management of clinical deterioration; and
3. To determine nursing satisfaction regarding education, training, and use of a new MEWS system.

Background

Two decades have passed since the original early warning scoring (EWS) instrument, consisting of five physiologic variables, was introduced to assist general ward nurses in recognizing and managing clinical deterioration in their vulnerable patient population (Mathukia et al., 2015). Utility of the instrument, and others that followed, was based on the premise that early clinical deterioration could be detected by monitoring slight changes in multiple physiologic variables (i.e., vital signs and consciousness level) versus relying on drastic changes in just one (Jones, 2013). Extensive research had previously unveiled the problems of failure to rescue events and

suboptimal care in general ward patients. In a majority, deviations in physiologic variables occurred in the hours and days preceding an SAE; however, they were frequently missed or mismanaged by nursing staff (Al-Qahtani & Al-Dorzi, 2010; Garvey, 2015; McQuillan et al., 1998; Mei et al., 2009; NCEPOD, 2005; PSF, 2008; Subbe & Welch, 2013). For example, one study reported an estimated 11% of patient deaths were a direct result of undetected or untreated clinical deterioration, while another 7.5% were due to problems in the management of deterioration (NPSA, 2007a; NPSA, 2007b; PSF, 2008). The NPSA (2007a) attributed the breakdown in care to three factors: a lengthy time between assessments (i.e., vital signs and complete physical assessments); a lack of recognition of deviations in physiologic variables; and a delay in the management of clinical deterioration despite assessments and recognition of deterioration. Odell (2014) added that the process of recognizing and managing deterioration was "highly complex, influenced by many factors to include organizational factors, local cultural rules, staff experience and education, and multidisciplinary team work" (p. 174). Even so, researchers agreed that patient outcomes were contingent upon "early detection, timeliness, and clinical response" (Bunkenborg, Poulsen, Samuelson, Ladelund, & Akeson, 2016; Royal College of Physicians [RCP], 2012, p. x). Comprehensive MEWS systems and other alert systems were developed and implemented with these contingencies in mind (Bunkenborg et al., 2016; Jones, 2013;NCEC, 2013; NPSA, 2007b; RCP, 2012).

The setting for this practice inquiry project was a 159-bed referral hospital in northeastern Kentucky. Nursing leadership was interested in examining the effectiveness of MEWS systems for possible implementation on two medical-surgical-telemetry units. An organizational framework of shared governance was already in place to support this study; nurse practice councils were structured to give autonomy to nurses over their clinical practice with a focus on patient safety, quality of care, and resource utilization (Dunbar, Park, Berger-Wesley, & Cameron, 2007; Kramer et al., 2009). Two integrative reviews were conducted: one examining the effectiveness of MEWS systems and the other investigating educational strategies to improve early recognition and management of clinical deterioration. Findings guided the development, implementation, and initial evaluation of a comprehensive MEWS system and an educational intervention for this hospital. Research questions for this study included:

1. How effective was the selected MEWS tool in detecting clinical deterioration prior to an SAE for this patient population?
2. How effective was a mixed method approach to educating and training nursing staff on use of a new MEWS system and essential skills for recognizing and managing clinical deterioration?

Methods

Institutional Review Board (IRB) approval was granted by the study hospital. Officials from the University of Kentucky (UK) deferred to the designated IRB for review and continuing oversight. The level of review was classified as expedited; risks were determined to be minimal. Additional approval was given by respective parties for use of the following: A MEWS tool and response algorithm adopted from Stony Brook Medicine, Stony Brook, New York (B. M. Mills, personal communication, November 1, 2016); an assessment/communication tool known as Rescuing-A-Patient-In-Deteriorating-Situations – RAPIDS Tool (S. Y. Liaw, personal communication, September 7, 2016); and an 11-item survey that was modified for an adult patient population and defined as a 10-item pretest/posttest (M. Kaul, personal communication, November 10, 2016).

Frameworks

Conceptual frameworks used for this practice inquiry project included the Logic Model and the Sociotechnical System Model. By definition, the Logic Model is "a systematic and visual way to present and share your understanding of the relationships among the resources you have to operate your program, the activities you plan, and the changes or results you hope to achieve" (W.K. Kellogg Foundation, 2004, p. 1). This step-by-step approach helped in the overall development, planning, and evaluation of this project. The Sociotechnical System Model, which "includes technology (e.g., software, hardware), people (e.g., clinicians, patients), processes (e.g., workflow), organization (e.g., capacity, decisions about how health IT is applied, incentives), and the external environment (e.g., regulations, public opinion)", was foundational in planning for an electronic MEWS system (Institute of Medicine [IOM], 2012, p. 3).

Study Design

Study design for this practice inquiry project was a retrospective, single center, mixed methods observational study. The scope of the project was limited to the development and testing of a comprehensive MEWS system and the education and training of nursing staff. Findings would serve as the foundation for a broader initiative of full implementation and evaluation of a comprehensive MEWS system. Because this project was multifaceted, two phases were used to describe it with better clarity:

1. Phase I – Development and testing of a comprehensive MEWS system (retrospective chart reviews).
2. Phase II – Education and training of nursing staff in utilization of a new MEWS system and early identification and management of clinical deterioration (3-hour workshops).

Study Population

In Phase I, study population included adult patients aged 18 years and older, males and females, admitted to one of two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky. Each unit had a 29-bed capacity and an average daily census of 16 patients. According to local health statistics, the population in this area, considered part of the Appalachian Region, was approximately 92.1% White, 3.1% Black, 1.9% Hispanic, 1.3% Asian, 1.3% other or unknown, 0.2% American Indian, and 0.03% Native Hawaiian or other Pacific Islander. Women made up 55.3% of the population. Major health concerns included adult diabetes, obesity, and cigarette smoking (Centers for Disease Control and Prevention [CDC], 2016; City-Data.com, 2016). The sample was selected based on specific outcome criteria (SAEs) for this study.

In Phase II, study population included nursing staff from two medical-surgical-telemetry units who were given an opportunity to participate in an education and training workshop. This group of approximately 70 individuals was comprised of 68% registered nurses (RNs) with a majority prepared at the associate degree level, 10% licensed practical nurses (LPNs), and 22% certified nurse aides (CNAs). An estimated 50% of nursing staff had less than three years nursing experience. Nursing staff from the intensive care unit (ICU) were also invited to attend the workshops. It was anticipated that up to 100 individuals (ward staff and ICU staff) would participate in one of the workshops; CNAs were not included in the workshops.

Subject Recruitment Method

In Phase I, retrospective chart reviews (RCRs) were completed between a 6-month study timeframe of September 2016 through February 2017. Subject recruitment was based on the following outcomes: in-hospital cardiac arrests, in-hospital deaths, unexpected transfers to ICU, and rapid response team (RRT) utilization specifically pertaining to the medical-surgical-telemetry units of interest. Inclusion criteria included patients aged 18 years or older admitted to one of these wards during the 6-month data collection period. For patients experiencing more than one SAE during their hospitalization, only data from the first event were used. Exclusion criteria included the following: patients who had do-not-resuscitate orders; incomplete (less than three physiologic parameters recorded) or unavailable records; and in-hospital cardiac arrests, in-hospital deaths, unexpected transfers to ICU, and RRT calls occurring outside of the medical-surgical-telemetry units. A waiver of informed consent was approved. Patient data were de-identified prior to analyses and anonymity was maintained in accordance with the hospital's IRB policy (see Appendix A for data collection tool).

In Phase II, nursing staff from two medical-surgical-telemetry units and ICU were invited to participate in a 3-hour education and training workshop. Workshops were offered the last two weeks in March 2017 and focused on early identification and management of clinical deterioration and utilization of a new comprehensive MEWS system. Recruitment of subjects occurred via direct communication from the nurse managers, in coordination with the Education and Nursing Research Councils, and with the support of the other shared governance councils. Informed consent was obtained from participants in an email containing an informed consent letter with a link to the hospital's Learning Management System; clicking on the link to register for a workshop signified consent (see Appendix B for workshop advertisement). Participation was strictly voluntary and individual scores and evaluations remained confidential.

Pre-Intervention

Prior to Phase I implementation, the principal investigator (PI) focused on the development and testing of a comprehensive MEWS system beginning with MEWS tool selection. Following an integrative review, the PI selected three MEWS tools based on the best evidence and moved them forward for approval by the Nurse/Physician Collaboration Council and the Quality Council. A brief PowerPoint presentation was prepared and delivered to both councils in November 2016, laying out the pros and cons for each MEWS tool. Stony Brook Medicine's MEWS tool was unanimously chosen for this study (Duncan et al., 2012). The MEWS tool consisted of six physiologic variables: "respiratory rate, heart rate, systolic blood pressure, level of consciousness, temperature, and oxygen saturation" (see Table 1 and Table 2 for MEWS system and response algorithm, respectively).

Prior to Phase II implementation, the PI developed a 3-hour education and training workshop (see Appendices C, D, E, F, and G for workshop agenda, workshop presentation, clinical deterioration simulation template, simulation scenario progression cheat sheet, and RAPIDS Tool, respectively). Curriculum focus was on use of a comprehensive MEWS system (the one developed and tested in Phase I) and on early identification and management of clinical deterioration. The comprehensive MEWS system included the MEWS tool, response algorithm, MEWS system policy with RRT and situation-background-assessment-recommendation (SBAR) protocol inclusion, RRT policy update, and MEWS system incorporation into the electronic medical records (EMR). The

topic of clinical deterioration was addressed through "recognition" by using the airway-breathing-circulation-disability-exposure (ABCDE) assessment mnemonic; "recording and reviewing" referring to use of the MEWS tool in the EMR; "reporting" using the SBAR communication tool; and "responding and rescuing" using the response algorithm (Considine & Currey, 2015; Liaw et al., 2015; Odell, Victor, & Oliver, 2009, p. 2000). The didactic portion of the workshop included a PowerPoint presentation with incorporation of lecture, discussion, and case studies. A simulation scenario provided participants an opportunity to increase their confidence, knowledge, and skill in assessing and managing clinical deterioration with use of a comprehensive MEWS system and an assessment tool (RAPIDS Tool).

In addition, the PI trained clinical educators in the delivery of an education and training workshop. An emphasis was placed on maintaining curriculum fidelity from one workshop to the next. The goal was adherence to learning objectives, agenda timeframes, topics, and activities to enhance fidelity and improve overall learning outcomes (LaChausse, Clark, & Chapple, 2013). A fidelity checklist was developed and used for this purpose (see Appendix H for fidelity checklist).

To better prepare participants, large informational binders were placed on each medical-surgical-telemetry unit for nursing staff to peruse before workshop attendance. Binder content included the following: a one-page executive summary of the practice inquiry project; a copy of the PowerPoint presentation given to the shared governance councils; a copy of the top three MEWS tools with response algorithms; an advertisement for the workshops with available dates and times; a copy of the COMPASS Adult Manual (an education program focused on understanding clinical deterioration in terms of physiological abnormalities and the body's compensatory mechanisms); articles on the problems of failure to rescue events and suboptimal care; articles on RRTs and their effectiveness; articles on MEWS systems; and miscellaneous articles on assessment, education strategies, and simulation (Avard et al., 2011). Binders remained on the units and served as a resource.

Data Collection

In Phase I, data collection from RCRs for qualifying patients included the following demographic data: gender, age, race/ethnicity, admission diagnosis, and comorbidities. Additionally, physiologic parameters (i.e., vital signs and level of consciousness) and nursing responses in the 24-hours leading up to an SAE were recorded. A MEWS was retrospectively calculated at 24-hours (defined as greater than 16-hour to 24-hour point), 16-hours (defined as greater than 8-hour to 16-hour point), and 8-hours (defined as 0-hour to 8-hour point) based on available data. Findings were used to determine tool utility (Kim et al., 2015). For timeframes with more than one set of physiologic parameters, the highest MEWS for that timeframe was used. Results guided the process of making MEWS tool modifications, developing a response algorithm, writing a MEWS system policy with RRT and SBAR protocol inclusion, updating the RRT policy, and making recommendations to information technology (IT) personnel for tool design in the EMR (see Appendices I and J for draft MEWS system policy and recommendations for IT).

In Phase II, data collection from the workshops included the following measures: demographic data of nursing staff embedded in the pretest/posttest to include position title, highest level of education, and years of nursing experience; pretest/posttest scores designed to measure confidence level, knowledge, and skill in early

identification and management of clinical deterioration; and evaluation survey to obtain immediate feedback on education and training workshop and utilization of a comprehensive MEWS system. Participants enrolled in one of 10 workshops offered over the course of a two-week period; 10 participant slots were available per workshop. Workshops were offered Monday through Friday from 8:00 A.M. to 11:00 A.M. A continental breakfast was provided each day. Participants were asked to complete a paper-based pretest at the beginning of each workshop and a paper-based evaluation survey at the conclusion of each workshop. In addition, participants were asked to complete a posttest two weeks following the workshops to assess if overall confidence, knowledge, and skill had improved as a result of workshop attendance. Pretest, posttest, and evaluation survey completion were incentivized.

Data Analysis

Data were analyzed using IBM SPSS Statistics version 22.0 software (IBM SPSS, 2010; Pallant, 2013). In Phase I, categorical variables (i.e., demographic data, SAEs, patient comorbidities, and highest MEWS in 24-hours leading up to an SAE) were presented as numbers and percentages; continuous variables (i.e., highest MEWS in first [$MEWS_8$], second [$MEWS_{16}$], and third timeframes [$MEWS_{24}$]) were presented as means and standard deviations. In Phase II, categorical variables (i.e., demographic data, pretest/posttest confidence levels, nursing response to most influential parameters in nursing assessment, and evaluation survey questions) were expressed as numbers and/or percentages; qualitative responses were examined for themes (i.e., recognition of and response to clinical deterioration, communication of concern, and satisfaction pertaining to workshops and MEWS tool).

Results

Phase I: Patient Demographic Data

During the 6-month study timeframe, a total of 207 patient charts met at least one SAE criterion (i.e., in-hospital cardiac arrest, in-hospital death, unexpected transfer to ICU, and RRT utilization). However, only 81 patient charts (39.1%) met study inclusion criteria and were fully reviewed. The remaining 126 patient charts (60.9%) were excluded for reasons such as do-not-resuscitate orders, incomplete or unavailable records, patients experiencing more than one SAE during their hospitalization, or SAEs occurring outside the medical-surgical-telemetry units of interest.

Demographic characteristics of the patients included in the RCRs (n = 81) yielded the following: 51.9% male, 76.5% sixty years of age or older, and 98.8% White. The most common admission diagnoses were respiratory in nature (29.6%); general medical and cardiac diagnoses were in second and third place, respectively (see Table 3 for complete demographic characteristics for Phase I). In addition, chronic disease was widespread in this patient population with over 50% suffering from hypertension, coronary artery disease, dyslipidemia, and/or chronic obstructive pulmonary disease (see Table 4 for the most common patient comorbidities for Phase I).

Phase I: Severe Adverse Events

A total of 65 patients (80.2%) met criteria for a single SAE; while16 patients (19.7%) met conditions for two or three SAEs, simultaneously. Total unexpected transfers to ICU comprised a majority of SAEs in this study (69.1%), followed by RRT calls (46.9%). Of the RRT calls, 36.8% (n = 14) resulted in unexpected transfers to ICU (see Table 3). SAEs occurred during hospitalization as follows: day of admission (14.8%), patient-day one (30.9%),

patient-day two (12.3%), and patient-day three or more (42.0%). Specific times of SAEs were also identified: from 7:00 A.M. to 3:00 P.M. (40.7%), from 3:00 P.M. to 11:00 P.M. (35.8%), and from 11:00 P.M. to 7:00 A.M. (23.5%). Reasons for unexpected transfers to ICU and RRT calls were primarily cardiac (33.3%), respiratory (24.7%), or neurological (24.7%) in nature. In terms of patient outcomes, most were discharged home (39.5%) or discharged to a nursing home (19.8%). Others died during hospitalization (11.1%) or were transferred to an acute care hospital (19.8%), an inpatient rehabilitation facility (7.4%), or a psychiatric hospital (2.5%).

Phase I: MEWS

$MEWS_{24}$ (n = 62) had a mean of 3.0, standard deviation (SD) of 1.6, and range of 1.0 – 7.0; $MEWS_{16}$ (n = 76) had a mean of 3.3, SD of 1.3, and range of 1.0 – 7.0; and $MEWS_8$ (n = 81) had a mean of 5.0, SD of 2.3, and range of 1.0 – 10.0. Sample sizes varied from $MEWS_{24}$, $MEWS_{16}$, and $MEWS_8$ due to SAEs occurring in some patients soon after admission before reaching designated time-points (i.e., $MEWS_{16}$ and/or $MEWS_{24}$). MEWS distribution for $MEWS_{24}$, $MEWS_{16}$, and $MEWS_8$ for scores 1.0 – 10.0 are represented in Figure 1. For example, MEWS of 1.0 at all three time-points were as follows: 15 patients with MEWS 1.0 at $MEWS_{24}$ (24.2%); four patients with MEWS 1.0 at $MEWS_{16}$ (5.3%); and three patients with MEWS 1.0 at $MEWS_8$ (3.7%). Although only the highest MEWS for each designated timeframe were used for statistical analysis, MEWS were calculated retrospectively for all sets of physiologic parameters (i.e., a minimum of three physiologic parameters was required for calculation) in the 24-hours leading up to an SAE (n = 726 MEWS). Individual line graphs were developed to display MEWS trends for every MEWS calculated for every patient (see Appendix K for line graphs of MEWS).

Phase I: Nursing Response

In terms of documenting physiologic variables, nursing staff recorded vital signs and level of consciousness approximately every 2.8 hours for $MEWS_{24}$, 2.7 hours for $MEWS_{16}$, and 2.1 hours for $MEWS_8$. As a result, 726 MEWS were calculated retrospectively (i.e., $MEWS_{24}$ = 182 scores; $MEWS_{16}$ = 226 scores; and $MEWS_8$ = 318 scores); once again, only the highest MEWS for each designated timeframe were used for statistical analysis Documentation of sets of vital signs/level of consciousness per patient ranged from a minimum of three to a maximum of 17 sets prior to an SAE. On average, sets of physiologic parameters were recorded as follows: 2.9 sets per 8-hours for $MEWS_{24}$, 3.0 sets per 8-hours for $MEWS_{16}$, and 3.9 sets per 8-hours for $MEWS_8$. All six physiologic variables (i.e., "respiratory rate, heart rate, systolic blood pressure, level of consciousness, temperature, and oxygen saturation") were recorded in 80.6% of $MEWS_{24}$, 85.5% of $MEWS_{16}$, and 74.1% $MEWS_8$ (see Table 1 for MEWS system). Temperature was the most frequently omitted variable (2.9% of MEWS), followed by level of consciousness (2.5% of MEWS) and respiratory rate (2.3% of MEWS). The physiologic variables most consistently recorded were heart rate and oxygen saturation; an omission of each occurred only once.

In over half of the cases, nursing staff entered a patient's room to carry out a routine assessment, do a follow-up, or administer a medication when they recognized signs of clinical deterioration in their patient (53.1%). Nurses were already at the bedside conducting an assessment, giving medications, rechecking vital signs, assisting a patient to the bathroom, or completing a nursing skill (e.g., inserting an indwelling urinary catheter or starting an IV) when the patient became symptomatic (23.5%). Other SAEs were identified as follows: a patient called for help (11.1%), a patient's family member called for help (4.9%), a respiratory therapist was at the bedside (2.5%), a

telemetry technician reported an arrhythmia (2.5%), a charge nurse was at the bedside (1.2%), and a personal care assistant reported concerns to a nurse (1.2%).

In the 24-hours leading up to SAEs, nursing staff documented their communication with a physician regarding various patient concerns in 30 of 81 patient charts (37.0%). In many instances, orders were given for medication administration, diagnostic/lab testing, and/or continued monitoring. Other nursing actions included paging a respiratory therapist, seeking assistance from a charge nurse, carrying out a nursing skill, documenting an additional assessment (i.e., cardiac, gastrointestinal, neurological, respiratory, and/or urinary), and/or contacting family members.

At the time of SAEs, nursing staff documented physician notification of clinical deterioration in 64 of 81 patient charts (79.0%). They also recorded diagnostic/lab testing in 39 patient charts (48.1%) and medication administration in 31 patient charts (38.3%). Other interventions included paging a respiratory therapist (28.4%), documenting an additional assessment (21.0%), administering an intravenous fluid bolus (17.3%), and notifying a charge nurse (6.2%). Standardized RRT reports provided the most thorough and reliable documentation of an SAE; detailed nursing documentation of unexpected transfers to ICU was less consistent.

Phase II: Nursing Staff Demographic Data

In Phase II, eight 3-hour education and training workshops were offered during a 2-week timeframe to nursing staff from two medical-surgical-telemetry units and ICU. Of nine participants, most were RNs (77.8%) with seven years or less nursing experience (66.6%). Three participants had over 15 years nursing experience (see Table 5 for complete demographic characteristics for Phase II).

A 10-item pretest was administered at the beginning of each workshop. The first three items were multiple-choice questions addressing demographic characteristics of the group. The next three items focused on nursing confidence in recognizing, responding, and communicating clinical deterioration. Multiple choice answers included the following: ‘not confident at all’, ‘somewhat confident’, ‘confident’, ‘very confident’, and ‘extremely confident’. In item-7, nursing staff were asked to select parameters in a nursing assessment believed most influential in determining a patient’s level of stability. In item-8 and item-9, a short patient scenario was provided and nursing staff were asked to select assessment findings and management options that were most appropriate for that particular situation. A final question addressed effective communication tools and work environment (see Appendix L for pretest/posttest survey questions).

Phase II: Pretest Responses and Themes

When nursing staff were asked about their confidence level in recognizing clinical deterioration, a majority responded they were either ‘somewhat confident’ or ‘confident’ (88.9%). No respondents claimed they were ‘very confident’ or ‘extremely confident’; one marked they were ‘not confident’. In terms of confidence level in responding to clinical deterioration, nursing staff maintained the following: ‘not confident’ (22.2%), ‘somewhat confident’ (22.2%), ‘confident’ (33.3%), ‘very confident’ (11.1%), and ‘extremely confident’ (11.1%). Finally, most claimed they were either ‘confident’, ‘very confident’, or ‘extremely confident’ in their ability to communicate concerns about a patient’s deteriorating status (77.8%); two were ‘somewhat confident’ (22.2%).

Nursing staff identified respiratory effort, level of consciousness, oxygen saturation, respiratory rate, blood pressure, and heart rate as the most influential parameters in a nursing assessment to determine a patient's level of stability (see Figure 2 for nursing response to most influential parameters). Given a patient scenario, they determined the following assessments to be of greatest concern: breathing labored (100%), appears lethargic and uncomfortable (88.9%), temperature of 101.2 ° F (77.8%), color pale (77.8%), and last urine output approximately eight hours ago (77.8%). Similarly, nursing staff named the following actions most appropriate based on the patient scenario: obtain order to place patient on cardiac monitor and continuous pulse oximetry (88.9%); obtain orders for medication therapy (88.9%); alert medical provider regarding the temperature, obtain order for antipyretic and recheck temperature in one hour (88.9%); obtain order to titrate oxygen to maintain oxygen saturation above 92% (77.8%); and obtain orders for fluid intake and output monitoring (77.8%).

In the final question on effective communication and work environment, nursing staff reported routine use of an SBAR communication technique in hand-offs, patient transfers, critical conversations, and telephone calls 44.4% of the time. Others claimed they used an SBAR tool occasionally (44.4%), while some reported using their own personal tool/technique (33.3%). Four participants responded to statements about work environment: three agreed 'all team members can contribute valuable input regardless of rank or position', three agreed 'open and receptive communication is valued', and all four agreed 'speaking out regarding a patient's safety will not be held against me'.

Phase II: Posttest Responses and Themes

As planned, paper-based posttests were delivered to participant mailboxes two weeks following workshop attendance. A box was placed on each unit for participants to return completed posttests; there was a 55.6% return on posttests. Because pretests and posttests were not coded, direct comparisons between the two were limited. However, nursing staff reported increased confidence in their ability to recognize clinical deterioration; four nurses marked 'very confident' in the posttest compared to zero in the pretest. Similarly, confidence in response and communication were also increased; three nurses in each case reported enhanced confidence in posttest answers. Nursing staff remained committed to what they considered the most influential parameters in a nursing assessment for determining clinical deterioration: respiratory effort, level of consciousness, oxygen saturation, respiratory rate, blood pressure, and heart rate.

Phase II: Evaluation Survey Responses and Themes

A 15-item evaluation survey was administered at the end of each workshop (see Appendix M for evaluation survey questions). In item-1, participants were asked to document the date of workshop attendance. The next 10 items focused on workshop content, design, instructor, and results; multiple choice answers included 'strongly agree', 'agree', 'undecided', 'disagree', and 'strongly disagree'. In item-12, nursing staff were asked to provide suggestions for workshop improvement from a list of options. The final three items were free-text questions and invited participants to recommend other improvements (item-13), share what they enjoyed most about the workshop (item-14), and list what they liked least (item-15).

A majority of nursing staff 'strongly agreed' or 'agreed' that workshop content was relevant to their job and difficulty level was appropriate (88.9%). In terms of instructor knowledge/preparedness and appropriate

workshop activities, 77.8 % of nursing staff selected ‘strongly agreed’ or ‘agreed. In addition, 66.7% of nursing staff ‘strongly agreed’ or ‘agreed’ on the following: objectives were clear and easy to understand; workshop met needs and expectations; activities gave sufficient practice and feedback; pace was appropriate; knowledge and skills were increased due to workshop; and workshop was a good way to learn content. For comments regarding workshop improvement, 66.7% of nursing staff did not select one of the prepared options. The remaining 33.3% suggested the following: provide better information prior to the workshop; increase content covered; improve workshop organization; make workshop more difficult; slow down the pace; allot more time for workshop; and shorten time for workshop (see Table 6 for free-text responses from evaluation survey).

Discussion

Phase I: Severe Adverse Events

Several studies reported the effects of MEWS system implementation pre- and post-intervention; variables used to measure effectiveness included in-hospital cardiac arrests, hospital mortality rates, unexpected transfers to ICU, and RRT utilization. For example, Drower, McKeany, Jogia, and Jull (2013) reported a reduction in cardiac arrests after implementing a MEWS system and a response team. Similar results were reported by Mathukia, Fan, Vadyak, Biege, and Krishnamurthy (2015), Maupin (2010), McGaughey et al. (2007), and Nishijima et al. (2016). Other studies described decreased mortality rates and/or an association between high MEWS and incidence of death (Huggan et al., 2015; Mapp et al., 2013; Maupin, 2010; Mitchell et al., 2010; Smith et al., 2014). Huggan et al. (2015), Mapp, Davis, and Krowchuk (2013), and Mitchell et al. (2010) reported a decrease in unexpected transfers to ICU and/or an association between high MEWS and ICU transfers. In addition, a number of studies reported increased RRT calls post-MEWS implementation (Ludikhuize et al., 2014; Mapp et al., 2013; Mathukia et al., 2015; Mitchell et al., 2010; Stewart, Carman, Spegman, & Sabol, 2014). Although the same SAEs were addressed in this study, only preliminary conclusions were made regarding utility of the selected MEWS tool due to the limited scope of the project. Of 81 patients, only a small percentage suffered in-hospital cardiac arrest (3.7%) and death (1.2%). In these instances, determination of MEWS tool effectiveness may not be conclusive due to an already low incidence of in-hospital cardiac arrest and death compared to other studies. Conversely, unexpected transfers to ICU and RRT calls made up the bulk of SAEs, 69.1% and 46.9% respectively; MEWS tool effectiveness may be better measured by monitoring the impact on these two variables. For example, MEWS 4.0 – 5.0 (orange category) were identified at $MEWS_{24}$ in 16 patients (25.8%) and $MEWS_{16}$ in 24 patients (31.6%); according to the response algorithm, these scores would require an assessment by the charge nurse and notification of the primary provider (see Table 1 and Table 2 for MEWS system and response algorithm, respectively). In addition, MEWS $\geq$ 6.0 (red category) were identified at $MEWS_{24}$ in four patients (6.4%) and $MEWS_{16}$ in six patients (7.9%); according to the response algorithm, these scores would require activation of the RRT. If a comprehensive MEWS system had been in place, the impact on unexpected transfers to ICU and RRT utilization may have been similar to previously mentioned studies with a decrease in unexpected ICU transfers and a significant increase in RRT calls.

Phase I: MEWS

The study provided an initial evaluation of the effectiveness of the selected MEWS tool in detecting clinical deterioration prior to SAEs in this adult patient population. As anticipated, patients experienced an increasing MEWS in the hours leading up to an SAE. A $MEWS_8$ average was higher than a $MEWS_{16}$ average and a $MEWS_{16}$ average was higher than a $MEWS_{24}$ average (i.e., $MEWS_8$ = mean of 5.0; $MEWS_{16}$ = mean of 3.3; and $MEWS_{24}$ = mean of 3.0). These results were based on the highest MEWS for each timeframe. However, when examining every set of physiologic parameters and retrospectively calculating corresponding MEWS, patient scores typically did not gradually increase right up to time zero of an SAE, as might be suggested by the aforementioned results. Instead, many patients had MEWS with no obvious upward trending until the exact time of the SAE or had MEWS that greatly fluctuated from one set of vital signs to the next. For example, Patient Chart 28 and Patient Chart 36 had MEWS ranging from 0.0 to 2.0 in the 24-hours leading up to an SAE; however, MEWS spiked at the time of events to 6.0 and 8.0, respectively. For Patient Chart 38 and Patient Chart 83, MEWS often fluctuated from one reading to the next; MEWS ranged from 0.0 to 7.0 in the 24-hours leading up to an SAE (see a MEWS snapshot for Patient Chart 28, 36, 38, and 83 below). In both sets of circumstances, the ability to recognize early clinical deterioration based solely on MEWS would have been challenging (see Appendix K for line graphs for MEWS). Interestingly, the highest MEWS occurred at time zero of an SAE in only 53.1% of total study cases; however, the highest MEWS at time zero of an SAE specifically for RRT calls were 71.1%.

- Patient Chart 28 MEWS: 2.0 at 10th hour, 2.0 at 9th hour, 2.0 at 8th hour, 2.0 at 7th hour, 2.0 at 3rd hour, and 6.0 at SAE (time zero).
- Patient Chart 36 MEWS: 2.0 at 22nd hour, 0.0 at 20th hour, 1.0 at 19th hour, 1.0 at 17th hour, 0.0 at 13th hour, 1.0 at 9th hour, 0.0 at 6th hour, 1.0 at 5th hour, 1.0 at 1st hour, and 8.0 at SAE (time zero).
- Patient Chart 38 MEWS: 3.0 at 20th hour, 4.0 at 17th hour, 1.0 at 13th hour, 0.0 at 11th hour, 5.0 at 10th hour, 0.0 at 9th hour, 2.0 at 7th hour, 2.0 at 6th hour, 4.0 at 3rd hour, 2.0 at 2nd hour, and 5.0 at SAE (time zero).
- Patient Chart 83 MEWS: 3.0 at 24th hour, 4.0 at 20th hour, 5.0 at 17th hour, 7.0 at 13th hour, 2.0 at 11th hour, 5.0 at 9th hour, 4.0 at 6th hour, 0.0 at 4th hour, 5.0 at 3rd hour, and 5.0 at SAE (time zero).

In a similar study by Kim et al. (2015), researchers examined frequency and trending of MEWS in the 24-hours prior to cardiac arrest; this was a prospective study that calculated highest MEWS at the same time-points: 24-hours, 16-hours, and 8-hours. In addition, "study subjects were divided into low- (0-2), intermediate- (3-4), and high-risk groups ($\geq$5) according to their MEWS value" (Kim et al., 2015, p. 3). Predictably, patients in the low-risk group decreased from $MEWS_{24}$ to $MEWS_{16}$ to $MEWS_8$; however, 45.3% of patients were still in the low-risk category 8-hours prior to cardiac arrest. In addition, only 46.8% of patients had an increased MEWS in the 24-hours leading up to cardiac arrest; $MEWS_{24}$ had a mean of 2.0, $MEWS_{16}$ had a mean of 2.0, and $MEWS_8$ had a mean of 3.0. Researchers attempted to identify specific patient characteristics to answer why some MEWS did not increase as time zero neared ($MEWS_8$); although study patients were older, no significant characteristics were found. Hence, researchers concluded the MEWS tool needed refinement and should not be the only means of monitoring for acute deterioration (Kim et al., 2015).

The proposed response algorithm for this study divided MEWS into four categories: green for MEWS 0.0-1.0, yellow for MEWS 2.0-3.0, orange for MEWS 4.0-5.0, and red for MEWS $\geq$ 6.0 (see Table 2 for a condensed version of response algorithm). Essentially, a green MEWS defaulted to routine care of the patient with vital signs every four hours by the primary nurse. In each of the subsequent categories, care requirements escalated as follows: a yellow MEWS called for an assessment by the charge nurse; an orange MEWS required the same plus notification of the attending healthcare provider; and a red MEWS necessitated a RRT call (see Appendix I for draft MEWS system policy). If characterized as low-, intermediate-, or high-risk as in the study by Kim et al. (2015), low-risk groups would be represented by green and yellow MEWS, intermediate-risk would include orange MEWS, and high-risk would be red MEWS. Likewise, patients in the low-risk group for this study decreased at each time point as they neared time zero (i.e., $MEWS_{24}$ = 67.7%, $MEWS_{16}$ = 60.6%, and $MEWS_{8}$ = 27.1%); however, only 27.1% of patients were in the low-risk category at $MEWS_{8}$ compared to 45.3% in the aforementioned study.

Phase I: Nursing Response

In a literature review by Kyriacos, Jelsma, and Jordan (2011), researchers deemed MEWS systems as useful tools in early identification and management of clinical deterioration; however, their usefulness was dependent on nursing knowledge and skills, accurate monitoring and assessment, nursing intuition, strong communication skills, and timely response. In other studies, researchers identified barriers impacting MEWS system effectiveness such as lack of monitoring of vital signs, complacency in monitoring vital signs, inaccuracy in taking or interpreting vital signs, poor communication or lack of urgency in reporting abnormalities, and lack of knowledge and skills in managing physiologic deterioration (DeVita et al., 2010; McGaughey et al., 2007; NCEC, 2013; NCEPOD, 2005; Robb & Seddon, 2010).

In this study, the PI assessed nursing response in the 24-hours leading up to SAEs by reviewing documentation of the following: frequency of vital sign observations; presence of complete sets of physiologic variables; conditions under which clinical deterioration was recognized; frequency of communication with provider and content of the exchange; and treatment of acute deterioration. In terms of vital sign monitoring, nursing staff recorded vital signs more frequently than hospital policy expectations of every four hours for all three timeframes. Although temperature, level of consciousness, and respiratory rate were not recorded in a small percentage of observations, reasons for their omission were hypothesized. For example, temperature was often recorded within a two-hour timeframe from the last set of vital signs; temperature was probably not considered a priority at the time of an SAE. Because level of consciousness was not routinely recorded with vital signs, the PI accessed this information in the EMR by reviewing In-Patient Admission Assessments, Daily Nursing Assessments, 2-Hour Patient Observations, and other miscellaneous nursing notes. Respiratory rate was the one vital parameter that nursing staff had to make a conscious effort to upload into the EMR; other vital parameters were automatically uploaded. Therefore, respiratory rate omissions may have been related to this process issue versus lack of observation as described by other studies (NCEC, 2013; Robb & Seddon, 2010).

In a study by Ludikhuize et al. (2014), researchers reported an increase in communication between nursing staff and physicians in the group using a new MEWS protocol. Likewise, Mathukia et al. (2015) reported similar results and credited the quantitative nature of the MEWS tool for improved communication. An assessment of

communication between nursing staff and providers in this study was limited; the collection of data merely concentrated on the number of times a physician was contacted and the types of orders received. By conducting a post-interventional study, comparisons could be made and conclusions drawn regarding communication patterns between interdisciplinary staff following MEWS system implementation.

Phase II: Education and Training Workshops

In a study by Liaw, Scherpbier, Klainin-Yobas, and Rethans (2011), researchers revealed the need to equip nurses with the knowledge and skills "in performing thorough assessments of the patients, in making sense of the physiologic findings, in articulating those finding to the appropriate healthcare staff , and in performing immediate nursing actions" (p. 302). Many studies reached similar conclusions; they agreed that well-developed educational strategies, regardless of method, were effective in improving the ability of nursing staff to recognize and manage acute deterioration (Brier et al., 2015; Buckley & Gordon, 2010; Chua, Mackey, & Liaw, 2013; Connell et al., 2016; Cooper et al., 2011; Fuhrmann, Perner, Klausen, Ostergaard, & Lippert, 2009; Harvey, Echols, Clark, & Lee, 2014; Kinsman et al., 2012; Liaw, Scherpbier, Klainin-Yobas, & Rethans, 2011; Liaw et al., 2015; Liaw et al., 2016; Massey, Chaboyer, & Anderson, 2016; Meade, 2017; NPSA, 2007a; Odell et al., 2009; Ozekcin, Tuite, Wilner, & Hravnak, 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010; Webbe-Janek, Lenzmeier, Lambden, Herrick, & Pliego, 2012). Hence, training and education workshops were developed and offered to nursing staff with these objectives in mind; mixed method teaching strategies were used (i.e., lecture, case studies, and simulation). Participants were introduced to the selected MEWS tool, a proposed response algorithm, and a combined assessment/communication tool (RAPIDS Tool). Results for this phase of the project were significantly diminished due to low participant turnout.

Phase II: Pretest/Posttest

A pretest/posttest survey, adopted and modified from a study by Kaul et al. (2014), was designed to examine self-reported confidence of participants in early recognition, communication, and management of clinical deterioration. McDonnell et al. (2012) conducted a mixed methods before-and-after study to determine impact of a new clinical model aimed at recognizing and managing clinical deterioration; nursing interviews revealed improved knowledge and confidence following face-to-face training. Liaw et al. (2016) reported similar results following an educational intervention; in this instance, nurses were exposed to web-based simulation. In this study, participants described improved confidence in all three areas post-intervention: recognition, communication, and response. In addition, nursing staff named respiratory rate and heart rate as significant physiologic parameters in a nursing assessment. In previous studies, respiratory rate and heart rate were determined to be the most sensitive indicators of early clinical deterioration (Avard et al., 2011; National University of Singapore, 2016). A majority of participants identified appropriate assessment findings indicating deterioration in the pretest/posttest patient scenario; nursing staff reported being most concerned about the patient's respiratory status (tachypnea and labored breathing), appearance (color pale), level of consciousness (lethargic and uncomfortable), and temperature (febrile). In terms of response to deterioration, participants were hesitant to do the following: consider a RRT call, ask the charge nurse and/or the provider to come to the patient's bedside to assess the patient, or call the provider to give an update on the patient's status. Finally, participants reported being confident in their ability to communicate concerns about a

patient's acute deterioration to the provider; further conclusions about nursing staff use of an SBAR communication tool were not drawn due to limited data collection.

Phase II: Evaluation Survey

Response to education and training workshops was extremely positive. Participants were excited to learn about a comprehensive MEWS system and discuss clinical indicators of early deterioration. They especially embraced the mixed method teaching strategy that included lecture, case studies, and simulation. Overall, participants reported high satisfaction with the workshops regarding the education, training, and use of a new MEWS system. Participants were interested in reviewing more case studies taken from their own patient population (see Table 6 for free-text responses from evaluation survey).

Limitations

Phase I of this study had several limitations. First, study design was characterized as an observational study involving RCRs from a single hospital. Due to the retrospective nature of the study, the PI was unable to ensure data entry in the EMR was accurate. Second, there was a small sample size (n = 81), a narrowed study focus (limited to developing and testing of a comprehensive MEWS system), and a short study period (6-months). Findings were not generalizable. Third, the accuracy of data collection and retrospective MEWS calculations was dependent upon the PI who reviewed and completed all RCRs. In addition, data analysis was limited to descriptive statistics. Conclusions were drawn based on preliminary results; consideration was given to the varied sample sizes for $MEWS_{24}$, $MEWS_{16}$, and $MEWS_{8}$.

Phase II of this study had its own unique limitations; the greatest shortcoming was a low participant turnout for the workshops. Although incentivized (i.e., paid hourly wage for 3-hour workshop; potential to win a $20 gift card for taking the pretest, evaluation, or posttest; and provision of a continental breakfast), participation was voluntary and required attendance on an off day. In terms of the pretest/posttest results, nursing staff self-reported their confidence level in recognizing, communicating, and responding to acute deterioration. In addition, conducting simulation with just one or two nurses was challenging.

Recommendations for Future Studies

Before full implementation of a comprehensive MEWS system, further research is needed to study effectiveness of the selected MEWS tool and proposed response algorithm. A prospective, single center, cohort observational study is recommended; the MEWS tool and response algorithm could be tested on the two medical-surgical-telemetry units of interests for all admissions through discharge over a defined time period. Researchers could investigate how well the tool predicts patient outcomes (i.e., in-hospital cardiac arrest and in-hospital death) and what effect there is on resource utilization (i.e., unexpected transfer to ICU, RRT utilization, and length of hospitalization). Comparisons between the two units could be made; findings could guide the next steps in implementation.

In terms of improving the educational component of this study, mandatory education and training is recommended. Many options are viable. For example, 3-hour workshops could be replaced by 1-hour interactive Lunch-and-Learns attended by nursing staff during scheduled work hours. Additionally, web-based and in situ

simulations could be offered; simulations planned with interdisciplinary team members would be ideal (Connell et al., 2016; Harvey et al., 2014; Liaw et al., 2015; Massey et al., 2016; Webb-Janek et al., 2012).

Conclusions

Preliminary results from RCRs indicated that a MEWS system would be feasible in identifying patients at risk for SAEs in this patient population. Additionally, introduction of a comprehensive MEWS system with an educational intervention had a positive effect on nursing staff in terms of self-reported confidence, knowledge, and skill in recognizing and managing clinical deterioration. This study supports the next steps in the implementation of a comprehensive MEWS system for use on two medical-surgical-telemetry units in northeastern Kentucky; great insight could be learned regarding tool utility, resource utilization, and staff preparedness.

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Table 3.1 Modified Early Warning Scoring (MEWS) System

Score	**3**	**2**	**1**	**0**	**1**	**2**	**3**
Respiratory Rate		< 8	8	9-17	18-20	21-29	≥ 30
Heart Rate		< 40	40-50	51-100	101-110	111-129	≥ 130
Systolic Blood Pressure	≤ 70	71-80	81-100	101-159	160-199	200-220	> 220
AVPU	Unresponsive	Responds to pain	Responds to voice	Alert	Agitation or confusion	New onset agitation or confusion	
Temperature		≤ 95°F	95.1-96.8°F	96.9-100.4°F	100.5-101.3 °F	≥ 101.4°F	
Oxygen saturation	< 90%	90-92%	93-95%	96-100%			

Note. AVPU = a basic assessment of a patient's level of consciousness; A = patient is awake and alert; V = patient responds to voice; P = patient responds to pain; U = patient is unresponsive. Adapted from Stony Brook Medicine's MEWS (Duncan et al., 2012; B. M. Mills, personal communication, November 3, 2016).

Table 3.2 Response Algorithm

Total MEWS	Response Definition
o Green = Score 0.0 – 1.0	o A green score requires reassessment of the patient with vital signs every four hours by the primary nurse.
o Yellow = Score 2.0 – 3.0	o A yellow score requires reassessment of the patient by the charge nurse on duty. If the charge nurse confirms that the score is accurate, he or she determines whether an intervention is required and documents the assessment in the medical record. The primary nurse provides the intervention, documents the intervention in the medical record, and reassesses the patient within two hours.
o Orange = Score 4.0 – 5.0	o An orange score requires reassessment by the charge nurse, notification of the attending healthcare provider of the change in the patient's condition, and appropriate action taken by the medical staff. The primary nurse reassesses the patient within one hour.
o Red = Score $\geq$ 6.0	o A red score requires notification of the rapid response team (RRT) and attending healthcare provider, who are all expected to respond to the patient's bedside. The RRT and primary care team collaborate on the patient's plan of care. The primary nurse reassesses the patient within one hour.

Note. Adapted from Stony Brook Medicine's Response Algorithm (Duncan et al., 2012; B. M. Mills, personal communication, November 3, 2016).

Table 3.3 Phase I – Demographic Characteristics

	n	%
Gender		
Female	39	48.1
Male	42	51.9
Age		
18 – 24	0	0.0
25 – 29	0	0.0
30-39	2	2.5
40-49	4	4.9
50-59	13	16.0
60-69	18	22.2
70 and over	44	54.3
Race/Ethnicity		
Black/African American	1	1.2
White/Caucasian	80	98.8
Other	0	0.0
Admission Diagnosis		
Cardiac/Circulatory	13	16
Gastrointestinal	12	14.8
Genitourinary	6	7.4
Medical	15	18.5
Musculoskeletal	3	3.7
Neurological	7	8.6
Respiratory	24	29.6
Surgical	1	1.2
Severe Adverse Event*		
In-hospital cardiac arrest	3	3.7
In-hospital death+	1	1.2
Unexpected ICU transfer	56	69.1
RRT call	38	46.9

Note. Phase I = the development and testing of a comprehensive MEWS system (retrospective chart reviews).

* Patients may have experienced more than one severe adverse event (i.e., RRT call and unexpected ICU transfer).

+ In-hospital death is defined as a severe adverse event resulting in death on one of the units of interest at the time of the event and does not pertain to patients who subsequently died later in their hospitalization.

Table 3.4 Phase I – Most Common Patient Comorbidities

	n	%
Chronic Disease		
Hypertension	63	77.8
Coronary Artery Disease	55	67.9
Dyslipidemia	48	59.3
Chronic Obstructive Pulmonary	45	55.6
Disease		
Diabetes Mellitus, Type 2	37	45.7
Cardiac (i.e., arrhythmias)	35	43.2
Heart Failure	33	40.7
Chronic Kidney Disease	31	38.3
Gastroesophageal Reflux Disease	28	34.6
Overweight, Obesity, Morbid Obesity	25	30.9

Table 3.5 Phase II – Demographic Characteristics

	n	%
Primary Nursing Practice Position		
Licensed Practical Nurse	1	11.1
Registered Nurse	7	77.8
ICU Staff/Other	1	11.1
Highest Level of Education		
Associate's Degree	4	44.4
Bachelor's Degree	4	44.4
Master's Degree	1	11.1
Nursing Experience		
Less than or equal to 3 years ($\leq$ 3 years)	4	44.4
More than 3 years but less than or equal to 7 years (> 3 years; $\leq$ 7 years)	2	22.2
More than 7 years but less than or equal to 10 years (> 7 years; $\leq$ 10 years)	0	0.0
More than 10 years but less than or equal to 15 years (> 10 years; $\leq$ 15 years)	0	0.0
More than 15 years (> 15 years)	3	33.3

Table 3.6 Phase II – Free –Text Responses from Evaluation Survey

13. What other improvements would you recommend for the education and training workshop?

- I would like to have seen more examples with patients specifically from our hospital and do more examples before, during, and after events with them.
- I would take a true scenario from the data you collected and work through that patient. The actual simulation would have been beneficial.
- Examples of what it would have looked like in Meditech.
- Not get off task too much.

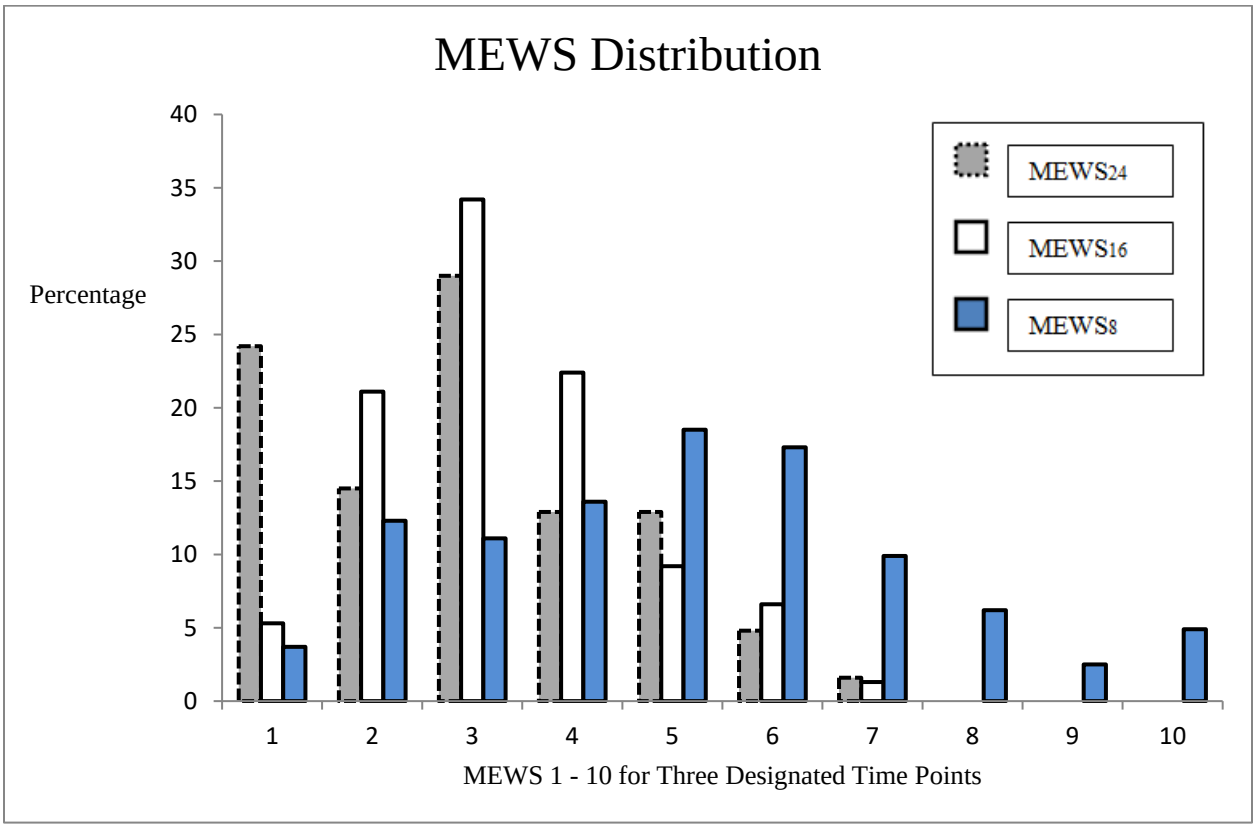
14. What did you like *most* about the education and training workshop?

- It was very informative. I feel like this will be a very good assessment tool that will help me provide better patient care.
- I feel it will help me evaluate patient vital signs in a more constructive manner.
- Case studies were good – thinking about this as a real life scenario.
- I am pretty excited about this!
- Interactive presentation.
- Very relevant and informative to the job that I perform.
- I feel the workshop increased my confidence in patient care. Knowing when to demand intervention and when to monitor a patient is something I struggle with.
- Hands on simulation and practice with MEWS tool.

15. What did you like *least* about the education and training workshop?

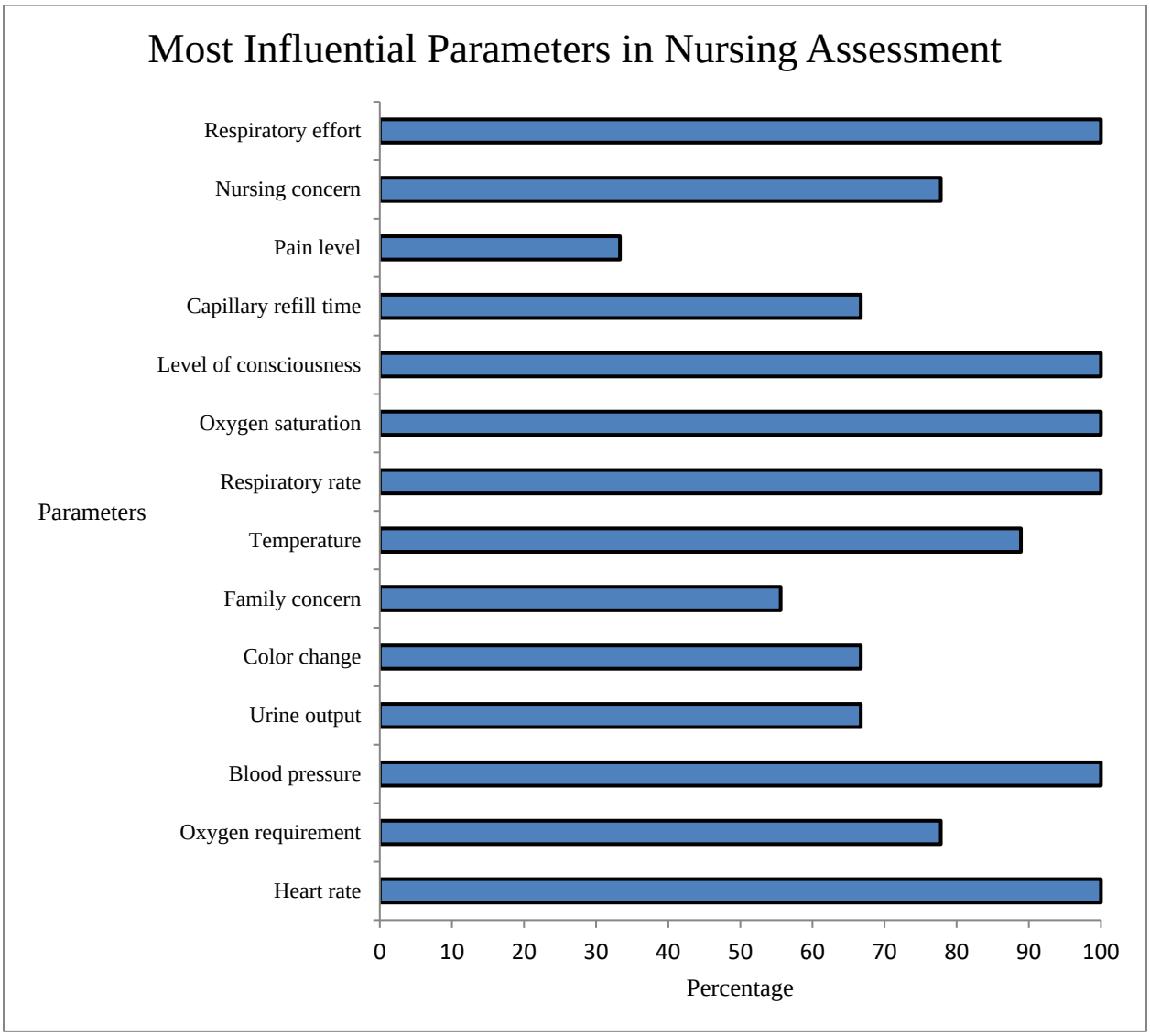
- The workshop was a little scattered and disorganized. Have more entertaining or get the groups focus better.
- Some interventions may be less applicable to my job and what interventions we can do on the floor.

Figure 3.1 Phase I – MEWS Distribution



Phase I – Distribution of highest modified early warning scores (MEWS) at 24-hour (n = 62), 16-hour (n = 76), and 8-hour (n = 81) time points. $MEWS_{24}$ defined as greater than 16-hour to 24-hour point; $MEWS_{16}$ defined as greater than 8-hour to 16-hour point; $MEWS_{8}$ defined as 0-hour to 8-hour point. Vertical access = percentage of patients; horizontal access = modified early warning scores (MEWS) ranging from "1" to "10" for three designated time points. Note MEWS of "8", "9", and "10" were only recorded for $MEWS_{8}$ representing patients who had only been on one of the medical-surgical-telemetry units for $MEWS_{8}$- timeframe. Adapted from "Modified Early Warning Score Changes Prior to Cardiac Arrest in General Wards," by W. Y. Kim, Y. J., Shin, J. M. Lee, J. W. Huh, Y. Koh, C. M. Lim, and S. B. Hong, 2015, *PLOS ONE, 10*(6), e0130523. doi:10.1371/journal.pone.0130523

Figure 3.2 Phase II – Most Influential Parameters in Nursing Assessment



Phase II – Nursing response to most influential parameters in nursing assessment that help to determine a patient's level of stability; a "SELECT ALL THAT APPLY" question on pretest/posttest. Adapted from "Implementation of the Bedside Paediatric Early Warning system (Bedside PEWS) for Nurse Identification of Deteriorating Patients," by M. Kaul, J. Snethen, S. T. Kelber, K. Zimmanck, K. Maletta, and M. Meyer, 2014, Journal of Specialists in Pediatric Nursing, 19(4), 339-349. doi:10.1111/jspn.12092

Practice Inquiry Project Conclusion

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Conclusion

Failure to rescue events and suboptimal care in acutely ill adult patients on medical-surgical units are well documented in the literature (Institute of Medicine [IOM], 1999, 2001, 2011; Kohn, Corrigan, & Donaldson, 2000; Mapp, Davis, & Krowchuk, 2013; National Patient Safety Agency [NPSA], 2007a, 2007b; Subbe & Welch, 2013; Taenzer, Pyke, & McGrath, 2011). Despite a paucity of high-level evidence to support them, rapid response teams (RRTs) and modified early warning scoring (MEWS) systems have been widely implemented to assist nursing staff in early recognition and management of clinical deterioration (Gao et al., 2007; Johnstone, Rattray, & Myers, 2007; Kyriacos, Jelsma, & Jordan, 2011; McGaughey et al., 2007; Roney et al., 2015; Smith et al., 2014). An integrative review on effectiveness of MEWS systems in predicting clinical deterioration and improving patient outcomes was conducted for the first manuscript. Although most studies were observational, a majority of researchers agreed MEWS system implementation was beneficial and feasible in terms of identifying patients at risk for severe adverse events such as cardiac arrest and/or death (Cei, Bartolomei, & Mumoli, 2009; De Meester et al., 2012; Duncan, McMullan, & Mills, 2012; Gardner-Thorpe, Love, Wrightson, Walsh, & Keeling, 2006; Huggan et al., 2015; Kim et al., 2015; Kyriacos et al., 2014; Ludikhuize et al., 2014; Ludikhuize, Smorenburg, de Rooij, & de Jonge, 2012; Mapp et al., 2013; Mathukia, Fan, Vadyak, Biege, & Krishnamurthy, 2015; Odell, 2014; Perera et al., 2011; Subbe, Davies, Williams, Rutherford, & Gemmell, 2003). Findings helped guide the development, implementation, and evaluation of a comprehensive MEWS system which involved selecting and testing a MEWS tool, developing a response algorithm, writing a MEWS system policy, and linking the MEWS tool to the RRT and communication policies.

In the second manuscript, an integrative review was conducted to investigate educational strategies and/or educational programs employed to improve medical-surgical nurses' abilities to recognize and manage clinical deterioration. Educational strategies were defined according to three broad categories: organization-based, patient-based, and nurse-based. Organization-based strategies included process modifications and utilization of decision-making models, standardized assessment tools, and standardized communication tools (Brier et al., 2015; Buckley & Gordon, 2010; Considine & Currey, 2015; Fuhrmann, Perner, Klausen, Ostergaard, & Lippert, 2009; Kinsman et al., 2012; Liaw, Scherpbier, Klainin-Yobas, & Rethans, 2011; Liaw et al., 2015; Liaw et al., 2016; Massey, Chaboyer, & Anderson, 2016; McDonnell et al., 2012; Ozekcin, Tuite, Willner, & Hravnak, 2015; Pantazopoulos et al., 2012). Patient-based strategies considered patient characteristics, comorbidities, and outcomes when designing educational programs (Buckley & Gordon, 2010; Chua, Mackey, & Liaw, 2013; Connell et al., 2016; Cooper et al., 2011; Harvey, Echols, Clark, & Lee, 2014; Liaw et al., 2011; Liaw et al., 2016; Ozekcin et al., 2015). Nurse-based strategies concentrated on enhancing nursing knowledge and skills. Competencies were directed at nurses having a fundamental understanding of the underlying causes of clinical deterioration, being able to recognize and manage clinical deterioration, and being able to effectively communicate patient concerns. Researchers agreed educational strategies and programs that incorporated knowledge, technical skills (e.g., hands-on airway assessment and management), non-technical skills (e.g., communication and leadership), and simulation were more likely to result in sustained learning outcomes (Buckley & Gordon, 2010; Chua et al., 2013; Connell et al., 2016; Cooper et al., 2011; Harvey et al., 2014; Liaw et al., 2011; Liaw et al., 2015; Liaw et al., 2016; McDonnell et al., 2012; Odell,

Victor, & Oliver, 2009; Ozekcin et al., 2015; Pantazopoulos et al., 2012; Preston & Flynn, 2010). Findings helped guide the development, implementation, and evaluation of an educational strategy for nursing staff on two medical-surgical-telemetry units in the study hospital.

In Phase I of this practice inquiry project, retrospective chart reviews of patients meeting criteria (i.e., in-hospital cardiac arrest, in-hospital death, unexpected transfer to an intensive care unit, and/or rapid response team utilization) were completed; data were collected pertaining to physiologic parameters (i.e., vital signs and level of consciousness) and nursing responses in the 24-hours leading up to SAEs. MEWS were retrospectively calculated at three time points: 24-hours, 16-hours, and 8-hours. Results found a MEWS system to be potentially beneficial and feasible in identifying patients at risk for severe adverse events (SAEs) in this patient population. However, further study is recommended before full implementation of a comprehensive MEWS system. A prospective study designed to test a comprehensive MEWS system for all admissions on the two medical-surgical-telemetry units would provide greater understanding of tool utility and resource utilization.

In Phase II, a 3-hour education and training workshop had a positive effect on nursing staff's self-reported confidence, knowledge, and skill in recognizing and managing clinical deterioration. A mixed method teaching strategy (i.e., lecture, case studies, and simulation) was used to introduce the selected MEWS tool, a proposed response algorithm, and a combined assessment/communication tool. Participants reported high satisfaction with the workshops. However, results for this phase of the project were significantly diminished due to low participant turnout. It is recommended that future education and training be mandatory; in addition, it must be accommodating to nursing schedules and time constraints.

In the study hospital, a culture focused on improving patient safety and quality of care is evident. An organizational framework of shared governance is in place and councils are active. Nursing staff are excited and motivated to enhance their knowledge and skills regarding early recognition and management of clinical deterioration. Introduction of a new comprehensive MEWS system with an educational intervention had positive results. Therefore, this practice inquiry project supports the next steps in implementation and evaluation of a comprehensive MEWS system for use on two medical-surgical-telemetry units in a large rural hospital in northeastern Kentucky.

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Appendix A

Data Collection Tool for 6-Month Pre-Intervention

Date and time of data collection:
Name and role of person collecting data:
Patient identification #:
Data collection method:

Demographics:

Gender:

- ☐ Female
- ☐ Male

Age:

- ☐ 18 – 24
- ☐ 25 – 29
- ☐ 30 – 39
- ☐ 40 – 49
- ☐ 50 – 59
- ☐ 60 – 69
- ☐ 70 and over

Race/Ethnicity:

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black/African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White/Caucasian
- ☐ Hispanic/Latino
- ☐ Other

Admission Diagnosis (Diagnoses):

- ☐ _____
- ☐ _____

Severe Adverse Event (SAE):

Choose **ALL** that apply.

- ☐ In-hospital cardiac arrest
- ☐ In-hospital death
- ☐ Unexpected transfer to the ICU
- ☐ RRT call

Time of SAE in relation to admission:

- ☐ Day of admission
- ☐ Patient Day #1
- ☐ Patient Day #2
- ☐ _____

Physiologic parameters and nursing action in the 24-hour timeframe

Time of SAE:						
Time of first signs of clinical deterioration:						
Time of nursing recognition, recording, and reviewing of clinical deterioration:						
Time of nursing reporting of clinical deterioration:						
Time of nursing response to clinical deterioration:						
Patient outcome:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
24 – hour						
MEWS						
Nursing action:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
23 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
22 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
21 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
20 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
19 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
18 – hour						
MEWS						
Nursing action:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
17 – hour						
MEWS						
Nursing action:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
> 16 – hour						
MEWS						
Nursing action:						
Other comments:						

Physiologic parameters and nursing action in the 16-hour timeframe

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
16 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
15 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
14 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
13 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
12 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
11 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
10 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
9 – hour						
MEWS						

Nursing action:

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
> 8 – hour						
MEWS						

Nursing action:

Other comments:

Physiologic parameters and nursing action in the 8-hour timeframe

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
8 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
7 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
6 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
5 – hour						
MEWS						
Nursing action:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
4 – hour						
MEWS						
Nursing action:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
3 – hour						
MEWS						
Nursing action:						
Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
2 – hour						
MEWS						
Nursing action:						

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
1 – hour						
MEWS						

Nursing action:

Timeframe	Parameter 1 HR	Parameter 2 RR	Parameter 3 SBP	Parameter 4 Temp	Parameter 5 LOC	Parameter 6 O_2 sat
> 0 – hour						
MEWS						

Nursing action:

Other comments:

Additional notes for this case:

Additional notes for this case:

Appendix B

An Education and Training Workshop

"Introduction of a Comprehensive Modified Early Warning Scoring (MEWS) System"

PROBLEMS:	Despite considerable emphasis on patient safety and high-quality care in U.S. hospitals for the past two decades, significant challenges remain in the early detection and treatment of clinical deterioration in adult medical-surgical patients contributing to poor patient outcomes, increased resource utilization, and increased costs. Failure to rescue events and suboptimal care in acutely ill adult patients on medical-surgical units are well documented in the literature.
PATIENT POPULATION:	Adult patients in acute care settings are particularly vulnerable to clinical deterioration leading to medical emergencies.
TARGET AUDIENCE:	**RN** and **LPN** Nursing Staff from 3 Center, 3 North, the ICU, and the Float Pool.
WORKSHOP OBJECTIVES:	(1) Recognize clinical deterioration using a MEWS tool and ABCDE assessment mnemonic. (2) Record and review observations using MEWS tool. (3) Report clinical deterioration using SBAR communication tool. (4) Respond and rescue patient from clinical deterioration using response algorithm.
SIGN-UP:	You will receive an email inviting you to participate in **ONE** of ten workshops to be offered. Please read the email closely as it will advise you to do the following: o Read the Letter of Consent to Participate in a Research Study, o Sign-up for **ONE** workshop using SCR's Learning Management System, and o Be prepared to take a 10-question paper-based pretest at the beginning of the workshop. Note that reading the Letter of Consent and taking the pretest will signify consent; participation will be voluntary and data will be presented in aggregate form only. Individual results and evaluations will remain confidential. Workshops are limited to 10 participants per session due to simulation scenario.
DATES:	Week #1, five workshops offered, Monday through Friday, March 20-24. Week #2, five workshops offered, Monday through Friday, March 27-31.
TIMES:	Workshops will be offered each day from 8:00 to 11:00 A.M.
LOCATIONS:	Workshops will take place in a MSU Department of Nursing Lab in the Center for Health Education and Research Bldg., located at 316 W. 2nd Street, Morehead, Kentucky, 40351. Week #1, Monday through Friday, March 20-24, MSU Nursing Lab **307** Week #2, Monday and Wednesday, March 27 and 29, MSU Nursing Lab **307** Week #2, Tuesday, Thursday, and Friday, March 28, 30, and 31, Nursing Lab **302**
ACTIVITIES:	Lecture, discussion, case studies, **SIMULATION**, debriefing, and evaluation.
INCENTIVES:	Five $20 gift cards will be given for each of the following: pretest, posttest, and evaluation. Nursing staff will receive their standard hourly wage for participating in 3-hour workshop.

Appendix C

Introducing a Comprehensive MEWS System: An Education and Training Workshop

Overall Learning Objectives:

1. Recognizes clinical deterioration utilizing the MEWS tool and ABCDE assessment mnemonic
2. Records and reviews observations utilizing MEWS tool in EMR
3. Reports clinical deterioration utilizing SBAR communication tool
4. Responds and rescues patient from clinical deterioration utilizing response algorithm

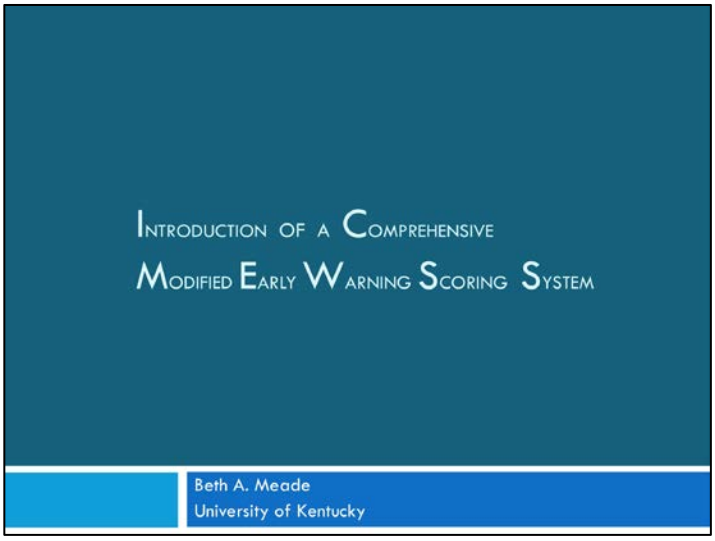
Agenda:

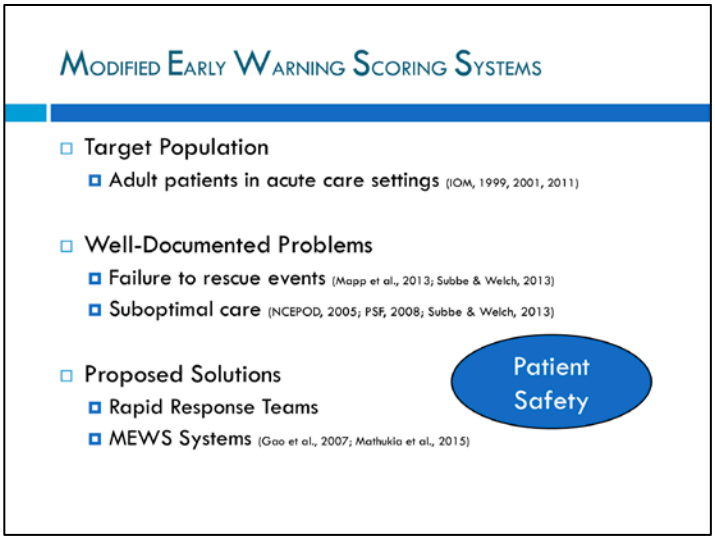
TIME	TOPIC	ACTIVITY
8:00 – 8:20	Continental Breakfast Introductions Overall Learning Objectives Agenda Housekeeping Rules	Lecture Discussion
8:20 – 8:40	Pretest	Assessment
8:40 – 9:20	PowerPoint Presentation 1. Provide general introduction for comprehensive MEWS systems 2. Focus on early identification and management of clinical deterioration • Recognition utilizing MEWS tool and ABCDE assessment mnemonic • Recording and reviewing utilizing MEWS tool in EMR • Reporting utilizing SBAR communication tool • Responding and rescuing utilizing response tool 3. Focus on utilization of a comprehensive MEWS system • MEWS tool • Response algorithm • MEWS system protocol with RRT and SBAR protocol inclusion • RRT protocol update • MEWS system incorporation into EMR	Lecture Discussion Case Studies
9:20 – 9:35	BREAK	BREAK
9:35 – 9:55	PowerPoint Presentation continued . . .	Lecture Discussion Simulation Debriefing
9:55 – 10:50	Introduction to Simulation – Primary Case 1. Assign participant roles 2. Introduce scenario overview with learning objectives 3. Conduct simulation 4. Conduct simulation debriefing 5. Repeat simulation if time allows	Lecture Discussion Simulation Debriefing
10:50 – 11:00	Evaluation Survey – A 15-item survey to obtain immediate feedback from participants on education and training workshop	Survey

Thank you so much for your participation!

Appendix D

Workshop Presentation





Modified Early Warning Scoring Systems

- Definition of MEWS
  - A tool that quantifies physiologic variables by assigning a score to each variable in a weighted manner
  - A score of zero is given to normal values (Mapp et al., 2013)
- Purpose of MEWS
  - A higher MEWS alerts the nurse to early signs of clinical deterioration in a patient – **recognition**
  - A higher MEWS prompts the nurse to take additional steps in the care of a patient – **management**

(Mapp et al., 2013; Roney et al., 2015)

Modified Early Warning Scoring Systems

- Original Early Warning Scoring (EWS) System
  - Introduced in 1997
  - Five physiologic parameters
    - Heart rate
    - Respiratory rate
    - Systolic blood pressure
    - Temperature
    - Consciousness level (Mathukia et al., 2015, p. 2)

Improved Outcomes

Modified Early Warning Scoring Systems

Stony Brook Medicine

Modified Early Warning System (MEWS)

	3	2	1	0	1	2	3
Respiratory rate per minute		Less than 8		9-17	18-20	21-29	More than 30
Heart rate per minute		Less than 40	40-50	51-100	101-110	111-129	More than 130
Systolic blood pressure	Less than 70	71-80	81-100	101-159	160-199	200-220	More than 220
Conscious level (AVPU)	Unresponsive	Responds to pain	Responds to voice	alert	Agitation or confusion	New onset of agitation or confusion	
Temperature		Less than 95.0° F 35.0° C	95.1-96.8° F 35.05-36° C	96.9-100.4° F 36.05-38° C	100.5-101.3° F 38.05-38.5° C	More than 101.4° F 38.55° C	
Pulse Oximetry	<90%	90-92% room air	93-95% room air	96-100% room air			

Green = 0-1 Score

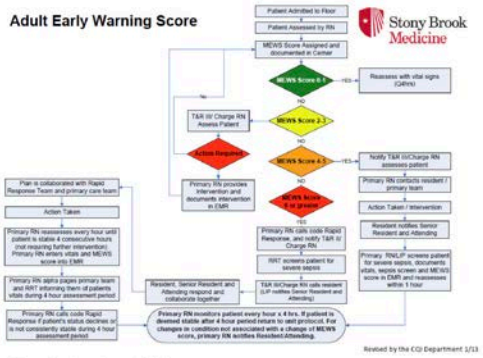
Yellow = 2-3 Score

Orange = 4-5 Score

Red = ≥6 Score

(Stony Brook Medicine, 2013)

Modified Early Warning Scoring Systems



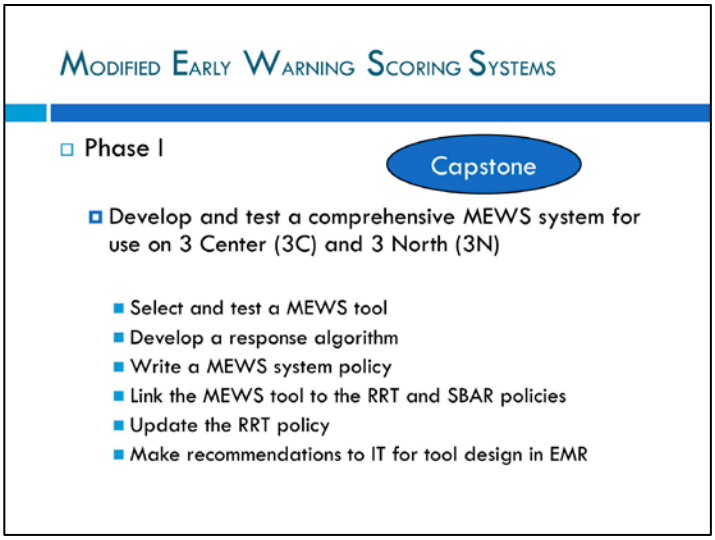
(Stony Brook Medicine, 2013)

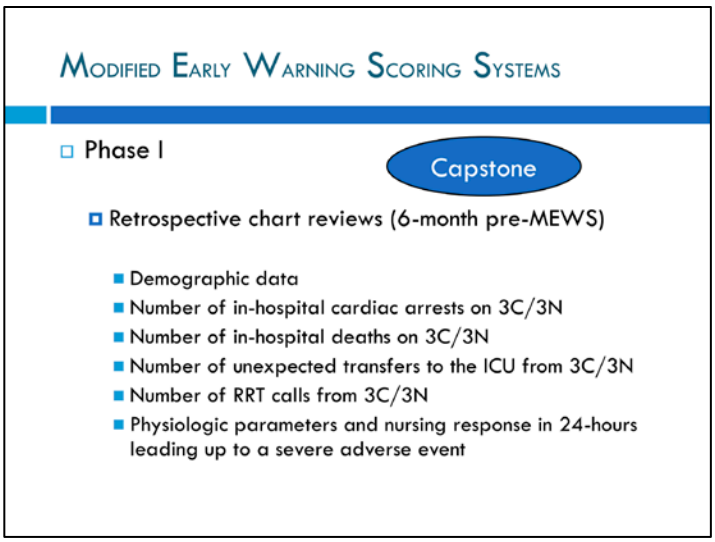
Modified Early Warning Scoring Systems

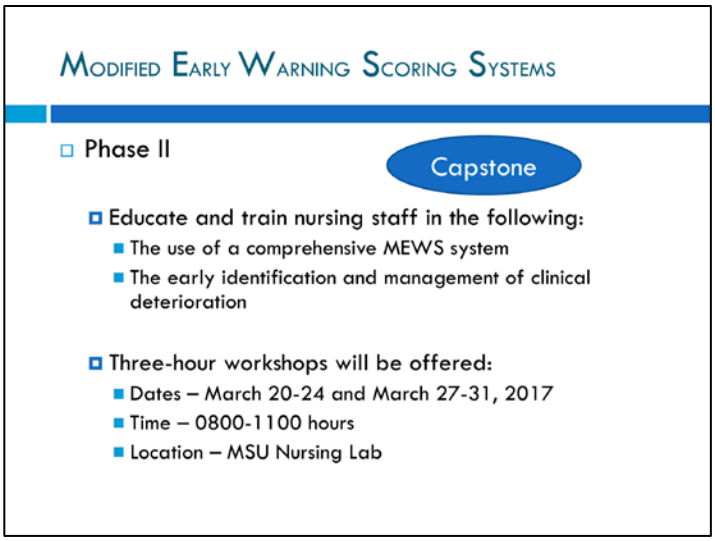
- Key Points
  - MEWS are simple tools that help to identify early clinical deterioration, primarily through abnormal vital signs (Gao et al., 2007; Mapp et al., 2013; Maupin, 2010).
  - Warning signs of subtle changes in a patient's condition may be present 72 hours prior to a severe adverse event (Garvey, 2015; NCEPOD, 2005).

Modified Early Warning Scoring Systems

- Key Points
  - Important for the nurse to do the following:
    - **R**ecognize
    - **R**ecord and **R**eview
    - **R**eport
    - **R**espond and **R**escue (Odell, Victor, & Oliver, 2009)
  - Early identification and effective intervention can improve patient safety and patient outcomes (Mauldenhauer, Sabel, Chu, & Mehler, 2009; Odell et al., 2009; Shever, 2011).


Modified Early Warning Scoring Systems
Phase I
Capstone
Develop and test a comprehensive MEWS system for use on 3 Center (3C) and 3 North (3N)
Select and test a MEWS tool
Develop a response algorithm
Write a MEWS system policy
Link the MEWS tool to the RRT and SBAR policies
Update the RRT policy
Make recommendations to IT for tool design in EMR


Modified Early Warning Scoring Systems
Phase I
Capstone
Retrospective chart reviews (6-month pre-MEWS)
Demographic data
Number of in-hospital cardiac arrests on 3C/3N
Number of in-hospital deaths on 3C/3N
Number of unexpected transfers to the ICU from 3C/3N
Number of RRT calls from 3C/3N
Physiologic parameters and nursing response in 24-hours leading up to a severe adverse event


Modified Early Warning Scoring Systems
Phase II
Capstone
Educate and train nursing staff in the following:
The use of a comprehensive MEWS system
The early identification and management of clinical deterioration
Three-hour workshops will be offered:
Dates – March 20-24 and March 27-31, 2017
Time – 0800-1100 hours
Location – MSU Nursing Lab

Modified Early Warning Scoring Systems

- Challenges to Selecting the Best MEWS Tool
  - Lack of robust research to support them
  - Diversity of MEWS systems in use
  - Multiple factors that influence clinical outcomes (Gao et al., 2007; Kyriacos et al., 2011)
- The Top Three MEWS
  - Stony Brook Medicine (Stony Brook Medicine, 2013)
  - ViEWS, Ireland's NEWS (Prytherch et al., 2010)
  - HEART of ENGLAND, NHS Foundation Trust (Heart of England NHS Foundation Trust, 2011)

Modified Early Warning Scoring Systems

- What is the best MEWS tool for SCR?

St. Claire Regional Medical Center. (2016). Employment at SCR [Image]. Retrieved from https://www.st-claire.org/Careers.aspx

Modified Early Warning Scoring Systems

Preliminary Retrospective Chart Review Results	
Number of in-hospital cardiac arrests	2
Number of in-hospital deaths	1
Number of unexpected transfers to ICU	47
Number of RRT calls	43
Number of RRT calls that led to ICU transfers	14

Modified Early Warning Scoring Systems

Retrospective Chart Review Results	
Number of respiratory checks	pending
Number of oxygen saturation checks	pending
Number of blood pressure checks	pending
Number of pulse checks	pending
Number of level of consciousness checks	pending
Number of temperature checks	pending

Modified Early Warning Scoring Systems

MEWS Breakdown			
	0-8 hrs	>8-16 hrs	>16-24 hrs
Number in green category , MEWS 0 – 1			
Number in yellow category, MEWS 2 – 3			
Number in orange category, MEWS 4 – 5			
Number in red category, MEWS ≥ 6			

Modified Early Warning Scoring Systems

- Examples of Sentinel Events
  - Patient admitted with pneumonia…
  - Patient admitted from nursing home with blood clot on the brain…
  - Nurse tried for 1 ½ hours to get patient assessed by surgical team…

(Australian Commission on Safety and Quality in Healthcare, 2008, p. 1)

Modified Early Warning Scoring Systems

- Examples of Sentinel Events continued…
  - Patient admitted to general ward with Epstein-Barr virus (EBV) pneumonitis (ACT Government Health, 2013)

Mother's Comments…

"I still believe that either someone or something failed my daughter on that weekend"

Modified Early Warning Scoring Systems

- Case Study…

  - Mr. Jones is a 62-year-old gentleman admitted to the medical-surgical unit for left hip replacement.
  - Past medical history: hypertension, ischemic heart disease, and COPD.
  - Post-operative day #1: a peripheral IV, a Foley catheter, a surgical drain, and O_2 at 2 L/nc; strict I/O and VS Q4 hrs; diet may be advanced as tolerated.

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

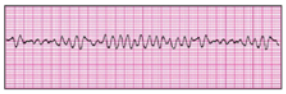
- Report to Charge Nurse…

  - Just finished nursing rounds…
  - All patients are fine except for Mr. Jones…
    - Staff Nurse: "He appears tired and is breathing fast BUT his O_2 sat is okay and he is resting now"…
    - Charge Nurse: "Keep a close eye on Mr. Jones"…

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

- Upon Reassessment …
  - Patient found unresponsive, not breathing, and without pulse…
  - A **CODE BLUE** is called and CPR is begun…
  - The monitor shows…



  - A shock is delivered…return of spontaneous circulation occurs…patient is stabilized…patient is transferred to ICU…(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

- Report to Charge Nurse…
  - Just finished nursing rounds…
  - All patients are fine except for Mr. Jones…
  - "He seems a bit tired…BUT…his vital signs are fairly stable"…(National University of Singapore, 2104)

T 98.9	P 101 ↑	R 28 ↑	BP 124/78	O_2 sat 95%	Alert
✓	Baseline 70	Baseline 16	✓	✓	✓

Modified Early Warning Scoring Systems

- Upon Reassessment…
  - Staff Nurse and Charge Nurse at bedside
  - Patient confirms he does not feel well
  - Physical assessment completed
  - Nursing actions taken
  - Follow-up assessment completed
  - Call to physician made using SBAR tool

ABCDE Assessment

SBAR Tool

Modified Early Warning Scoring Systems

SBAR Communication Tool	
SITUATION	State own identity
	State location
	State patient's identity
	Briefly describe the problem
BACKGROUND	State admitting diagnosis
	State medical history
	Provide a brief outline of treatment to date
ASSESSMENT	Offer possible diagnosis
RECOMMENDATION	Ask for help or advice in a clear manner

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

SBAR Communication Tool		
SITUATION	• Hello. Is this Dr. Joe?	ID
	• I am Jane Doe, the Charge Nurse for 3 C.	ID, location
	• I am worried about our patient, Mr. Jones, in bed 3.	ID, location
	• He seems to be deteriorating. • His RR is elevated to 28 (baseline of 16). • His HR is elevated to 101 (baseline of 70). • However, his O_2 sat and BP are WNL (95%; 124/78) • He is afebrile. • Upon examination, I noticed he had decreased lung sounds in the bases and wheezes throughout. • I gave him his Ventolin inhaler but he is not better. • He remains on O_2 at 2L/nc.	Brief description of problem

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

SBAR Communication Tool	
BACKGROUND	• He has a past medical history of HTN, ischemic heart disease, and COPD. • Today is 1st POD for his left hip replacement.
ASSESSMENT	• I think he has impaired respiratory function.
RECOMMENDATION	• He may need more Ventolin doses and more oxygen. • Can you come *now* to assess the patient?

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

OXYGEN DELIVERY

Cardiac Output	X	Arterial O_2 Content

Failure of oxygen delivery

↓

Anaerobic metabolism

↓

Lactate production

↓

Stimulation of respiration

↓

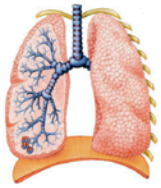
Tachypnea

(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- Arterial Oxygen Content
  - Pulmonary ventilation brings O_2 from environment into alveoli
  - O_2 diffuses into pulmonary capillaries where most O_2 binds to hemoglobin of RBCs forming arterial O_2 content
  - CO_2 is diffused through alveoli to be exhaled out through the lungs

(ACT Government Health, 2013; National University of Singapore, 2014)



Modified Early Warning Scoring Systems

OXYGEN DELIVERY

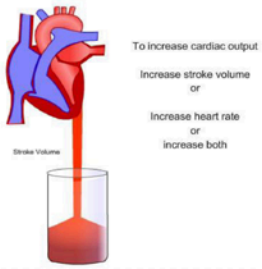
Cardiac Output (SV x HR)	X	**Arterial O_2 Content** ⇩
O_2 attached to hemoglobin ⇩	+	**O_2 dissolved in blood is partial pressure x 0.003**

Hemoglobin concentration (Hgb) X Arterial O_2 saturation (SaO_2) X 1.39

(ACT Government Health, 2013; National University of Singapore, 2014)

Modified Early Warning Scoring Systems

- Cardiac Output (CO)
  - CO = Total volume of blood pumped by the heart in one minute
  - CO = Stroke volume X HR



To increase cardiac output
Increase stroke volume
or
Increase heart rate
or
increase both

(ACT Government Health, 2013; National University of Singapore, 2014)

Modified Early Warning Scoring Systems

OXYGEN DELIVERY

Cardiac Output	X	Arterial O_2 Content
Heart Rate X Stroke Volume		Hemoglobin X SaO_2
		+
		Dissolved O_2

(ACT Government Health, 2013; National University of Singapore, 2014)

Modified Early Warning Scoring Systems

BLOOD PRESSURE

Cardiac Output	X	Peripheral Vascular Resistance
⇩		
Heart Rate X Stroke Volume		
⇩		
Determinants of Stroke Volume		
• Preload → Venous return to the heart • Afterload → Peripheral vascular resistance • Contractility → Contractility of heart muscles		

(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- Why decreased CO, maybe?
  - Blood loss from surgery → reduced circulatory volume
  - Heart conditions → increased risk of developing ACS or heart failure → impaired cardiac contractility
- Why decreased arterial O_2 content, maybe?
  - Loss of Hgb from bleeding → less Hgb for O_2 binding
  - Lung disease → at risk for impaired gas exchange

(ACT Government Health, 2013; National University of Singapore, 2014)

Modified Early Warning Scoring Systems

OXYGEN DELIVERY		
Cardiac Output ↓ **SV X HR**	**X**	**Arterial O_2 Content**
Loss of blood from surgery ⬇		
Decreased preload ⬇		
Decreased stroke volume ⬇		
Decreased cardiac output		

(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- Body's Response to Inadequate O_2 Delivery…

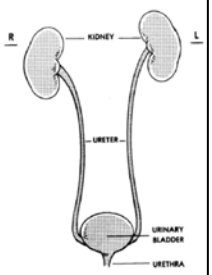
COMPENSATORY MECHANISMS
↑ heart rate and contractility
↑ respiratory rate and depth

- A drop in BP can be a late sign of deterioration.
- A decreased O_2 sat can be a late sign of deterioration.

(ACT Government Health, 2013; National University of Singapore, 2014)

Modified Early Warning Scoring Systems

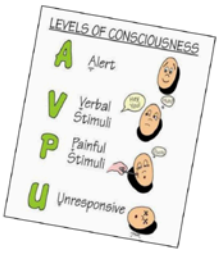
- Urine Output
  - Dependent on BP in glomerulus of kidney
  - Dependent on O_2 delivery to kidney
- Kidney Perfusion
  - Dependent on adequate CO
  - Dependent on no obstructions in vessels to kidneys



(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- Level of Consciousness
  - Altered LOC is common in acute illness.
  - Causes include:
    - Epilepsy
    - Meningitis
    - CVA
    - Hypotension
    - Hypoglycemia
    - Sedative drugs
    - Pain



(ACT Government Health, 2013).

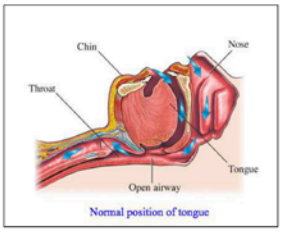
Modified Early Warning Scoring Systems

The ABC's of OXYGEN DELIVERY		
Airway **A**	Arterial O_2 Content	Arterial saturation is dependent upon: - Adequate airway - Adequate protection of airway
Breathing **B**	Arterial O_2 Content	Arterial saturation is dependent upon: - Effective lung mechanics - Effective lung tissue
Circulation **C**	Cardiac Output	Cardiac output is dependent upon: - Effective circulation - Effective cardiac output

(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- ABCDE Assessment
  - Airway
    - Assess for signs of airway obstruction
    - Perform head tilt/chin lift or jaw thrust
    - Place patient on the side
    - Insert artificial airway
    - Perform suctioning



(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

- ABCDE Assessment
  - Breathing
    - Count respiratory rate
    - Assess breathing pattern
    - Check for cyanosis
    - Measure O_2 sat level
    - Listen to breath sounds
    - Place patient in head-up position
    - Initiate and titrate O_2

Count respiratory rate for one full minute.

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

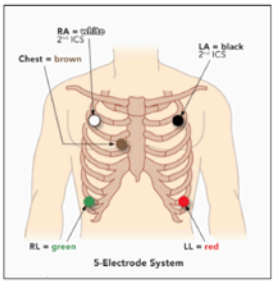
- ABCDE Assessment
  - Circulation
    - Count pulse rates
    - Palpate pulses
    - Measure BP
    - Check peripheral skin (color/temp/moisture)
    - Measure capillary refill time (normal < 2 seconds)
    - Measure body temperature

Consider getting a manual BP.

(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

- ABCDE Assessment
  - Circulation
    - Check urine output
    - Lower patient head of bed
    - Establish IV access
    - Prepare 0.9% Normal Saline
    - Attach cardiac monitor
    - Perform 12-lead ECG



(National University of Singapore, 2014)

Modified Early Warning Scoring Systems

- ABCDE Assessment
  - Disability
    - Assess LOC
      - AVPU
      - Glasgow Coma Scale
    - Examine pupils
      - Size
      - Equality
      - Reaction
    - Monitor blood glucose level

TABLE 38-2
Glasgow Coma Scale

BEHAVIOR	RESPONSE	SCORE
Eye opening response	Spontaneously	4
	To speech	3
	To pain	2
	No response	1
Best verbal response	Oriented to time, place, and person	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
	No response	1
Best motor response	Obeys commands	6
	Moves to localized pain	5
	Flexion withdrawal from pain	4
	Abnormal flexion (decorticate)	3
	Abnormal extension (decerebrate)	2
	No response	1
Total score:	*Best response*	15
	Comatose client	8 or less
	Totally unresponsive	3

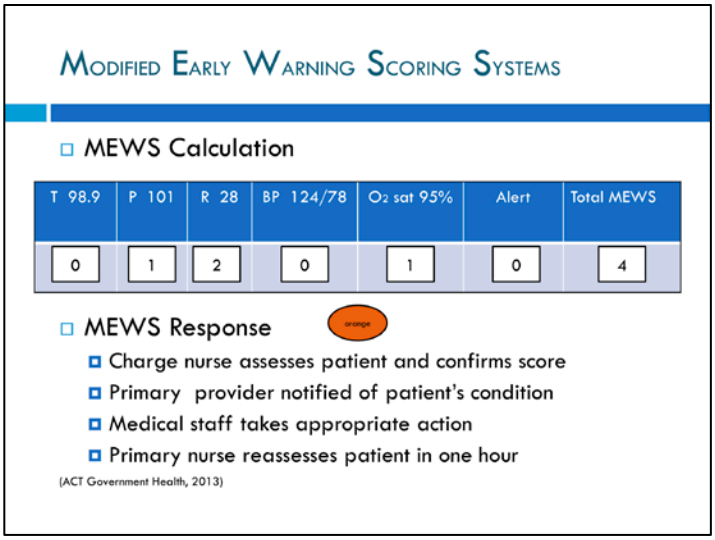
(National University of Singapore, 2014)

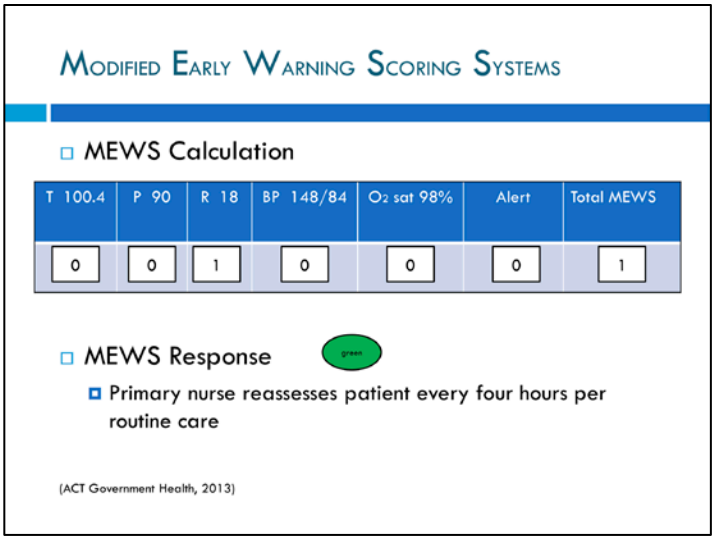
Modified Early Warning Scoring Systems

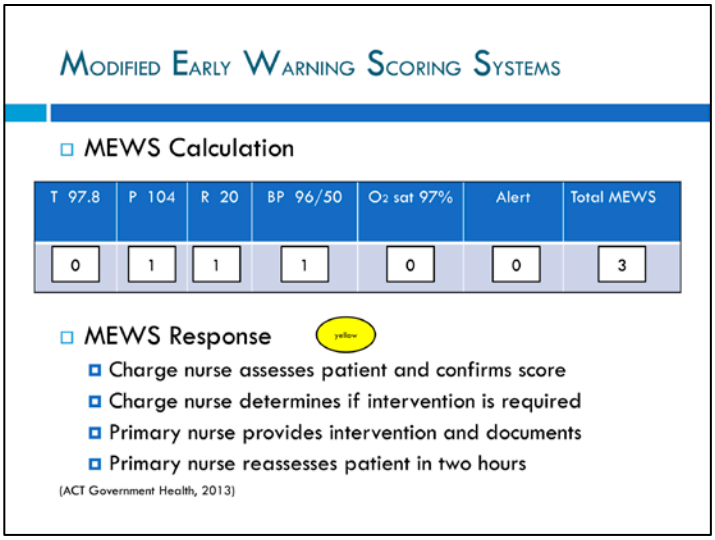
- ABCDE Assessment
  - Expose & Examine
    - Expose body for physical exam
    - Examine invasive catheters, tubes, lines, and/or drains
    - Examine pain
      - PQRST
      - OLDCARTS
    - Examine patient's chart
    - Examine prescribed medicine
    - Examine results of investigations (labs/diagnostics)

"Walks like a duck, looks like a duck, but I need some more quacking tests first."

(National University of Singapore, 2014)


Modified Early Warning Scoring Systems
MEWS Calculation
T 98.9 | P 101 | R 28 | BP 124/78 | O2 sat 95% | Alert | Total MEWS
0 | 1 | 2 | 0 | 1 | 0 | 4
MEWS Response
orange
Charge nurse assesses patient and confirms score
Primary provider notified of patient's condition
Medical staff takes appropriate action
Primary nurse reassesses patient in one hour
(ACT Government Health, 2013)


Modified Early Warning Scoring Systems
MEWS Calculation
T 100.4 | P 90 | R 18 | BP 148/84 | O2 sat 98% | Alert | Total MEWS
0 | 0 | 1 | 0 | 0 | 0 | 1
MEWS Response
green
Primary nurse reassesses patient every four hours per routine care
(ACT Government Health, 2013)


Modified Early Warning Scoring Systems
MEWS Calculation
T 97.8 | P 104 | R 20 | BP 96/50 | O2 sat 97% | Alert | Total MEWS
0 | 1 | 1 | 1 | 0 | 0 | 3
MEWS Response
yellow
Charge nurse assesses patient and confirms score
Charge nurse determines if intervention is required
Primary nurse provides intervention and documents
Primary nurse reassesses patient in two hours
(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- MEWS Calculation

T 101	P 110	R 24	BP 170/90	O_2 sat 90%	Agitated	Total MEWS
1	1	2	1	2	1	8

- MEWS Response
  - RRT is called and charge nurse is notified
  - RRT takes appropriate action
  - Primary provider is called
  - Primary nurse reassesses every hour until stable

(ACT Government Health, 2013)

Modified Early Warning Scoring Systems

- In Summary…

References

- Al-Qahtani, S., & Al-Dorzi, H. M. (2010). Rapid response systems in acute hospital care. *Annals of Thoracic Medicine, 5*(1), 1-4. doi:10.4103/1817-1737.58952
- American Heart Association. (2013). *ACLS for experienced providers.* South Deerfield, MA: Channing Bete Company.
- Australian Commission on Safety and Quality in Health Care. (2008). *Recognizing and responding to clinical deterioration: Background paper.* Retrieved from https://www.safetyandquality.gov.au/wp-content/uploads/2012/01/BackgroundPaper.pdf
- Complete list of references upon request.

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Appendix E

CLINICAL DETERIORATION SIMULATION

INTRODUCTION

Primary Case: COPD and Pneumonia

This case presents a patient who is admitted to the medical-surgical-telemetry unit with a two-day history of fever, chills, increasing shortness of breath, cough, generalized weakness, and decreased appetite. The participants will be expected to follow a new policy – a comprehensive modified early warning scoring (MEWS) system – for the treatment and management of clinical deterioration.

SCENARIO OVERVIEW

Estimated Scenario Time: 15 – 20 minutes
Debriefing: 20 minutes

Target Groups: Nursing staff

Brief Summary:

This case presents a patient who is admitted to the medical-surgical-telemetry unit with a two-day history of fever, chills, increasing shortness of breath, cough, generalized weakness, and decreased appetite. The participants will be expected to follow a new policy – a comprehensive modified early warning scoring (MEWS) system – for the treatment and management of clinical deterioration.

Overall Learning Objectives:

- ☐ Recognizes clinical deterioration
- ☐ Records and reviews observations
- ☐ Reports clinical deterioration
- ☐ Responds and rescues patient from clinical deterioration

Scenario Specific Objectives:

- ☐ Obtains adequate history
- ☐ Obtains and records vital signs accurately
- ☐ Reviews vital signs and calculates MEWS correctly using MEWS tool
- ☐ Completes primary assessment using ABCDE assessment tool
- ☐ Refers to response algorithm based on MEWS for management of clinical deterioration
- ☐ Uses SBAR communication tool to appropriately escalate concerns
- ☐ Implements nursing actions according to response algorithm

REPORT TO PARTICIPANTS

Time: 2:00 P.M.

Mrs. Sally Jones is a 71-year-old female admitted directly from the physician's office to the medical-surgical-telemetry unit with a 2-day history of fever, chills, increasing shortness of breath, cough, generalized weakness, and decreased appetite. Following initial testing, the patient is diagnosed with COPD exacerbation and pneumonia. She has a medical history of Type II diabetes mellitus, COPD, hypertension, ischemic heart disease, and hyperlipidemia. She has been assisted into a patient gown and in the hospital bed. Her granddaughter is at her side. Her chart is complete with Physician Orders.

Clinical Signs Immediately Visible:

- ☐ Alert and responsive
- ☐ Short of breath
- ☐ Using accessory muscles of shoulder and neck to breathe
- ☐ Pale
- ☐ Anxious

ADDITIONAL INFORMATION, MEDICAL HISTORY

Patient Data:	Female – Age 71 years. Weight 121 pounds (50 kg). Height – 5 feet 5 inches (65 inches)
DOB:	02/21/1946
Medical Record #:	SCR2017A
Past Medical History:	Patient has a medical history of Type II diabetes mellitus, COPD, hypertension, ischemic heart disease, and hyperlipidemia. She has a 50-year history of smoking one pack of cigarettes per day. She has continued to smoke despite the requests of her family and physician to quit. In the last year she has experienced three exacerbations requiring hospitalization.
Recent Medical History:	Patient has reported increased fatigue and generalized weakness with activities of daily living. She has had difficulty getting adequate sleep at night and has noticed an increase in sputum production and coughing spells.

Home Medications:

- ☐ Micronase (glyburide) – 10 mg daily
- ☐ Advair 250/50 Diskus (fluticasone/salmeterol) – 1 inhalation twice daily
- ☐ Zestril (lisinopril) – 20 mg daily
- ☐ Aspirin (acetylsalicylic acid) – 81 mg daily
- ☐ Nitrostat (nitroglycerin) – 0.4 mg sublingual (take 1 tab sublingually Q 5 minutes x 3 for chest pain)
- ☐ Lipitor (atorvastatin) – 10 mg daily

Prescribed Medications:

- ☐ Accuneb (albuterol) – 2.5 mg via nebulizer 3 – 4 times per day as needed
- ☐ Deltasone (prednisone) – 30 mg daily
- ☐ Duramorph (morphine) – 4 – 10 mg IV push or IM every 3 – 4 hours as needed
- ☐ Levaquin (levofloxacin) – 500 mg IV piggy back every 24 hours

Diagnostics:

- ☐ Chest X-ray
- ☐ Labs – complete blood count (CBC) and complete metabolic panel (CMP)

EQUIPMENT CHECKLIST

Equipment	Medications and Fluids
☐ Hospital bed	☐ Accuneb (albuterol) nebulizer
☐ VitalSim manikin	☐ Deltasone (prednisone) tablets
☐ Patient identification bracelet	☐ Duramorph (morphine) IV or IM
☐ Allergy bracelet	☐ Levaquin (levofloxacin) IV piggy back
☐ Medication cart	**Documentation Forms**
☐ Crash cart	☐ MEWS Tool
☐ Universal precautions equipment	☐ MEWS Response Algorithm
☐ Thermometer	☐ Glasgow Coma Scale
☐ Automatic blood pressure cuff	☐ Documentation flow sheet
☐ Manual blood pressure cuff	☐ Code recording flow sheet
☐ Stethoscope	**Diagnostics Available**
☐ Oxygen saturation monitor	☐ Chest X-ray
☐ Oxygen regulator and supply source	☐ CBC
☐ Oxygen devices (nasal cannula; simple face mask)	☐ CMP
☐ Nebulizer device and tubing	
☐ Suction regulator and supply source	
☐ Suction equipment (Yankauer with tubing)	
☐ Artificial airways (oropharyngeal/nasopharyngeal)	
☐ Cue card for body temperature	
☐ Cue card for skin temperature, color, and moisture	
☐ Cue card for urine output; lab results)	
☐ Cue card for physician	
☐ IV pump, tubing, and cannula	
☐ Cardiac monitor and ECG machine	
☐ AVPU and Glasgow Coma Scale	
☐ Pain scale (PQRST and OLDCARTS)	
☐ Pen light	
☐ Blood glucose monitor	

PREPARATION OF VITALSIM MANIKIN

☐ Place – Medical-Surgical-Telemetry Unit
☐ Clothing – patient gown
☐ Position – sitting in semi-fowlers position in hospital bed
☐ Prop – patient identification bracelet with name, date of birth, and medical record #
☐ Prop – allergy bracelet with NKDA
☐ Prop – IV in left hand with 0.9% Normal Saline infusing at 75 mL/hr

PARTICIPANT ROLES

☐ Charge nurse
☐ Primary nurse
☐ Secondary nurse
☐ Physician
☐ Rapid response team
☐ Family member
☐ Observer

INSTRUCTOR ROLES

☐ Facilitator of simulation
☐ RAPIDS-Tool Scorer
☐ Presentation Monitor

5 MINUTES (Admission process with first set of vital signs and ABCDE assessment – MEWS = 6)

Monitor	**Vital signs:** RR 24 [2] HR 94 [0] BP 102/58[0] T 101.2 °F [1] Alert [0] O_2 sat 89%[3] **Initial MEWS** = 6 **O_2 trend for next time-frame:** RR 18 – 20 O_2 sat 90 - 92% **MEWS trend for next time-frame:** New MEWS after application of O_2 = 5
Manikin	**Auscultation sounds:** Wheezes **Vocal sounds:** LOC – Alert; manikin responds appropriately to questions; rates pain at a "4"; pain in chest only with coughing spells
Participant	**Initial actions:** Wash hands, introduce self, identify patient, obtain vital signs, assess pain, review physician orders, complete ABCDE assessment, administer O_2, calculate MEWS, and refer to response algorithm
Cue/Prompt	**A:** Airway patent as evidenced by patient's clear speech; no suctioning required at this time; patient with productive sputum **B:** RR 24, breathing shallow, even, and labored as evidenced by use of accessory muscles of shoulder and neck; no circumoral or peripheral cyanosis; O_2 sat 89% on room air; wheezes throughout lung fields; place in high Fowler's position; initiate O_2 per physician orders **Prompt:** If participant does not apply O_2 as ordered, patient will complain of increased dyspnea. **C:** HR 94; pulses strong, regular, and fast; BP 102/58; skin pale, warm, and dry; capillary refill time less than 3 seconds; T 101.2 °F (febrile); patient reports last urine output approximately 8 hours ago; IV already established; administer IV fluids per physician orders **D:** Alert; pupils equal, round, and reactive to light bilaterally; labs drawn for blood glucose **E:** Expose body to look for fluid retention, rashes, bruises, etc.; pain "4"; review physician orders; review home medications; review labs **Red** – A red score (> 6) requires notification of the rapid response team (RRT) and attending healthcare provider, who are all expected to respond to the patient's bedside. The RRT and primary care team collaborate on the patient's plan of care. The primary nurse reassesses the patient within one hour.

5 – 10 MINUTES (Repeat vital signs and ABCDE assessment following administration of oxygen – MEWS = 5)

Monitor	**Vital signs:** RR 20 [1] HR 90[0] BP 100/58[1] T 101.2 °F [1] Alert [0] O_2 sat 91%[2] **New MEWS** (after O_2 application) = 5 **O_2 trend for next time-frame:** RR 18 – 20 O_2 sat 93 – 95% **MEWS trend for next time-frame:** New MEWS after administration of breathing treatment, 250 mL fluid bolus, antibiotic, and Tylenol = 3 RR 19 [1] HR 104 [1] BP 120/60[0] T 100.4 [0] O_2 sat 93%[1]

Manikin	**Auscultation sounds:** wheezes **Vocal sounds:** LOC – alert; rates pain at a "4"; pain in chest only with coughing spells
Participant	**Actions:** After administering O_2 per physician orders, review physician orders, administer breathing treatment, administer IV fluid bolus, prepare to administer IV antibiotic, administer Tylenol, obtain new set of vital signs, reassess with ABCDE assessment, re-calculate MEWS, and refer to response algorithm
Cue/Prompt	**A:** Airway patent as evidenced by patient's clear speech; no suctioning required at this time; patient with productive sputum **B:** RR ↓ 20, breathing shallow, even, and labored as evidenced by use of accessory muscles of shoulder and neck; no circumoral or peripheral cyanosis; O_2 sat ↑ 91% on O2 at 2 L/nasal cannula; ↓ wheezes throughout lung fields after breathing treatment; place in high Fowler's position **Prompt:** If participant does not administer breathing treatment as ordered, patient will complain of increased dyspnea. **C:** HR 90; pulses strong, regular, and fast ; BP 100/58; skin pale, warm, and dry; capillary refill time less than 3 seconds; T 101.2 °F (febrile); patient reports last urine output approximately 8 hours ago; IV already established; administer IV fluids per physician orders **Prompt:** If participant does not administer fluid bolus, patient will complain of increased light-headedness, dizziness, and thirst. **D:** Alert; pupils equal, round, and reactive to light bilaterally; review lab results (blood glucose) **E:** Expose body to look for fluid retention, rashes, bruises, etc.; pain "4"; review physician orders; review home medications; review lab results **Orange** – An orange score (4 – 5) requires reassessment by the charge nurse, notification of the attending healthcare provider of the change in the patient's condition, and appropriate action taken by the medical staff. The primary nurse reassesses the patient within one hour.

10 – 20 MINUTES (Repeat vital signs and ABCDE assessment following administration of breathing treatment, IV fluid bolus, antibiotic, and Tylenol – MEWS = 3)

Monitor	**Vital signs:** RR 19 [1] HR 104 [1] BP 120/60[0] T 100.4 [0] Alert [0] O_2 sat 93%[1] **New MEWS** (after breathing treatment, 250 mL fluid bolus, antibiotic, and Tylenol) = 3
Manikin	**Auscultation sounds:** Few scattered wheezes **Vocal sounds:** LOC – alert; rates pain at a "2"; pain in chest only with coughing spells
Participant	**Actions:** After administering breathing treatment, IV fluid bolus, antibiotic, and Tylenol per physician orders, obtain new set of vital signs, reassess with ABCDE assessment, re-calculate MEWS, and refer to response algorithm
Cue/Prompt	**A:** Airway patent as evidenced by patient's clear speech; no suctioning required at this time; patient with productive sputum **B:** RR ↓ 19, breathing shallow, even, and unlabored following breathing treatment; no circumoral or

	peripheral cyanosis; O_2 sat ↑ 93% on O_2 at 2 L/nasal cannula; ↓ wheezes throughout lung fields after breathing treatment; remains in high Fowler's position **C:** HR ↑104; pulses strong, regular, and fast (tachycardia possibly due to breathing treatment) ; BP ↑ 120/60 (possibly due to IV fluid bolus); skin pale, warm, and dry; capillary refill time less than 3 seconds; T ↓ 100.4 °F (Tylenol beginning to work); patient reports last urine output approximately 8 hours ago; IV already established; administer IV fluids per physician orders **D:** Alert; pupils equal, round, and reactive to light bilaterally; review lab results (blood glucose) **E:** Expose body to look for fluid retention, rashes, bruises, etc.; pain ↓"2" (coughing less); review physician orders; review home medications; review lab results **Yellow** – A yellow score (2 – 3) requires the reassessment of the patient by the charge nurse on duty. If the charge nurse confirms that the score is accurate, he or she determines whether an intervention is required and documents assessment in the medical record. The primary nurse provides the intervention, documents the intervention in the medical record, and reassesses the patient within two hours.

PHYSICIAN ORDERS

Patient Name: Sally Jones DOB: 2/21/1946 Age: 71 Height: 5 ft 5 in (65 in) Weight: 121 pounds (50 kg) Medical Record #: SCR2017A	Diagnoses: COPD Exacerbation; Pneumonia
Allergies (drug, food, other): No known allergies (NKA)	

Date Time	Physician Orders
03/XX/17 1400 hrs	Admit to 3rd floor Medical-Surgical-Telemetry Unit, Dr. Hook's service
	Labs: CBC, CMP
	Diagnostic: STAT portable chest X-ray
	Oxygen therapy: O_2 @ 2 L/nasal cannula to keep O_2 sat 90-92%
	Vital signs every 4 hrs
	Diet: Cardiac diet
	Activity: Bed rest with bathroom privileges
	IV maintenance: 0.9% Normal Saline @ 75 mL/hr
	☐ IV bolus: Administer 250 mL 0.9% Normal Saline bolus now
	Medications:
	☐ Accuneb (albuterol) – 2.5 mg via nebulizer 3 – 4 times per day as needed
	☐ Deltasone (prednisone) – 30 mg daily
	☐ Duramorph (morphine) – 4 – 10 mg IV push or IM every 3 – 4 hours as needed
	☐ Levaquin (levofloxacin) – 500 mg IV piggy back every 24 hours
	☐ Tylenol (acetaminophen) – 650 mg every 3 – 4 hours as needed
	Home medications:
	☐ Micronase (glyburide) – 10 mg daily
	☐ Advair 250/50 Diskus (fluticasone/salmeterol) – 1 inhalation twice daily
	☐ Zestril (lisinopril) – 20 mg daily
	☐ Aspirin (acetylsalicylic acid) – 81 mg daily
	☐ Nitrostat (nitroglycerin) – 0.4 mg sublingual – take 1 tab Q 5 minutes x 3 for pain
	☐ Lipitor (atorvastatin) – 10 mg daily
	Thank you.
	Dr. Hooks

PROPOSED CORRECT TREATMENT

- ☐ Wash hands
- ☐ Introduce self
- ☐ Identify patient (name, ID band, DOB, and medical record #)
- ☐ Identify allergies (NKA)
- ☐ Determine patient responsiveness (level of consciousness)
- ☐ Obtain and record vital signs (T P R BP O_2 sat)
- ☐ Assess pain level (PQRST or OLDCARTS tools)
- ☐ Position in high Fowler's
- ☐ Review physician orders
- ☐ Administer oxygen
- ☐ Calculate MEWS
- ☐ Complete physical assessment (ABCDE assessment)
- ☐ Use response algorithm based on MEWS
- ☐ Escalate concerns appropriately (SBAR communication tool)

SIMULATION DEBRIEFING TEMPLATE

Time Taken: **Recommended Time:**					**Score:**
KEY QUESTIONS FOR REFLECTION: **Q1 What happened to the patient?** **Q2 What actions were performed?** **Q3 What are all the critical actions that should be performed for this scenario?** **Q4 What are all the inappropriate actions for this scenario?**					
		Q2	**Q3**	**Q4**	**Rationale**
Assess Responsiveness					
RESPONSE	Ask patient condition				
	Tap on shoulder				
Assess and Manage Deterioration Using ABCDE					
AIRWAY	Assess for signs of airway obstruction (look/listen/feel)				
	Perform head-tilt-chin-lift or jaw thrust maneuver				
	Place patient on the side				
	Insert artificial airway				
	Perform suctioning				
BREATHING	Count respiratory rate				
	Assess breathing pattern				
	Assess chest movement				
	Check for cyanosis				
	Measure oxygen saturation level				
	Auscultate chest for breath sounds				
	Place patient in a head-up position				
	Initiate or titrate oxygen				
CIRCULATION	Count pulse rate				
	Palpate pulses				
	Measure blood pressure				
	Check for peripheral skin				
	Measure capillary refill time				
	Measure body temperature				
	Check urine output				
	Lower patient head of bed patient				
	Establish intravenous (IV) access				
	Prepare or administer IV Normal Saline 0.9%				
	Attach cardiac monitor				
	Perform 12-lead electrocardiogram (ECG)				

SIMULATION DEBRIEFING TEMPLATE CONTINUED

DISABILITY	Assess level of consciousness using AVPU or GCS				
	Examine pupils (size/equality/reaction)				
	Monitor blood glucose level				
EXPOSE/EXAMINE	Expose body for physical examination				
	Examine invasive catheter/tube/lines/drainage				
	Examine pain				
	Examine patient's recorded chart or notes				
	Examine prescribed medication				
	Examine lab/diagnostic test results				
Call For Help Using ISBAR Mnemonic					
CALL FOR HELP	Identify				
	Situation				
	Background				
	Assessment				
	Recommendation				

Appendix F

Simulation Scenario Progression		
5 minutes	**5-10 minutes**	**10-20 minutes**
Monitor settings: T 101.2 [1] P 94 [0] R 24 [2] BP 102/58 [0] O_2 sat 89% on R/A [3] Pain 4 LOC Alert [0] MEWS = 6	**Monitor settings:** T 101.2 [1] P 90 [0] R 20 [1] BP 100/58 [1] O_2 sat 91% on R/A [2] Pain 4 LOC Alert [0] MEWS = 5	**Monitor settings:** T 100.4 [0] P 104 [1] R 19 [1] BP 120/60 [0] O_2 sat 93% on R/A [1] Pain 2 LOC Alert [0] MEWS = 3
Manikin settings: Lung sounds – wheezes Vocal sounds – alert; responds appropriately to questions; rates pain at a 4; pain in chest only with coughing spells	**Manikin settings:** Lung sounds – wheezes Vocal sounds – coughing; rates Pain at a 4; pain in chest only with coughing spells	**Manikin settings:** Lung sounds – few wheezes Vocal sounds – patient feels better; rates pain at a 2; pain in chest only with occasional cough
Participant actions: Wash hands Introduce self Identify patient Obtain vital signs Assess pain Review physician's orders Complete ABCDE assessment Apply O_2 per physician's order Calculate MEWS Review response algorithm	**Participant actions:** Administer breathing treatment Administer 250 mL fluid bolus Administer antibiotic Administer Tylenol Reassess vital signs Reassess with ABCDE Recalculate MEWS Review response algorithm	**Participant actions:** Reassess vital signs Reassess with ABCDE Recalculate MEWS Review response algorithm
Trends: Respiratory rate ↓ with O_2 O_2 sat ↑ with O_2	**Trends:** Respiratory rate ↓ with treatment O_2 sat continues to ↑ Heart rate ↑ due to treatment SBP ↑ due to fluid bolus Temperature ↓ due to Tylenol	**Trends:** Patient resting comfortably without distress
Cues or Prompts: **A:** Airway patent as evidenced by patient's clear speech; no suctioning required at this time; patient with productive sputum **B:** RR 24, breathing shallow, even, and labored as evidenced by use of accessory muscles of shoulder and neck; no circumoral or peripheral cyanosis; O_2 sat 89% on room air; wheezes throughout lung fields; place in high semi-fowler position; initiate O_2 per physician orders **Prompt:** If participant does not apply O_2	**Cues or Prompts:** **A:** Airway patent as evidenced by patient's clear speech; no suctioning required at this time; patient with productive sputum **B:** RR ↓ 20, breathing shallow, even, and labored as evidenced by use of accessory muscles of shoulder and neck; no circumoral or peripheral cyanosis; O_2 sat ↑ 91% on O2 at 2 L/nasal cannula; ↓ wheezes throughout lung fields after breathing treatment; place in high Fowler's position **Prompt:** If participant does not	**Cues or Prompts:** **A:** Airway patent as evidenced by patient's clear speech; no suctioning required at this time; patient with productive sputum **B:** RR ↓ 19, breathing shallow, even, and unlabored following breathing treatment; no circumoral or peripheral cyanosis; O_2 sat ↑ 93% on O_2 at 2 L/nasal cannula; ↓ wheezes throughout lung fields after breathing treatment; remains in high Fowler's position

as ordered, patient will complain of increased dyspnea. **C:** HR 94; pulses strong, regular, and fast; BP 102/58; skin pale, warm, and dry; capillary refill time less than 3 seconds; T 101.2 °F (febrile); patient reports last urine output approximately 8 hours ago; IV already established; administer IV fluids per physician orders **D:** Alert; pupils equal, round, and reactive to light bilaterally; labs drawn for blood glucose **E:** Expose body to look for fluid retention, rashes, bruises, etc.; pain "4"; review physician orders; review home medications; review labs	administer breathing treatment as ordered, patient will complain of increased dyspnea. **C:** HR 90; pulses strong, regular, and fast ; BP 100/58; skin pale, warm, and dry; capillary refill time less than 3 seconds; T 101.2 °F (febrile); patient reports last urine output approximately 8 hours ago; IV already established; administer IV fluids per physician orders **Prompt:** If participant does not administer fluid bolus, patient will complain of increased light-headedness, dizziness, and thirst. **D:** Alert; pupils equal, round, and reactive to light bilaterally; review lab results (blood glucose) **E:** Expose body to look for fluid retention, rashes, bruises, etc.; pain "4"; review physician orders; review home medications; review lab results	**C:** HR ↑104; pulses strong, regular, and fast (tachycardic possibly due to breathing treatment) ; BP ↑ 120/60 (possibly due to IV fluid bolus); skin pale, warm, and dry; capillary refill time less than 3 seconds; T ↓ 100.4 °F (Tylenol beginning to work); patient reports last urine output approximately 8 hours ago; IV already established; administer IV fluids per physician orders **D:** Alert; pupils equal, round, and reactive to light bilaterally; review lab results (blood glucose) **E:** Expose body to look for fluid retention, rashes, bruises, etc.; pain ↓"2" (coughing less); review physician orders; review home medications; review lab results
Red – A red score (≥ 6) requires notification of the rapid response team (RRT) and attending healthcare provider, who are all expected to respond to the patient's bedside. The RRT and primary care team collaborate on the patient's plan of care. The primary nurse reassesses the patient within one hour.	**Orange** – An orange score (4 – 5) requires reassessment by the charge nurse, notification of the attending healthcare provider of the change in the patient's condition, and appropriate action taken by the medical staff. The primary nurse reassesses the patient within one hour.	**Yellow** – A yellow score (2 – 3) requires the reassessment of the patient by the charge nurse on duty. If the charge nurse confirms that the score is accurate, he or she determines whether an intervention is required and documents assessment in the medical record. The primary nurse provides the intervention, documents the intervention in the medical record, and reassesses the patient within two hours.
Main Ideas: Recognizes transition period of admission Recognizes clinical deterioration Records and reviews vital signs Completes assessment using ABCDE assessment tool Calculates MEWS appropriately Determines appropriate response Reports clinical deterioration using SBAR tool Responds and rescues patient from deterioration using response algorithm		

Appendix G

Revised RAPIDS-Tool

Participant ID: _____

Part I: Assessing and Managing Clinical Deterioration Using ABCDE				
CHECKLIST *Please rate each item by ticking in the box (1 = performed; 0 = not performed; NA = Not Applicable)*		**1**	**0**	**NA**
AIRWAY	Assess for the signs of airway obstruction (look/listen/feel)			
	Perform head tilt chin lift or jaw thrust			
	Place patient on the side			
	Insert artificial airway (e.g., oropharygneal/nasopharyngeal airway)			
	Perform suctioning			
BREATHING	Count respiratory rate			
	Assess breathing pattern (e.g., regularity/depth)			
	Assess chest movement			
	Check for cyanosis			
	Measure oxygen saturation level			
	Auscultate chest for breath sounds			
	Place patient in head-up position			
	Initiate oxygen			
	Titrate oxygen (keep SpO2 > 94% ; for COPD, keep SpO2 90-92% or at baseline)			
CIRCULATION	Count pulse rates			
	Palpate pulses (e.g. regularity/strength)			
	Measure blood pressure			
	Check peripheral skin (e.g., color/temperature/moisture)			
	Measure capillary refill time (normal < 2 seconds)			
	Measure body temperature			
	Check urine output (oliguria < 0.5ml/kg/hr)			
	Lower patient head of bed position			
	Establish intravenous (IV) access			
	Prepare or administer IV Normal Saline 0.9%			

	Attach cardiac monitor			
	Perform 12-lead electrocardiogram (ECG)			
DISABILITY	Assess level of consciousness using AVPU or GCS			
	Examine pupils (size/equality/reaction)			
	Monitor blood glucose level			
EXPOSE / EXAMINE	Expose body for physical examination (e.g., inspection/palpation/percussion/ auscultation)			
	Examine invasive catheter/ tube/lines/drainage			
	Examine pain (e.g., PQRST)			
	Examine patient's recorded chart or notes (e.g., history, baseline, trend)			
	Examine prescribed medicines			
	Examine investigations result (e.g., laboratory/diagnostic)			

Global Rating Scale:
Please circle the appropriate rating for each of the core competencies on the participants' overall performance in assessing and managing deteriorating patient.

Clinical Judgment: *Interpret assessment findings; apply clinical reasoning on possible diagnosis; make appropriate decision on treatmets.*

1	2	3	4	5	6	7	8	9
	Unsatisfactory			Satisfactory			Outstanding	

Management of Care: *Prioritize and provide care systematically; seek help at appropriate time*

1	2	3	4	5	6	7	8	9
	Unsatisfactory			Satisfactory			Outstanding	

Safe Practice: *Follow safe skills practice; avoid harmful practice*

1	2	3	4	5	6	7	8	9
	Unsatisfactory			Satisfactory			Outstanding	

Part II: Communicating deterioration using ISBAR				
CHECKLIST *Please rate each item by ticking in the box (1 = performed; 0 = not performed; NA = Not Applicable)*		1	0	NA
IDENTITY	State own identity (name/position)			
	State location			
	State patient identity			
SITUATION	State current problem			
	State important vital signs and appropriate clinical findings			
BACKGROUND	State admitting diagnosis			
	State medical history			
	State any outline of treatments or relevant investigations			
ASSESSMENT	Offers possible diagnosis			
RECOMMENDATION	Ask for help or advice clearly			

Global Rating Scale:
Please circle the appropriate rating on the participants' communication skills in reporting about patient's deterioration

Communication: *Convey urgency; convey main issues clearly and concisely*

1	2	3	4	5	6	7	8	9
Unsatisfactory			Satisfactory			Outstanding		

Total ISBAR Score_____

_____ (Total ABCDE Score) + _____(Total ISBAR Score) = _____(Total RAPIDS-Tool score)

National University of Singapore. (2016). *eRAPIDS – Rescuing a Patient in Deteriorating Situations.* Retrieved from http://medicine.nus.edu.sg/nursing/rapids/educational-resources/web-based-simulation/index.html

Appendix H

Workshop Presentation Fidelity Checklist

"Introducing a Comprehensive MEWS System: An Education and Training Workshop"

Activity	Yes	No	N/A
1. Lead facilitator introduces self and other facilitators.			
2. Lead facilitator presents overall learning objectives in a clear and concise manner.			
3. Lead facilitator reviews agenda.			
4. Lead facilitator reviews housekeeping rules.			
5. Lead facilitator provides paper-based pretest assessments to participants and emphasizes importance of keeping answers anonymous – no names on pretests.			
6. Lead facilitator begins PowerPoint presentation with a general introduction to comprehensive MEWS systems.			
7. Lead facilitator focuses on the early identification and management of clinical deterioration in the presentation by emphasizing the following: • Recognition utilizing MEWS tool and ABCDE assessment mnemonic; • Recording and reviewing utilizing MEWS tool in EMR; • Reporting utilizing SBAR communication tool; and • Responding and rescuing utilizing response tool.			
8. Lead facilitator focuses on the utilization of a comprehensive MEWS system in the presentation by discussing the following: • MEWS tool; • Response algorithm; • MEWS system protocol with RRT and SBAR protocol inclusion; • RRT protocol update; and • MEWS system incorporation into EMR.			
9. Lead facilitator encourages discussion and questions during PowerPoint presentation.			
10. Lead facilitator incorporates case studies into PowerPoint presentation.			
11. Lead facilitator introduces a simulation primary case to participants as follows: • Assigns participant roles; • Introduces scenario overview with learning objectives; • Conducts simulation; • Conducts simulation debriefing; and • Repeats simulation if time allows.			
12. Lead facilitator uses RAPIDS Tool for simulation evaluation.			
13. Lead facilitator provides paper-based evaluation surveys to participants and emphasizes importance of keeping answers anonymous – no names on surveys.			
14. Lead facilitator keeps workshop on-time according to agenda schedule.			

Appendix I

St. Claire Regional Medical Center ***Policy & Procedure Manual***

	Subject: **M**odified **E**arly **W**arning **S**coring (MEWS) System	**Department:** Administration **Section:** Patient Care **Policy Number:** **Effective Date:** **Supersedes:**

Policy: To provide clear instruction to staff on use of a comprehensive **M**odified **E**arly **W**arning **S**coring (MEWS) system when patient vital signs are carried out [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23].

Purpose: To improve outcomes of adult patients on medical-surgical-telemetry units who are vulnerable to clinical deterioration by using an electronic MEWS system that:

- Improves documentation of patient vital signs;
- Calculates scores automatically;
- Displays trends in MEWS;
- Provides easy access to a color-coded response algorithm; and
- Prompts timely patient evaluation and response [1,3,11].

Scope: Use of the comprehensive MEWS system is intended for all adult patients (age ≥ 18) on the medical-surgical-telemetry units of 3 Center and 3 North.

Use of the comprehensive MEWS system may be ruled inappropriate for certain patients (e.g., patients with do-not-resuscitate status).

- A primary care team makes this determination (i.e., primary provider, charge nurse, and primary nursing staff).
- A decision to "snooze the MEWS" must be clearly documented in the patient record [7].

Trigger thresholds for physiologic parameters specific to the MEWS tool may need to be reset for certain patients (e.g., patients with COPD who are routinely tachypneic and mildly hypoxic).

- A primary care team makes this determination (i.e., primary provider, charge nurse, and primary nursing staff).
- A decision to reset physiologic parameter trigger thresholds specific to the MEWS tool must be clearly documented in the patient record [7].

Definition: The comprehensive MEWS system refers to the following:

- Selected MEWS tool,
- Response algorithm, and
- MEWS policy.

The MEWS system is incorporated into the hospital's electronic medical record system MEDITECH (see Appendix A for MEWS tool and condensed version of response algorithm).

A MEWS tool is a physiologic scoring system that helps to quantify physiologic variables by assigning a score to each variable in a weighted manner [7,11,14].

A score of "0" is given to physiologic variables that fall into predetermined normal ranges; a score of "1" to "3" is given to physiologic variables that fall outside of these ranges [5,14].

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An aggregate score (i.e., a MEWS) is automatically calculated from all variables in MEDITECH; a MEWS greater than "1" alerts staff to deviations in vital parameters and warrants action [11,14].

The physiologic variables in this scoring system include:

- Respiratory rate,
- Heart rate,
- Systolic blood pressure,
- Level of consciousness,
- Temperature, and
- Oxygen saturation [5].

The MEWS tool is coupled with a color-coded response algorithm that outlines appropriate nursing action based on the score (see Appendices B and C for response algorithms) [4,5,11,20,21,22].

Green =0-1 Score **Yellow** = 2-3 Score **Orange** = 4-5 Score **Red** = ≥ 6 Score

Background: Despite considerable emphasis on patient safety and high-quality care in U.S. hospitals for the past two decades, significant challenges remain in early detection and treatment of clinical deterioration in adult medical-surgical patients contributing to poor patient outcomes, increased resource utilization, and increased costs [8,9,10,13,14,18,19].

The literature highlights problems of failure to rescue events and suboptimal care in this patient population in which clinical deterioration is frequently missed or mismanaged by primary nursing staff [1,6,15,16,17,21,23]. Reasons for the breakdown in patient care are multifactorial (e.g., communication factors; education and training factors; and organizational factors) [13].

Warning signs of changes in a patient's physiologic condition may be present as early as 72 hours prior to a severe adverse event such as in-hospital cardiac arrest and/or death [6,17,23]. Patients regularly exhibit changes in vital signs and/or level of consciousness. Yet these signs go unrecognized and/or untreated. Concurrently, patient care in the hours preceding a severe adverse event is often judged to be suboptimal [1,6,15,16,17,21,23].

Rapid response teams (RRTs) and comprehensive MEWS systems have been widely implemented to assist staff in early recognition and management of clinical deterioration. MEWS systems are based on the premise that early clinical deterioration can be detected by monitoring slight changes in multiple physiologic variables versus relying on drastic changes in one [5,11,18,19].

General: Upon arrival to 3 Center or 3 North (i.e., admission or transfer), a patient will have an initial set of vital signs completed; a MEWS will be calculated at the same time or within 30 minutes of arrival. Thereafter, a MEWS will be calculated with every set of vital signs [1,7].

For patients under frequent vital sign protocol, a MEWS will be calculated a minimum of every 30 minutes [7].

For patients for whom use of the comprehensive MEWS system is deemed inappropriate, a primary care team (i.e., primary provider, charge nurse, and primary nursing staff) will make this determination and clearly document "snooze the MEWS" in the patient record [1,7].

For some patients, trigger thresholds for physiologic parameters specific to the MEWS tool may need to be reset; a primary care team (i.e., primary provider, charge nurse, and primary nursing staff) will make this determination and clearly document the reset in the patient record [1,7].

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For patients meeting RRT criteria, a RRT call needs to be made; a MEWS response algorithm does not override activation of the RRT [1,7].

Instructions: The comprehensive MEWS system is to be implemented as follows:

1. Calculate a MEWS with every set of vital signs.

    1.1. Obtain vital signs and level of consciousness a minimum of every 4 hours.

    1.2. Include the following physiologic variables: temperature, pulse, respiratory rate, blood pressure, oxygen saturation, and level of consciousness (LOC).

    1.3. Note temperature, pulse, blood pressure, and oxygen saturation are transmitted wirelessly into MEDITECH while at patient's bedside.

    1.3. Manually enter respiratory rate and level of consciousness into portable medical device for wireless upload into MEDITECH while at patient's bedside.

    1.4. Review vital signs in MEDITECH on assigned patients and respond accordingly.

    1.5. Obtain MEWS by using dropdown menu to select appropriate values for vital signs and level of consciousness to include:

    - Respiratory rate (RR),
    - Heart rate (HR),
    - Systolic blood pressure (SBP),
    - LOC (i.e., AVPU – alert, responds to voice, responds to pain, and unresponsive),
    - Temperature (Temp), and
    - Oxygen saturation (SpO_2).

    1.6. Note scores are automatically generated and color-coded to reflect level of alert.

    1.7. Note actions are mandated by a color-coded response algorithm which can be accessed by clicking on a link on the same screen as the automatically calculated MEWS.

    1.8. Follow MEWS trend by clicking on a link on the same screen as the automatically calculated MEWS.

2. Determine appropriate action based on MEWS (see Appendices B and C).

    2.1. For MEWS 0 – 1 (GREEN Score): Primary nurse reassesses vital signs and MEWS every 4 hours or per ordered monitoring.

    2.2. For MEWS 2 – 3: (YELLOW Score): Charge nurse assesses patient to confirm MEWS and determines need for intervention.

        2.2.1. If the charge nurse confirms that the score is accurate, he or she determines whether an intervention is required and documents assessment in the medical record.

        2.2.2. Primary nurse carries out intervention per charge nurse and documents.

        2.2.3. Primary nurse reassesses patient in 2 hours.

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2.3. For MEWS 4 – 5 (ORANGE Score): Charge nurse assesses patient to confirm MEWS.

2.3.1. If the charge nurse confirms that the score is accurate, he or she documents assessment in the medical record.

2.3.2. Primary nurse notifies the attending healthcare provider of the change in the patient's condition.

2.3.3. Primary nurse carries out intervention per provider, screens patient for severe sepsis, and documents.

2.3.4. Primary nurse monitors the patient every hour for 4 hours.

2.3.5. Primary nurse returns to routine/ordered monitoring if patient stable after 4-hour period.

2.3.6. Primary nurse notifies attending healthcare provider of any changes in patient status not related to MEWS.

2.3.7. Primary care team (i.e., primary healthcare provider, charge nurse, and primary nurse) considers transferring patient to higher level of care if patient not stable in 4-hour period.

2.4 For MEWS $\geq$ 6 (RED Score): Primary nurse calls RRT and notifies charge nurse.

2.4.1. RRT screens patient for severe sepsis.

2.4.2. Charge nurse calls attending healthcare provider.

2.4.3. Attending healthcare provider responds to patient's bedside and collaborates on plan of care with RRT, charge nurse, and primary nurse.

2.4.4. Primary nurse carries out intervention and documents.

2.4.5. Primary nurse monitors the patient every hour for 4 hours and updates provider, RRT, and charge nurse on patient status.

2.4.6. Primary nurse returns to routine/ordered monitoring if patient stable after 4-hour period.

2.4.7. Primary nurse notifies attending healthcare provider of any changes in patient status not related to MEWS.

2.4.8. Healthcare team (i.e., RRT, primary healthcare provider, charge nurse, and primary nurse) considers transferring patient to higher level of care if patient not stable in 4-hour period.

Quality Control:

To ensure proper use of the MEWS protocol, retrospective chart reviews may be performed. The information will be used to detect trends in comprehensive MEWS system utilization and adjust education accordingly.

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Appendix A

Modified Early Warning Scoring (MEWS) Tool and Response Algorithm (Condensed Version)

St. Claire Regional Medical Center's Modified Early Warning Scoring (MEWS) System								
	3	**2**	**1**	**0**	**1**	**2**	**3**	**Green** =0-1 Score **Yellow** = 2-3 Score **Orange** = 4-5 Score **Red** = ≥ 6 Score
RR		< 8	8	9-17	18-20	21-29	≥ 30	
HR		< 40	40-50	51-100	101-110	111-129	≥ 130	
SBP	≤ 70	71-80	81-100	101-159	160-199	200-220	> 220	
AVPU	Unresponsive	Responds to pain	Responds to voice	Alert	Agitation or confusion	New onset agitation or confusion		
Temp		≤ 95°F (35.0°C)	95.1-96.8°F (35.05-36°C)	96.9-100.4°F (36.05-38°C)	100.5-101.3 °F (38.05-38.5°C)	≥ 101.4°F (38.55°C)		
SpO_2	< 90%	90-92%	93-95%	96-100%				

Response Algorithm

Green – For a green score, the primary nurse reassesses vital signs and MEWS every 4 hours or per ordered monitoring.

Yellow – For a yellow score, the charge nurse assesses patient to confirm MEWS, determines need for an intervention, and documents assessment in MEDITECH. If an intervention is required, the primary nurse carries out the intervention per charge nurse and documents in MEDITECH.

Orange – For an orange score, the charge nurse assesses patient to confirm MEWS and documents assessment in MEDITECH. The primary nurse notifies the attending healthcare provider of the change in the patient's condition, carries out intervention per provider, screens patient for severe sepsis, and documents in MEDITECH. The primary nurse reassesses the patient every hour for 4 hours and returns to routine/ordered monitoring if patient stable after 4-hour period. The primary nurse notifies attending healthcare provider of any changes in patient status not related to MEWS. The primary care team considers transferring the patient to higher level of care if patient not stable in 4-hour period.

Red – For a red score, the primary nurse calls the rapid response team (RRT) and notifies the charge nurse. The RRT screens the patient for severe sepsis. The charge nurse calls the attending healthcare provider. The attending healthcare provider responds to the patient's bedside and collaborates on plan of care with RRT, charge nurse, and primary nurse. The primary nurse carries out intervention and documents. The primary nurse reassesses the patient every hour for 4 hours and returns to routine/ordered monitoring if patient stable after 4-hour period. The primary nurse notifies attending healthcare provider of any changes in patient status not related to MEWS. The healthcare team considers transferring the patient to higher level of care if patient not stable in 4-hour period.

Note. Adapted from Stony Brook Medicine's MEWS and Response Algorithm (Duncan et al., 2012; B.M. Mills, personal communication, November 3, 2016).

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Appendix B

Response Algorithm

St. Claire Regional Medical Center's MEWS tool has six physiologic variables:

- Respiratory rate (RR),
- Heart rate (HR),
- Systolic blood pressure (SBP),
- Level of consciousness (i.e., AVPU – alert, responds to voice, responds to pain, and unresponsive),
- Temperature (Temp), and
- Oxygen saturation (SpO_2).

Points ranging from "0" to "3" are allocated for each physiologic variable per preset MEWS tool ranges.

Physiologic variables in "normal" ranges are given a score of "0".

An aggregate score (i.e., a MEWS) is automatically calculated in MEDITECH as nurse enters vital sign data.

MEWS greater than "1" alerts staff to deviations in vital parameters and warrants action.

A MEWS tool is coupled with a response algorithm that outlines appropriate nursing action based on score.

The response algorithm is color-coded to enhance alerting staff to the extent of deviation in vital parameters.

Green =0-1 Score **Yellow** = 2-3 Score **Orange** = 4-5 Score **Red** = ≥ 6 Score

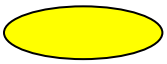
Definition:

- **Green** = 0 – 1 Score
- **Green** – A green score requires reassessment of the patient to include vital signs every 4 hours by the primary nurse.

Process:

- Patient admitted to floor.
- Patient assessed by primary nurse.
- MEWS assigned and documented in MEDITECH by primary nurse.
- MEWS 0 – 1 requires reassessment of patient to include vital signs every 4 hours by primary nurse.

Definition:



- **Yellow** = 2 – 3 Score
- **Yellow** – A yellow score requires reassessment of the patient by the charge nurse on duty. If the charge nurse confirms that the score is accurate, he or she determines whether an intervention is required and documents assessment in the medical record. The primary nurse provides the intervention, documents the intervention in the medical record, and reassesses the patient within 2 hours.

Process:

- Patient admitted to floor.
- Patient assessed by primary nurse.
- MEWS assigned and documented in MEDITECH by primary nurse.
- MEWS 2 – 3 requires reassessment of patient by charge nurse on duty.
- MEWS assigned and documented in MEDITECH by charge nurse.
- If charge nurse confirms that MEWS is accurate, he or she determines whether an intervention is required.
- If an intervention is required, intervention is provided and documented in MEDITECH by primary nurse.
- Patient reassessed by primary nurse within 2 hours.

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Definition:

- **Orange** = 4 – 5 Score

- **Orange** – An orange score requires reassessment by the charge nurse, notification of the attending healthcare provider of the change in the patient's condition, and appropriate action taken by the medical staff. The primary nurse reassesses the patient within 1 hour.

Process:

- Patient admitted to floor.
- Patient assessed by primary nurse.
- MEWS assigned and documented in MEDITECH by primary nurse.
- MEWS 4 – 5 requires reassessment of patient by charge nurse on duty.
- MEWS assigned and documented in MEDITECH by charge nurse.
- Primary nurse contacts attending healthcare provider.
- Primary nurse provides intervention per attending healthcare provider.
- Primary nurse screens patient for severe sepsis.
- Primary nurse documents vital signs, sepsis screening, and MEWS in MEDITECH.
- Primary nurse reassesses the patient within 1 hour.
- Primary nurse monitors patient every hour for 4 hours.
- Primary nurse returns to routine/ordered monitoring if patient stable after 4-hour period.
- Primary nurse notifies attending healthcare provider of any changes to patient status not related to MEWS.
- Primary care team (i.e., primary healthcare provider, charge nurse, and primary nurse) considers transferring the patient to a higher level of care if patient not stable in 4-hour period.

Definition:

- **Red =** $\geq$ 6 Score

- **Red** – A red score requires notification of the rapid response team (RRT) and attending healthcare provider, who are all expected to respond to the patient's bedside. The RRT and primary care team collaborate on the patient's plan of care. The primary nurse reassesses the patient within 1 hour.

Process:

- Patient admitted to floor.
- Patient assessed by primary nurse.
- MEWS assigned and documented in MEDITECH by primary nurse.
- MEWS $\geq$ 6 requires primary nurse to call RRT and notify charge nurse on duty.
- RRT screens patient for severe sepsis.
- Charge nurse calls attending healthcare provider.
- Attending healthcare provider responds to patient's bedside and collaborates on patient's plan of care with RRT, primary care nurse, and charge nurse.
- Action is taken.
- Primary nurse reassesses the patient every hour until patient is stable 4 consecutive hours (not requiring further intervention).
- Primary nurse documents vital signs and MEWS into MEDITECH.
- Primary nurse updates RRT and primary team (charge nurse and attending healthcare provider) of patient's vital signs and MEWS during 4-hour assessment period.
- Primary nurse calls RRT if patient's status declines or is not consistently stable during 4-hour assessment period.
- Primary nurse monitors patient every hour for 4 hours.
- Primary nurse returns to routine/ordered monitoring if patient stable after 4-hour period.
- Primary nurse notifies attending healthcare provider of any changes to patient status not related to MEWS.
- Healthcare team (i.e., RRT, primary healthcare provider, charge nurse, and primary nurse) considers transferring the patient to a higher level of care if patient not stable in 4-hour period.

Note. Adapted from Stony Brook Medicine's Response Algorithm (Duncan et al., 2012; B.M. Mills, personal communication, November 3, 2016).

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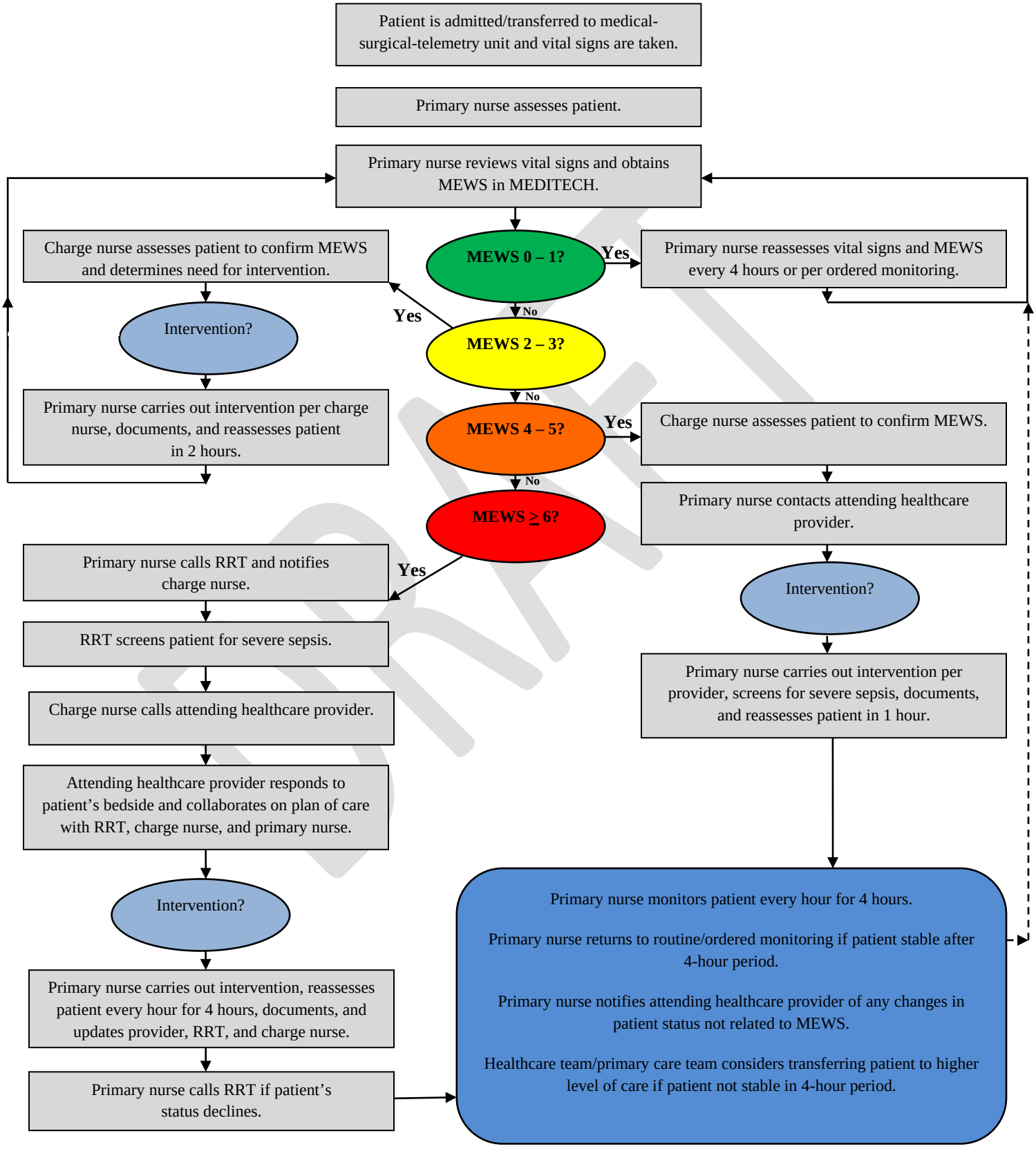
Appendix C

Response Algorithm for MEWS System



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Appendix J

Electronic **M**odified **E**arly **W**arning **S**coring System: Recommendations to IT

Resource: The primary resource for this document was *Health IT and Patient Safety: Building Safer Systems for Better Care* (Institute of Medicine [IOM], 2012). Although recommendations to IT were specific to the study hospital, the IOM (2012) laid the foundation for these recommendations.

Framework: The Sociotechnical System consists of the following components (IOM, 2012, p. 3):

- Technology (e.g., software and hardware of health IT),
- People (e.g., nurses, physicians, and patients),
- Process (e.g., workflow),
- Organization (e.g., hospital rules/regulations and decisions about how health IT applied), and
- External environment (e.g., federal/state regulations and public opinion).

Statement: According to the Institute of Medicine (2012),

> Safely functioning health IT should provide easy entry and retrieval of data, have simple and intuitive displays, and allow data to be easily transferred among health professionals. Many features of software contribute to its safe use, including usability and interoperability. Although definite evidence is hard to produce, the committee believes poor user-interface design, poor workflow, and complex data interfaces are threats to patient safety (p. 4).

Golden Rules: Eight "golden rules" for interface design identified by Shneiderman, Plaisant, Cohen, and Jacobs (2009):

- Strive for consistency;
- Cater to universal usability;
- Offer informative feedback;
- Design dialogs to yield closure;
- Prevent errors;
- Permit easy reversal of actions;
- Support internal locus of control; and
- Reduce short-term memory load.

Critical Path: To best articulate software requirements and development activities,

> A critical path for identifying and validating requirements for software functionality includes assessment of current-state workflow, mapping the current state to the desired future state, and devising a plan to identify and address the gaps between the two (IOM, 2012, p. 93).

Condensed Version of Current-State Workflow

CNA obtains vital signs a minimum of every 4 hours.
- Temperature
- Pulse
- Respiratory rate
- Blood pressure
- Oxygen saturation

→

A portable medical device provides wireless transmission of all collected vital signs, except respiratory rate, into the MEDITECH documentation system.
- Recent implementation that automatically uploads vital signs into MEDITECH.

→

CNA manually enters respiratory rate into portable medical device to ensure upload.
- Accomplished while at patient's bedside.

↓

Nurse reviews vital signs in MEDITECH on assigned patients and responds accordingly.
- Routine care
- Escalation of care

CNA alerts nurse to abnormal vital signs and/or concerns in appropriate timeframe.
- Timing dependent upon degree of physiologic derangement.

→

Nurse addresses problem of abnormal vital signs and/or concerns in appropriate timeframe.
- Reassess vital signs.
- Complete assessment.
- Recognize problem.
- Communicate concerns.
- Manage problem.

Condensed Version of Desired-State Workflow

CNA obtains vital signs and level of consciousness a minimum of every 4 hours.
- Temperature
- Pulse
- Respiratory rate
- Blood pressure
- Oxygen saturation
- Level of consciousness*

→

A portable medical device provides wireless transmission of all collected vital signs, except respiratory rate, into the MEDITECH documentation system.
- Recent implementation that automatically uploads vital signs into MEDITECH.

→

CNA manually enters respiratory rate and level of consciousness into portable medical device to ensure upload.
- Respiratory rate entered while at patient's bedside.
- Ideally, level of consciousness entered while at patient's bedside.*

↓

Nurse reviews vital signs in MEDITECH on assigned patients and responds accordingly.
- Obtain MEWS by using dropdown menu to select appropriate values for vital signs and level of consciousness.*
- Scores are automatically generated and color-coded to reflect level of alert.*
- Actions are mandated by a color-coded response algorithm which can be accessed by clicking on a link on the same screen as the automatically calculated MEWS.*
- Follow MEWS trend by clicking on a link on the same screen as the automatically calculated MEWS.*

CNA alerts nurse to abnormal vital signs and/or concerns in appropriate timeframe.
- Timing dependent upon degree of physiologic derangement.

→

Nurse addresses problem of abnormal vital signs and/or concerns in appropriate timeframe.
- Reassess vital signs.
- Complete assessment.
- Obtain MEWS by using dropdown menu to select appropriate values for vital signs and level of consciousness*
- Scores are automatically generated and color-coded to reflect level of alert.*
- Actions are mandated by a color-coded response algorithm which can be accessed by clicking on a link on the same screen as the automatically calculated MEWS.*

*Workflow change/addition.

Gaps Between Current-State and Desired-State Workflow

Current-State: CNA manually enters respiratory rate into portable medical device that wirelessly transmits data into MEDITECH. This occurs at patient's bedside.

- A limitation pertaining to portable medical device that provides wireless transmission of all collected vital signs except respiratory rate.

Desired-State: CNA to manually enter respiratory rate and level of consciousness into portable medical device that wirelessly transmits data into MEDITECH. This will occur at patient's bedside.

- An added step in work, but CNA already manually entering respiratory rate.
- Nurse will not be able to obtain MEWS if level of consciousness not documented.
- Logically, an omission of either is less likely.
- Potential barrier may be that level of consciousness cannot be entered at patient's bedside.

Desired-State: Nurse to obtain MEWS on all assigned patients by using dropdown menu in MEDITECH to select corresponding values for vital signs and level of consciousness according to MEWS tool.

- An added step in work, but nurse buys-in to significance of trending MEWS.
- Dependent upon nurse to enter data (vital signs and level of consciousness) correctly from a dropdown menu.

Desired-State: Scores to be automatically calculated in MEDITECH and color-coded to reflect level of alert.

- Automatically generated scores reduce MEWS calculation errors.
- Nurse will see MEWS and color-coded alert on computer screen.
    - Example: MEWS **1** = Green Alert

Desired-State: Actions by nurse to be mandated by color-coded response algorithm which will be accessible by clicking a link in the same screen as the MEDITECH-generated MEWS.

- Response algorithm must be easily accessible, thorough, clear, and concise.
- Response algorithm outlines appropriate nursing action based on MEWS.
    - Green Alert for scores 0 – 1
    - Yellow Alert for scores 2 – 3
    - Orange Alert for scores 4 – 5
    - Red Alert for scores ≥ 6
    - Nurse must click box to see algorithm. RESPONSE ALGORITHM
- Must consider how the primary nurse will handle patients with high MEWS at admission.
- Must consider how the primary nurse will keep up with extra monitoring as per response algorithm under certain color-coded categories.
- Must consider potential impact in terms of increased workload on charge nurse, provider, and RRT.
- Must consider exact workflow when CNA alerts nurse to abnormal vital signs in terms of stopping to calculate a MEWS.
- Must consider how the primary nurse will handle situations whereby the patient is stable but MEWS is high (e.g., patient with COPD who normally has tachypnea and mild hypoxia).
- Must address how the primary nurse will handle situations whereby a MEWS is not appropriate for a patient (e.g., a patient with do-not-resuscitate orders).

Note. Adapted from Stony Brook Medicine's MEWS Tool and Response Algorithm (Duncan, McMullan, & Mills, 2012; B.M. Mills, personal communication, November 3, 2016).

Implementation: Successful clinical implementation of health IT includes five stages:

- Planning and goal setting,
- Deployment,
- Stabilization,
- Optimization, and
- Transformation (IOM, 2012, p. 105).

Planning: For the planning and goal setting stage, implementation of an electronic MEWS system to aid in detection of early clinical deterioration in medical-surgical-telemetry patients is the targeted improvement.

Rationale: An electronic MEWS system has potential to improve MEWS system effectiveness by featuring:

- Automatic MEWS calculations,
- Easy access to color-coded response algorithm, and
- Display of MEWS trends (Bonnici, Gerry, Wong, Knight, & Watkinson, 2016; Jones et al., 2011.)

An electronic MEWS system has potential to impact:

- Care coordination – keep healthcare team apprised of patient status related to MEWS trending.
- Care quality – alert nursing staff in real-time to first signs of clinical deterioration.
- Patient safety – capture real-time data to enhance decision-making and avert adverse events.
- Interdisciplinary collaboration – enhance teamwork and communication.
- Care specialties – extend initiative to labor & delivery and pediatrics.
- Evidence-based documentation – standardize protocol and improve compliance.

(Duncan, McMullan, & Mills, 2012; HealthIT.gov, 2014; Jones et al., 2011; MEDITECH, 2017).

RECOMMENDATIONS

1. Work closely with MEDITECH vendor in understanding MEDITECH's full EMR capabilities.

2. Understand the plan/goal is to implement an electronic MEWS system to aid in detection of early clinical deterioration in medical-surgical-telemetry patients.

3. Understand current MEWS tool has six physiologic parameters: respiratory rate (RR), heart rate (HR), systolic blood pressure (SBP), level of consciousness (i.e., AVPU acronym for alert, responds to voice, responds to pain, and unresponsive), temperature (Temp), and oxygen saturation (SpO_2).

4. Understand MEWS tool has a color-coded response algorithm that outlines appropriate nursing action based on score; urgency of response depends on score and pre-determined response algorithm (Duncan et al., 2012).

5. Observe and document current workflow pertaining to vital sign monitoring and patient assessments.

6. Interview nursing staff on current workflow pertaining to vital sign monitoring and patient assessments; current policy states vital signs assessed a minimum of every four hours on all medical-surgical-telemetry patients.

7. Understand a portable medical device provides wireless transmission of all collected vital signs, except respiratory rate, into MEDITECH.

8. Understand respiratory rate must be manually entered into portable medical device for wireless transmission into MEDITECH; this is achieved at patient's bedside.

9. Determine if level of consciousness (LOC) can be entered into portable medical device for wireless transmission into MEDITECH; this would be achieved at the patient's bedside just like respiratory rate.

10. Determine alternative workflow if LOC cannot be manually entered into portable medical device; nursing staff may have to enter LOC at main computer at same time obtaining MEWS on assigned patients.

11. Plan for nurse to review vital signs and LOC on assigned patients at main computer as per current-state workflow.

12. Plan for nurse to obtain MEWS from vital signs and LOC on assigned patients at main computer by using dropdown menu to select appropriate range for each physiologic variable (i.e., RR, HR, SBP, AVPU, Temp, and SpO_2).

    - Make screenshot of vital signs and LOC visible for user while entering data in MEWS dropdown menu.
    - Make dropdown selections very distinct (e.g., HR and SBP ranges can be easily confused at a glance).
    - Consider best order for physiologic variables in dropdown selections (i.e., current MEWS tool with RR and HR at top as their derangement often signals earliest signs of deterioration).
    - Prompt nurse to review data entry and select "SAVE" icon.

    - Generate automatic MEWS calculation when nurse selects "SAVE" icon.
    - Design screen to display MEWS and corresponding alert (e.g., MEWS "1" – Green Alert).

- Design screen to display condensed version of color-coded response algorithm. See example below.

Color-Coded Response Algorithm		
	Green Alert for scores 0 – 1	Routine care with vital signs every four hours.
	Yellow Alert for scores 2 – 3	Assessment by charge nurse to determine intervention.
	Orange Alert for scores 4 – 5	Assessment by charge nurse and notification of provider.
	Red Alert for scores $\geq$ 6	Activation of rapid response team (RRT).

- Provide link for nurse to select to see full response algorithm (e.g.,

).
- Provide link for nurse to select to see MEWS trends for patient (e.g.,

).

13. Plan to display most recent MEWS and summary of MEWS on a central dashboard.

14. In regards to a safely functioning health IT, ask questions about an electronic MEWS system post-implementation (not an exhaustive list).
    - Is MEWS data accurate, timely, reliable, and easy to retrieve?
    - Is new MEWS feature user friendly?
    - Is new MEWS feature simple and easy to understand?
    - Is new MEWS feature easy to navigate?
    - Does new MEWS feature arm nursing staff with reliable and valid data to make informed decisions?
    - How is new MEWS feature viewed by users? Does it enhance workflow or increase it?
    - Is new MEWS feature valued by other healthcare providers (IOM, 2012, p. 78)?

15. In regards to the eight "golden rules" for interface design, ask questions about an electronic MEWS system post-implementation (not an exhaustive list).
    - Is MEWS feature designed for consistency and universal usability?
    - Is MEWS feature designed to provide informative feedback?
    - Is MEWS feature equipped with dialog that yields closure?
    - Is MEWS feature designed to minimize errors?
    - Is MEWS feature designed to allow for easy reversal of actions?
    - Is MEWS feature designed to support internal locus of control?
    - Is MEWS feature designed to reduce short-term memory load (IOM, 2012, p. 85)?

Recommendations are based on previous conversations and meetings with study hospital IT personnel.

References

Bonnici, T., Gerry, S., Wong, D., Knight, J., & Watkinson, P. (2016). Evaluation of the effects of implementing an electronic early warning score system: Protocol for a stepped wedge study. *BioMed Central Medical Informatics and Decision Making, 16*(19), 1-8. doi:10.1186/s12911-016-0257-8

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Jones, S., Mullally, M., Ingleby, S., Buist, M., Bailey, M., & Eddleston, J. M. (2011). Bedside electronic capture of clinical observations and automated clinical alerts to improve compliance with an Early Warning Score protocol. *Critical Care and Resuscitation, 13*(2), 83-88.

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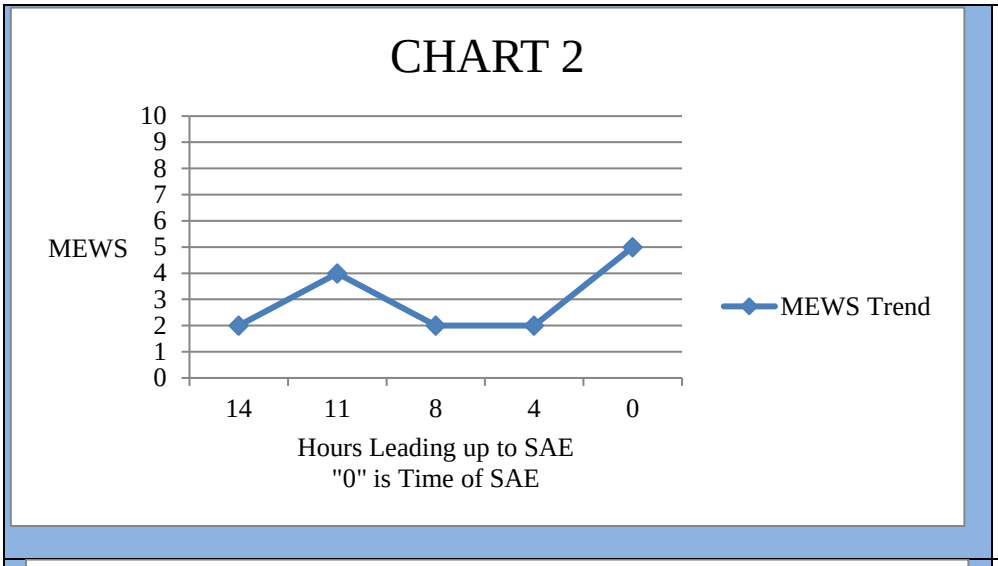
Appendix K

Line Graphs of MEWS in 24-Hours Leading-Up to a Severe Adverse Event for Each Patient Chart

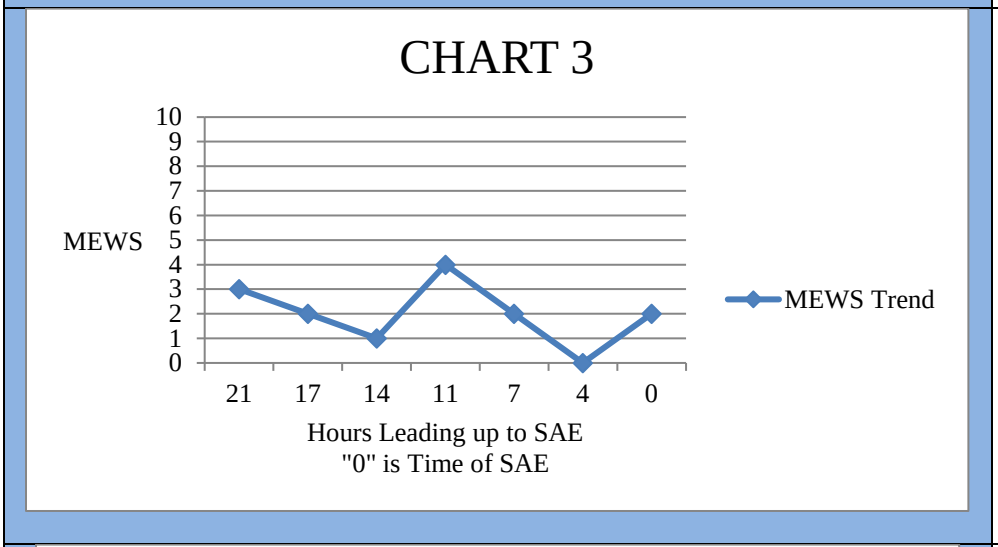


Admission diagnosis: hip fracture

SAE category: RRT call

Reason for RRT call: decreased O_2 sat to 60% related to narcotic administration

Patient outcome: discharged home after 5-day hospitalization

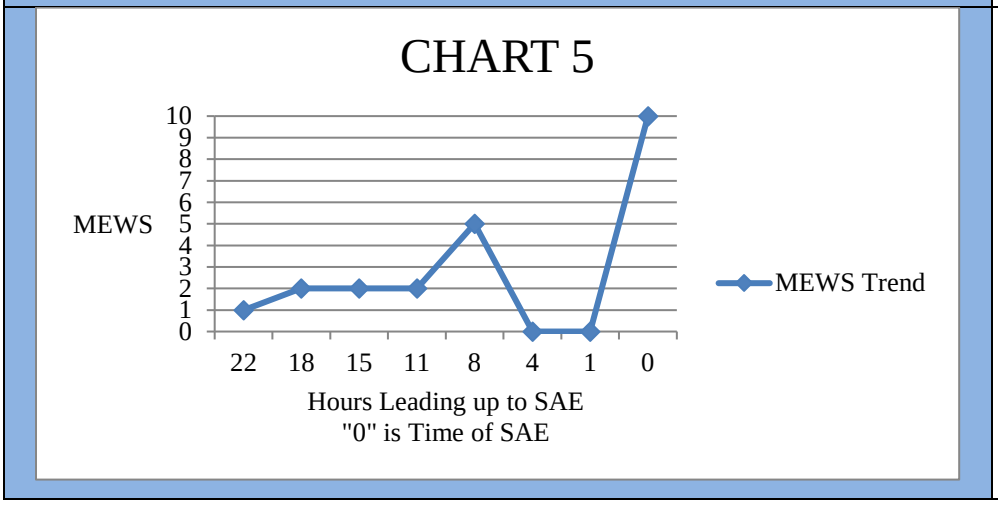


Admission diagnosis: chronic lower extremity ischemia

SAE category: RRT call

Reason for RRT call: mental status change; staff worried

Patient outcome: discharged to nursing home

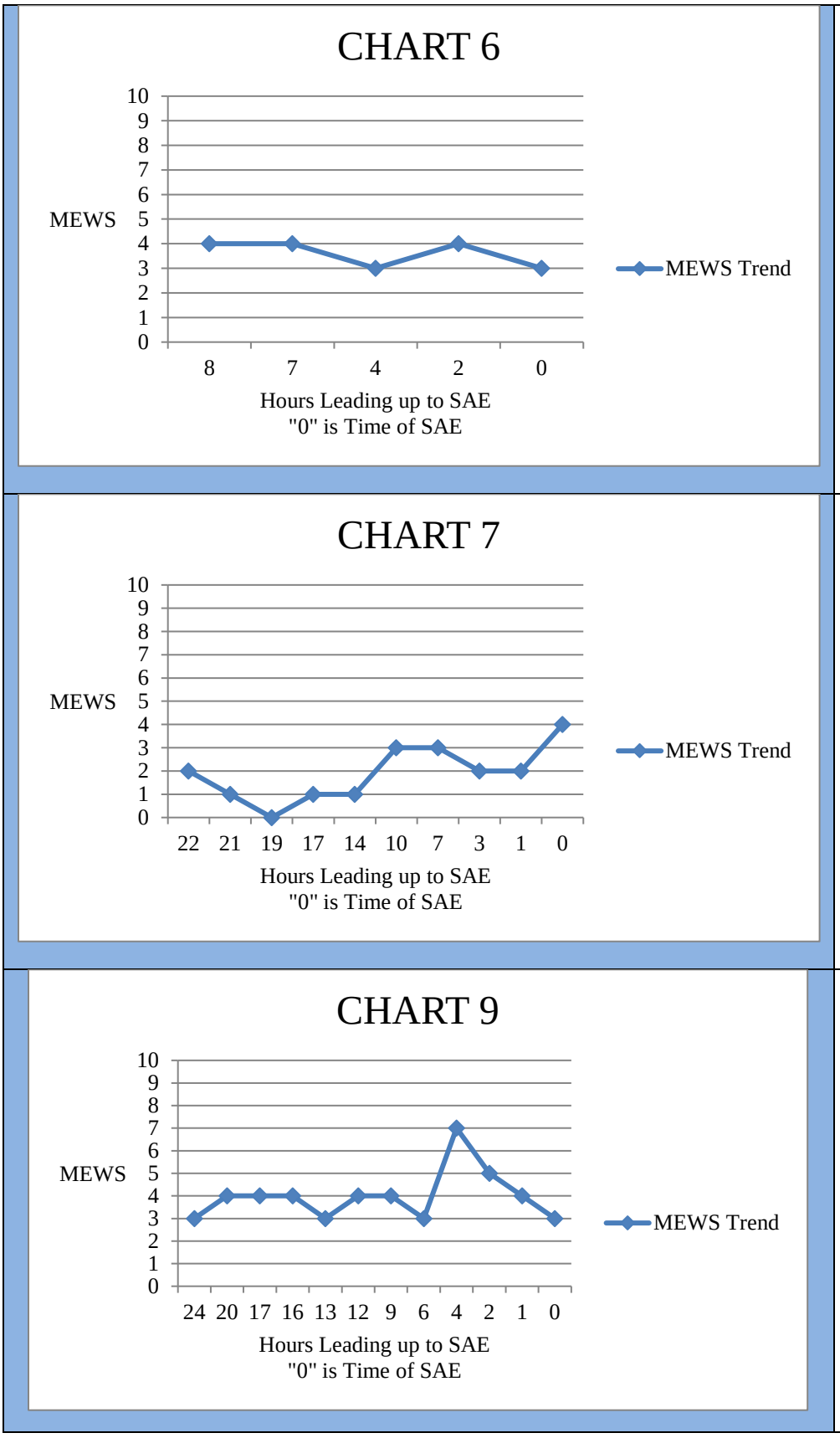


Admission diagnosis: pulmonary edema

SAE category: RRT call, cardiac arrest, unexpected transfer to ICU

Reason for RRT call: seizures

Patient outcome: transferred to ICU but later died same day as SAE



Admission diagnosis: respiratory failure; heart failure

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; HR < 40; RR < 8

Patient outcome: transferred to ICU; discharged to nursing home after 4-day hospitalization

Admission diagnosis: status epilepticus

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: seizures

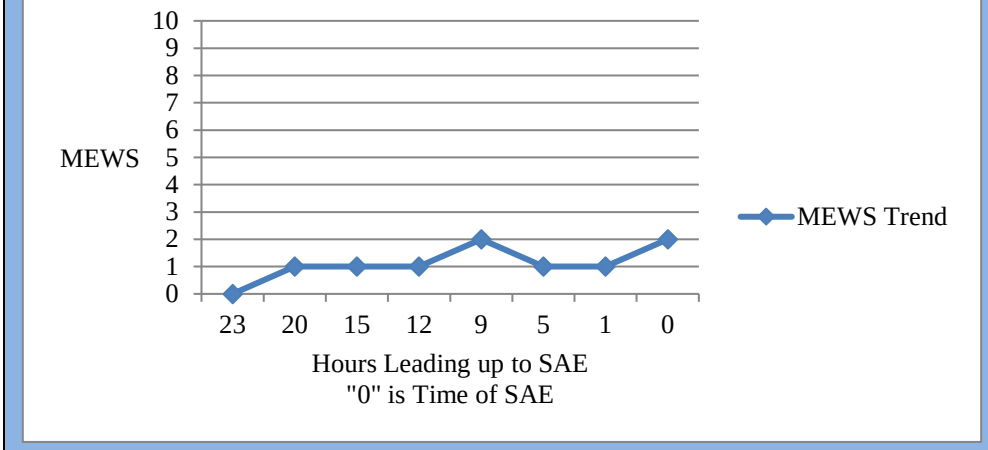
Patient outcome: transferred to ICU; discharged to acute care hospital after 5-day hospitalization

Admission diagnosis: acute respiratory failure; pneumothorax

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; O_2 sat < 90%

Patient outcome: transferred to ICU; transferred to acute care hospital after 28-day hospitalization

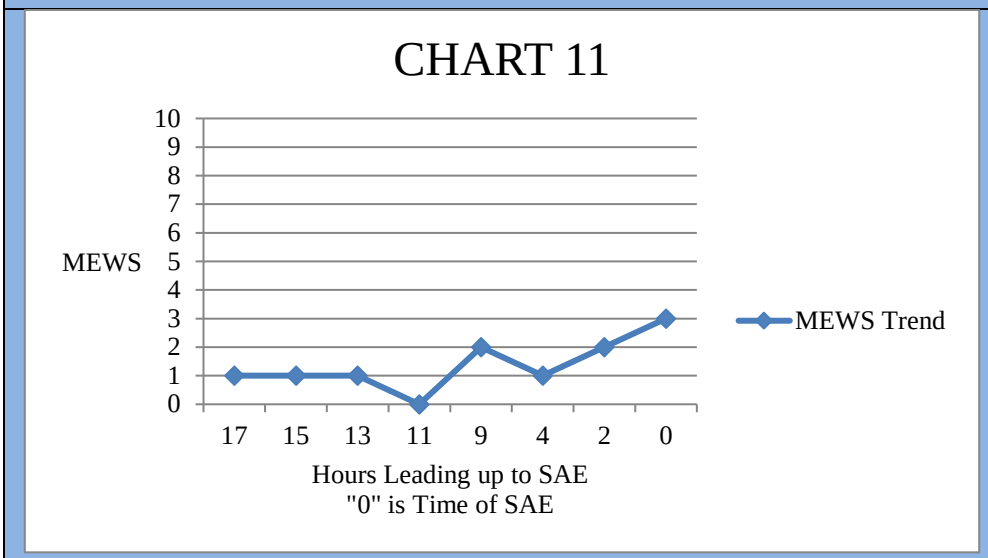


Admission diagnosis: pancreatitis

SAE category: RRT call

Reason for RRT call: staff worried; family worried; mental status change

Patient outcome: transferred to telemetry; discharged to home

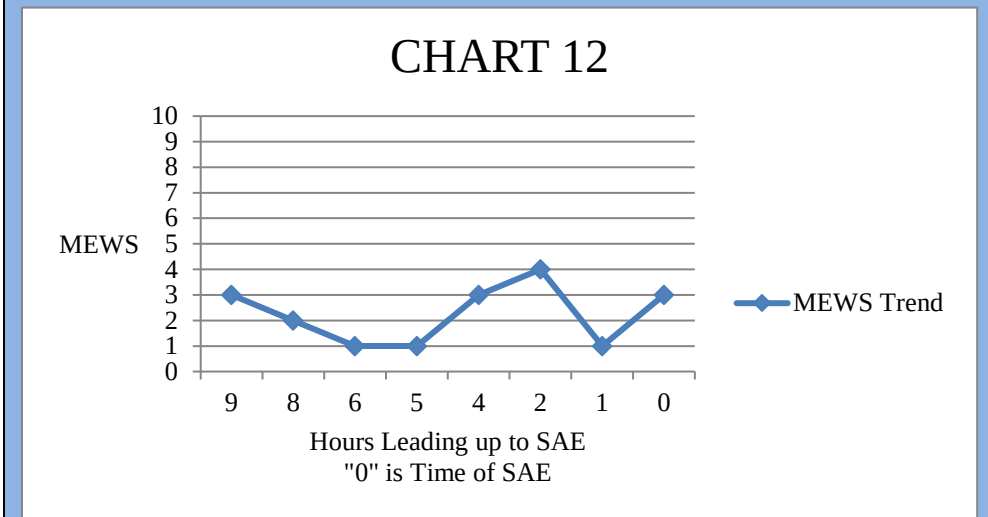


Admission diagnosis: chest pain; unstable angina

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; chest pain

Patient outcome: transferred to ICU; discharged home after 1-day hospitalization

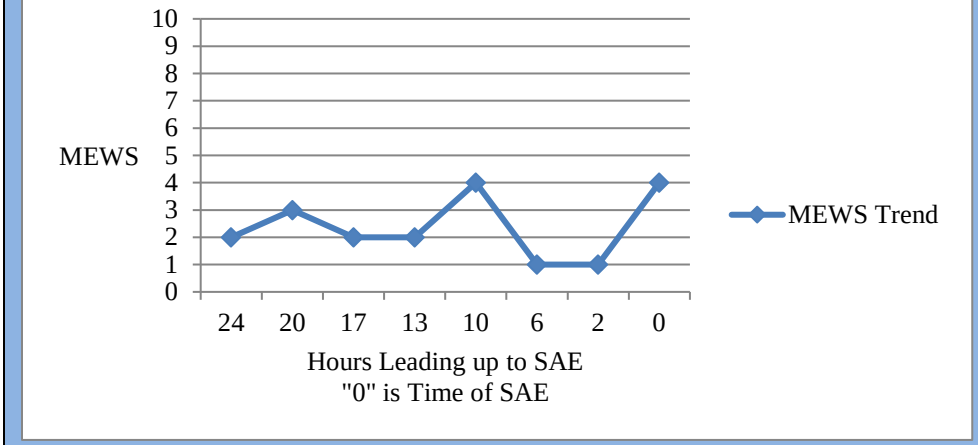


Admission diagnosis: gangrene of digit

SAE category: RRT call

Reason for RRT call: staff worried; mental status change

Patient outcome: discharged home after 15-day hospitalization

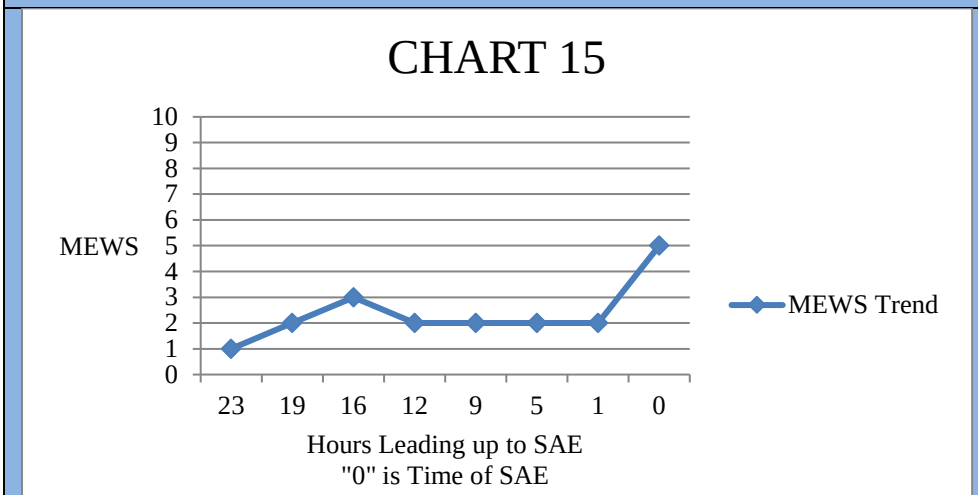


Admission diagnosis: AKI

SAE category: RRT call

Reason for RRT call: staff worried; SPB < 90; mental status change

Patient outcome: transferred to telemetry; discharged to nursing home after 7-day hospitalization

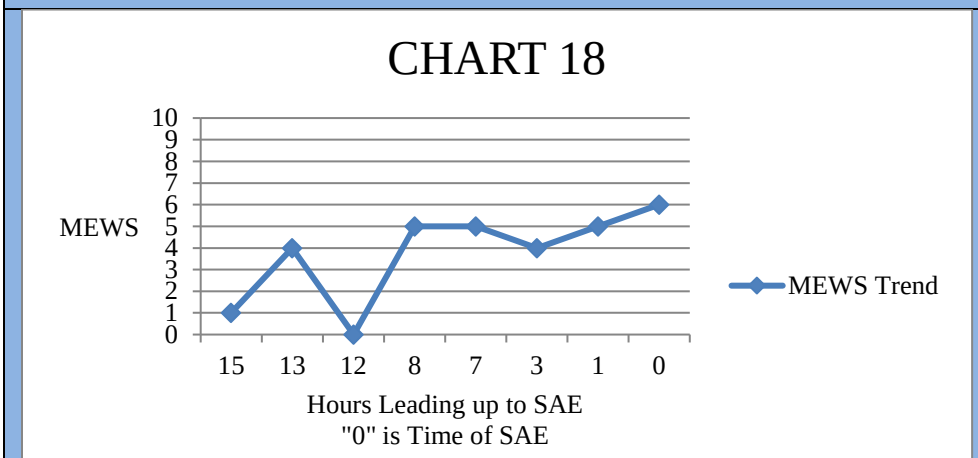


Admission diagnosis: heart failure exacerbation

SAE category: RRT call

Reason for RRT call: staff worried; HR > 130

Patient outcome: discharged to nursing home after 6-day hospitalization

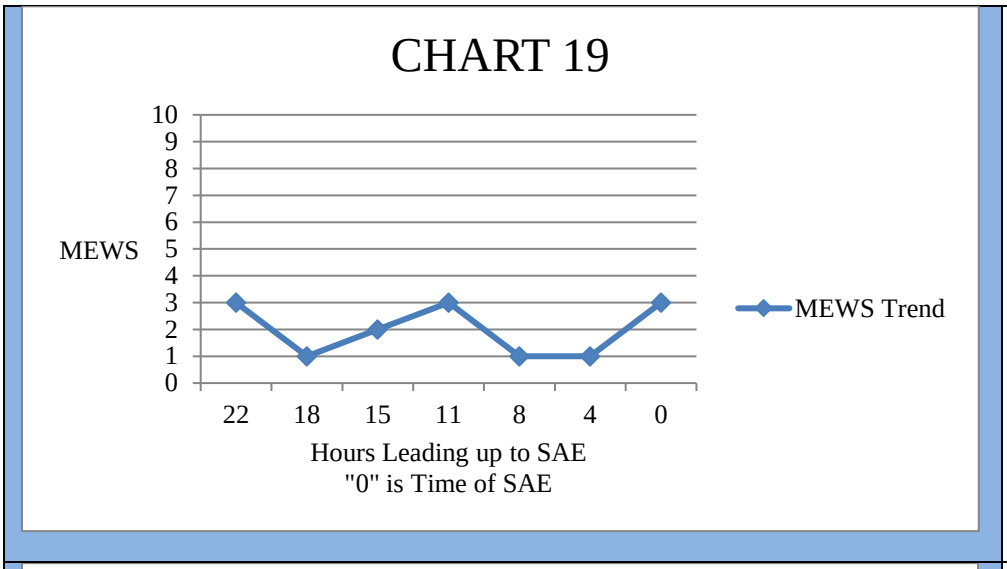


Admission diagnosis: pancreatitis

SAE category: RRT call

Reason for RRT call: family worried; HR > 130

Patient outcome: patient died after 2-day hospitalization

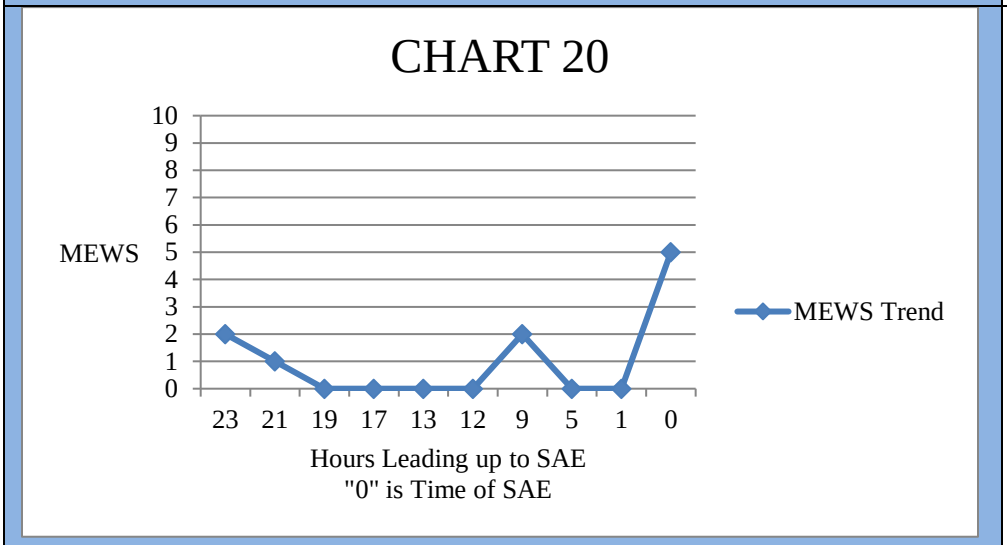


Admission diagnosis: s/p I&D of abscess

SAE category: RRT call

Reason for RRT call: staff worried; stroke symptoms

Patient outcome: transferred to acute care hospital after 3-day hospitalization

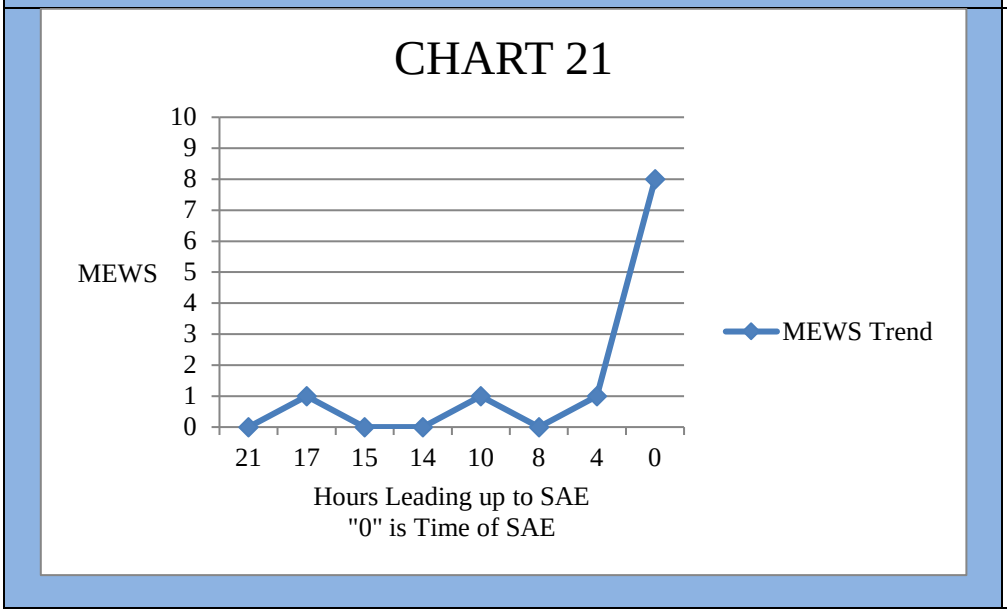


Admission diagnosis: COPD exacerbation

SAE category: RRT call

Reason for RRT call: mental status change; RR > 24

Patient outcome: discharged to nursing home after 8-day hospitalization

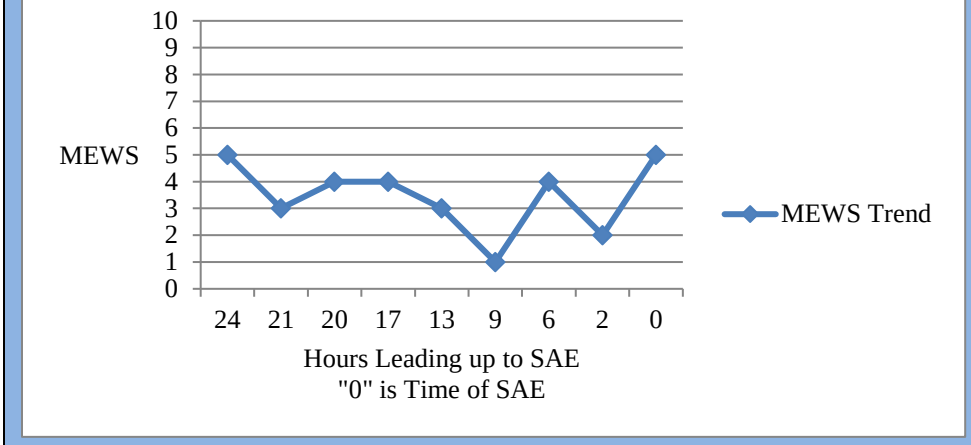


Admission diagnosis: AMS

SAE category: RRT call

Reason for RRT call: staff worried; mental status change; RR > 24

Patient outcome: discharged to nursing home after 6-day hospitalization

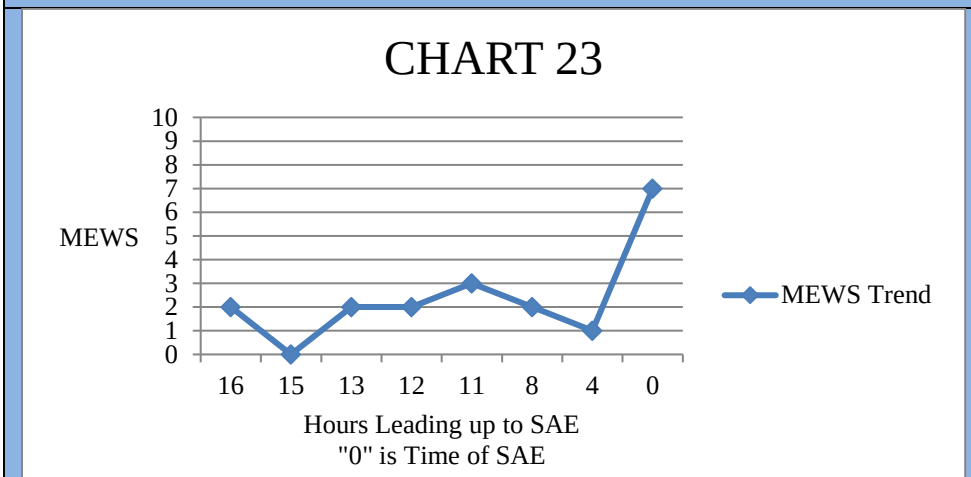


Admission diagnosis: AKI; dehydration

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; family worried; mental status change

Patient outcome: transferred to ICU; transferred to acute care hospital after 12-day hospitalization

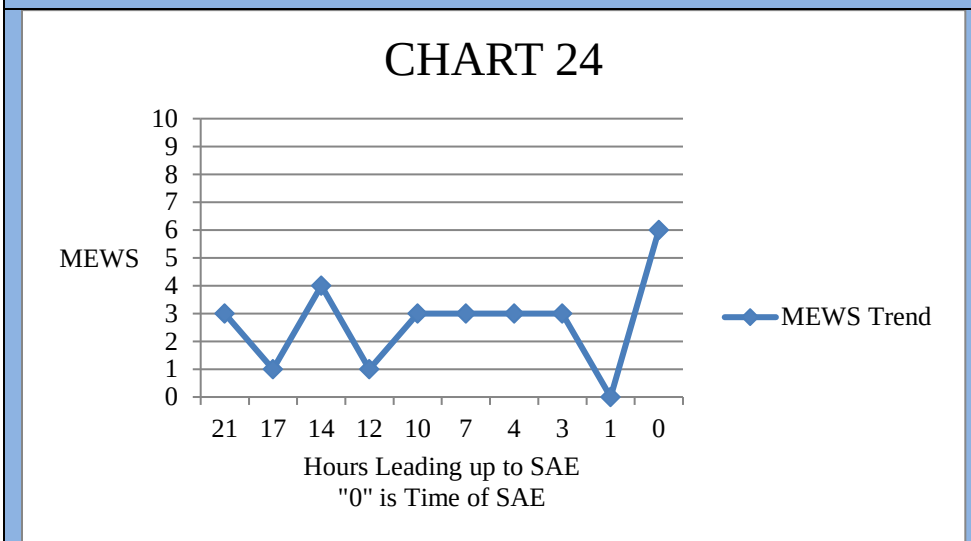


Admission diagnosis: acute respiratory failure; sepsis; colitis

SAE category: RRT call

Reason for RRT call: staff worried; family worried; O_2 sat < 90%; RR > 24

Patient outcome: transferred to acute care hospital after 5-day hospitalization

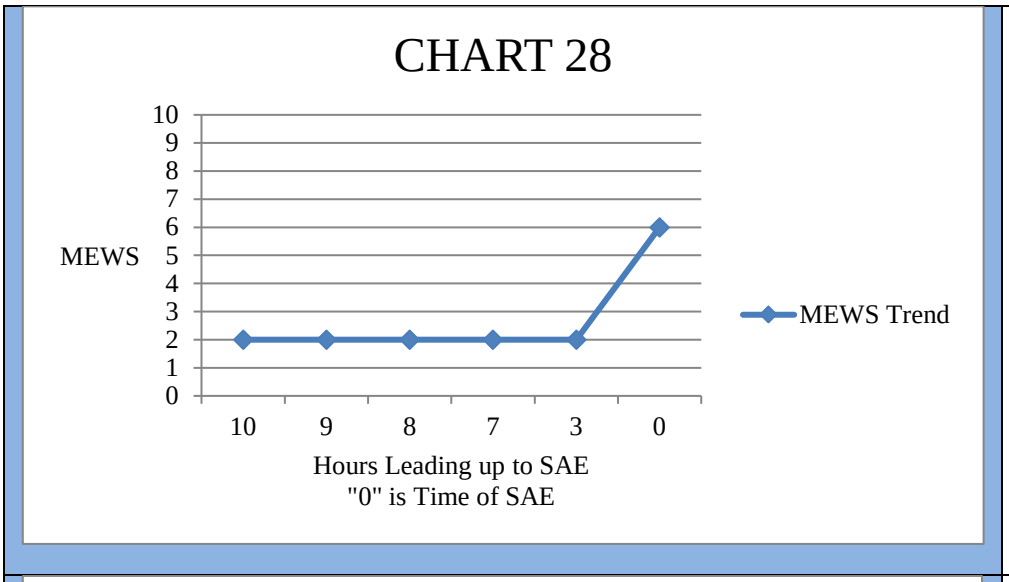


Admission diagnosis: NSTEMI

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; BP < 90; altered mental status

Patient outcome: transferred to ICU; discharged home after 6-day hospitalization

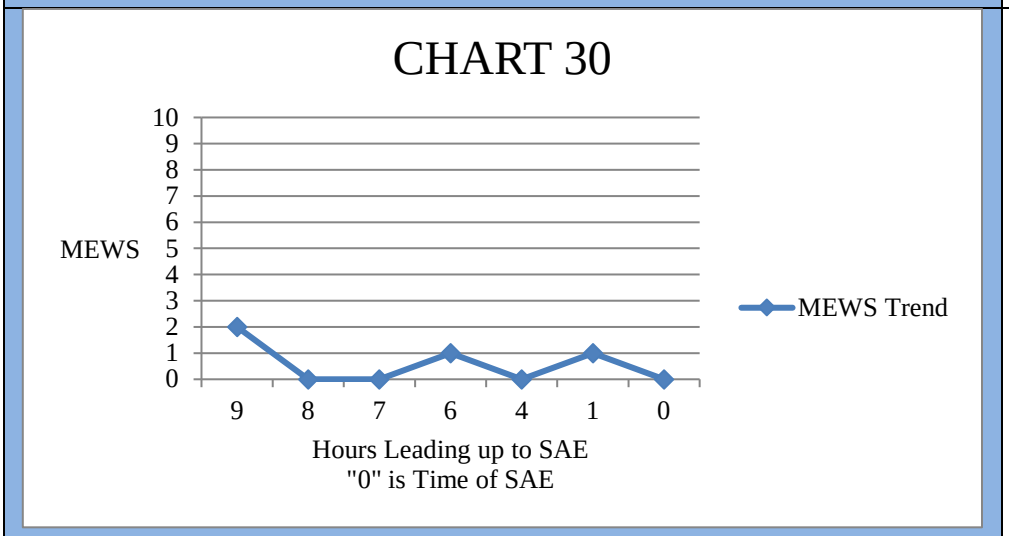


Admission diagnosis: Chest pain

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: patient agitation; nausea; SOA

Patient outcome: transferred to ICU; transferred to acute care hospital after 1-day hospitalization

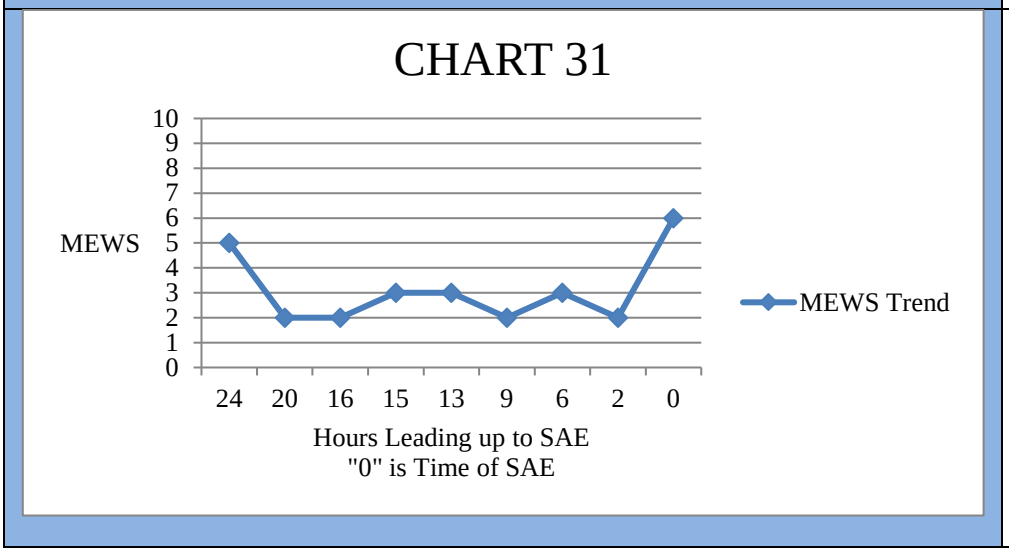


Admission diagnosis: AMS

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; stroke symptoms

Patient outcome: transferred to ICU; transferred to acute care hospital after 1-day hospitalization

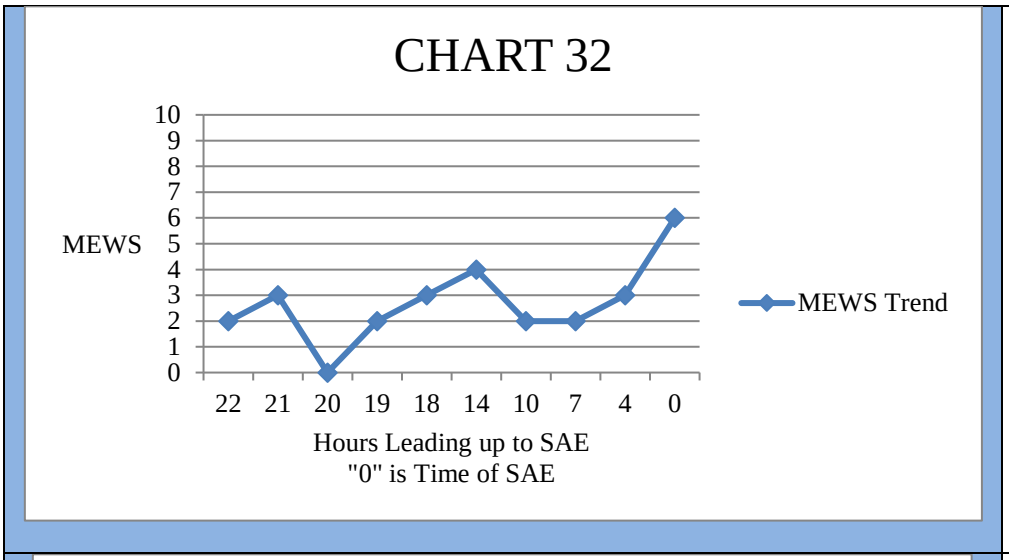


Admission diagnosis: HCAP

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; HR > 130

Patient outcome: transferred to ICU; discharged to nursing home after 10-day hospitalization

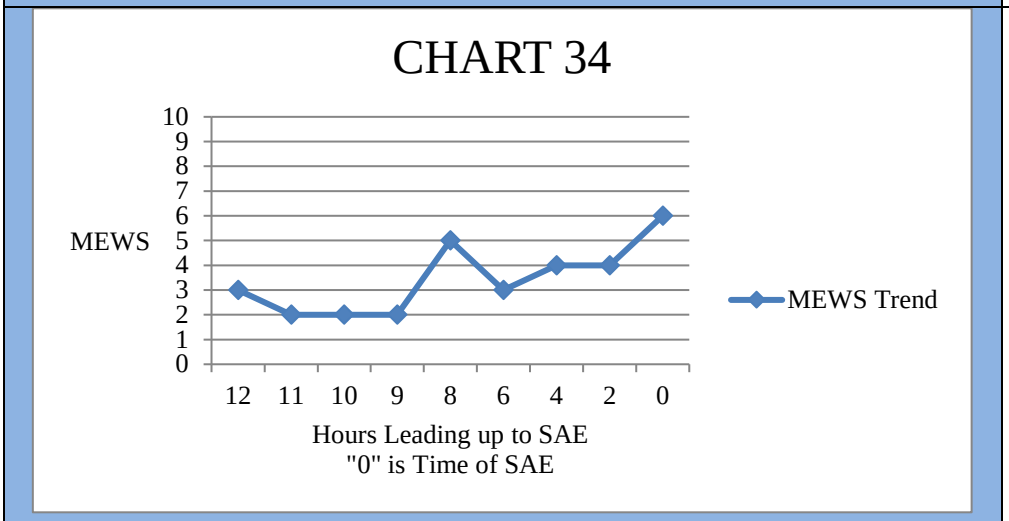


Admission diagnosis: sepsis; urinary retention; decubitus

SAE category: RRT

Reason for RRT call: staff worried; O_2 sat < 90%; RR > 24

Patient outcome: transferred to telemetry; transferred to inpatient rehab facility after 7-day hospitalization

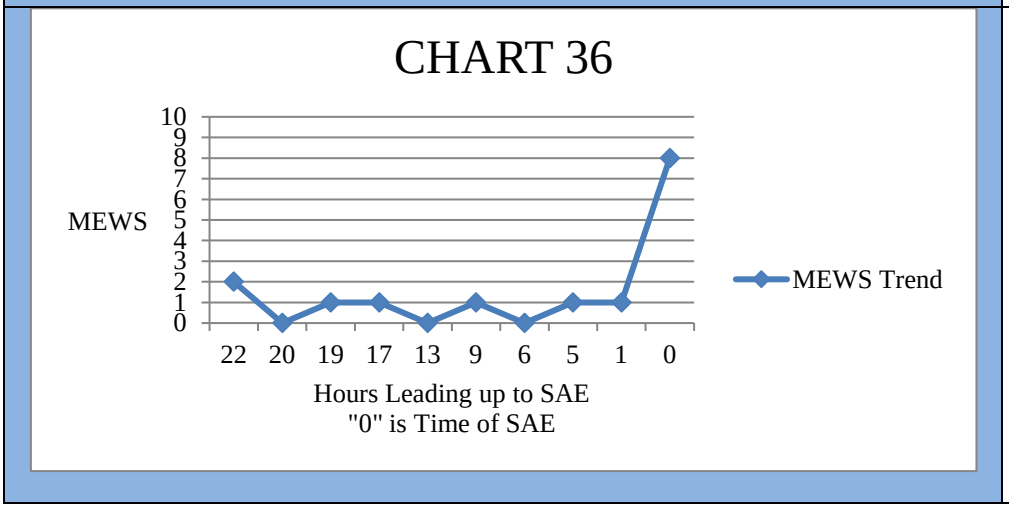


Admission diagnosis: acute onset respiratory failure

SAE category: RRT call

Reason for RRT call: staff worried; family worried; HR > 130

Patient outcome: patient died after 2-day hospitalization

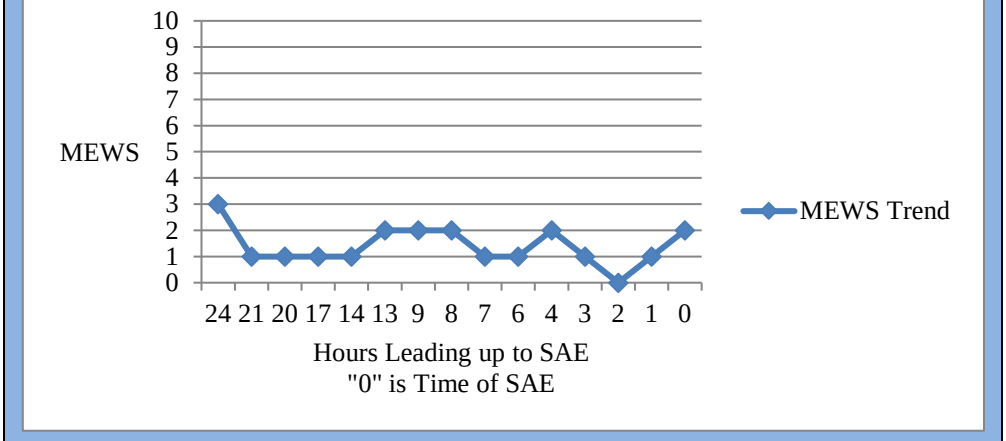


Admission diagnosis: chest pain

SAE category: RRT call

Reason for RRT call: staff worried; HR < 40; SBP < 90; mental status change

Patient outcome: discharged home after 2-day hospitalization

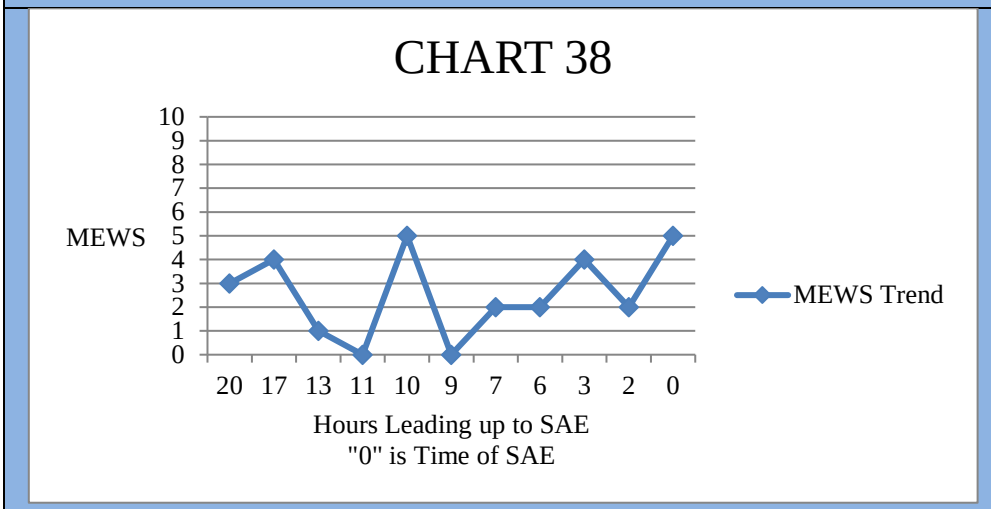


Admission diagnosis: shock

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; family worried; mental status change

Patient outcome: transferred to ICU; discharged home after 7-day hospitalization

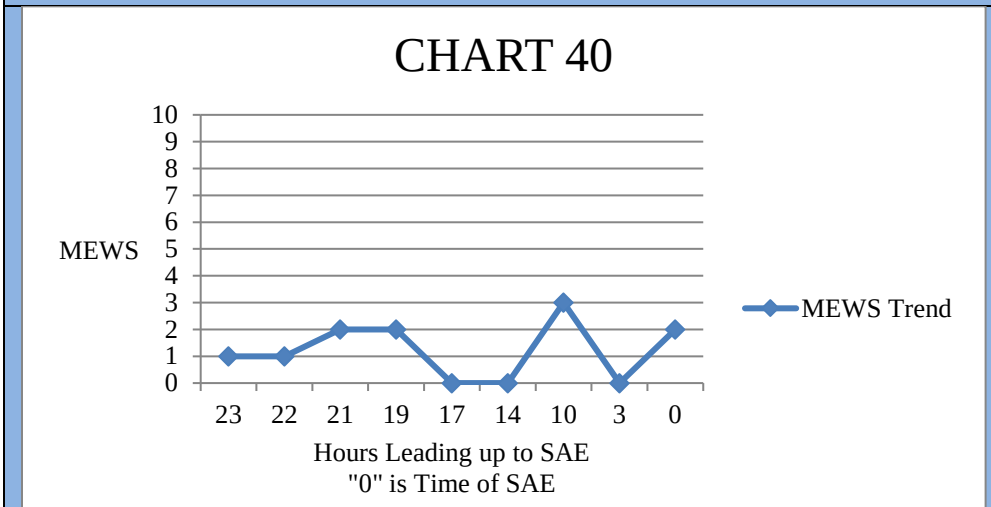


Admission diagnosis: sepsis; a-fib

SAE category: RRT call

Reason for RRT call: staff worried; O_2 sat < 90%; RR > 24

Patient outcome: transferred to acute care hospital after 7-day hospitalization

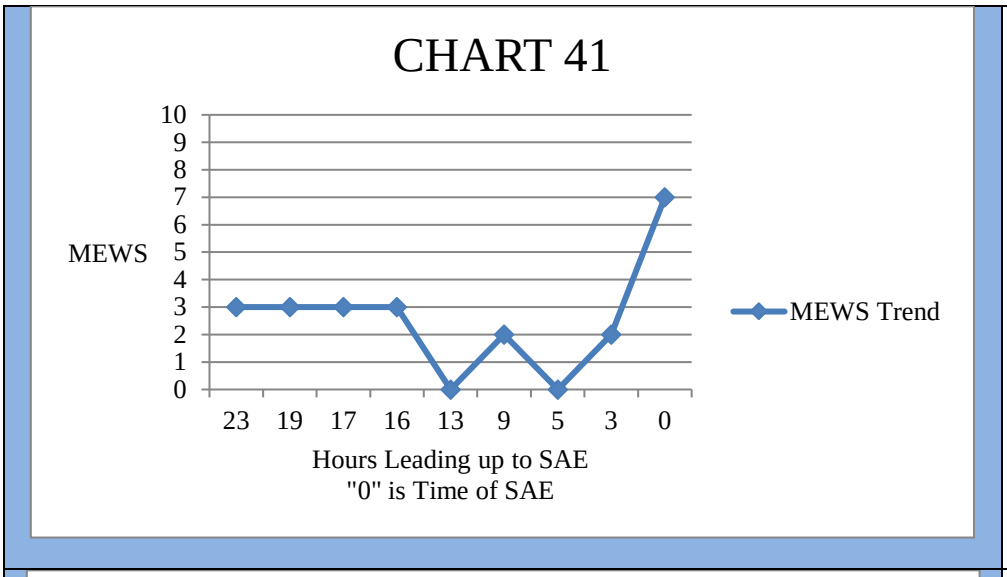


Admission diagnosis: UTI; possible seizure

SAE category: RRT call

Reason for RRT call: staff worried; mental status change

Patient outcome: discharged to nursing home after 2-day hospitalization

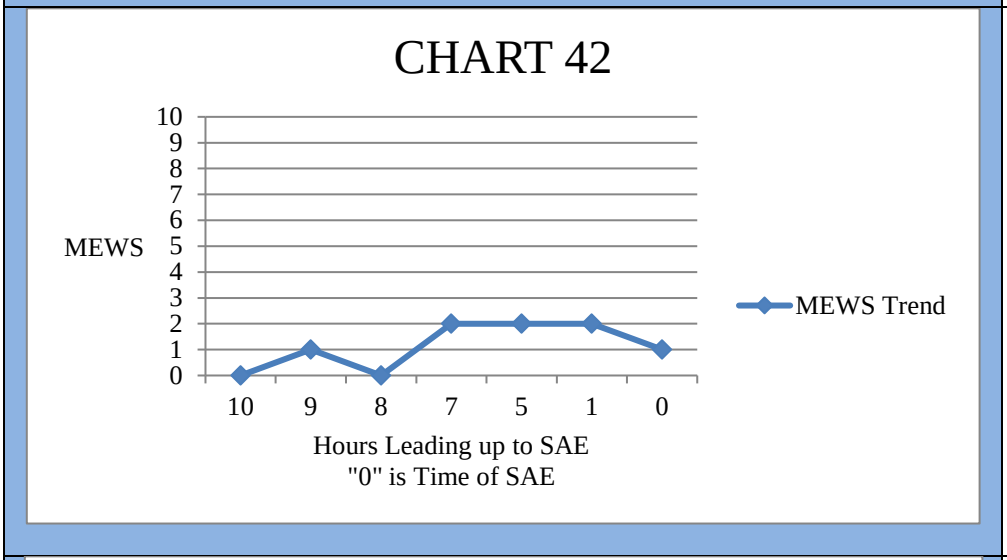


Admission diagnosis: SOA

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: O_2 sat < 90%; mental status change

Patient outcome: transferred to ICU; discharged to home after 5-day hospitalization

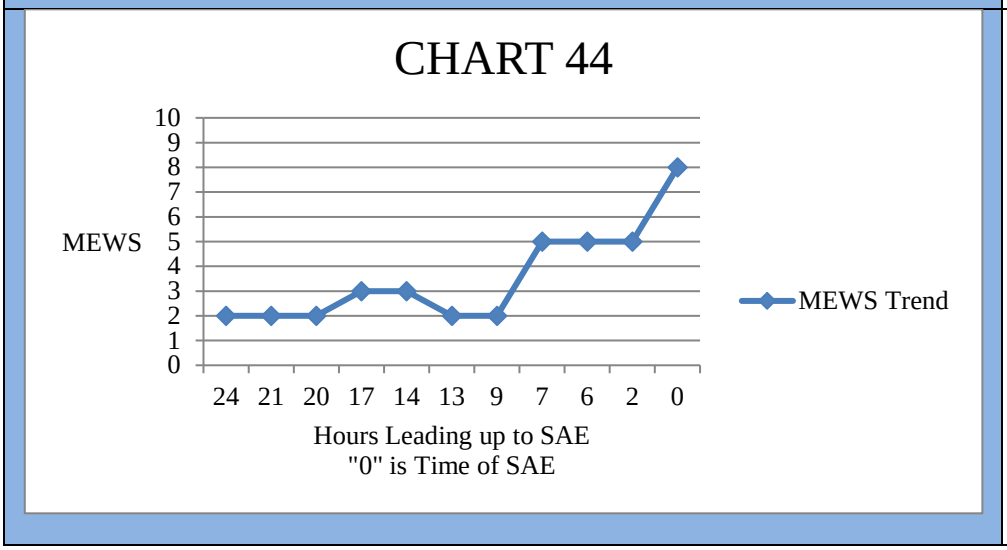


Admission diagnosis: seizure disorder

SAE category: RRT call

Reason for RRT call: seizures

Patient outcome: discharged home after 3-day hospitalization

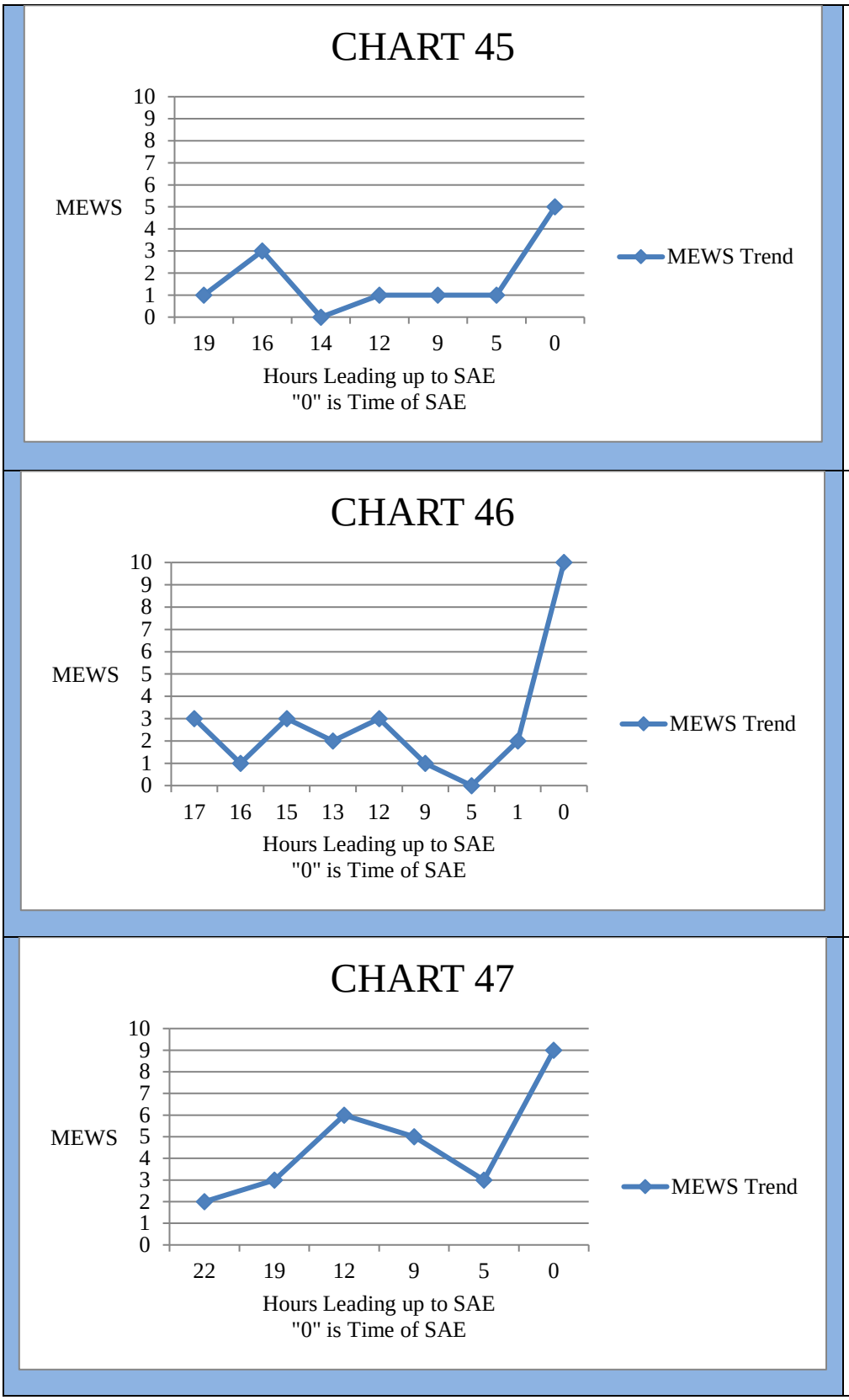


Admission diagnosis: flu; fever; hypoxia

SAE category: RRT call

Reason for RRT call: staff worried; family worried; O_2 sat < 90%; HR > 130

Patient outcome: discharged home after 7-day hospitalization



Admission diagnosis: unstable angina, COPD exacerbation; heart failure

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: O_2 sat < 90%; mental status change

Patient outcome: transferred to ICU; patient died after 1-day hospitalization

Admission diagnosis: heart failure

SAE category: cardiac arrest; unexpected transfer to ICU

Reason: Code Blue

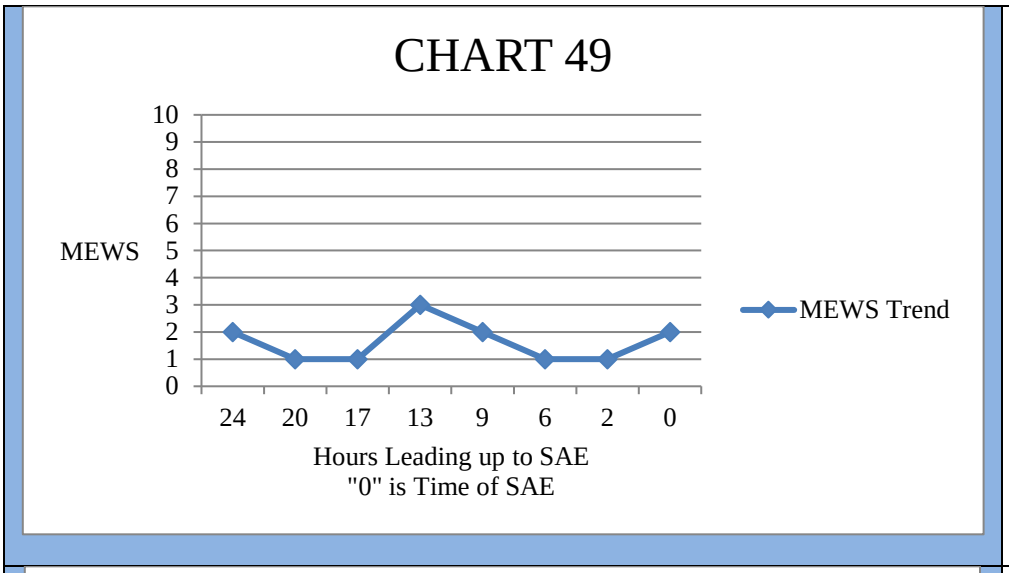
Patient outcome: patient survived Code Blue but died after 9-day hospitalization

Admission diagnosis: pneumonia

SAE category: cardiac arrest; unexpected transfer to ICU; death

Reason: Code Blue

Patient outcome: patient died during transfer to ICU

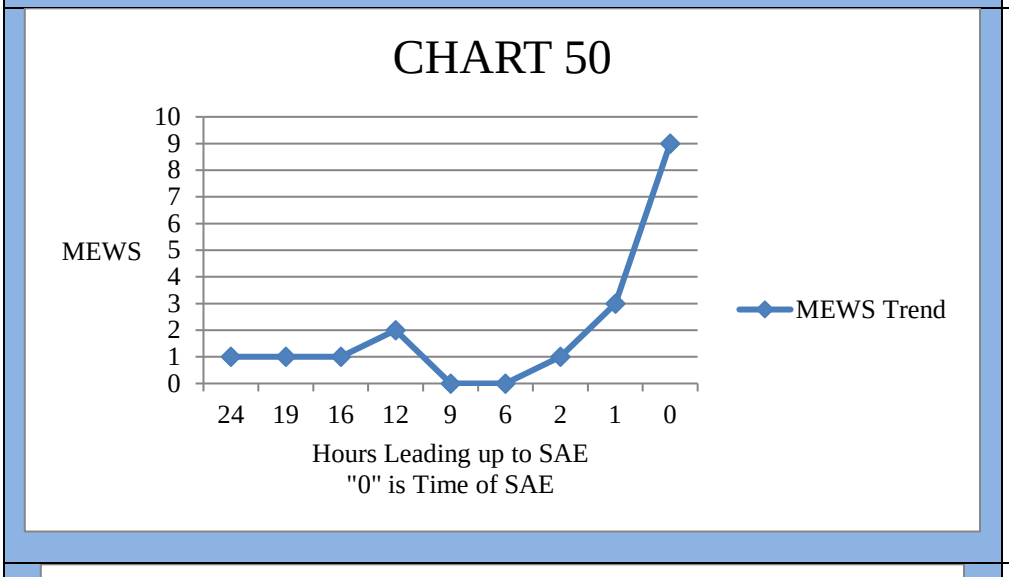


Admission diagnosis: AKI; AMS

SAE category: RRT call

Reason for RRT call: staff worried; failure to respond to treatment; mental status change

Patient outcome: transferred to psych hospital after 16-day hospitalization

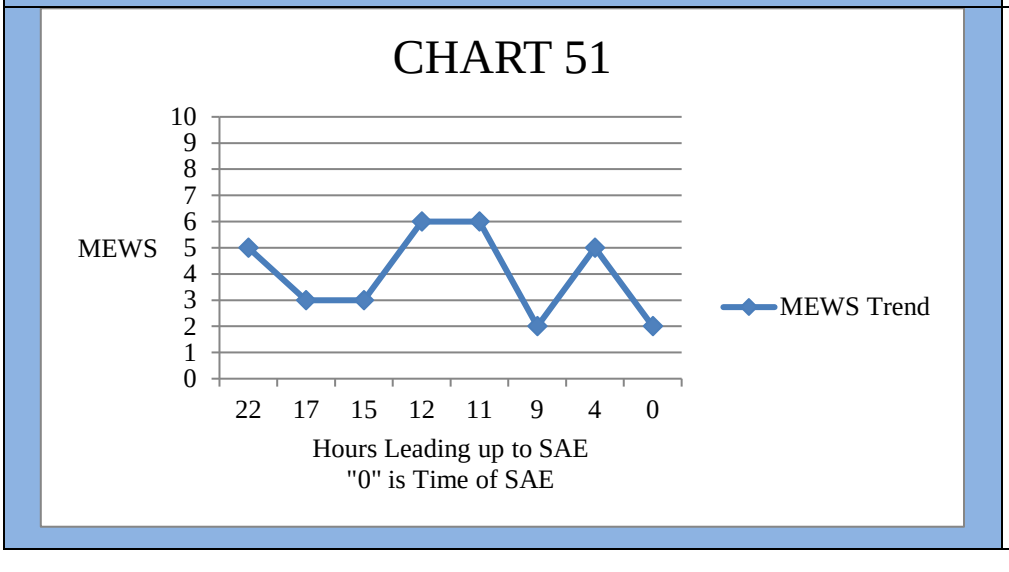


Admission diagnosis: sepsis

SAE category: RRT call

Reason for RRT call: staff worried, O_2 sat < 90%; RR > 24; HR > 130

Patient outcome: transferred to inpatient rehab facility after 30-day hospitalization

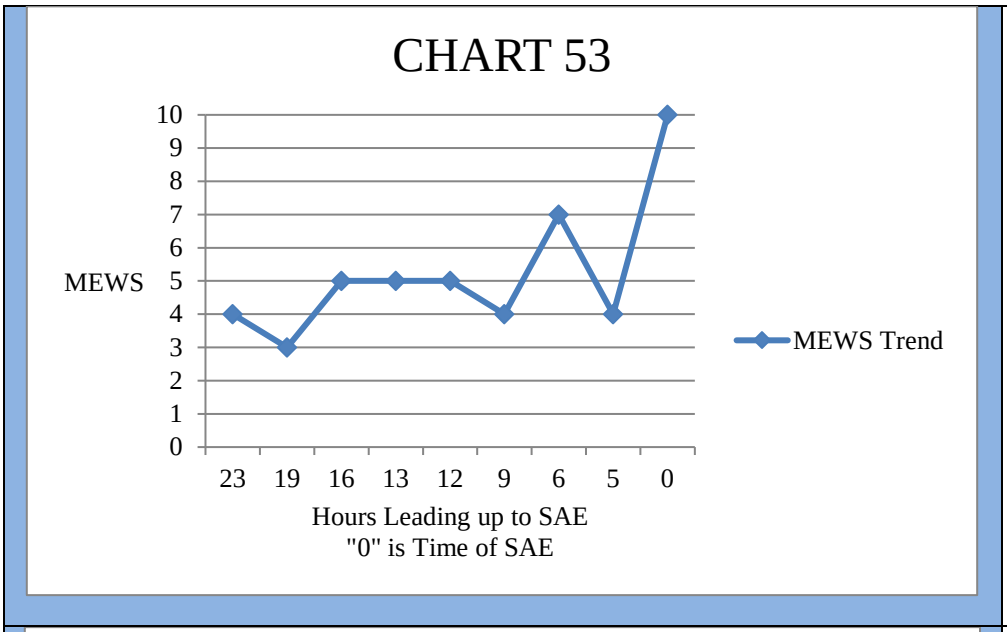


Admission diagnosis: post-surgical procedure; anemia

SAE category: RRT call

Reason for RRT call: staff worried; mental status change

Patient outcome: discharged home with home health

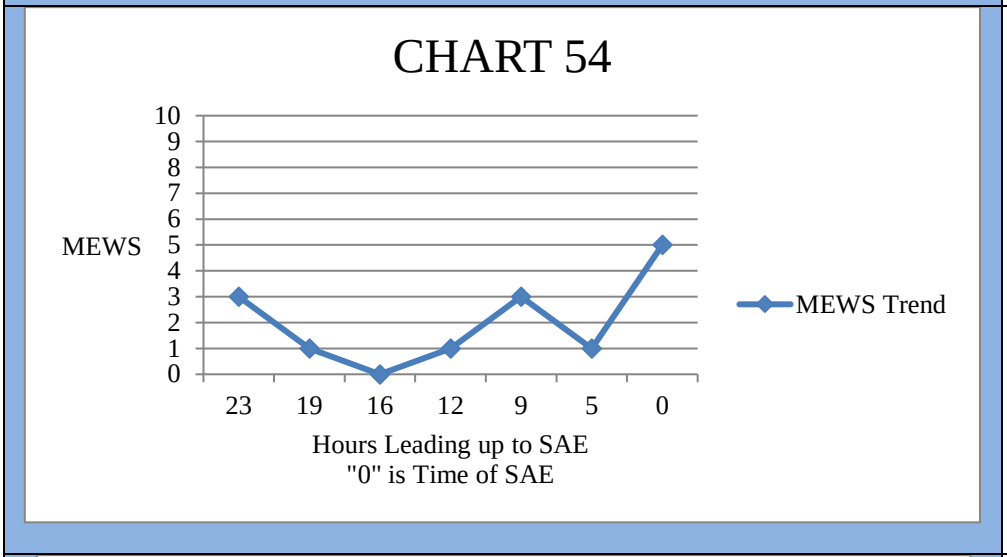


Admission diagnosis: wound dehiscence and repair

SAE category: RRT call; unexpected transfer to ICU

Reason for RRT call: staff worried; SPB < 90; O_2 sat < 90%; acute bleed; mental status change

Patient outcome: transferred to ICU; transferred to acute care hospital after 4-day hospitalization

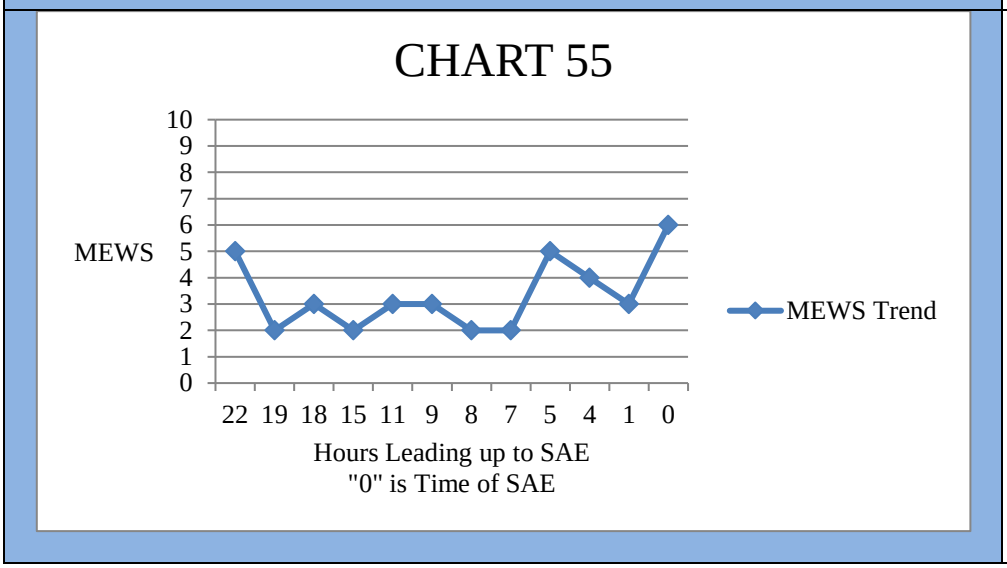


Admission diagnosis: respiratory failure

SAE category: RRT call

Reason for RRT call: staff worried; SBP < 90; failure to respond to treatment; RR > 24

Patient outcome: discharged home after 7-day hospitalization

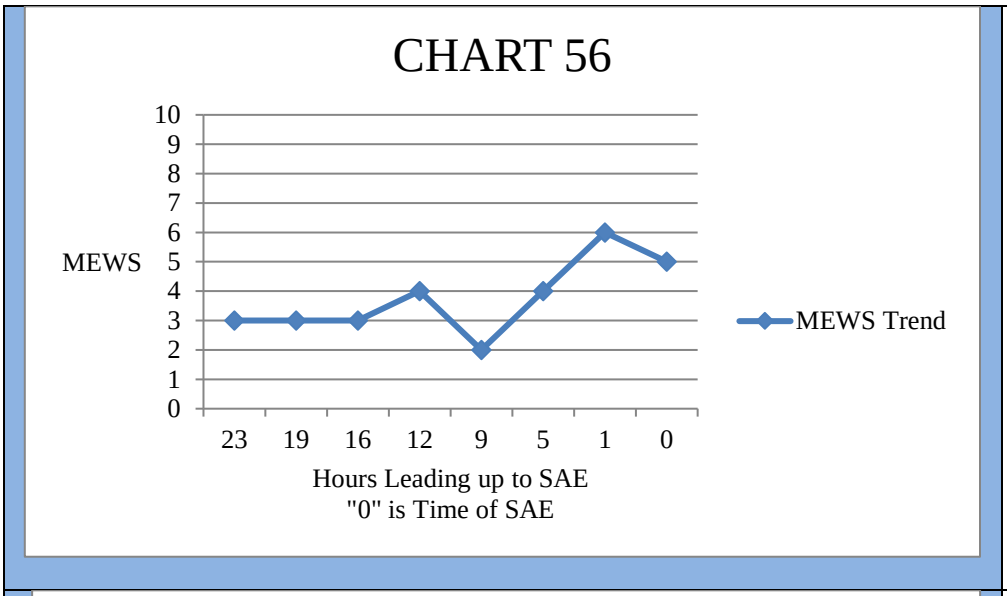


Admission diagnosis: sepsis; pneumonia

SAE category: RRT call

Reason for RRT call: staff worried; HR > 130

Patient outcome: discharged home after 8-day hospitalization

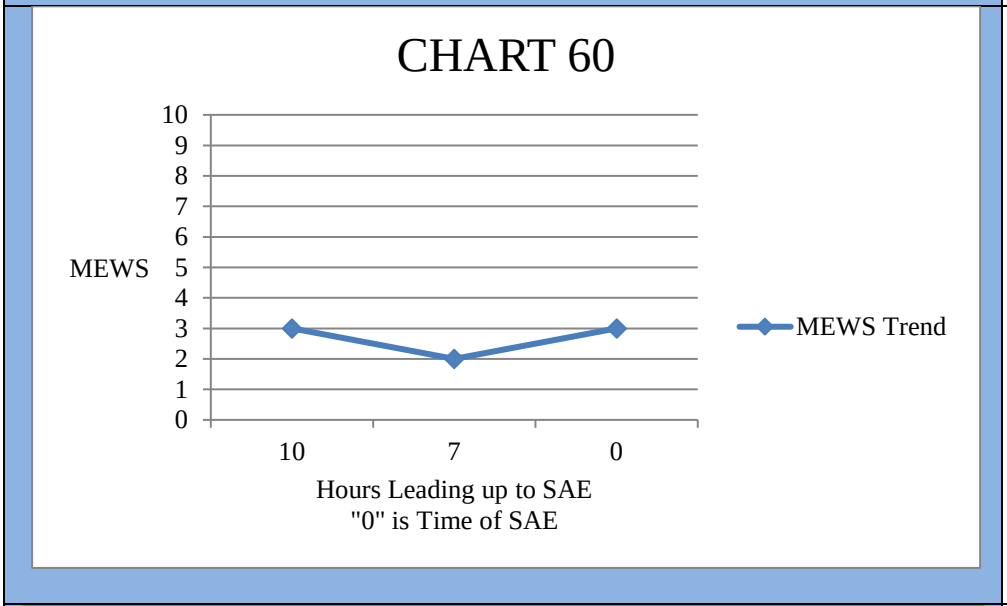


Admission diagnosis: AMS; benzodiazepine withdrawal

SAE category: RRT call

Reason for RRT call: staff worried; SBP < 90

Patient outcome: discharged home after 3-day hospitalization

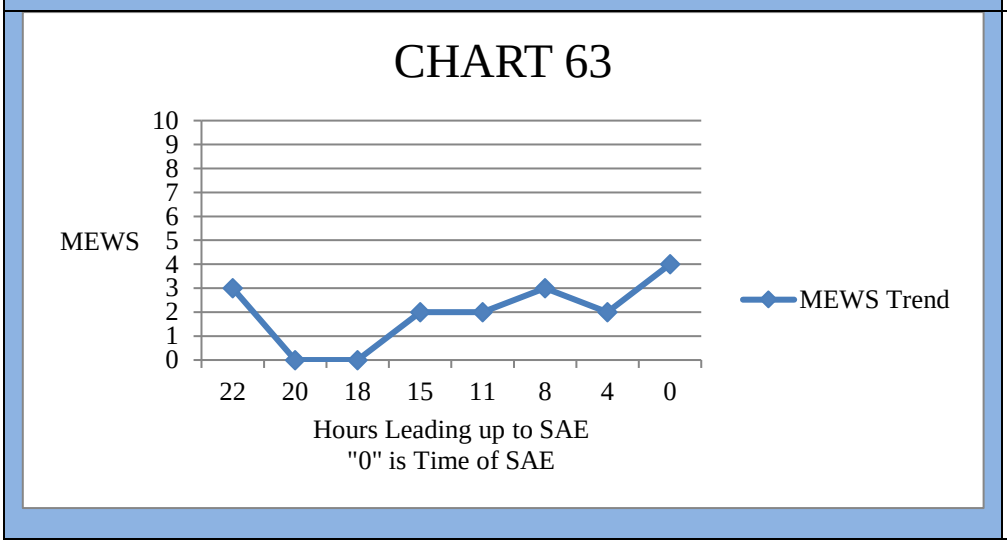


Admission diagnosis: AMS

SAE category: unexpected transfer to ICU

Reason for transfer: increased confusion

Patient outcome: transferred to ICU; discharged to psych hospital after 1-day hospitalization

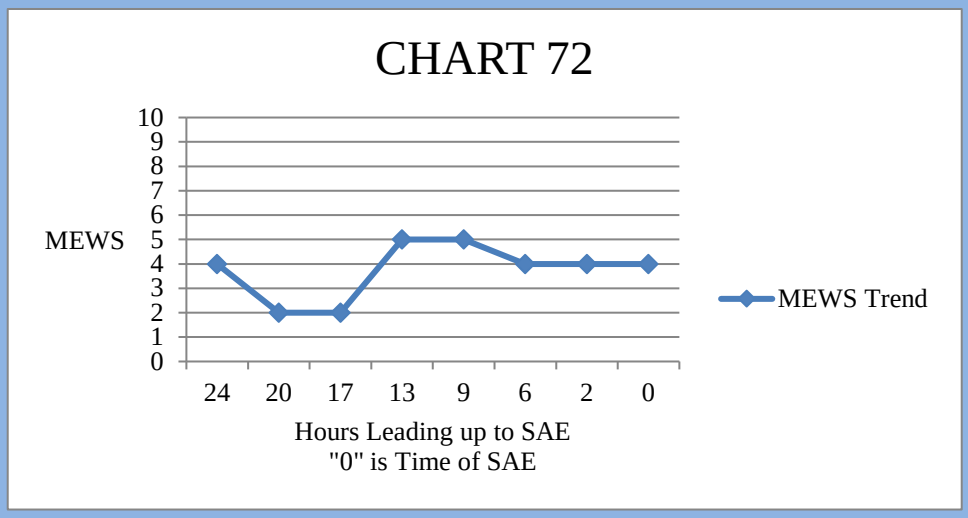


Admission diagnosis: hip fracture

SAE category: unexpected transfer to ICU

Reason for transfer: mental status change; patient concern; a-fib

Patient outcome: transferred to ICU; transferred to inpatient rehab facility after 12-day hospitalization

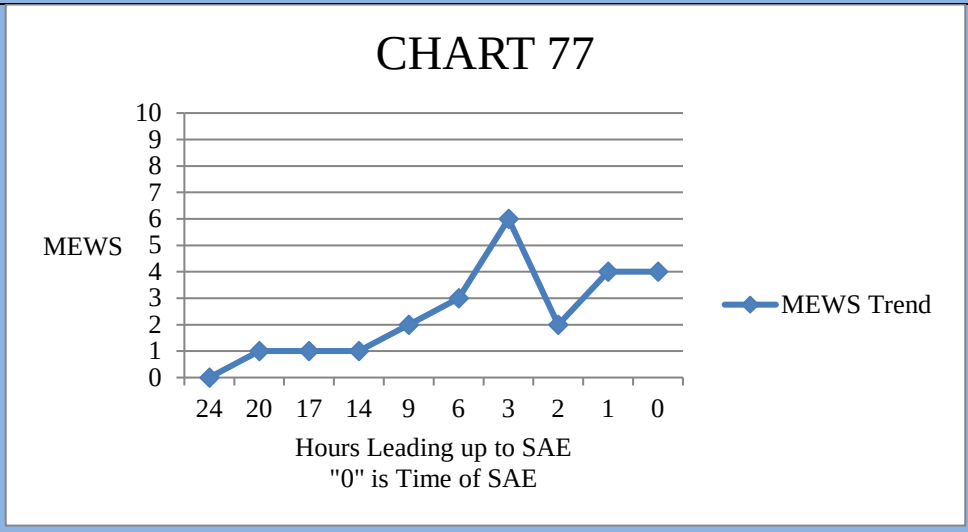


Admission diagnosis: colitis; GI bleed

SAE category: unexpected transfer to ICU

Reason for transfer: SOA; chest pain

Patient outcome: transferred to ICU; patient died after 12-day hospitalization

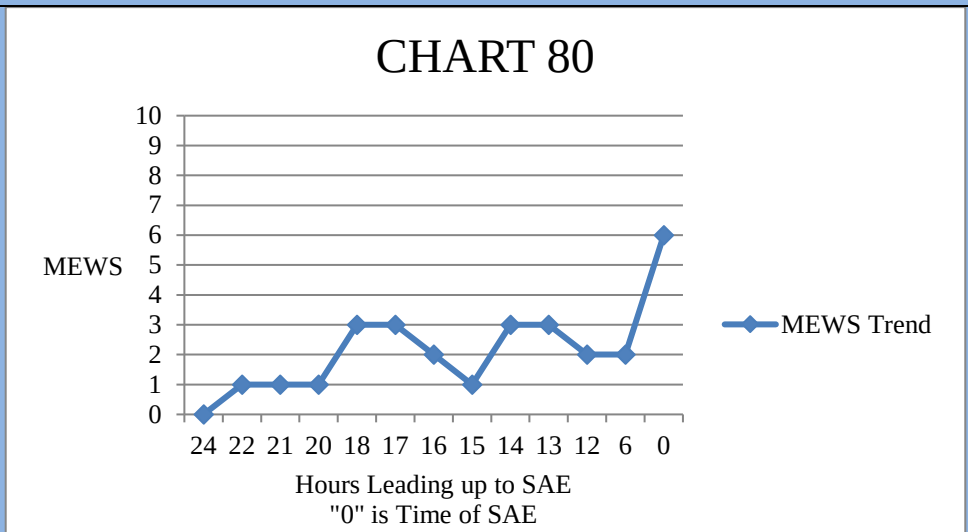


Admission diagnosis: CAP; dehydration

SAE category: unexpected transfer to ICU

Reason for transfer: SOA; tachypnea; chest pain

Patient outcome: transferred to ICU; discharged home after 6-day hospitalization

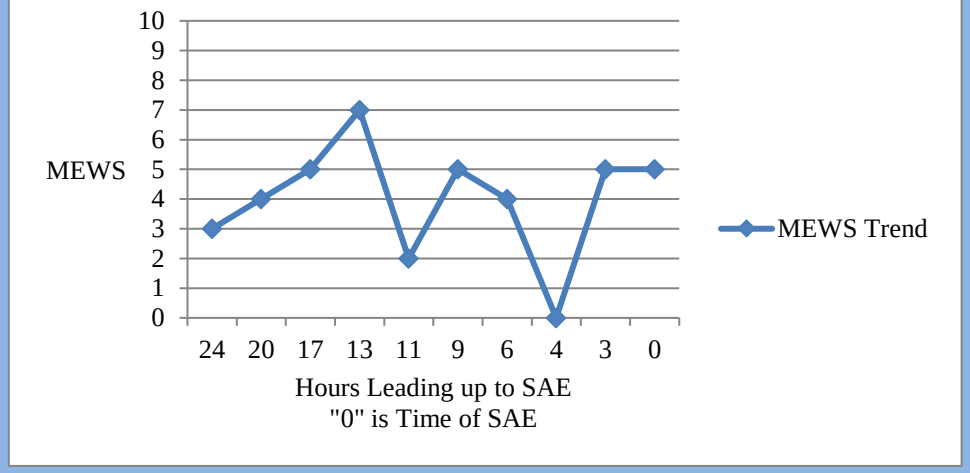


Admission diagnosis: GI complication

SAE category: unexpected transfer to ICU

Reason for transfer: a-fib; SBP < 90

Patient outcome: transferred to ICU; discharged home after 13-day hospitalization

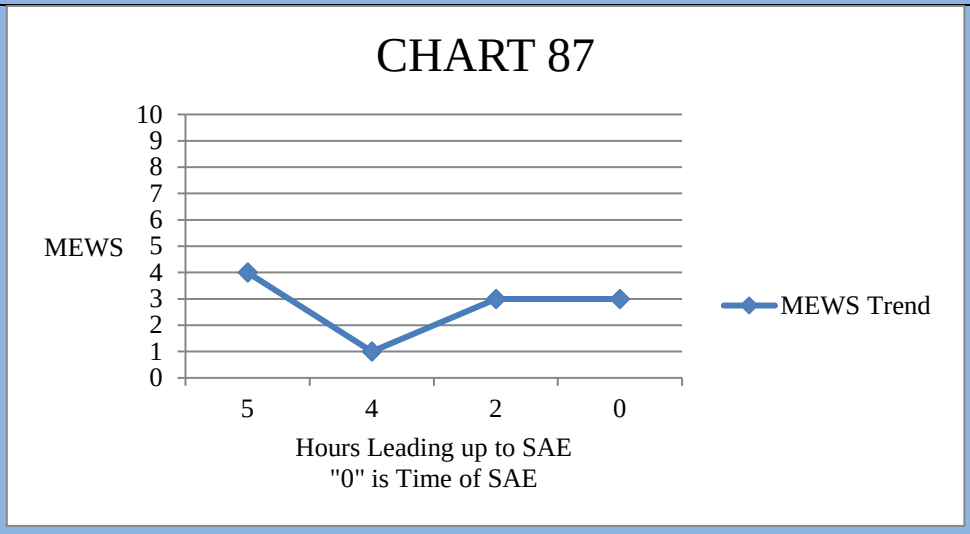


Admission diagnosis: cellulitis

SAE category: unexpected transfer to ICU

Reason for transfer: RR > 24; mental status change

Patient outcome: transfer to ICU; discharged home after 10-day hospitalization

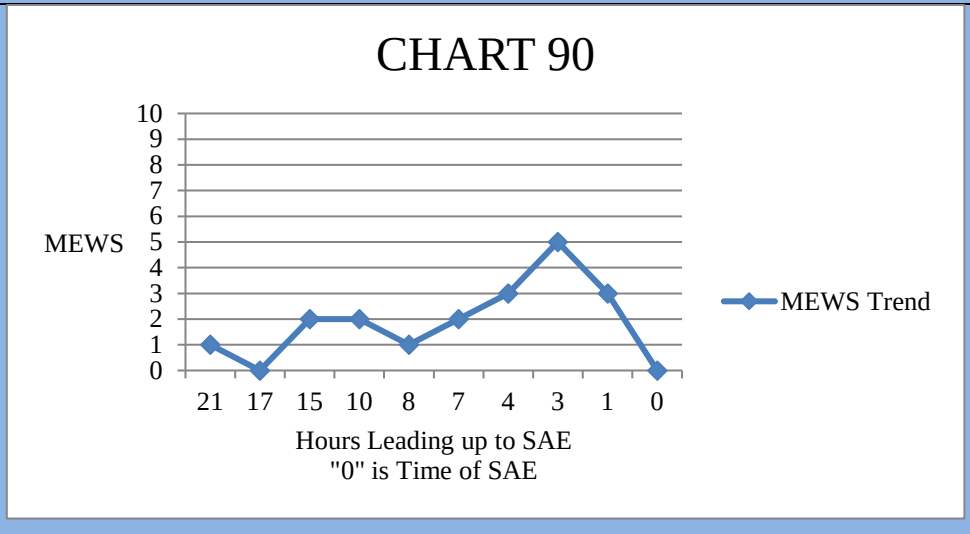


Admission diagnosis: respiratory failure; pneumonia; a-fib

SAE category: unexpected transfer to ICU

Reason for transfer: runs of V-tach versus a-fib

Patient outcome: transferred to ICU; discharged home after 7-day hospitalization

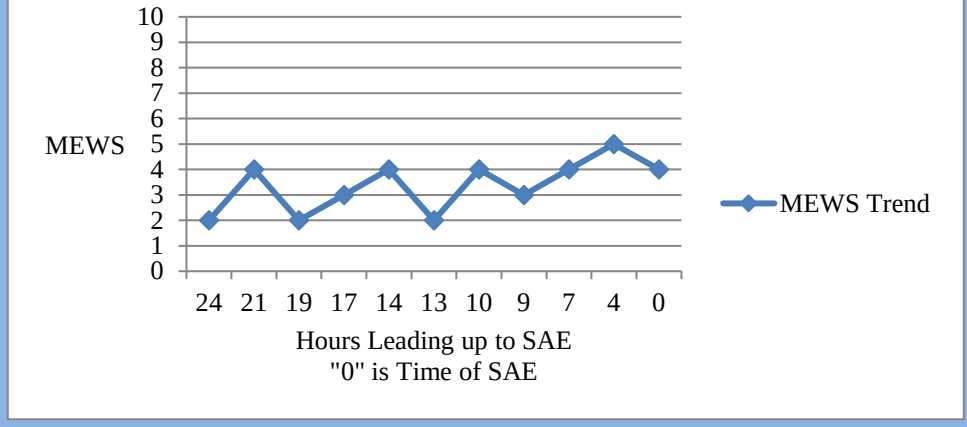


Admission diagnosis: pneumonia; hypoxia

SAE category: unexpected transfer to ICU

Reason for transfer: a-fib with RVR

Patient outcome: transferred to ICU; discharged to nursing home after 25-day hospitalization

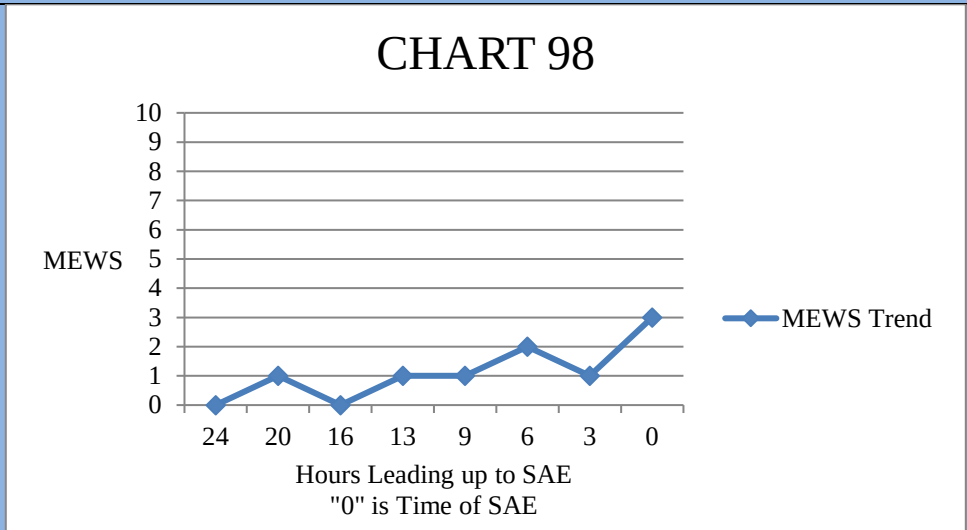


Admission diagnosis: AMS

SAE category: unexpected transfer to ICU

Reason for transfer: patient combative

Patient outcome: transferred to ICU; discharged home after 3-day hospitalization

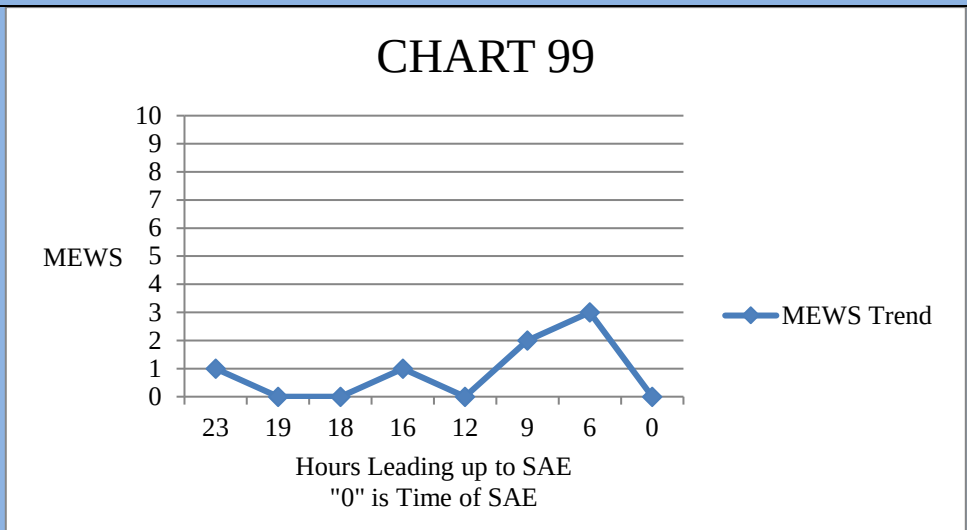


Admission diagnosis: pancreatitis

SAE category: unexpected transfer to ICU

Reason for transfer: vagal response

Patient outcome: transferred to ICU; discharged home after 34-day hospitalization

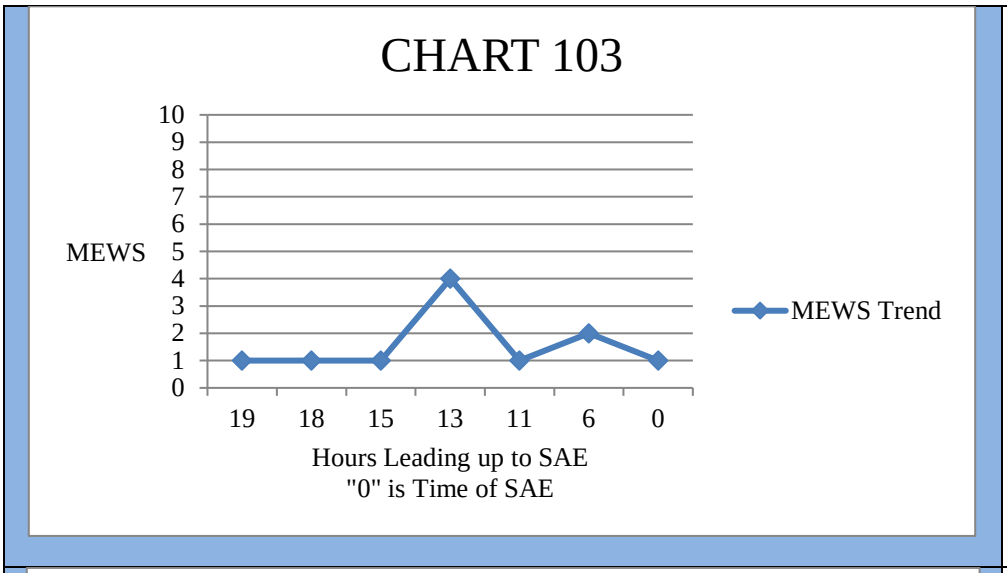


Admission diagnosis: sepsis

SAE category: unexpected transfer to ICU

Reason for transfer: respiratory distress and replacement of blood products

Patient outcome: transferred to ICU; transferred to inpatient rehab facility after 30-day hospitalization

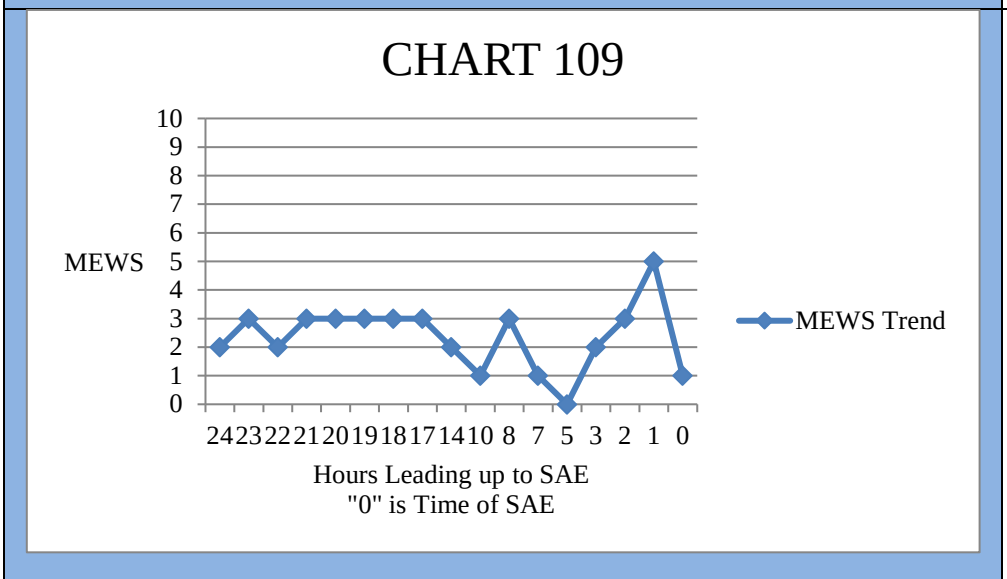


Admission diagnosis: abdominal pain; diverticulitis; c-diff

SAE category: unexpected transfer to ICU

Reason for transfer: bradycardia

Patient outcome: unexpected transfer to ICU; discharged home after 7-day hospitalization

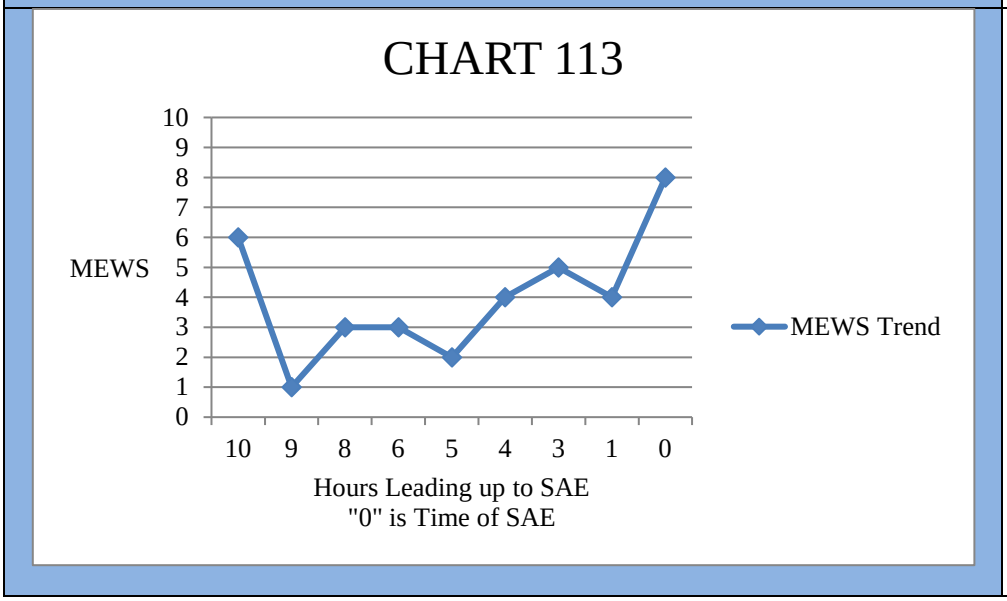


Admission diagnosis: blood loss anemia; GI bleed

SAE category: unexpected transfer to ICU

Reason for transfer: bleeding; replacement of blood products

Patient outcome: transferred to ICU; transferred to acute care hospital after 6-day hospitalization

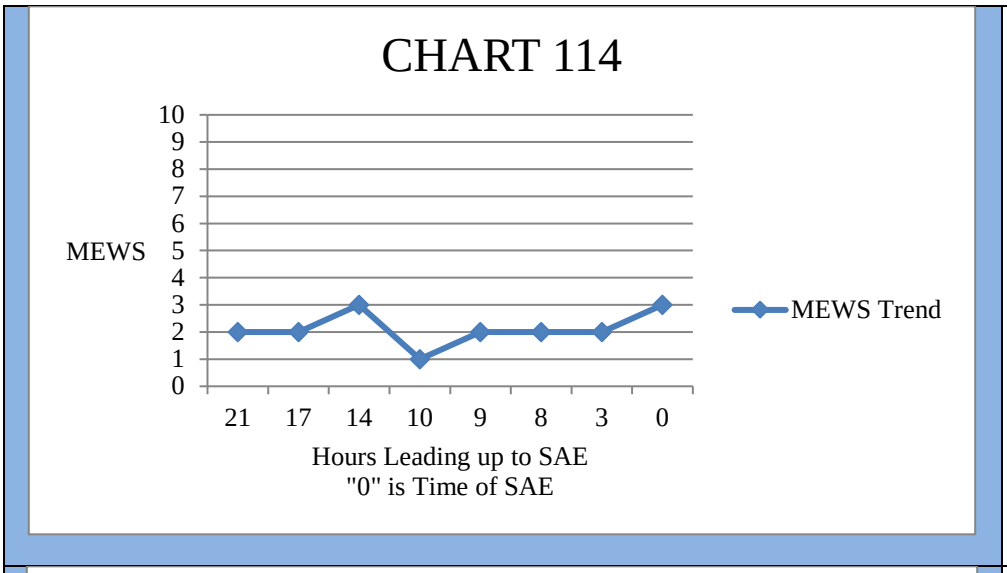


Admission diagnosis: sepsis

SAE category: unexpected transfer to ICU

Reason for transfer: HR > 130; fever; generalized pain

Patient outcome: transferred to ICU; transferred to acute care hospital after 7-day hospitalization

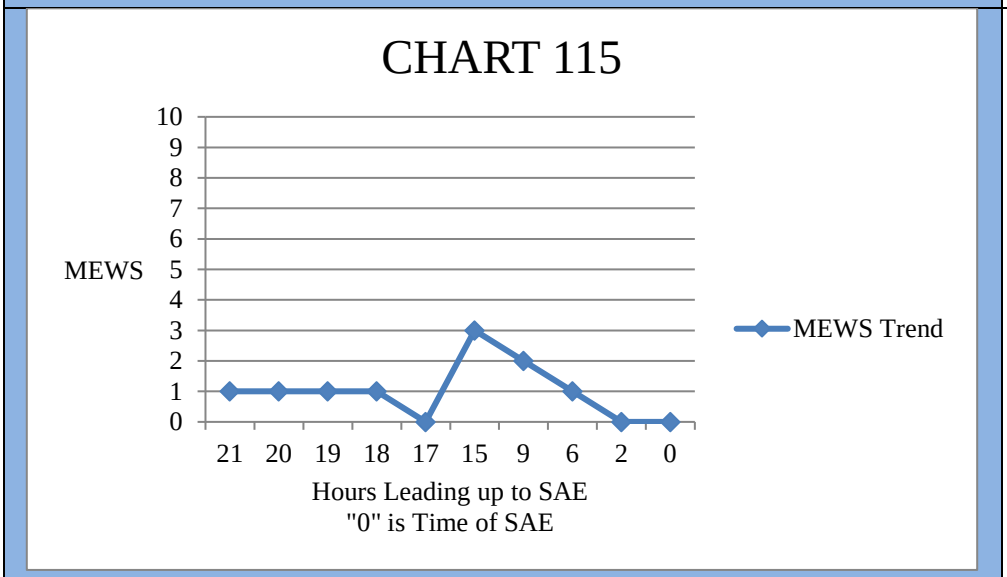


Admission diagnosis: colitis

SAE category: unexpected transfer to ICU

Reason for transfer: pre-op for emergency surgery

Patient outcome: transferred to ICU; transferred to inpatient rehab facility after 11-day hospitalization

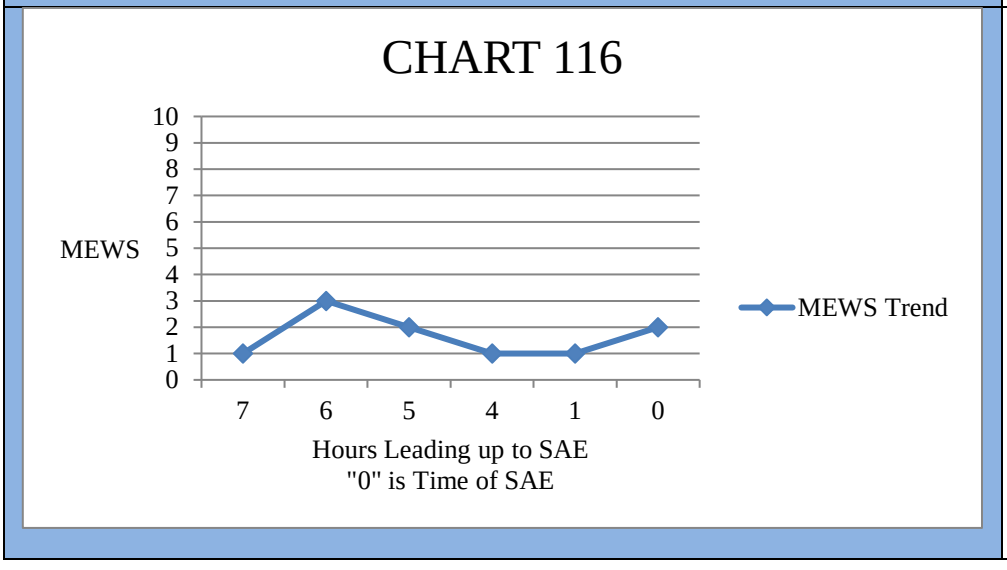


Admission diagnosis: GI bleed

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring

Patient outcome: transferred to ICU; discharged to nursing home after 5-day hospitalization

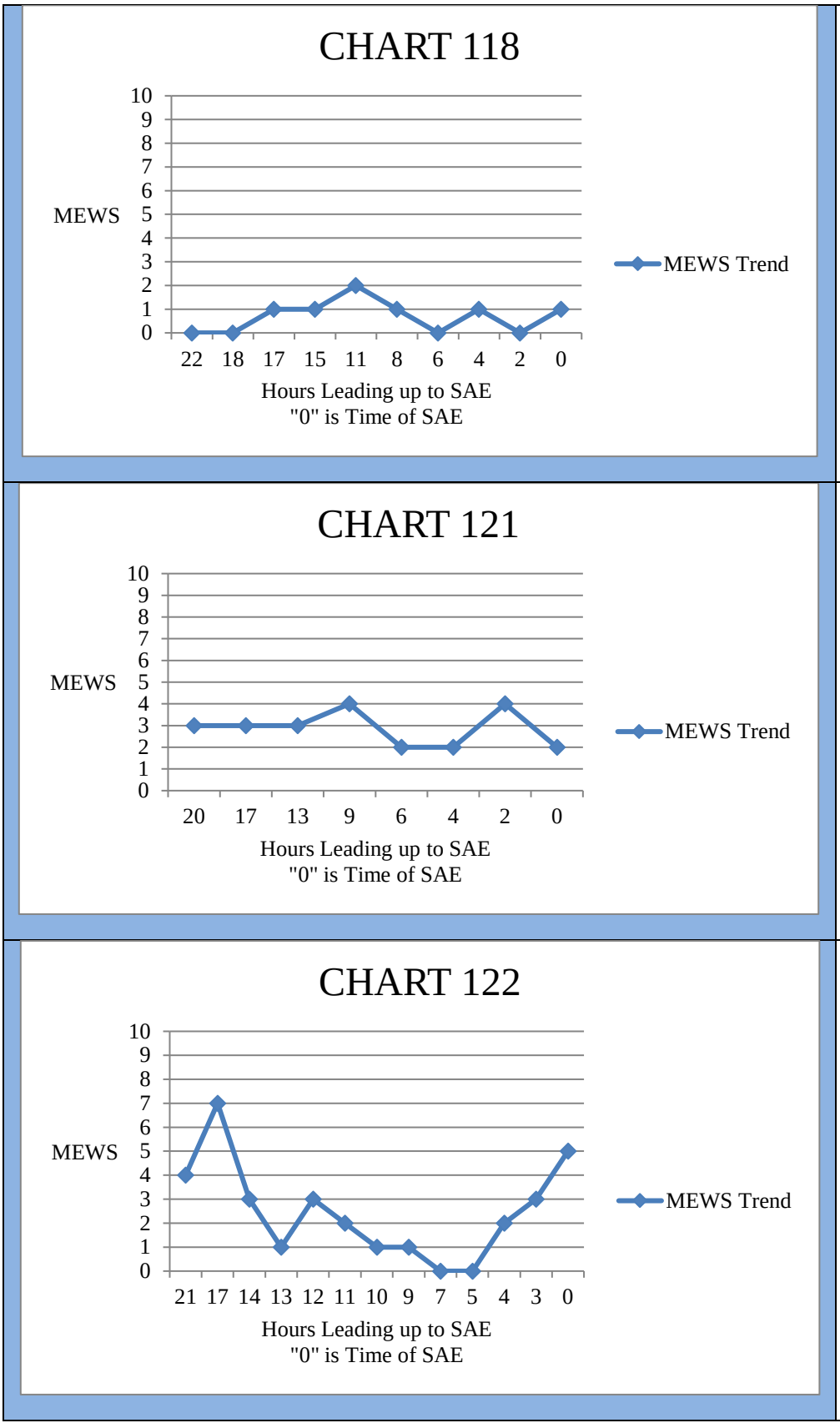


Admission diagnosis: chest pain

SAE category: unexpected transfer to ICU

Reason for transfer: uncontrolled chest pain

Patient outcome: transferred to ICU; discharged home after 1-day hospitalization



Admission diagnosis: pneumonia

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring

Patient outcome: transferred to ICU; transferred to acute care hospital after 6-day hospitalization

Admission diagnosis: sepsis; C-diff; colitis

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring

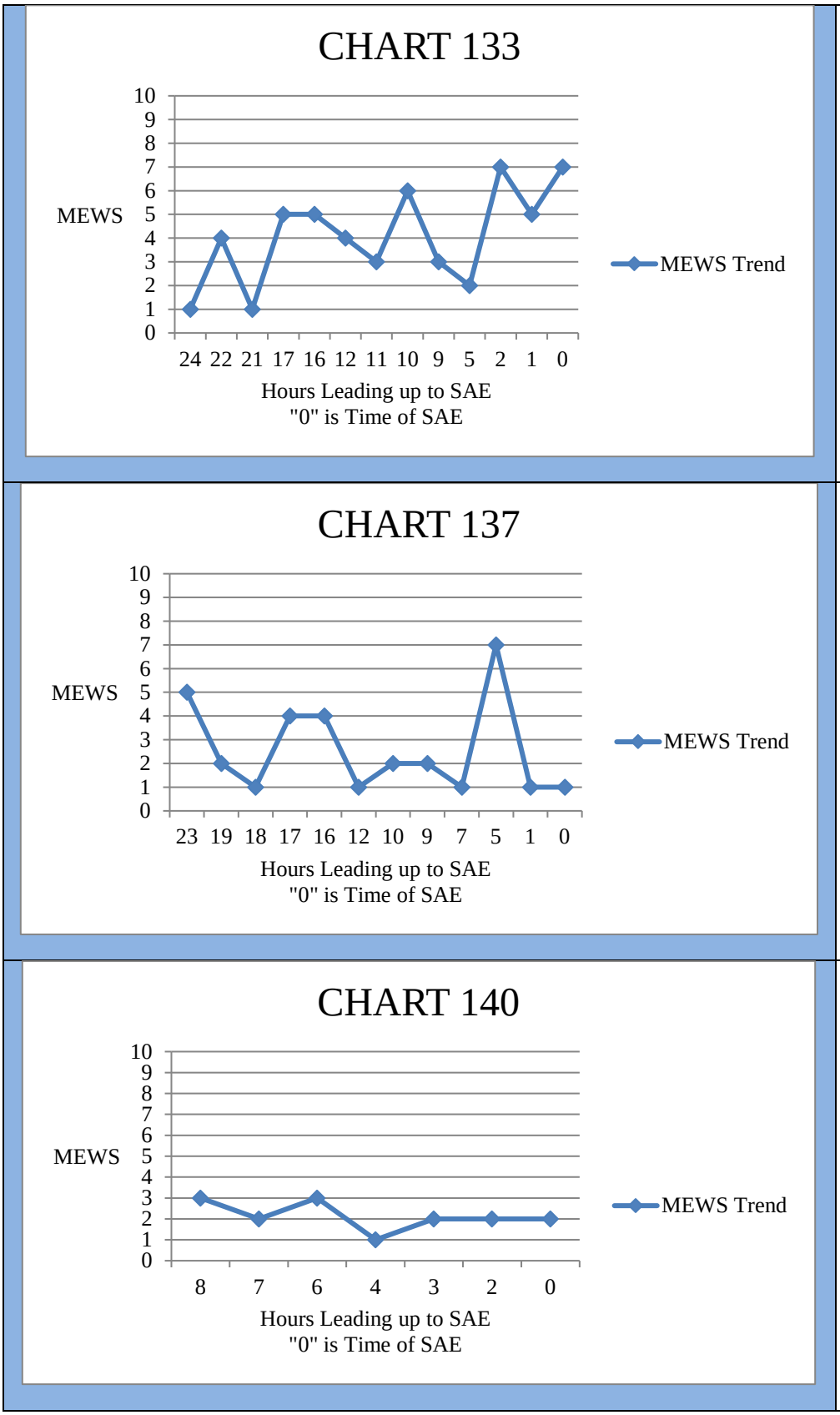
Patient outcome: transferred to ICU; discharged to nursing home after 22-day hospitalization

Admission diagnosis: AKI; dehydration; syncope

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring

Patient outcome: transferred to ICU; transferred to acute care hospital after 8-day hospitalization



Admission diagnosis: pancreatitis

SAE category: unexpected transfer to ICU

Reason for transfer: O_2 sat < 90%; bradycardia

Patient outcome: transferred to ICU; patient died after 2-day hospitalization

Admission diagnosis: GI bleed

SAE category: unexpected transfer to ICU

Reason for transfer: pulmonary edema; abnormal ABG

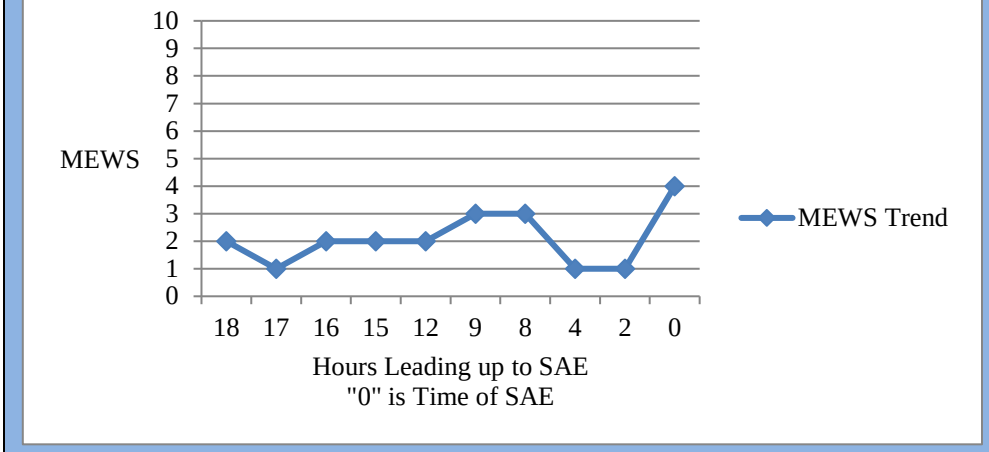
Patient outcome: transferred to ICU; discharged home after 13-day hospitalization

Admission diagnosis: SOA

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring; increased BP

Patient outcome: transferred to ICU; discharged home after 4-day hospitalization

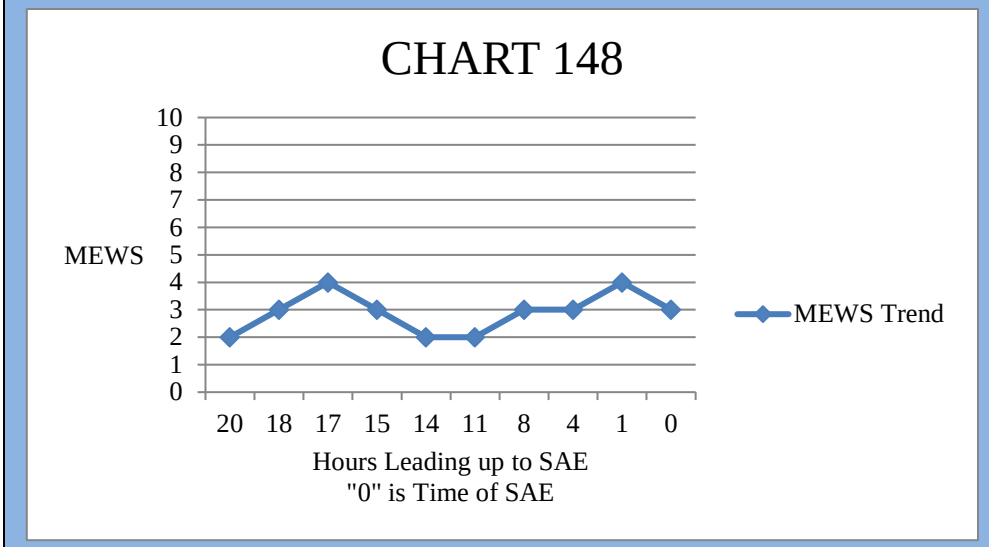


Admission diagnosis: hip fracture

SAE category: unexpected transfer to ICU

Reason for transfer: drop in BP requiring fluid bolus and vasopressors

Patient outcome: transferred to ICU; discharged to nursing home after 6-day hospitalization

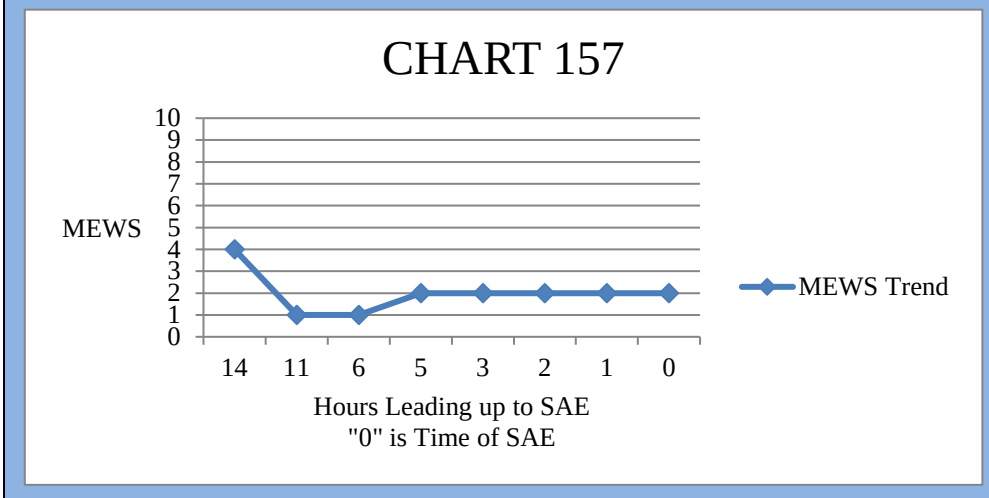


Admission diagnosis: respiratory failure

SAE category: unexpected transfer to ICU

Reason for transfer: respiratory condition worsened

Patient outcome: transferred to ICU; discharged home after 10-day hospitalization

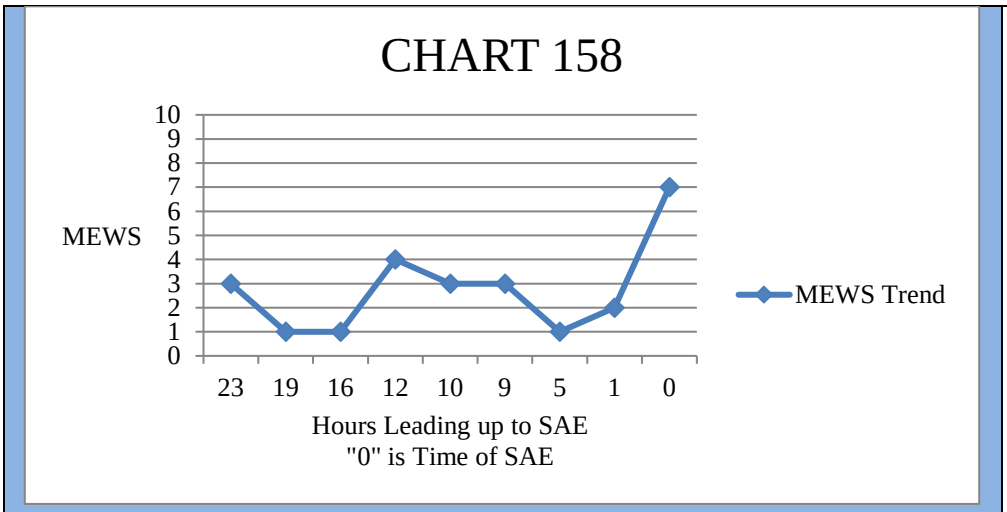


Admission diagnosis: heart failure; NSTEMI

SAE category: unexpected transfer to ICU

Reason for transfer: chest pain

Patient outcome: transferred to ICU; discharged home after 3-day hospitalization

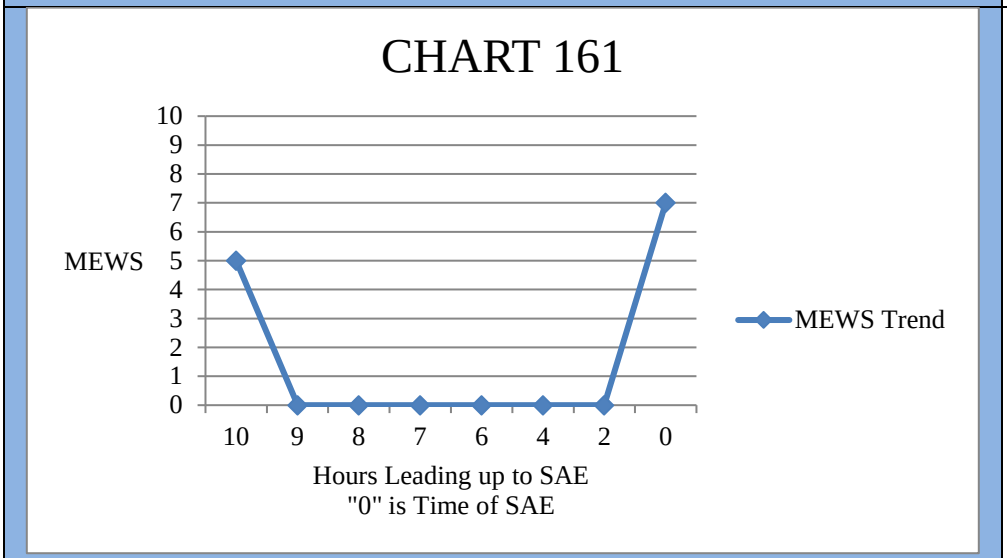


Admission diagnosis: respiratory failure; sepsis; colitis

SAE category: unexpected transfer to ICU

Reason for transfer: mental status change; O_2 sat < 90%

Patient outcome: transferred to ICU; transferred to acute care hospital after 4-day hospitalization

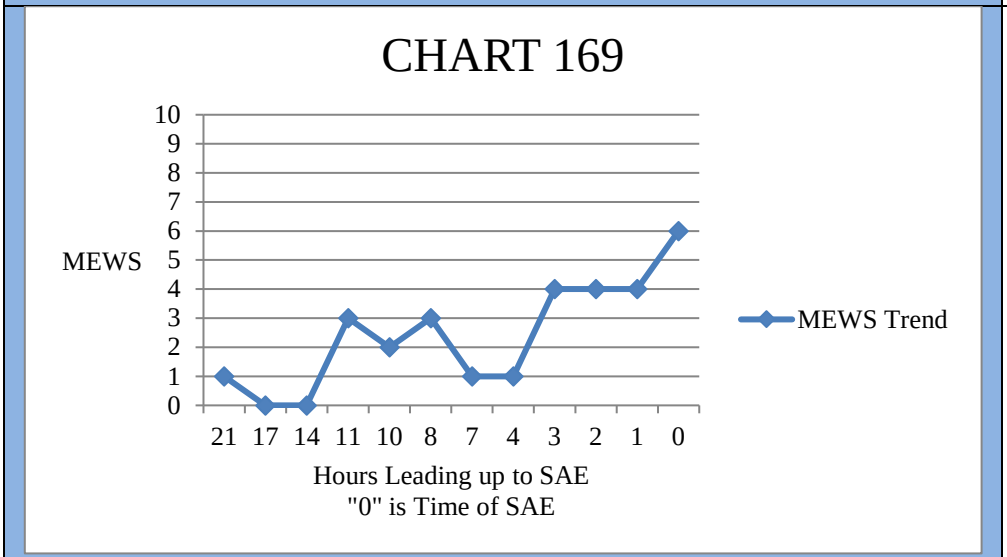


Admission diagnosis: COPD; pneumonia

SAE category: unexpected transfer to ICU

Reason for transfer: respiratory distress

Patient outcome: transferred to ICU; discharged to nursing home after 16-day hospitalization

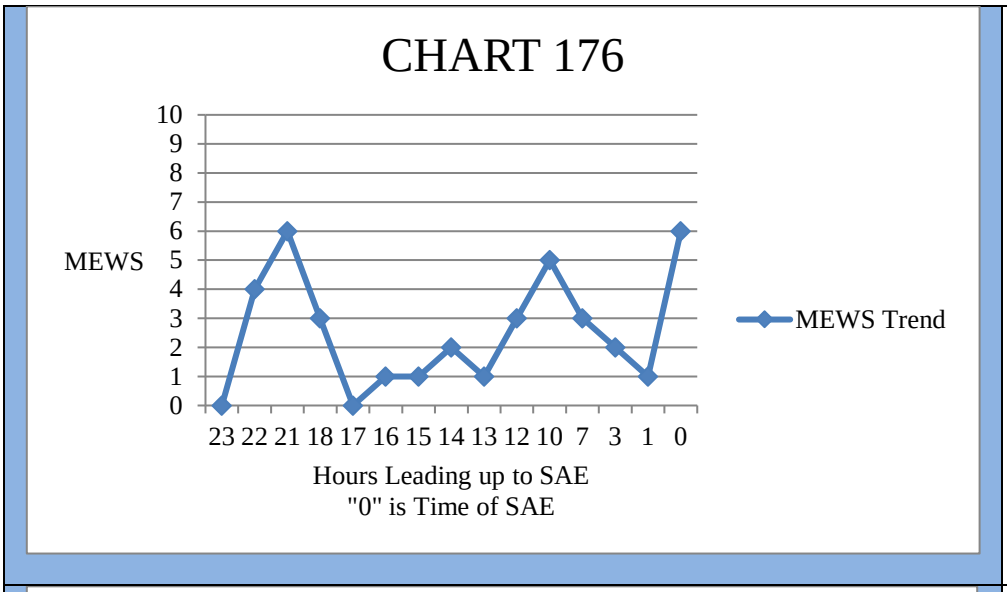


Admission diagnosis: abdominal pain; melena

SAE category: unexpected transfer to ICU

Reason for transfer: a-fib with RVR; Cardizem drip

Patient outcome: transferred to ICU; discharged home after 5-day hospitalization

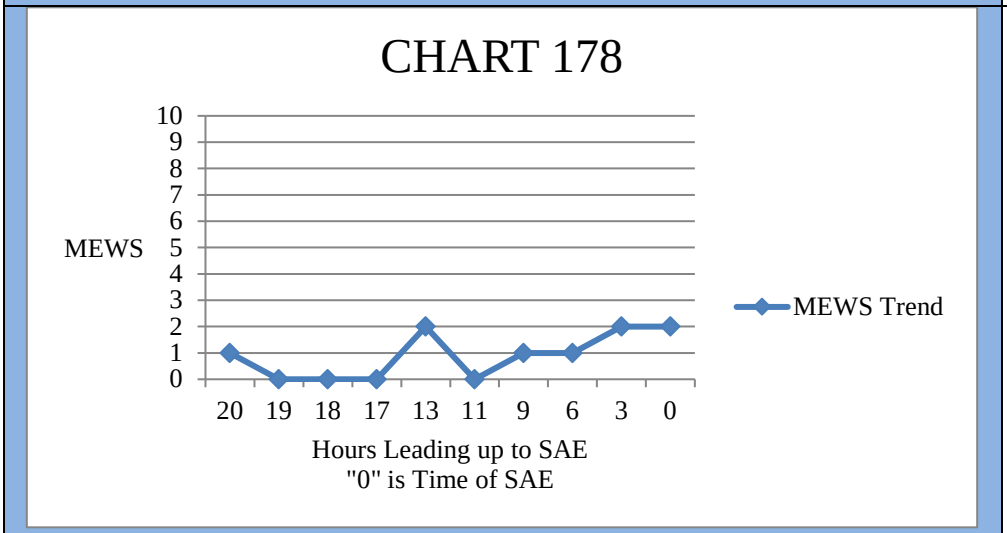


Admission diagnosis: influenza; weakness

SAE category: unexpected transfer to ICU

Reason for transfer: DKA with need for insulin drip

Patient outcome: transferred to ICU; discharged home after 11-day hospitalization

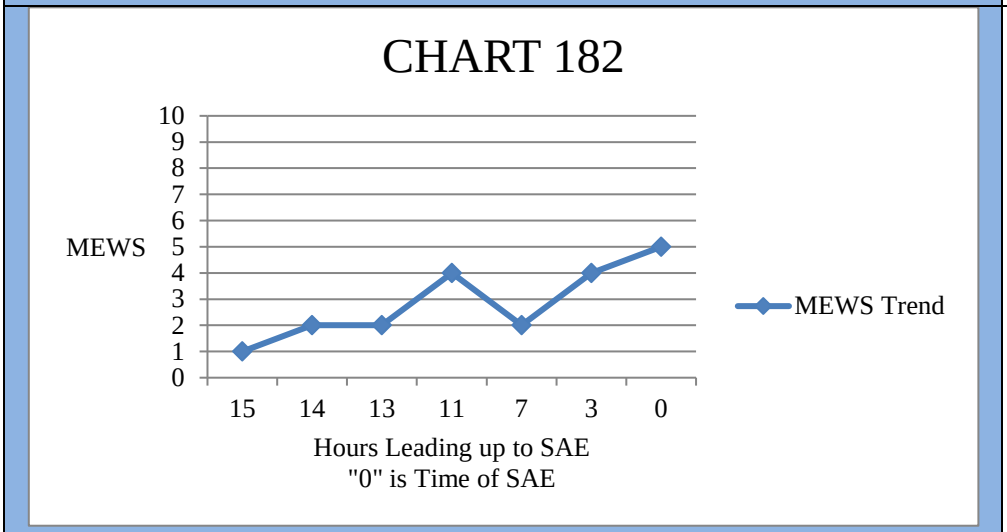


Admission diagnosis: chest pain

SAE category: unexpected transfer to ICU

Reason for transfer: SOA; chest pain

Patient outcome: transferred to ICU; discharged home after 4-day hospitalization

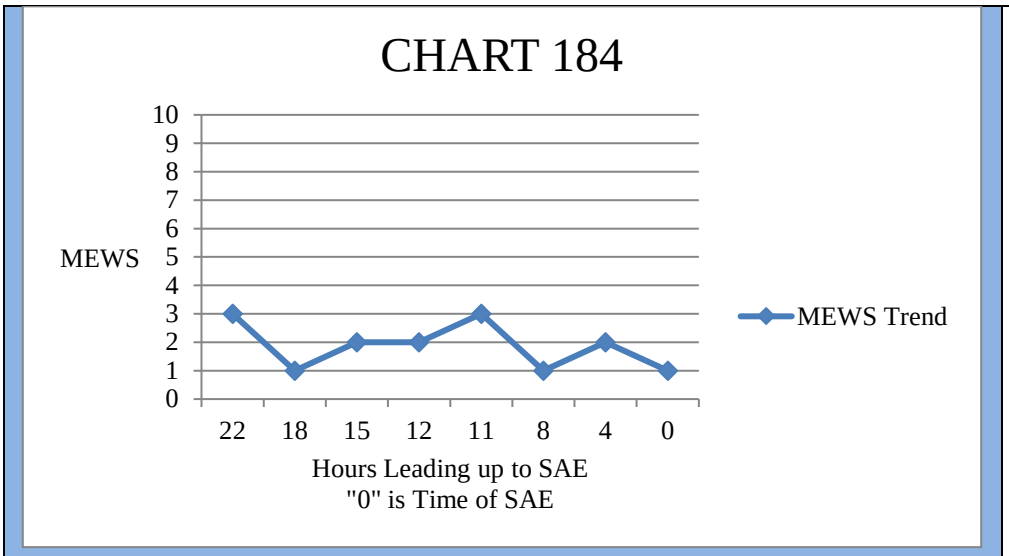


Admission diagnosis: heart failure; pneumonia

SAE category: unexpected transfer to ICU

Reason for transfer: Troponin trending upward

Patient outcome: transferred to ICU; patient died after 15-day hospitalization

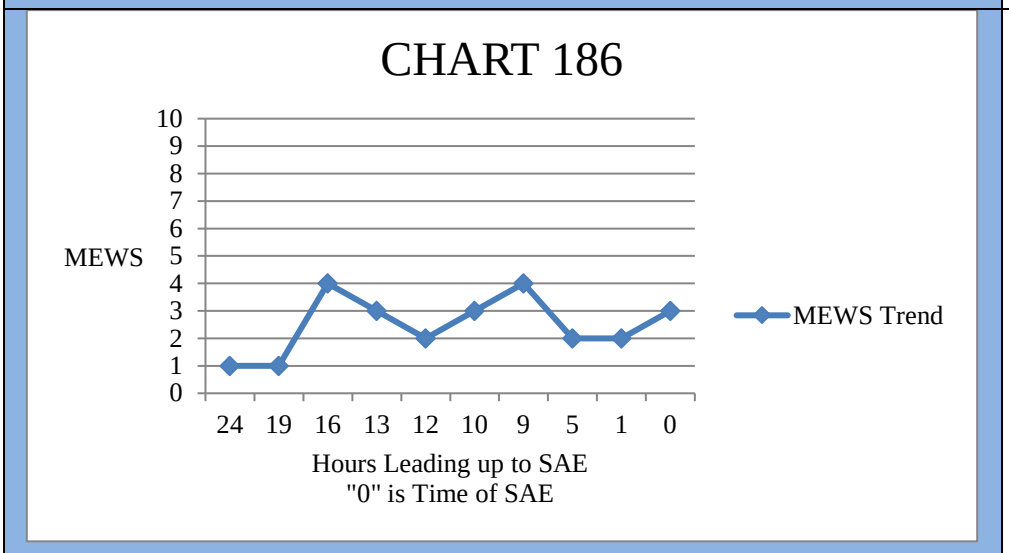


Admission diagnosis: chronic respiratory failure; COPD exacerbation

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring

Patient outcome: transferred to ICU; discharged home after 6-day hospitalization

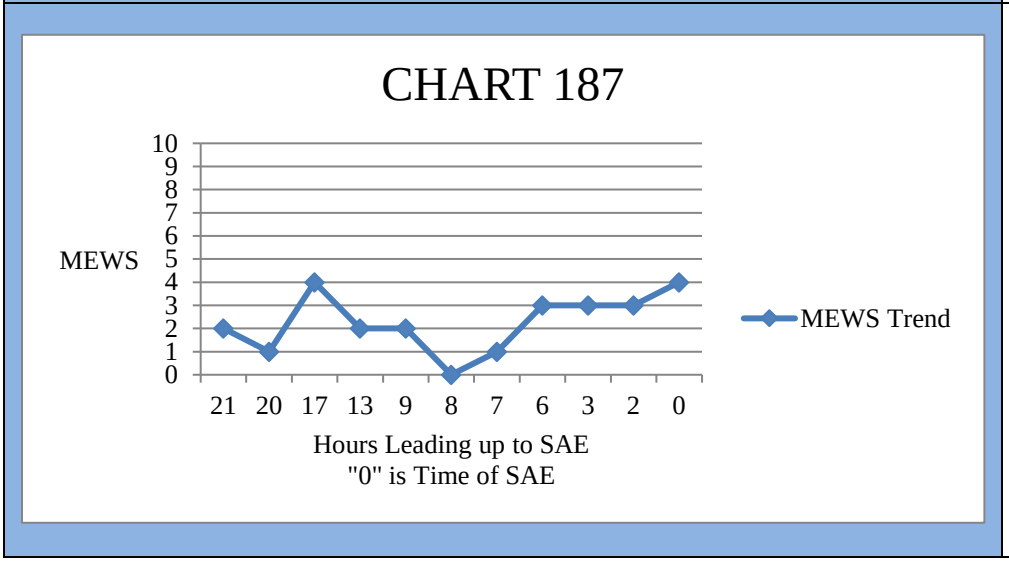


Admission diagnosis: heart failure; COPD exacerbation; pneumonia

SAE category: unexpected transfer to ICU

Reason for transfer: a-fib with RVR; Cardizem drip; SOA

Patient outcome: transferred to ICU; discharged home after 7-day hospitalization

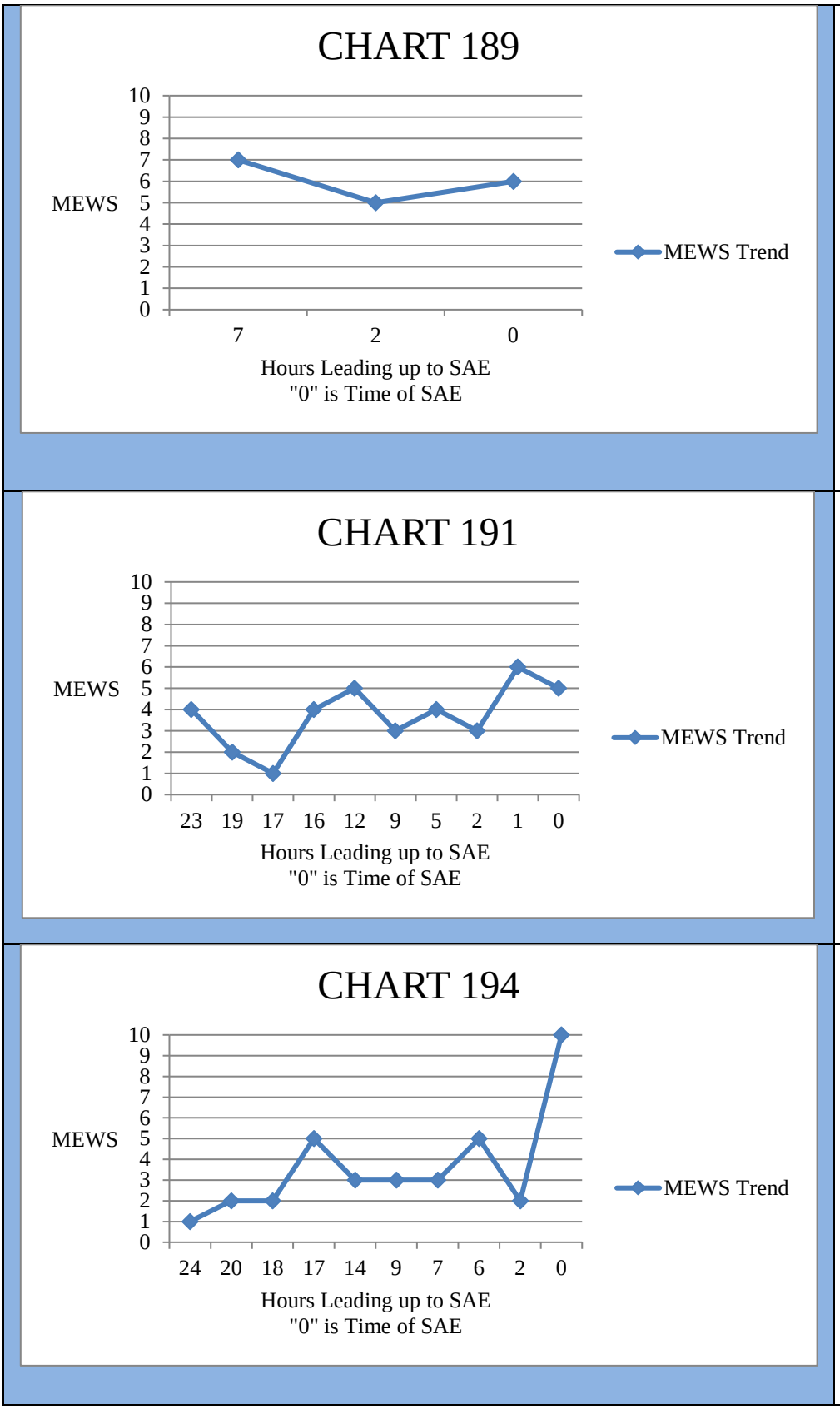


Admission diagnosis: pneumonia

SAE category: unexpected transfer to ICU

Reason for transfer: closer monitoring of patient; central line placement

Patient outcome: transferred to ICU; transferred to acute care hospital after 6-day hospitalization



Admission diagnosis: acute respiratory failure; COPD exacerbation

SAE category: unexpected transfer to ICU

Reason for transfer: respiratory distress; RR > 24; HR > 130

Patient outcome: transferred to ICU; discharged to nursing home after 12-day hospitalization

Admission diagnosis: complicated UTI

SAE category: unexpected transfer to ICU

Reason for transfer: mental status change

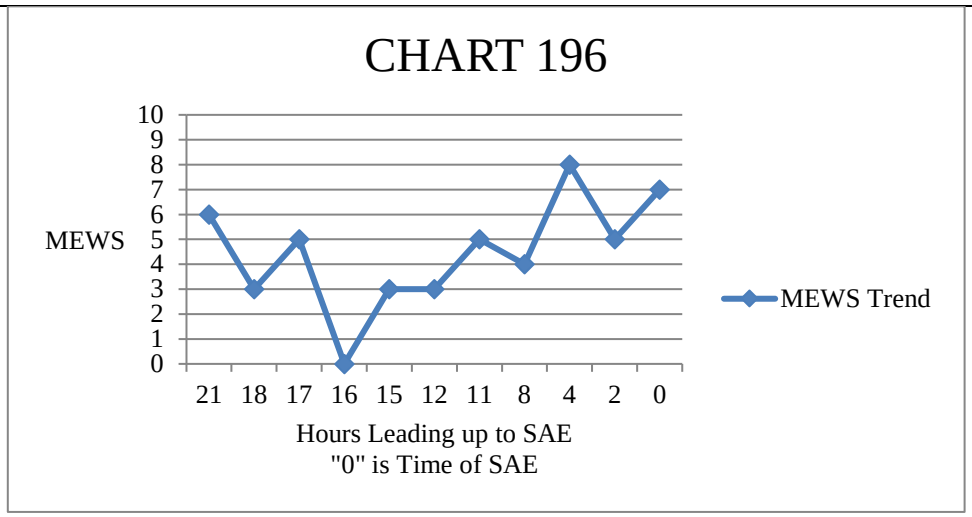
Patient outcome: transferred to ICU; discharged to nursing home after 8-day hospitalization

Admission diagnosis: pneumonia

SAE category: unexpected transfer to ICU

Reason for transfer: family concern; respiratory distress; O_2 sat < 90%; RR > 24

Patient outcome: transferred to ICU; transferred to inpatient rehab facility after 24-day hospitalization

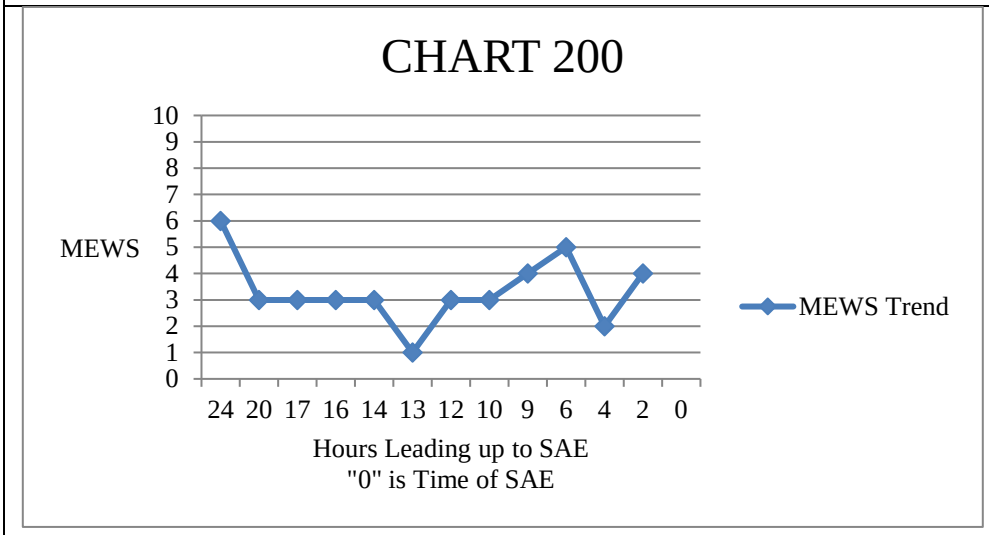


Admission diagnosis: CAP

SAE category: unexpected transfer to ICU

Reason for transfer: respiratory distress; O_2 sat < 90%

Patient outcome: transferred to ICU; discharged to nursing home after 22-day hospitalization

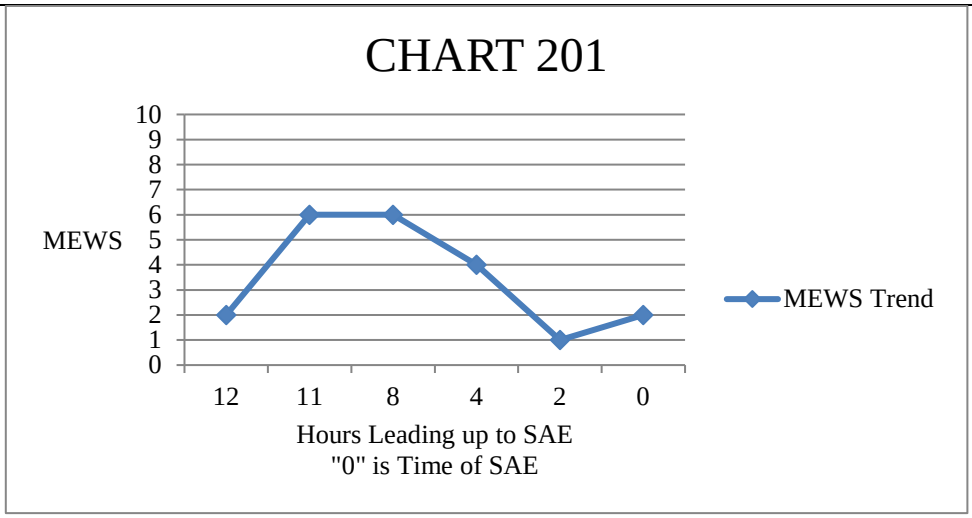


Admission diagnosis: HCAP

SAE category: unexpected transfer to ICU

Reason for transfer: DKA with need for insulin drip

Patient outcome: transferred to ICU; transferred to acute care hospital after 7-day hospitalization



Admission diagnosis: HCAP

SAE category: unexpected transfer to ICU

Reason for transfer: decreased BP; need for vasopressors

Patient outcome: transferred to ICU; discharged home after 9-day hospitalization

Appendix L

An Education & Training Workshop Pretest/Posttest

1. Please identify the position title that *most* closely corresponds to your primary nursing practice position:

    - o 3 Center LPN
    - o 3 Center RN
    - o 3 North LPN
    - o 3 North RN
    - o ICU Nursing Staff
    - o Other

2. What is your *highest* level of education?

    - o Trade/technical/vocational training
    - o Diploma degree
    - o Associate's degree
    - o Bachelor's degree
    - o Master's degree
    - o Other

3. Please identify the number of years that *most* closely corresponds to your nursing experience:

    - o Less than or equal to 3 years ($\leq$ 3 years)
    - o More than 3 years but less than or equal to 7 years (> 3 years; $\leq$ 7 years)
    - o More than 7 years but less than or equal to 10 years (> 7 years; $\leq$ 10 years)
    - o More than 10 years but less than or equal to 15 years (>10 years; $\leq$ 15 years)
    - o More than 15 years (> 15 years)

4. How confident are you in your ability to recognize individual aspects of a patient's assessment that serve as an early red flag for a patient's deterioration?

    - o Not confident at all
    - o Somewhat confident
    - o Confident
    - o Very confident
    - o Extremely confident

5. When you recognize that a patient is clinically deteriorating, how confident are you in knowing what next steps to take to escalate the needed care? (Next steps include what nursing actions to take, what monitoring to add, how frequently to reassess the patient, and who to contact.)

    - o Not confident at all
    - o Somewhat confident
    - o Confident
    - o Very confident
    - o Extremely confident

6. How confident are you in your ability to communicate your concerns about a patient's deteriorating status with the medical provider?

    - o Not confident at all
    - o Somewhat confident
    - o Confident
    - o Very confident
    - o Extremely confident
    - o I report to an LPN or RN

7. What are the *most* influential parameters in your nursing assessment that you use to determine a patient's level of stability? **(SELECT ALL THAT APPLY.)**

- o Heart rate
- o Oxygen requirement
- o Blood pressure
- o Urine output
- o Color change
- o Family concern
- o Temperature
- o Other parameters
- o Respiratory rate
- o Oxygen saturation
- o Level of consciousness
- o Capillary refill time
- o Pain level
- o Nursing concern
- o Respiratory effort

Please read the following scenario and use it to answer the next set of questions.

A 71-year-old woman is admitted to the medical-surgical-telemetry unit with a 2-day history of fever, chills, increasing shortness of breath, cough, generalized weakness, and decreased appetite.

The patient has a medical history of Type II diabetes mellitus, COPD, hypertension, ischemic heart disease, and hyperlipidemia.

Following initial testing, the patient is diagnosed with COPD exacerbation and pneumonia.

Her temperature is 101.2 °F (38.4 °C), pulse 94 beats/minute, respirations 24 breaths/minute, O_2 sat 89% on room air, and blood pressure 100/58 mm Hg.

Her color is pale. She appears lethargic and uncomfortable. She states that her chest hurts every time she coughs.

The patient rates her pain a "4" on a pain scale of zero to ten (zero representing no pain and ten representing severe pain).

Her breathing is labored and lung fields have wheezes throughout with diminished breath sounds in the bases.

Her skin is warm and dry with a capillary refill time of less than 3 seconds.

The patient reports last urine output approximately 8 hours ago.

The patient is placed on 2 liters of oxygen via nasal cannula.

IV access is established and a 250 mL bolus of 0.9% Sodium Chloride is administered.

8. Which assessment findings concern you the *most*, if any? **(SELECT ALL THAT APPLY.)**

- o Temperature 101.2 °F (38.4 °C)
- o Pulse 94 beats/minute
- o Respirations 24 breaths/minute
- o O_2 sat 89% on room air
- o Patient placed on 2 liters of oxygen via nasal cannula
- o Blood pressure 100/58
- o Color pale
- o Appears lethargic and uncomfortable
- o Chest pain associated with coughing rated a "4" on pain scale
- o Breathing labored; lung fields have wheezes throughout with diminished breath sounds in bases
- o Skin warm and dry with capillary refill less than 3 seconds
- o Last urine output approximately 8 hours ago
- o Patient given a 250 mL bolus of 0.9% Sodium Chloride
- o I am not concerned with these findings
- o Other concerns

9. What actions do you feel are *most* appropriate for the nurse to take based on this admission assessment? **(SELECT ALL THAT APPLY.)**
    - o Reassess patient in 4-hours to determine if clinical status has improved
    - o Consider call to Rapid Response Team (RRT)
    - o Obtain order to place patient on pulse oximetry upon admission to unit, with vital signs, and PRN respiratory distress
    - o Obtain order to place patient on cardiac monitor and continuous pulse oximetry
    - o Obtain order for 12-lead electrocardiogram (ECG)
    - o Obtain order to titrate oxygen to maintain oxygen saturation above 92%
    - o Obtain orders for medication therapy (antibiotics, corticosteroids, inhaled medications, etc.)
    - o Obtain orders for fluid intake and output monitoring
    - o Obtain order for Foley catheter placement
    - o Obtain order for IV maintenance fluids
    - o Alert the medical provider regarding the temperature, obtain an order for and administer antipyretic, and recheck temperature in 1-hour
    - o Request charge nurse at bedside for patient assessment
    - o Request medical provider at bedside for patient assessment
    - o Complete reassessment of patient including vital signs within 15 minutes of admission
    - o Consider communication with charge nurse requesting decreased patient care assignment
    - o Call medical provider to provide update on patient's status
    - o Document nursing note regarding notification of charge nurse
    - o Document nursing note regarding notification of medical provider
    - o Consider reassessment of patient including vital signs within 1-hour of admission
    - o Consider recommendation for ICU transfer
    - o Other actions

10. Which of the following do you feel *most* accurately describes your situation pertaining to effective communication? **(SELECT ALL THAT APPLY.)**
    - o I routinely use a Situation-Background-Assessment-Recommendation (SBAR) communication technique in hand-offs, patient transfers, critical conversations, and telephone calls.
    - o I sometimes use an SBAR communication technique in hand-offs, patient transfers, critical conversations, and telephone calls.
    - o I rarely use an SBAR communication technique in hand-offs, patient transfers, critical conversations, and telephone calls.
    - o I use my own communication technique in hand-offs, patient transfers, critical conversations, and telephone calls.
    - o I work in an environment whereby any and all team members can contribute valuable input regardless of rank or position.
    - o I work in an environment whereby speaking out regarding a patient's safety will not be held against me.
    - o I work in an environment whereby open and receptive communication is valued.
    - o Other

Appendix M

EVALUATION SURVEY

1. When did you attend the education and training workshop?
(PLEASE PROVIDE SHORT ANSWER.)

2. The learning objectives for the education and training workshop were clear and easy to understand.
(WORKSHOP CONTENT RELATED)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

3. The education and training workshop met my needs and expectations.
(WORKSHOP CONTENT RELATED)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

4. The content of the education and training workshop was relevant to my job.
(WORKSHOP CONTENT RELATED)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

5. The activities in the education and training workshop were appropriate and reasonable in the time allowed.
(WORKSHOP DESIGN)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

6. The activities in the education and training workshop gave me sufficient practice and feedback.
(WORKSHOP DESIGN)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

7. The difficulty level of the education and training workshop was appropriate.
(WORKSHOP DESIGN)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

8. The pace of the education and training workshop was appropriate.
(WORKSHOP DESIGN)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

9. The instructor for the education and training workshop was knowledgeable and well-prepared.
(WORKSHOP INSTRUCTOR)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

10. My knowledge and skills have increased as a result of the education and training workshop.
(WORKSHOP RESULTS)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

11. The education and training workshop was a good way for me to learn the content.
(WORKSHOP RESULTS)
    - o Strongly Agree
    - o Agree
    - o Undecided
    - o Disagree
    - o Strongly Disagree

12. How would you improve this education and training workshop?
(SELECT ALL THAT APPLY.)

    - o Provide better information before the workshop.
    - o Clarify the workshop objectives.

    - o Reduce the content covered in the workshop.
    - o Increase the content covered in the workshop.

    - o Update the content covered in the workshop.
    - o Improve the instructional methods.

    - o Make workshop activities more stimulating
    - o Improve workshop organization.

    - o Make the workshop less difficult.
    - o Make the workshop more difficult.

    - o Slow down the pace of the workshop.
    - o Speed up the pace of the workshop.

    - o Allot more time for the workshop.
    - o Shorten the time for the workshop.

13. What other improvements would you recommend for the education and training workshop?

14. What did you like *most* about the education and training workshop?

15. What did you like *least* about the education and training workshop?

Thank you so much for your participation!

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