Evaluation of an Evidence-based Algorithm for Patients with Acute Respiratory Failure: A Quality Improvement Project

THE DNP SCHOLARLY PROJECT

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Abstract

Background: The past decade, and particularly the past few years, there has been an increased focus on early recognition and responding to deteriorating hospitalized patients. One emerging approach gaining support is the use of early warning scoring (EWS) systems. These systems are designed to detect potential patient deterioration which can lead to initiate early intervention and management, such as increasing nursing attention and informing the provider. However, many hospitals across the United States are not utilizing these systems (Casserly, 2015). The Epic Deterioration Index (EDI) is an EWS. For patients at risk for acute respiratory failure (ARF), the utilization of EDI can promote early detection, which will lead to timely intervention and improve patients' outcomes. In addition, the EDI can help promoting awareness of the need for institutions to independently validate evidence-based practice algorithms for timely intervention to prevent failure to rescue in patients with ARF. The purpose of this quality improvement (QI) project is to evaluate the implementation of an ARF evidence-based algorithm in the intermediate unit (IMU) to help facilitate timely intervention to patients at risk.

Method: IMU providers were given instruction and training in the use of EDI in the context of the hospital's electronic medical records system. Post-intervention data associated with patient intubation or unplanned transfers to the intensive care unit (ICU) was collected and analyzed against similar pre-intervention data. Statistical analyses of changes in patient care were based in the Pearson's *chi*-square procedure.

Results: There was a reduction but not statistically significant in the difference of pre- and post-intervention on intubation rates and unplanned transfer to the ICU. However, there was a statistically significant in the use of EWS reports to prompt use of the evidence-based clinical algorithm and promoting appropriate patient care.

Conclusion: The evidence-based algorithm utilization is a valid tool to alert healthcare providers in identifying a deteriorating patient condition for timely escalation of care.

Keywords: acute respiratory failure, failure to rescue, early warning score system, epic deterioration index, nurses, evidence-based algorithm

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Section I: Responding to Patient in Acute Respiratory Failure

Introduction

Acute respiratory failure (ARF) is the most common acute organ dysfunction in United States (US) hospitals, with an incidence of 430 episodes/100,000 population with most (70%) requiring mechanical ventilation (Gong et al., 2016). ARF is when the respiratory system fails in one or both of its gas exchange functions with either oxygenation or carbon dioxide elimination (Kaynar, 2021). In 2017, there were an estimated 1,146,195 discharges with diagnosis of respiratory failure and procedural code for mechanical ventilation. The average length of stay for these patients was 10.5 days at an average cost of $158, 443 per patient (Kempker et al., 2020). ARF is the most common reason for admission to the intensive care unit (ICU) and has an in-hospital mortality rate of 33% to 37% among those who require mechanical ventilation (Stefan et al., 2013).

In 2004, the Institute of Healthcare Improvement introduced rapid response teams (RRTs) as an intervention that health care facilities could implement to decrease patient mortality and improve patient safety (Stolldorf, 2008). However, there are numerous studies that have failed to demonstrate that RRTs have improved clinical outcomes (Hall et al., 2020). Hospitals with RRTs typically report a reduction in the number of cardiac arrests, unplanned transfers to intensive care units (ICUs) and overall mortality rates. However, frontline staff must activate the RRT for it to be effective. It is important to resolve why the clinical staff fail to activate RRTs in a timely manner. This project is seeking to improve early recognition and timely intervention for ARF.

The intermediate care unit (IMU) at large tertiary facilities provide care to acutely ill patients who require care at a higher level available than acute care floors but do not require critical or intensive care unit level of care. Complications can arise within any healthcare organization or hospital unit; however, providing urgent or emergent care to a patient whose clinical decline was unrecognized places a huge burden on patients, clinicians, and healthcare systems. Failure to rescue (FTR) is the failure to prevent patient deterioration and can be a measure of institutional competence in this context (Burke et al., 2020).

Reducing FTR events is a common quality metric for US hospitals. In this IMU setting, some root causes of FTR in ARF and explored the salient factors that lead to failure to recognize emerging or established complications. The circumstances leading to FTR are probably multi-causal. A recent report on the IMU, the project setting, indicted that over an 11-day span, there were 21,461 oxygen saturation (SpO2) alarms with an average 3-6-minute response. These data imply failure to recognize a patient in ARF, possible alarm fatigue, and a lack of sense of urgency. Reducing the incidence of SpO2 alarms and optimizing the management of these complications are critical goals for healthcare organizations (Burke et al., 2020).

The objectives associated with this quality improvement (QI) project were to implement an evidence-based algorithm for bedside nurse use in recognizing early signs of deteriorating patient condition for timely escalation of care (See Appendix A), provide an informational session and a set skill set focusing on early rescue to assure safety and quality care delivery. For this project, SMART (an acronym for S=specific, M=measurable, A=achievable, R= relevant and T=time bound) guided the development project goals (Jillings, 2018). The SMART goal for the project was to implement an algorithm tool for bedside nurses for use in recognizing early signs of ARF and prevent unplanned ICU admission, intubation and/or decrease rapid response calls in the IMU and assess its efficacy in helping nurses rescue early and prevent further deterioration over the next few months after algorithm implementation.

Practice Setting

The setting for this QI project was an academic research institute with a large tertiary care level health care system. The health care system consists of eight hospitals that deliver comprehensive inpatient, outpatient, and extended care to patients in the surrounding community. In addition, this health care system has more than 20 orthopedic and sports medicine locations. Specifically, the organization operates 1,403 licensed beds in the Texas Medical Center (TMC) and treats a wide variety of medical and surgical patients of all ages. This hospital employs over 8, 428 employees and services over 40, 861 patients in the area. The TMC location has 228 acute care beds and 102 ICU beds. This project solely focused on implementation within the IMU with 19 beds. The Epic Deterioration Index (EDI) was introduced and implemented in November 2021. The early warning system (EWS) had been introduced to the project site a few years prior to this project but had no clear protocol on how to utilize it properly in the IMU setting.

Target Population

The target population were IMU patients aged 18 and older with ARF concerns or issues. The IMU is a transitional unit for patients in critical condition but who do not need as much attention as those in the ICU. The inclusion criteria were the nurse caregivers of patients aged 18 years and older, admitted to IMU for congestive heart failure, chronic obstructive pulmonary disease (COPD), pulmonary disease/disorders, neuromuscular disorders at risk for aspiration (e.g., amyotrophic lateral sclerosis [ALS], myasthenia gravis), pulmonary hypertension, elderly, pneumonia, pre-post lung transplant, or post-COVID. Exclusion criteria were patients with palliative care and comfort care only. Convenience sampling was performed for this project to ensure all patients with respiratory risk were evaluated.

Needs Assessment

ARF is very common among patients in the IMU. Early identification of deteriorating IMU patients, can help reduce need of transfer to higher acuity units, reduce hospital lengths of stay and cost, and improve survival rates (Plate et al., 2017; Vincent et al., 2018). Nurses are the frontline workers in healthcare and ideally positioned to detect subtle signs of declining clinical conditions (Hall et al., 2020). Early recognition and intervention are key to optimizing treatment outcomes. One emerging approach to early recognition is the development and implementation of early warning scoring systems. These systems are designed to detect specific physiological deterioration and alert the health care team of an emerging condition that may need urgent attention (Casserly, 2015). The purpose of this QI project is to evaluate the implementation of an ARF evidence-based algorithm in the IMU. The desired outcome measure is to improve the timing of resuscitative efforts, thus illustrating the value of implementing an evidence-based algorithm in the IMU setting.

SWOT Analysis

This QI project used a strength, weakness, opportunities, and threats (SWOT) analysis method to assess and evaluate factors that influence a specific topic (Wang & Wang, 2020). Based on the results of the assessment, the SWOT can assist with formulating appropriate strategies, plans, and countermeasures. Harris et al. (2020) defines a SWOT analysis as a technique that provides “clarification and discussion of internal strengths and weaknesses within the organization as well as external opportunities and threats outside the organization that currently or potentially support or mitigate actualization of the idea” (p.112). A SWOT analysis was used to help determine if a tool or algorithm could help bedside nurses to recognize subtle signs of ARF and escalate intervention.

Strength

The core strength of creating a tool or algorithm is to improve clinical outcomes. Nurses play a pivotal role in early recognition of ARF and intervening in a timely manner. Research has shown early identification of patients at higher risk for ARF and prompt intervention to improve survival and mitigate the severity of organ failure; which will ultimately reduce the mortality rates, length of stay (LOS) and cost (Gong et al., 2016; Stolldorf, 2008). The Institute of Healthcare Improvement (IHI) established the RRTs to decrease in-hospital mortality rates and they are widely used in the US hospitals (Gong et al., 2016). The hospital this project is focused on implemented RRTs greater than two decades ago; however, failure to recognize patient deterioration may result in missed opportunity to intervene in a declining patient. Another strength includes the standardized early indicators score systems for ARF. Tools and standardized algorithms remove speculation about a patient’s condition and support the prudence and critical thinking of bedside nurses’ clinical judgment (Gong et al., 2016). Many studies have shown an improvement in clinical outcomes with standardized early warning score systems (Gong et al., 2016).

Weakness

Of course, the obverse sides of these strengths are some weaknesses that accrue with new practice algorithms or guidelines. The IMUs where this tool or algorithm is implemented have several groups of pulmonologists who admit and round on patients. One weakness that will likely occur is clinical variation and adherence. Lee and Hulse (2019), in a factorial experiment, found that physician adherence with guidelines varies with different types of "patients" and with the length of clinical experience. While over 50% of physicians would follow a third of the recommended actions, there is low adherence among the physicians with too many of the guidelines. Lee and Hulse also found lowered motivation among healthcare professionals to adhere to "yet" another guideline or a lack of integration in decision-making tools. Motivation is an important driver for health professionals to maintain their positive contributions to their workplace. Nurses can choose to ignore the new algorithm and continue to practice in the same manner. Finally, lack of integration or compliance can interfere with quality care outcomes. Nurses' workload is a significant barrier to integration of tools. Lack of knowledge of the tool can lead to a lack of integration. These lacks are evidenced by the Kolic et al. (2015) prospective observational study with 370 adult patients with whom a national EWS (NEWS) tool was used. The NEWS prescribes an appropriate response for the deteriorating patient in need of urgent medical care. In 18.9% of patients the NEWS score was calculated incorrectly which interfered with the clinical response.

Opportunities

Several opportunities, both educational and clinical, can improve quality of care and outcomes. There is a significant implication for clinical education. Management of rapid patient deterioration requires critical thinking, prompt recognition, and swift response of the bedside nurse (Stolldorf, 2008). Majority of the nurses in this project setting are either new graduates or have less than four years of experience. Some of the major failure to rescue for ARF comes from a lack of recognition or fear of criticism of being "wrong". This project can improve intra-professional communication between nursing staff and other colleagues. A unit culture with open communication and collaboration with other colleagues can lead to better outcomes (Burke et al., 2020). This evidence suggests that our ability to recognize and escalate interventions will improve quality of care. Influencing policy and implementing quality improvement initiatives ought to focus on maintaining and developing bedside nurses' competences to decrease mortality rates and improve healthcare outcomes (Stolldorf, 2008).

Threats

The project lead (PL), an experienced nurse and doctoral student perceived several potential threats. One ongoing threat that could continue is having a lack of safety culture. Many new nurses may not recognize the sense of urgency. Timely recognition and intervention require prudent nursing care and accountability. Other barriers that affect patient care indicate issues of synergy between patient need and nursing competence. Another threat is the possibility of the pulmonologist not supporting the algorithm. Physician adherence and buy-in with clinical practice guidelines is highly variable (Halm et al, 2000). Halm et al., (2000) suggest "guideline implementation strategies should take into account the heterogeneous forces that can influence physician decision making" (p. 104). Finally, regulatory change is a daunting task and warrants time. It is important to create strategies for implementing new practices, and again support from key stakeholders.

Inquiry Question

The EBP process starts with a clinical question known as PICOT, a mnemonic is derived from its elements: patient, intervention, comparison, outcome and (sometimes) time (Harris et al., 2020). A synthesized collection of EBP research data support the formation of the PICOT question. Literature to support this project was be collected based upon the following PICOT question: (P) In adult patients in the intermediate unit with early signs of ARF (I) does implementation of an evidence-based algorithm (C) compared to no algorithm (O) affect the number of intubations and unplanned admissions to the intensive care unit (T) over a 4-week period?

Aim/Objectives

The aim of this Doctor of Nursing Practice (DNP) project was to explore the efficacy of an EWS for ARF and intervention algorithm as tools for IMU bedside nurse use to decrease FTR, unplanned ICU transfers, prolonged hospitalization, and overall decrease mortality. The provided evidence-based education intervention focused on nurse critical thinking and should have increased nurse use of these tools which, in turn, improve patient outcomes (decrease adverse events, transfer to the ICU, and death).

Another objective was to facilitate early recognition of ARF by the utilization and reporting the EWS to providers. Early recognition and implementation of algorithms will prompt timely intervention.

Theoretical Framework: Iowa Model of Evidence Based Practice

This DNP project is a QI initiative. The Iowa model of evidence-based practice (Titler et al., Appendix A) provided a systematic process to direct the evidence-based practice (EBP) change and improve outcomes for patients with ARF. The first step in the Iowa model is to identify either a problem-focused trigger or knowledge focused trigger where an EBP change might be warranted. Problem-focused triggers are those problems that derive from risk management data, financial data, or the identification of clinical problems. Problem focused triggers for this project included quality metric benchmarks such as failure to rescue rates, significant increase respiratory alarms with delayed response times of 3-6 minutes, unplanned transfer from IMU to ICU, failure to activate RRT or provider of change in condition and failure to utilize the EWS to identify decline in patient's condition. Knowledge focused triggers are those that come forward when new research findings are presented or when new practice guidelines are warranted (Buckwalter et al., 2017; Titler et al., 2001). The knowledge focused trigger of this project was the identification of an EBP algorithm that could be used to intervene with early signs of ARF (See Appendix B).

In the Iowa model, once triggers for change are identified, three decision points and feedback loops provide directions to effectively manage the project. The initial decision is to determine whether the problem at hand is a priority for the organization, department, or unit (Titler, et al., 2001). This project aligns with the organization's mission and vision to empower bedside staff to deliver safe, high-quality, and reliable care that can improve clinical outcomes (Houston Methodist, n.d.). Following the Iowa model, an EBP algorithm to decrease FTR in ARF is amenable to both quality and safety to improve clinical outcomes. Once the priority has been determined, the next step was to form a team consisting of members that will help develop, evaluate, and implement the EBP algorithm. Therefore, literature was reviewed, critiqued, synthesized, and then evaluated if there is a sufficient research base to pilot the change in practice.

The “pilot the change in practice” step in the Iowa model was the focus of the DNP project. Some of the key components of this step in the Iowa model included establishing outcomes measures that were identified in the PICOT question; collecting baseline data from January 2019-June 2019, and developing algorithm, implement EBP algorithm on IMU units and then evaluate the EBP change (Buckwalter et al., 2017; Titler et al., 2001). The objective of this project was to decrease FTR rates in the context of unplanned ICU transfers, intubation rates, etc. Pre and post algorithm implementation data on these metrics was obtained and used evaluate the impact of the EBP change.

The Iowa model concludes with the third decision point, if the intervention is successful in pilot implementation, it’s possible adoption as an organization practice change. This model provides organizations with a systematic process to methodically trial EBP change in a real setting on a smaller scale (Titler et al., 2001). Also, of note, this methodology can enhance change success by refining practice change prior to large-scale implementation which will be a future endeavor goal.

Project Design

The QI objective was to provide education on EWS to detect early signs and symptoms of ARF and an EBP algorithm for nurses to implement timely intervention to keep patients from further decline in clinical status. Pre-existing quality metrics revealed that FTR in ARF is subpar to the standards of care in the IMU setting. The IMU’s medical director and nursing director acknowledged the need to reduce the delay in response to respiratory alarms, unplanned transfers to ICU, intubation rates, and the lack of compliance with EWS/Rothman index. Official members of the QI team included IMU medical director, IMU nursing director in IMU, and the associate chief of nursing. Other stakeholders include the pulmonologist and unit nurse practitioners.

Section II: Evidence

Search Strategy

The literature search was undertaken using online databases: CINAHL, Sage, PubMed, and Scopus. The search terms included “acute respiratory failure”, “failure to rescue”; “respiratory failure indicators", “tools used to assess acute respiratory failure”, “nurse competences”, “national early warning score (NEWS) or early warning score (EWS)”, and “heart rate, consciousness, oxygenation, and respiratory rate (HACOR)” were utilized to gather relevant research articles. The literature suggests respiratory deterioration is evident up to 8 hours before the event occurs (Kempker et al., 2020; Kelly, 2018; Shever, 2011). Researchers have used the failure to rescue indication when attempting to correlate mortality rates with organizational structure, processes, and quality patient outcomes (Shahian et al, 2010).

Level of Evidence

The John Hopkins nursing evidence-based practice (JHNEBP; See Appendix C) structured approach to research translation was utilized to ensure the current research findings and best practices are expeditiously and appropriately integrated into patient care (Dang & Dearholt, 2018).

- Level I: Experimental study, randomized control trial (RCT); systematic review of RCTs, with or with or without meta-analysis
- Level II: Quasi-experimental study; systematic review of a combination of RCTS and quasi-experimental, or quasi-experimental studies only, with or without meta-analysis
- Level III: Non-experimental study; qualitative study or systematic review, with or without meta-analysis
- Level IV: Opinion of respected authorities and/or nationally recognized expert committees/consensus panels based on scientific consensus evidence; clinical practice guidelines and consensus panels
- Level V: Experimental and non-research evidence; literature review, QI, Case reports

Critical Appraisal

A total of 143 articles were generated and 13 of these were selected for review and the synthesis of finding for presentation. Derived from the JHNEBP evidence levels (Dang & Dearholt, 2018) of the selected articles, critical analysis identified one Level 1 study, six Level II studies, three Level III studies, two Level IV documents, and one Level V publication. A predominance of the resources found were based on older literature and/or non-specific to the PICO question. There seemed to be a deficit of literature discussing EWS with accessible guidelines for workflow in the acute care setting.

The PL used the *Appraisal of Guidelines for Research and Evaluation II* tool (AGREE II) to evaluate the research and guidelines. AGREE II assists in the analysis of the methodological rigor and transparency in which guidelines are established (Brouwers et al, 2010). Accordingly, the AGREE II structures the recommendations made by the authors of the publications, key differences between these recommendations, discrepancies that exist between the recommendations, and helps provide support for recommendations should be applied or translated into clinical practice.

Evidence Synthesis

The PL found the review of literature supported early detection and prompt action when life threatening complications develop as two important nursing activities that can promote early rescue and prevent further decline (Burke et al., 2020). Additional resources demonstrated that delivery of high-quality rescue skills require competent nursing and adequate treatment (Burke et al., 2020; Kelly, 2018;). Thus, rapid response teams (RRT) were designed to provide swift assessment and intervention to any non-ICU patient who might be exhibiting signs of acute clinical deterioration.

Moriarty et al. (2014) performed a longitudinal study in two Canadian institutions to determine the effects or rapid response team (RRT) implementation on FTR. The study showed a reduction in FTR with a substantial increase in RRT activation. Despite that, a cross-sectional survey by Wakeam et al. (2014) sought an understanding of critical care characteristics predictive to FTR performance at the hospital level. These researchers found that internist or intensivists on the RRT were predictors of high performance and clinical outcomes. Burke and colleagues (2020) focused on FTR and determined that a failing to identify a patient's deterioration may result in missing the window of opportunity to rescue them from further decline. Although medical staffing might be a variable associated with FTR, it is also highly sensitive to nursing care, and as such, it has been advocated as a nursing-sensitive outcome measure (Burke et al., 2020).

Kendall‑Gallagher et al. (2011) explains that an increased nurse-patient ratio has no effect on FTR rate in hospitals with poor working environments; however, perceived better working environments had a 10% reduction in FTR. A meta-analysis and systematic review performed by Kane et al. (2007) examined the association between registered nurses (RN) staffing and patient outcomes in acute care settings. The findings showed increased nursing staffing in hospitals are associated with lower FTR. These results also insinuate that organizations with a greater proportion of bachelor prepared nurses may have lower FTR rates.

Mark et al. (2007) showed availability and access to resources improved clinical outcomes or reduce FTR, but this access alone does not resolve the problem of FTR. Effective rescue may require increased nursing surveillance and training as well as additional hospital clinical resources, such as interventional or high-technology services (i.e., EWS). The nurse-sensitive indicators of FTR are, in essence, a “FTR " and reflect the progressive nature of these events. This project moves the concept from an event that has already occurred toward indicators designed to intercept its occurrence (Mushta et al., 2017; Wakeam et al., 2014).

Dziadzko et al. (2018) conducted an observational cohort study to determine if a risk stratification tool could identify patients at risk for ARF requiring mechanical ventilation or death within 48 hours. The findings showed using a risk stratification tool can be feasible in predicting real-time risk identification. These researchers suggest using a tool or algorithm such as ROX index (respiratory rate- oxygenation - defined as the ratio of peripheral oxygen saturation and fraction of inspired oxygen) to the respiratory rate.

Prower et al. (2021) conducted a retrospective cohort study to describe physiological antecedents to deterioration, test the predictive validity of the NEWS and compared this to ROX index. The findings showed that NEWS may underperform in COVID-19 due to intrinsic limitations of the design and unique pathophysiology of this disease. NEWS is widely recommended for respiratory failure. However, the ROX index has greater predictive validity than NEWS for deterioration in ARF (Gianstenfani et al., 2021; Prower et al., 2021).

The EDI is a prediction model that has been used in acute settings for medical decision-making during the COVID-19 pandemic. Nonetheless, it has not been independently evaluated and other models have been shown to be biased against vulnerable populations; hence, Singh et al. (2020) independently examined the EDI in hospitalized patients with COVID-19 overall and in disproportionately affected subgroups. Singh et al. found that the EDI has good discrimination in identifying small subsets of high-risk and low-risk patients with COVID-19, although its clinical use as an EWS is limited to low sensitivity.

Roca et al. (2016) conducted a prospective observational study to describe early predictors of the need for mechanical ventilation for patients with pneumonia and hypoxemic ARF and to develop prediction tools that accurately identified those who could continue to be treated with high-flow nasal cannula (HFNC). Findings show patients with ARF and pneumonia, the ROX index or EWS can identify patients at low HFNC failure in whom therapy can be continued.

There are some encouraging findings that early treatment with HFNC and non-invasive ventilation (NIV) can prevent patients suffering with ARF from further deterioration and eventually require mechanical ventilation. A recent RCT showed merits of HFNC as regards to mortality and intubation in severe patients with hypoxemic ARF (Frats et al., 2017). Researchers Zhao et al. (2017) performed a meta-analysis and systematic review to evaluate whether there were differences between HFNC therapy and conventional oxygen therapy (COT) in patients with ARF. The subgroup analysis showed that compared to COT, when ARF patients were treated with HFNC greater or equal to 24 hours, the rate of both escalation of respiratory support and intubation may decrease. Frats et al. (2017) explains how HFNC seems to be an acceptable alternative to COT and NIV as treatment for patients with hypoxemic ARF. Sang et al. (2020) used Bayesian meta-analysis to investigate the efficacy of respiratory methods in adults undergoing unplanned extubation. The results showed NIV reduces the reintubation rates in adult patients undergoing planned extubation compared to COT and HFNC. In a meta-analysis and systematic review, Zhao et al. examined whether HFNC was superior to either COT or NIV in adult ARF patients. The findings revealed compared to COT, HFNC reduced the rate of intubation, mechanical ventilation, and the escalation of respiratory support. When compared to NIV, HFNC showed no better outcomes. This suggests that NIV and HFNC have similar outcomes in adult patients suffering with ARF.

Use of a treatment algorithm incorporating HFNC, and NIV can be associated with short -term mortality lower than 50% in the event of ARF. HFNC can be used in those patients who are not responding to COT as it seems to improve oxygenation in a relevant number of cases per findings. The algorithm would include the stepwise application of NIV to reverse carbon dioxide (CO2) retention after correction of hypoxemia and to avoid trauma for tracheal intubation in a significant proportion of cases. (Innocenti et al., 2020; Frats et al., 2015)

Themes

The literature review originated four common themes: 1) FTR is a nurse-sensitive indicator; 2) EWS can improve patient outcomes; 3) the hierarchy of HFNC is a subcategory of HFNC; and 4) guidelines may focus on different modalities of oxygen supplement in ARF.

Utility/Feasibility

Early recognition of patients at risk for ARF coupled with the EWS and an evidence-based algorithm might allow earlier interventions to prevent or mitigate further decompensation. When evaluating feasibility associated with patients with life-threatening ARF, the outcome of interest is patient survival. Standardized monitoring and intervention practice for patients with comparable mechanisms of deterioration may enhance the ability to predict ARF and prevent its occurrence (Morris et al., 2017). Based on the literature review and needs assessment on the use of the EWS, implementation of the evidence-based algorithm and standardization of workflow provides strategies, such as intervention, positively impacts the outcomes of patients suffering with ARF in the IMU.

Project Design

Recent research demonstrated that providing nurses with an EWS alert alone did not improve patient management or outcomes (Burns et al., 2019). Early detection and timely intervention require clinical judgement and integrated workflow. The overall objective of this project is to implement an evidence-based algorithm and standardized workflow that will hasten the response once triggered by the

EWS. Thus, the IMU staff will use the EWS to not only recognize early signs of ARF but to also review and examine pertinent clinical data to determine the significance of the change and initiate the appropriate intervention.

The PL scholar was able to host informational training sessions for IMU staff on how to use the EWS tool, standardized workflow, and evidence-based algorithm. A PowerPoint presentation and workflow sheet was given to the attendees for future reference. The IMU staff reported that they appreciated to the informational sessions. Rather than diminishing the decision-making ability of nurses and RTs, this initiative will help facilitate critical thinking and timely decision-making.

Section III: Methodological Framework

The Inquiry Question

For adult patients in the intermediate care unit with early signs of acute respiratory failure will the implementation of an evidence-based algorithm, compared to no algorithm, affect the number of intubations and unplanned admissions to intensive care units, over a 4-week period?

Data Analysis Plan

An analytical tool known as a run chart was used in this QI project. Run charts demonstrate how improvement takes place over time. Determining if improvements have really happened and if it is lasting requires observing patterns over time. The run chart allowed this DNP led team to formulate aims by depicting how well (or poorly) a process was performing, comprehending the value of a particular change, and to distinguish between common and special causes of variation. Also, the run charts can help determine when change is truly improving by displaying a pattern of data that can be observed in real time (Health Resources & Services Administration, 2018). The aim was to evaluate weekly run charts and implement ongoing education or instruction as warranted. Common causes of variance are the usual quantifiable and historical variations in a system that are natural. Though variance is an obstacle, it is an essential part of a process—variance will eventually permeate in, and there is not much that can be done about this, especially like high turnover rate.

Institutional Review Board

The hospital Institutional Review Board (IRB) is composed of physician investigators and administrators who oversee the regulatory review and approval process of human subject research studies conducted at the organization. This process provides oversight for researchers since a committee of their peers evaluates their proposed use of human subjects and ensures that the research is well-designed and ethical. This project proposal was submitted to both the Pl's university and project site and both rendered an IRB exemption (See Appendix, D). The university required a completion certificate to the CITI course and then submission of application to the Cayuses. The project site determined that the project did not meet the definition of Human Subject Research per 45 CFR 46 and did require prior IRB review and approval. The institutional ethics committee approval was not required since IRB determined that initiative is not research of human subjects.

Interprofessional Collaboration

This QI project is being led by a DNP student. DNP graduates are individuals who have been immersed in practice experiences appropriate the highest levels of nursing practice (Hooshmand et al., 2019). The essential role of the DNP is to translate evidence into practice, generate new knowledge through innovation of practice change, and implement QI processes in practice settings, organizations, or with specific populations to improve health outcomes. To accomplish this objective, priority is placed on the importance of implacable foundational collaborative partnerships between academia and practice. Interprofessional focus and scope are inherent in the practice immersion experience. DNP projects are the pinnacle of the DNP educational process and as such reflect the achievement of doctoral level scholarships that develop graduates to be leaders in providing next-level quality, accessible health care and creating health care organizations that are valid and responsive to the needs of a diverse population (Roush & Tesoro, 2018).

Practice immersion experiences cannot be successful without incorporating colleagues from other disciplines in the project experience. Therefore, practice immersion experiences allow the opportunity to apply, integrate, and synthesize the DNP essentials necessary to affirm achievement of desired outcomes in an area of advanced nursing practice (American Association of Colleges of Nursing [AACN], 2006). The DNP essential domains prepare DNP graduates to understand the importance of interprofessional collaboration within a multitiered healthcare environment. These essential skills broaden the collaboration that naturally occurs among professionals by ensuring that DNP graduates will foster the expertise needed to assume leadership roles when collaborating with teams, as well as participate in the work of the team (AACN, 2021).

This QI project was conducted in the hospital in one IMU with patients who are at increased risk for acute respiratory failure. This project was discussed with nursing department members, starting with the on-site preceptor, medical director, and other stakeholders. The stakeholders are those individuals, groups, or organizations that have an interest in a business and maybe patients, employees, clinicians, researchers, advocacy groups, professional societies, businesses, policymakers, or others (Agency for Healthcare Research and Quality [AHRQ], n.d.). The stakeholders of this project include the IMUs' medical director, nursing director, nurse managers, preceptor, pulmonologists, nurse practitioner for the IMU and registered nurses. Other stakeholders include faculty leads, chair committee members for FTR and Rothman index/EWS. The external stakeholders include patients and leaders both within and outside the medical profession.

One of the first tasks launched was identifying how stakeholders could make the greatest impact on the QI project that was then being contemplated. Next, the task was to construct an awareness of who will be affected by the project and who can contribute to making the project more successful (Pandi-Perumal et al., 2015). As aforementioned, the stakeholders play a major role in ensuring successful adoption of evidence in health care. Stakeholder participation can (a) improve relevance, (b) promote visibility and research transparency. (c) accelerate and translate the research findings to actual practice, (d) enhance greater project acceptance as confidence derived in the decision during project's milestones developments (Pandi-Perumal et al., 2015).

The medical director plays a decisive role in providing necessary leadership and guidance that promotes the adoption of proposed change. The unit director, nurse managers and unit-based nurse practitioner play a major role in ensuring the nurses adopt the EBP algorithm by requiring documented attendance to in-services for the implementation and utilization of EWS. The IMU nurses are the primary care providers who have the crucial role in translating the algorithm and EWS into actual practice while caring for the patients. The on-site preceptor is responsible for collaboration to ensure that the QI project aligns with organization's goals and policy and procedures.

The PL's DNP project faculty leads serve as the primary support for mentoring and guiding the development, implementation, evaluation, and dissemination of the QI project. The other stakeholders, including other pulmonologists, will provide clinical knowledge and expert opinion regarding the EBP algorithm and additional support for the adoption of the change. The chair committee members or organization managers are crucial stakeholders to support the project because they influence the hospital's policies and procedures. Patients are the end consumers and hopefully this project can improve patient care and an opportunity to critically appraise evidence-based literature.

The DNP scholar's purpose is to form partnerships and collaborate on interprofessional and/or interdisciplinary teams, with patients who are consumers of healthcare, within organizations that provide health care, and with policy makers on committees in leadership positions (Waldrop et al., 2015). The development of interprofessional educational collaborative competencies necessarily required moving profession-specific educational efforts to engage the DNP student of different professions in interactive learning with each other (Schmitt et al., 2011). The three communication and relationship building skills that are being utilized to build a community for the DNP project are (1) working with individuals of other professions to maintain a climate of mutual respect; (2) use the knowledge of one's own role and those of other professions to appropriately assess and address the health care needs of patients and to promote and advance the health and population; and (3) applying relationship-building values and the principles of team dynamics to perform effectively in different team roles to plan, deliver, and evaluate patient/population-centered and population health programs and policies that are safe, timely, efficient, effective, and equitable (Schmitt et al., 2011). Although stakeholders differ considerably in their expertise and endeavors, their involvement were essential since they facilitate the completion of the project.

The PL's communication, interpersonal and management skills sharpen by articulating the need and implications of the project. Engaging with some stakeholders can be intimidating process. The leadership strategies employed were associated with ongoing communication. Communication is key. For example, some stakeholders may lack appropriate knowledge or skill sets, or perhaps believe they do not have appropriate knowledge to contribute (Pandi-Perumal et al., 2015). Communicating roles and responsibilities to stakeholders is a challenge at the beginning phase of most projects. Generating interest and involvement in a project which might be perceived to have little or immediate relevance can be difficult but is critical for sustaining a successful initiative.

Collaboration is one of the keys for unlocking sustainability. Communication is a key component to maintaining engagement and participation by all the stakeholders. Ongoing dialogue will improve decision-making and accountability for stakeholders. As this project developed and progressed, communication was maintained with scheduled meetings and by sending out periodic emails to all the key stakeholders. Additionally, stakeholder engagement provided opportunities to further align QI with stakeholder needs and objectives and helped drive long-term sustainability. For this reason, it was important to meet with them in person or via zoom calls, send periodic updates, and meet expectations. Stakeholder participation had a direct effect on sustainability integration. Presumably all stakeholders' matter; however, if resources become limited stakeholders become subject to prioritization. Such prioritization can be determined by organizations' assessment of relational stakeholder attributes such as power, legitimacy, and urgency (Yuen et al., 2020).

The four outline themes to validate the advancing community partnership for impact and sustainable improvement include the following: 1) the organization's mission and vision, 2) Donabedian's approach (i.e., structure, processes, outcomes), 3) partnership and collaboration, and 4) evidence-based research.

Data Evaluation Plan

The Donabedian model was utilized to provide the conceptual framework for this QI project. The Agency for Healthcare Research and Quality suggests use of Donabedian's framework. The AHRQ

(2018) states that, "structure of care is a feature of a healthcare organization or clinician related to the capacity to provide high quality health care". Donabedian suggested that the relationship among *structure*, *process*, and *outcome* indicators are convoluted, yet fundamental for valid evaluation of quality of care (Moore et al., 2015).

Structure refers to relatively inert characteristics of the providers who provide care and of the setting where the care is delivered (Moore et al., 2015). Characteristics of providers include in-service, training, experience, and certification. The settings where the care is provided is composed of the adequacy of the facility's staffing, technology, safety devices, and overall organization. Process identifies all the activities taking place during the delivery of care to the patients. It is the way in which care is delivered and includes broad aspects such as technical (e.g., technology, EWS) and interpersonal (e.g., provider-patient relationship or multidisciplinary teams). Finally, outcomes can be identified as the quality of care or outcome measures (Best, 2004). The IMU nurses and respiratory therapists are central members of this evidence-based practice implementation and quality improvement teams. As key stakeholders, nurses, and respiratory therapists can help outline significant components of the structure, process, and outcomes of care. These efforts will advance the highest quality of care for patients who are admitted to the IMU with risk of acute respiratory failure.

Budget, Timeline, and Resources Plan

This project was completed within the planned time allotted of 8 weeks (Appendix E). The total cost for project implementation was less than $200.00 for breakfast and lunch for QI team members attending informational sessions. The software license fee (i.e., EWS), and video, equipment, utilities, and conference room costs were absorbed by the existing program. The resources identified for this project included both the FTR and EDI committees at the project site. The university's Center for Research Design and Analysis (CRDA) provided a statistician who provided information support for all three phases of the data collection process (i.e., pre-analysis, analysis, and results).

Metrics Grid

Data was recorded by the PL to an Excel spreadsheet. To certify accuracy and consistency, data was entered only by the PL. The PL attended the required CITI training which provides formal instruction in human subjects' protection in the planning, conduct and analysis of research (Appendix D). However, this project was granted IRB exemption since the board determined this is not research of human subjects. Prior to obtaining or entering data, the PL consulted with a biostatistician at the university's CRDA to select and apply an appropriate data analysis method for the project. In addition, a power analysis was conducted using G-Power. The estimated target sample for 80% power with a *p*-value of .03 and medium effect size of .50. A desired sample size of 88 was deemed sufficient. The electronic medical records (EMR) or hospital report system were utilized to obtain data in this project. Demographic data collected were age, EWS, gender, intubation and/or ICU transfer. Data collection was methodic and allowed for preparation for analysis - including categorization of data of findings from the EMR related to EWS/algorithm implementation. A *t*-test was utilized for comparison of EWS use pre-post intubation. A weekly run chart provided analysis regarding unplanned transfers to ICU and intubation rates over a 4-week period. Correspondingly, a *chi*-square test was used to analyze patient outcomes pre-post implementation of intervention (See Appendix F).

Section IV: Findings/Results

Characteristics of Sample

Data was collected daily for patients admitted to IMU who met the inclusion criteria. The PL performed a pre-post intervention between October 2021-March 2022. Patients over the age 18 who required intubation were included as participants. The PL excluded any patients who failed to maintain airway (i.e., status epilepticus), inability to protect the airway against aspiration, failure to ventilate, failure to oxygenate, any anticipation of a deterioration course that would eventually lead to respiratory arrest or profound shock. The primary outcome measure was the patient intubation rate; a secondary outcome measure was unplanned transfer to the ICU. A dataset of patients meeting criteria was generated via a query of the project site electronic medical record (EMR) system EPIC.

The pre-intervention group was labeled Group I and the post-intervention group was labeled Group II. Group I had 275 patients and Group II had a total of 253 patients. However, some of those patients were in both groups due to their length of stay in the IMU setting. Therefore, the PL and statistician decided to eliminate these duplicate cases or MRNs. Accordingly, the new sample size was 261; Group I with 151 patients and Group I with 110 patients. The demographic characteristics included patient age and gender. The median age was 63 (range 21-98) and both sexes were represented almost equally (55.6% vs 44.4%).

QI interventions occurred in two phases: an initial intervention focused on nursing education only, which included a lecture with a power point. A subsequent intervention included teaching nursing assessment skills at the bedside.

Outcomes

ARF occurs regularly in hospitalized patients and invariably starts before ICU admission (Dziadzko et al., 2018). From October 2021 through March 2022, a total of 528 patients were admitted to the IMU with ARF criteria; 261 patients were eligible for inclusion in the intervention. Cross tabulation using Pearson's *chi*-square and Cramer's *V* test conducted to compare pre- and post-intervention intervention intubation rates and unplanned transfers to the ICU. The pre- and post-implementation relationship comparison has $n = 261$, $x^2 = 1.025$, $df = 1$, $p < 0.311$, Cramer's $V = 0.063$. Although no differences were statistically significant in the duration of this project, there was a reduction in the intubation rates and unplanned admissions to the ICU. Both the observed outcomes were reduced by 16.2% (See Appendix G for relevant tables and figures).

There were over 55 patients who avoided intubation with early recognition using the EWS and timely intervention using the evidence-based algorithm. The evidence-based algorithm was implemented at least 9 times a day by the PL whether the EWS was reported by RN/RT or not. Except for EWS and evidence-based algorithms, between unplanned ICU transfers and intubation rates, no significant heterogeneity was observed in the outcome measures.

Patient safety must remain a paramount consideration, especially in the generation of increased pressure on healthcare systems, cost, and clinical staff. There were statistically significant improvements in the IMU staff reporting the EWS to provider post-intervention. Crosstabulation using Pearson's *chi*-square and Cramer's *V* test were conducted to compare the result of pre- and post-intervention; $x^2 = 0.554$, $df = 1$, $p = 0.000$, and Cramer's $V = 0.46$ demonstrated improvement with awareness and adherence to the EWS. Patient safety relies on nurses using a standardized tool and exercising clinical judgment (Jensen et al., 2019). Of note, the effectiveness of the EWS is dependent on the IMU staff engagement with the tool and compliance. In this project, the nurses reporting the EWS increased from 0 to more than 9 times per day. The findings demonstrates that EWS was perceived as useful, effective, and beneficial to improving early detection and timely intervention for early signs of ARF.

The percentage of EWS acknowledged by the IMU staff for patients increased from 0% to 45% within 6 weeks and remained above or at the median for the duration of the project. The EWS is calculated to provide a score which may indicate a needed escalation response. The data collected relating to the EWS compliance using run charts provided a positive reporting system to prevent further decompensation of ARF or unplanned transfers to the ICU. The EWS prompted the treatment of the algorithm that improved the measurable outcomes. Having a standard protocol in the IMU for reference during management of ARF patients may itself ameliorate the different level of care. Further research is warranted to evaluate patient outcomes when EWS is used and to best support nursing practice and workflow.

Discussion

During the project implementation period, more than half the patients were admitted to the IMU with respiratory failure, mostly acute. Respiratory failure has consistently been a leading discharge diagnosis, followed by other respiratory conditions and pneumonia including aspiration pneumonia (Diaz-Prieto et al., 2014; Fini et al., 2014). Over the past two decades, there have been many studies to identify clinical precedence to in-hospital mortality as well as strategies to respond to those events (Hall & Gale, 2020). FTR represents a prevalent and significant problem and is therefore an important indicator of care quality. Efforts to address inadequacy in early recognition of clinical deterioration have resulted in numerous strategies to improve clinical response (Vincent et al., 2018). Some studies of EWSs have shown improvement in patient outcomes compared to single parameter vital sign systems (Vincent et al., 2018).

FTR is a key determinant of patient outcome. Use of preventative tools and protocols decrease complication rates in the IMU so the additional an evidence-based algorithm and standardized workflow were implemented to promote early detection and timely and appropriate intervention to reduce their impact.

Prior to implementation of this project, comprehension around the EWS was substandard and the tool was not being utilized in identifying clinical deterioration. The pre-intervention data collected demonstrated that the IMU staff was not reporting the high risk EWS scores or increased increment changes to the providers. The initial objective was to provide IMU staff education to increase awareness and knowledge on EWS scoring. The second objective was to provide all the IMU staff with an evidence-based standardized workflow with utilization of the EWS score. The third objective was to identify patients at risk for ARF and to have an IMU staff member recommend the use of the evidence-based algorithm based on EWS score and respiratory function. Introduction of EWS and a simple workflow to trigger the use of the algorithm significantly improved over the course of the project The fourth objective was to continue surveillance of patients at respiratory risk.

The PL audited weekly to ensure adherence to the new practice of the EWS, workflow and algorithm. The data showed significant improvement in compliance and follow-up. Compliance and adherence to standardized workflow and escalation recommendations of the algorithm are crucial to the success of the EWS. Although this project showed a statistically significant difference in compliance pre- to post-intervention, there was some observed regression in the reporting of the EWS. Some possible contributing factors to the nursing shortage and high turnover rates that are experienced in the IMU.

As hypothesized, this project demonstrated early recognition and timely intervention of ARF with standardized strategies can improve patient's outcome appears to be an indicator of quality care. Many

RNs and respiratory therapists who participated in this project indicated that the enhanced EWS increased their awareness of changes in patients' conditions, resulting in earlier response and reassessment times.

Conclusion

This project had a direct impact on the IMU staff practice and indirect impact on organizational culture by enriching communication, collaboration, and accountability. The project demonstrated that early detection and timely intervention is paramount to improving patient safety and clinical outcomes. The adoption of the evidence-based algorithm by combining the EWS as a prompt will continue to reduce unnecessary intubations and transfers to the ICU from the IMU setting. The standardized workflow will assist the IMU staff with strategies to learn, escalate and intervene in patients at risk for ARF. Currently, the standardized workflow is being reviewed and revised by the Medical Director for policy and procedure implementation.

Limitations

The primary limitation in this QI was the difficulty in analyzing other providers' accuracy in assimilating clinical data; therefore, the PL had to extract all the data independently. The COVID-19 has intensified some of the limitations identified in this QI project. The post-pandemic nursing shortage played a significant role in this project. The project site IMU was using flex-nursing which influenced the training and adherence to the project. When COVID-19 surged early January 2022, the IMU where data was being collected had to halt because the IMU converted into a COVID-19 IMU for approximately 3-weeks. Due to the limitation on time, secondary to the COVID-19 surge data had to be obtained only by the PL of the project to keep integrity and accuracy of the project. A subsequent QI project could target improving the capture and reporting of this data.

Another unforeseen limitation was the increased number of tracheostomy patients who were admitted to the IMU post-intervention. In the pre-intervention phase tracheostomy rate was 12.7 % and in the post-intervention phase tracheostomies increased by 16.2% to 28.9%. Therefore, majority of the patients admitted post-intervention had an artificial airway and were attached to the ventilator. This change demonstrated that the need for higher level of care regarding ARF could be managed in the IMU setting.

Although, the results of the project demonstrated significant improvement in the intubation rates and unplanned ICU transfers. EWS with advanced technology is still a new concept, so the impact of an enhanced EWS on nursing behaviors or practice has not yet been studied (Burns et al., 2019). Finally, this project was performed in a single hospital and single IMU, which inherently limits its generalizability.

Section V: Recommendations for Practice

Implications for Practice

This project has implications for nursing practice and organizational outcomes as well because it adds to the body of literature on the impact evidence-based practice has on patient safety. The evidence-based algorithm and EWS application can lead to increased knowledge about early recognition of deterioration, adapt nurses as professionals, promote timely treatment and teamwork, and thereby improve patient safety and clinical outcomes. While the findings from this project have led to a reduction in intubation rates and unplanned transfer to the ICU, FTR as a nurse sensitive outcome has inherent relevancy because of nurses' roles in surveillance of patient safety monitoring. Hence, the implementation of the algorithm indicates timing of the intervention aligns with better clinical outcomes.

AACN Essentials

This QI project integrates the AACN (2016) Essential 2.6a: Implement individualized plan of care using established protocols. This project intervention includes the implementation of a standardized, evidence-based workflow algorithm. Opportunities for improved workflow processes and interpersonal collaboration to impact nurses' success, also known as retention, transition of evidence-based practice, and prepare practical nurses for immediate entry into the workforce. By employing the evidence-based algorithm and standardized care plan or protocols for the aim of translating and widely disseminating best practices. In conjunction with, analytic methods were used in this project to critically appraise relevant literature and clinical data to determine and implement the best practice for the algorithm.

The AACN (2021) DNP Essential 1.3: Demonstrate clinical judgment founded on a broad knowledge base was also adopted for this project. The focus of this QI project was on IMU nurses and respiratory therapists' knowledge of the meaning of clinical judgment and determinants influencing the development of clinical judgment in the clinical setting (van Graan et al., 2016). This project has implications not only for nursing practice but also organizational outcomes as well because it adds to the body of knowledge on the impact evidence-based practice has on clinical outcomes and patient safety.

Ethical Considerations

This project was formally determined by the IRB as non- human subject research since it was a QI project (See Appendix C). Institutional ethics committee approval was not required given that IRB determined that this is not research of human subjects. All participants were protected by the Health Insurance Portability and Accountability Act of 1996 (HIPAA) which among other guarantees, protects the privacy of patients' health information (Modifications to the HIPAA Privacy, Security, Enforcement, and Breach Notification, 2013). Additionally, the PL who conducted this project followed the standards of care for the practice in the IMU. All data obtained as part of analyzing the impact of this project was aggregated data from the patients and excluded any potential patient identifiers. The only identifiable data was the medical record number (MRN). The MRN was stored on an excel spreadsheet on a password-protected computer in a locked office at the hospital with access to only the PL.

Self-Reflection

Essential Domain 10.3 in the *Essential of Doctoral Education for Advanced Nursing Practice* focuses on developing capacity for leadership (AACN, 2021). Leadership is critical to improve outcomes of patients and the healthcare system and will enable organizations to cultivate safety for patients and provide high quality in practice. Competencies on the professional leadership domain appear to be clearly formulated and provide for sufficient direction to further develop the nursing profession (Bridges et al., 2011). DNPs are being called upon to fill the gap in learning and working collaboratively is an essential component of the educational curriculum. Current nursing education standards include requirements for interprofessional collaboration. The nursing profession must produce leaders throughout the healthcare system, from the bedside to the boardroom, who can serve as full partners with other health professionals and be accountable for their own contributions to delivering high-quality care while working collaboratively with leaders from other health professions (Woodson, 2011).

The DNP PL's scholarly communication, interpersonal and management skills have sharpened to through the articulation of the importance and implications of the project. Engaging with some stakeholders can be an intimidating process, especially for a shy individual like myself. The leadership strategies that the DNP scholar employed are ongoing communication. The greatest challenge faced by the DNP scholar was having to balance family, work, and academe. The greatest takeaway is learning tenacity and perseverance.

Dissemination

The PL's project presentation can be used to educate clinicians, students, and policy makers about the implementation of the evidence-based algorithm. This DNP project findings will be shared with all the stakeholders. This manuscript itself will be posted in university's institutional repository which makes it discoverable by the public. A poster will be created and presented to members of the partnering organization and committees.

After the DNP scholar is no longer managing the quality improvement project, the sustainability will be accomplished by the following: 1) updating the policy and procedure for oxygen and ventilation therapy, 2) increasing the respiratory therapists and nurses' knowledge of the early warning score (EWS) system, and evidence-based algorithm, and 3) functional champions in the IMU.

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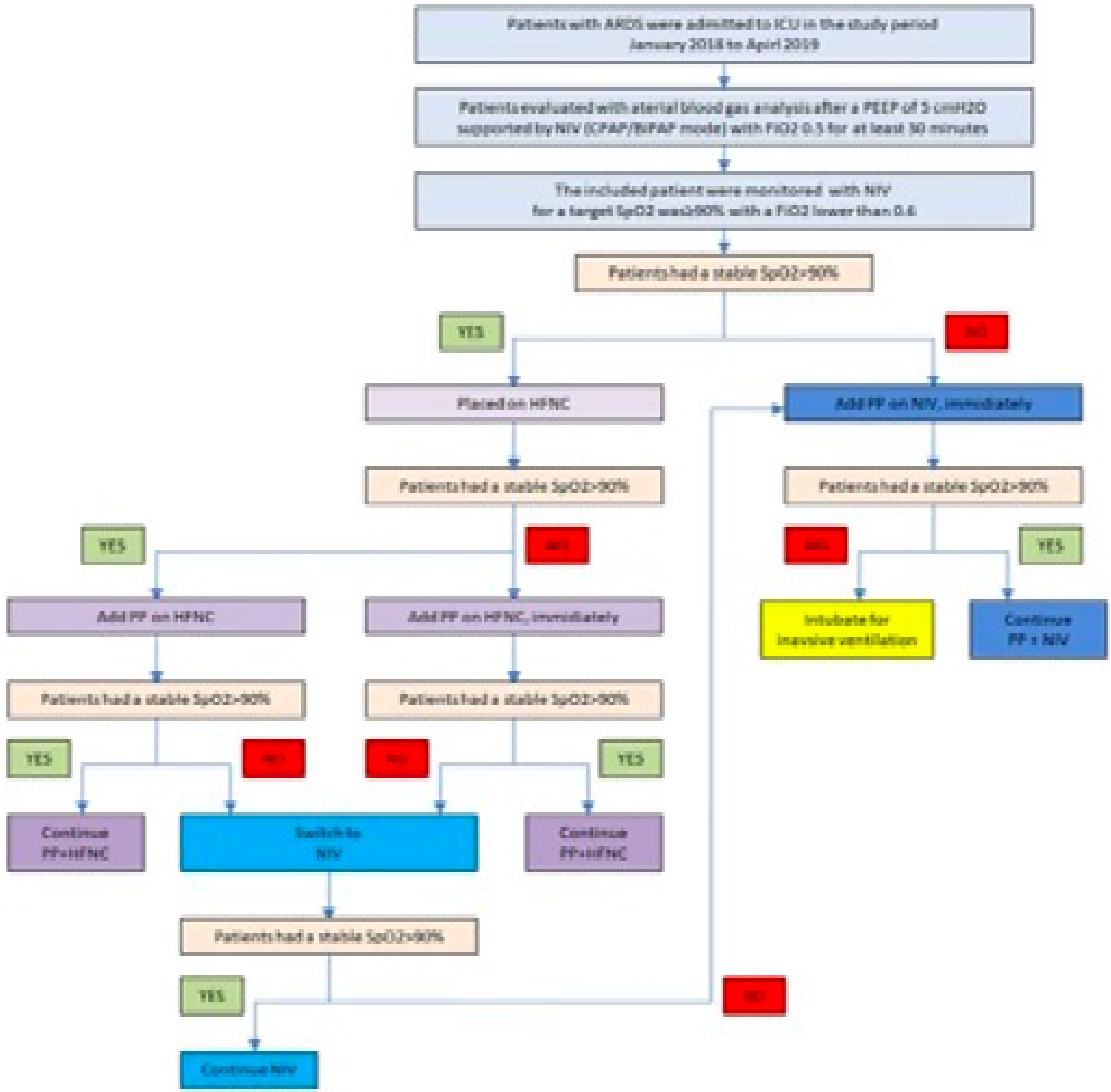
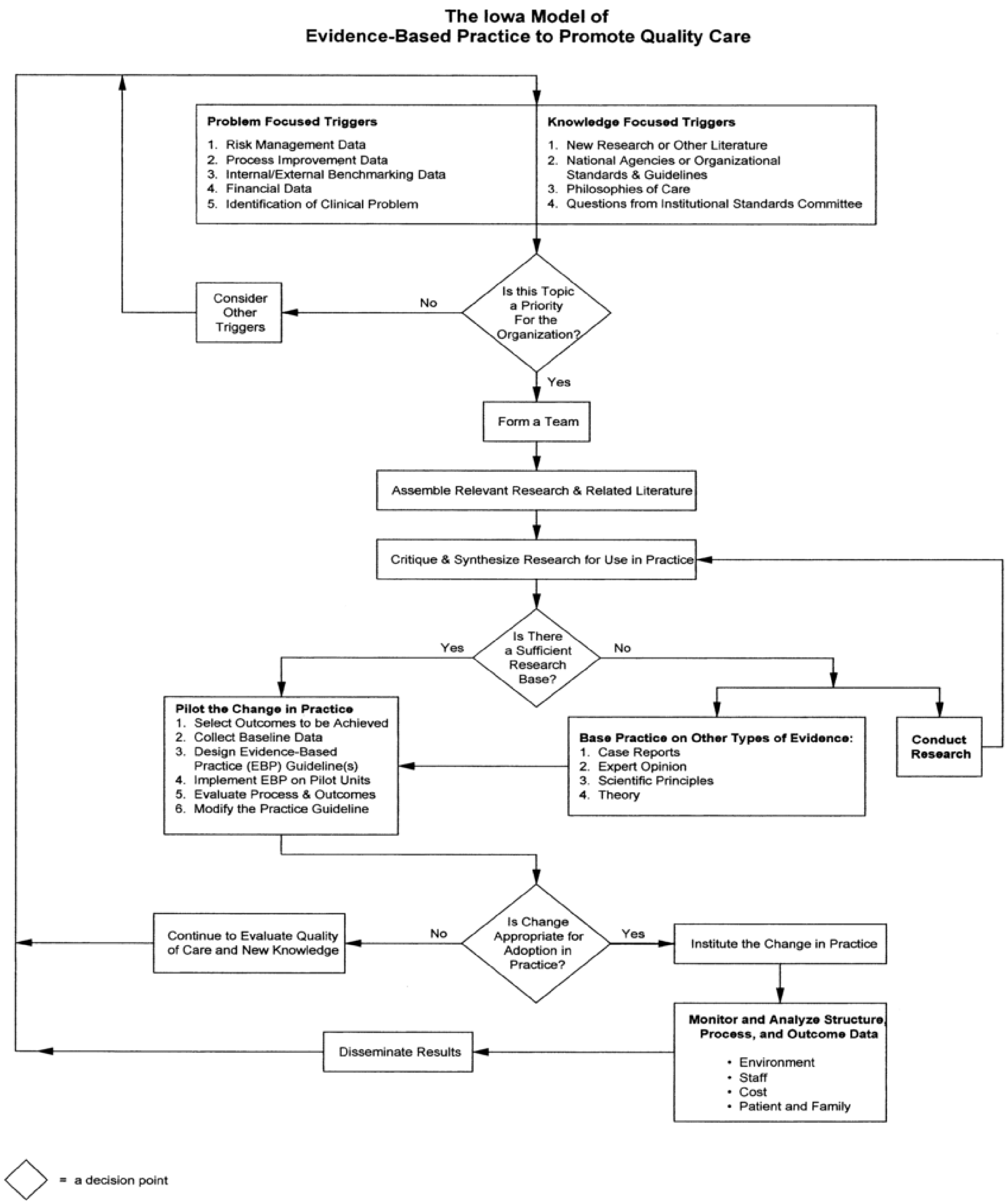
Appendix A

Recognizing Early Signs of Deteriorating Patient Condition – Algorithm


Patients with ARDS were admitted to ICU in the study period
January 2018 to April 2019
Patients evaluated with aterial blood gas analysis after a PEEP of 5 cmH2O
supported by NIV (CPAP/BiPAP mode) with FiO2 0.5 for at least 30 minutes
The included patient were monitored with NIV
for a target SpO2 was≥90% with a FiO2 lower than 0.6
Patients had a stable SpO2>90%
YES
Placed on HFNC
Add PP on NIV, immediately
Patients had a stable SpO2>90%
YES
Add PP on HFNC
Add PP on HFNC, immediately
Patients had a stable SpO2>90%
YES
Intubate for
invasive ventilation
Continue
PP + NIV
Patients had a stable SpO2>90%
Patients had a stable SpO2>90%
YES
YES
Continue
PP+HFNC
Switch to
NIV
Continue
PP+HFNC
Patients had a stable SpO2>90%
YES
Continue NIV

Appendix B

Iowa Model and Workflow



Note. From "The Iowa model of evidence-based practice to promote quality care" by M. G. Titler, C. Kleiber, B. Rakel, G. Budreau, L. Q., et al., *Critical Care Nursing Clinics of North America,13*:497-509.

Standardized Evidence-Based Workflow

Description: ● Target population: 18+ adult requiring IMU for ARF concerns or risk o Pulmonary Disorder o Neuromuscular Disorder o Elderly o Postoperative
Epic Deterioration Index (EDI) aim: ● Proactive Surveillance and Assessment ● Early Intervention ● Decrease Mortality
Who must utilize this Process? ● Physicians, NPs, RNs, RTs, PCAs
Epic Deterioration Index (EDI) Risk Scoring ● High Risk (score 60 or greater) ● Medium Risk (score 30-60) ● Low Risk (score 0-30)
Process Requirements: ● EDI score greater than or equal to 65, RN/RT must notify MD/NP ● EDI scores increase by 13 points within 35 minutes, RN/RT notify MD/NP ● EDI score must be assessed within the 1 hours of assuming care of patient and ""Mark as Reviewed"
Respiratory Inclusion Contributing Factors: ● Respiratory Rate ● Supplemental Oxygen (HFNC or NIV) ● Pulse Oximetry ● Glasgow Coma Scale ● Age ● Neurological exam ● Cardiac rhythm
(Cummings et al., 2021)

Standardized Evidence-Based Workflow: Process Step in Sequence

Process Step	Sequence	RN/RT Action
Handoff	1. At the beginning of shift the off-going RN/RT should review the EDI score with the oncoming RN/RT 2. RN/RT should priority their patient list by the highest EDI score to the lowest. 3. RN/RT should review each patient with a score of 65 or greater 4. RN/RT should review their patients who were EDI alert during previous shift 5. Mark as Reviewed with Comment if score is 65 or greater	● Assess the patient ● Review data, determine if anything change (e.g., contributing factors) ● Activate Pre-Cert ● Notify MD/NP, to implement the Evidence-Based algorithm ● Notify the Charge Nurse ● Document intervention/Action taken.
High-Risk	1. EDI score greater than or equal to 65 or score increase greater than 13; notify MD/NP immediate; Pre-Cert 2. EDI score in the high-risk range (60 or greater) RN/RT review patient's score contributors, if Respiratory contributors- Notify MD/NP for the utilization of Acute Respiratory Failure (ARF) Evidence-based algorithm 3. Document in patient record any interventions as usual 4. After patient needs addressed, review the EDI (time since reviewed column) by selecting "Mark as Reviewed"	● Assess the patient ● Review data, determine if anything change (e.g., contributing factors) ● Activate Pre-Cert ● Notify MD/NP, to implement the ARF Evidence-Based algorithm ● Notify the Charge Nurse ● Document intervention/Action taken ● Monitor patient closely ● ***IF action requires intubation or Higher Level of Care, refer to Handoff sequence.
Medium Risk	1. EDI score 30-59, RN/RT to review patient's score contributors via EDI patient list. 2. RN/RT review patient's EDI trend graph via Deterioration Accordion View; if score is increasing by 13 consecutively; Notify MD/NP for utilization of ARF evidence-based algorithm 3. Document in patient's record any interventions as usual 4. After patient needs addressed, review the EDI (time since reviewed column) by selecting "Mark as Reviewed"	● Assess the patient ● Determine what data has changed ● Notify MD/NP, if score is increasing by 13 consecutively ● Do EDI contributing factors meet criteria to implement the ARF Evidence-Based algorithm ● Notify the Charge Nurse ● Document intervention/Action taken ● Monitor patient closely ● ***IF action requires intubation or Higher Level of Care, refer to Handoff sequence.
Low Risk	1. EDI score 0-29, RN/RT to review patient's score contributors 2. Continue to monitor closely 3. RN/RT review the EDI by selecting "Mark as Reviewed"	● Assess the patient ● Determine what data has changed ● Notify MD/NP, if score is increasing by 13 consecutively ● Monitor patient closely

(Cummings et al., 2021)

Appendix C

Analysis and Appraisal of Support Literature

Authors/ Date	Study Type	Research Question/Hypothesis	Methodology	Level of Evidence	Critical Appraisal	Findings
Kendall-Gallagher et al., 2011	Cross-sectional Study	To determine the impact of nursing staff, nursing education, and work environment are associated with patient outcome.	665 US hospitals; 1.2 million patients, 40K staff nurses	III	Reliable, with no significant change in outcome.	Increase nurse-patient ratio has no effect on FTR rate in hospitals with poor working environments; best working environment had a 10% reduction in FTR
Duan et al., 2016	Prospective Observational Cohort Study	To develop and validate a scale using variables easily obtained at bedside for prediction of failure of noninvasive ventilation (NIV) in ARF hypoxemic patients.	N= 449 and 39.4% test and validation cohorts. To validate the scale, a separate group of 358 patients enrolled in the validation cohort.	II	Applicable to clinical practice	The failure rate of NIV was 47.8 and 39.4% in the test and validation cohorts, respectively. Among patients with a HACOR score of > 5 at 1 hr of NIV, mortality was lower in those received intubation < 12 of NIV.
Dziadzko et al, 2018	Observational Cohort	To determine if a risk stratification tool can identify patient at risk of death or ARF requiring mechanical ventilation with > 48 hours.	Clinical data extracted from the EHRs 2013-2015	II	? reliable, compared Modified early warning score and National Early Warning	Showed using a risk stratification can be feasible to predict real-time risk identification.

Authors/ Date	Study Type	Research Question/Hypothesis	Methodology	Level of Evidence	Critical Appraisal	Findings
					scores to the APPROVE	
Frat et al., 2015	Prospective, RCT	To determine if high-flow oxygen through a nasal cannula can offer an alternative to patients with hypoxemia	N=310 patient analyzed; study 23 ICUs in France and Belgium; multicenter trial	I	Great validity.	There was a significant difference in favor of high-flow oxygen in 90-day mortality.
Innocenti et al., 2020	Retrospective Study	To examine if early evaluation through a predictive score system could identify subjects at risk for in-hospital mortality or non-invasive ventilation (NIV)	N=644 patients	III or IV?	Very applicable to practice.	The individuals treated with NIV for ARF, (heart rate, acidosis, consciousness, oxygenation, and respiratory rate (HACOR) score was useful to identify high risk patients for in-hospital mortality.
Kane et al., 2007	Meta-analysis and Systematic Review	To examine the association between registered nurse (RN) staffing and patient outcomes in acute care hospitals	unknown	I	Reliable	Increased nurse staffing in hospitals is associated with lower FTR. It is suggested that a greater proportion of BSN degree nurse may result in lower FTR rates.
Mark et al., 2007	Retrospective cohort study	To determine whether, following implementation of California's minimum nurse legislation,	36.2 million patient discharges in 600 hospitals	IIa	Reliable, reduction in FTR 1quartile 30.7% P <	After implementation of minimum nurse staffing levels mixed effects of quality of care were found.

Authors/ Date	Study Type	Research Question/Hypothesis	Methodology	Level of Evidence	Critical Appraisal	Findings
		changes in acuity-adjusted nurse staffing and quality of care.			0.05 and 4 quartile 32.9% P < 0.05, respectively	
Marmor et al., 2021	Outcomes Cohort	To find the incidence, mortality, cost, and clinical determinants of prolonged hospitalization(pLos) among patients with ARF.	Sample data from 2004-2014 over n=5.5 million patients with ARF	III	Undetermined if applicable to practice	Showed incidence and mortality decreased among patients with ARF and pLos, but cost increased. Also, it showed a variation in pLOS by US region, hospital teaching status and patient insurance coverage.
Moriarty et al., 2014	Longitudinal	To determine the prolonged effect or rapid response team (RRT) implementation on FTR.	2 Canadian institutions	IV	reliable, reduction in FTR within a 12-month period	Reduction in FTR with a substantial increase in RRT activation
Prower et al., 2021	Retrospective Cohort Study	To describe physiological antecedents to deterioration, test the predictive validity of NEWS and compare this to the ROX index	186 patients;1/30/20 to 3/5/20 with positive results of SARs-CoV-RNA. The physiological observation and NEWS were extracted and analyzed.	III	Somewhat reliable.	NEWS may under-perform in COVID-19 due to intrinsic limitations of the design and unique pathophysiology of the disease.
Roca et al., 2016	Prospective Observat	To describe early predictors and to develop a prediction	4 years prospective observational 2 centers	II	? Reliable; some patients data	Patients with ARF and pneumonia, the ROX index can identify

Authors/ Date	Study Type	Research Question/Hypothesis	Methodology	Level of Evidence	Critical Appraisal	Findings
	ional Cohort Study	tool that accurately identifies the need for mechanical ventilation in pneumonia patients with hypoxemic ARF treated HFNC.			were extracted from previously published prospective observational study.	patients at low for HFNC failure in whom therapy can be continued after 12 hours.
Sang et al., 2020	Meta-Analysis and Systematic Review	To investigate the efficacy of respiratory methods in adults undergoing planned extubation using a Bayesian network meta-analysis.	Reviewed reference list. Study type, RCT, study population, ICU, and intervention HFNC vs. NIV, HFNC vs COT and NIV vs. COT	I	? Reliable	NIV reduces the reintubation rate in adult patients undergoing planned extubation compared with COT and HFNC
Schjorring et al., 2021	RCT	Hypothesized that using a lower target for partial pressure of arterial oxygen would result in lower mortality than using a higher target.	Randomized n=2928; multicenter trial	I	Great validity and reliable.	Adult patients with ARF with hypoxemia in the ICU, a lower oxygenation target did not result in lower mortality at 90 days.
Wakeam et al., 2014	Cross-Sectional Survey	To seek understand critical care characteristics predictive to FTR performance at the hospital level.	67 hospitals; surveyed ICU directors/managers	n/a	Reliable	Internist or Intensivist on the RRT were predictors of high performance.
Zhao et al., 2016	Meta-Analysis and	The objective was to present study to investigate whether	11 studies enrolled n= 3459 patients, (HFNC, n= 1681); only RCT	I	Reliable	Compared to COT, HFNC reduced the rate of intubation,

Authors/ Date	**Study Type**	**Research Question/Hypothesis**	**Methodology**	**Level of Evidence**	**Critical Appraisal**	**Findings**
	Systematic Review	HFNC was superior to either COT or NIV in adult ARF patients.	comparing HFNC with COT or HFNC with NIV were included.			mechanical ventilation, and the escalation of respiratory support. When compared to NIV, HFNC showed no better outcomes.

Appendix D

Institutional Ethics Committee Approval Documents

1. Facility letter

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SHamlin@HoustonMethodist.org

February 10, 2022

TO: LaTisha Wilson, APRN ACNP-BC MSN CCRN

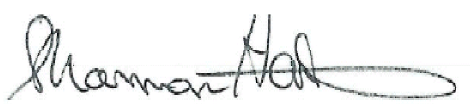
SUBJECT: HMAI Determination of Not Human Subject Research: The Evaluation of an Evidence-Based Algorithm for Patients with Acute Respiratory Failure: A Quality Improvement Project

Based on the information and protocol provided, the HMRI IRB has determined that the project referenced above does not meet the definition of Human Subject Research per 45 CFR 46 and does not require prior IRB review and approval at Houston Methodist.

Please understand that should your protocol change in any way your new protocol will need to be resubmitted for review and a new IRB determination made before any data collection can begin.

If you have any questions, do not hesitate to contact me. Best of luck on a successful quality improvement project!

Sincerely,



Shannan Hamlin, PhD, RN, AGACNP-BC, CCRN, NE-BC, FCCM
HMAI IRB Designated Member

2. University Decision Letter

TEXAS WOMAN'S
UNIVERSITY™

October 22, 2021

Latisha Wilson
Nursing – Dallas

Re: IRB Not Required for IRB-FY2022-72 "The Evaluation of an Evidence-Based Algorithm for Patients with Acute Respiratory Failure: A Quality Improvement Project"

Dear Latisha Wilson,

The above referenced project has been received by the TWU IRB – Dallas and it has been determined that this project does not require IRB review.

This project falls under quality improvement with no intent to contribute to generalizable knowledge and therefore does not need IRB review.

If you have any questions or need additional information, please contact the IRB at irb@twu.edu or refer to the IRB website.

Sincerely,

TWU IRB – Dallas

3. Human Subjects Training Certificate

CITI PROGRAM

Completion Date 28-Jul-2021
Expiration Date 27-Jul-2024
Record ID 43812082

This is to certify that:

LaTisha Wilson

Has completed the following CITI Program course:

Not valid for renewal of certification through CME.

Social & Behavioral Research - Basic/Refresher
(Curriculum Group)
Social & Behavioral Research - Basic/Refresher
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Texas Woman's University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w138b5f44-4e8b-4545-b3cd-cb36af2f61a3-43812082

Appendix E

Budget

ONE-TIME COST		**PROJECT**	**On-Going**
Staff Training	Staff (RNs and RTs)	Hourly wage	1 hour/in-service
	Breakfast	$200.00	
Total:		$200.00	
Capital Cost			
Equipment, video, utilities, conference room	cost absorbed by existing program	$0	No
Total:		$0	
On-going Cost			
Software License Fees (EWS)	cost absorbed by existing program	$0	
Total:		$0	

Appendix F

Metrics Grid

Measure of Interest	Measure or Metric Needed	Time Period for Measure (Annual, quarterly, monthly, weekly)	Type of Measure (Process, Outcome, Balancing)	Operational Definition-Denominato r	Denominator Exclusions	Operationa l Definition-Numerator	Numerato r Exclusions	Data elements needed to operationalize the measure (list each data element separately, using multiple rows)	Level of Measure Need for Data	Location of data (clinical system, survey, quality department)	Requires Permissio n from Data Owner for Use Y/N	Data owner
# Of unplanne d ICU admission s	Transfer rates from IMU to ICU	January 2019-Decembe r 2019	overall unplanne d transfer to ICU from IMU	Patient who has other reason for transfer to ICU that did not involve respiratory failure	Patients with other clinical disease/issue s that do not involve respiratory failure	The number of patients during the defined period transferred from IMU to ICU with ARF (COPD, CHF, PAH, PE, Pulmonary edema, CF, Pre-Post lung transplant, etc.)	Duplicate MRN (will count only Respirator y Failure Dx)	the number of patients transferred to ICU unplanned from IMU for ARF that required intubation/cod e blue	Count the unplanne d admission s from IMU with a Dx: ARF	EPIC/EMR	Y	HMH organization
# Of incidence where the early warning score EWS	To record the rate that Rothman Index score was not rep	January 2019-Decembe r 2019	overall unplanne d transfer to HLOC; into	transferred to ICU unplanned from the number IMU for of ARF patients that	Exclude patients without primary diagnosis of Respiratory Disorder or Failure	The number of patients during the defined period transferred from IMU to ICU	Duplicate MRN (will count only Respirator y Failure Dx)	ICU unplanned from IMU for ARF that required intubation/ code blue	Measure the data for low Rothman index	EPIC/EMR and analysis Failure to r	Y	Committee and HMH organization s

Appendix G

Group Intubation rates/Unplanned ICU transfers Crosstabulation

Count				
		ICU		Total
		0	1	
Group	1	147	4	151
	2	109	1	110
Total		256	5	261

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.025[a]	1	0.311		
Continuity Correction[b]	0.308	1	0.579		
Likelihood Ratio	1.122	1	0.290		
Fisher's Exact Test				0.401	0.299
Linear-by-Linear Association	1.021	1	0.312		
N of Valid Cases	261				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.11.

b. Computed only for a 2x2 table

Intubation rate and Unplanned ICU transfer

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.025[a]	1	0.311		
Continuity Correction[b]	0.308	1	0.579		
Likelihood Ratio	1.122	1	0.290		
Fisher's Exact Test				0.401	0.299
Linear-by-Linear Association	1.021	1	0.312		
N of Valid Cases	261				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.11.
b. Computed only for a 2x2 table

Symmetric Measures

		Value	Approximate Significance
Nominal by Nominal	Phi	-0.063	0.311
	Cramer's V	0.063	0.311
N of Valid Cases		261	

Group IMU staff compliance with EWS

Count

		RN report EWS		
		0	1	Total
Group	1	151	0	151
	2	75	35	110
Total		226	35	261

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	55.486[a]	1	0.000		
Continuity Correction[b]	52.780	1	0.000		
Likelihood Ratio	68.115	1	0.000		
Fisher's Exact Test				0.000	0.000
Linear-by-Linear Association	55.274	1	0.000		
N of Valid Cases	261				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.75.
b. Computed only for a 2x2 table

Symmetric Measures

	Value	Approximate Significance

Nominal by Nominal	Phi	0.461	0.000
	Cramer's V	0.461	0.000
N of Valid Cases		261	

Appendix H

Needs Assessment: Fishbone Diagram

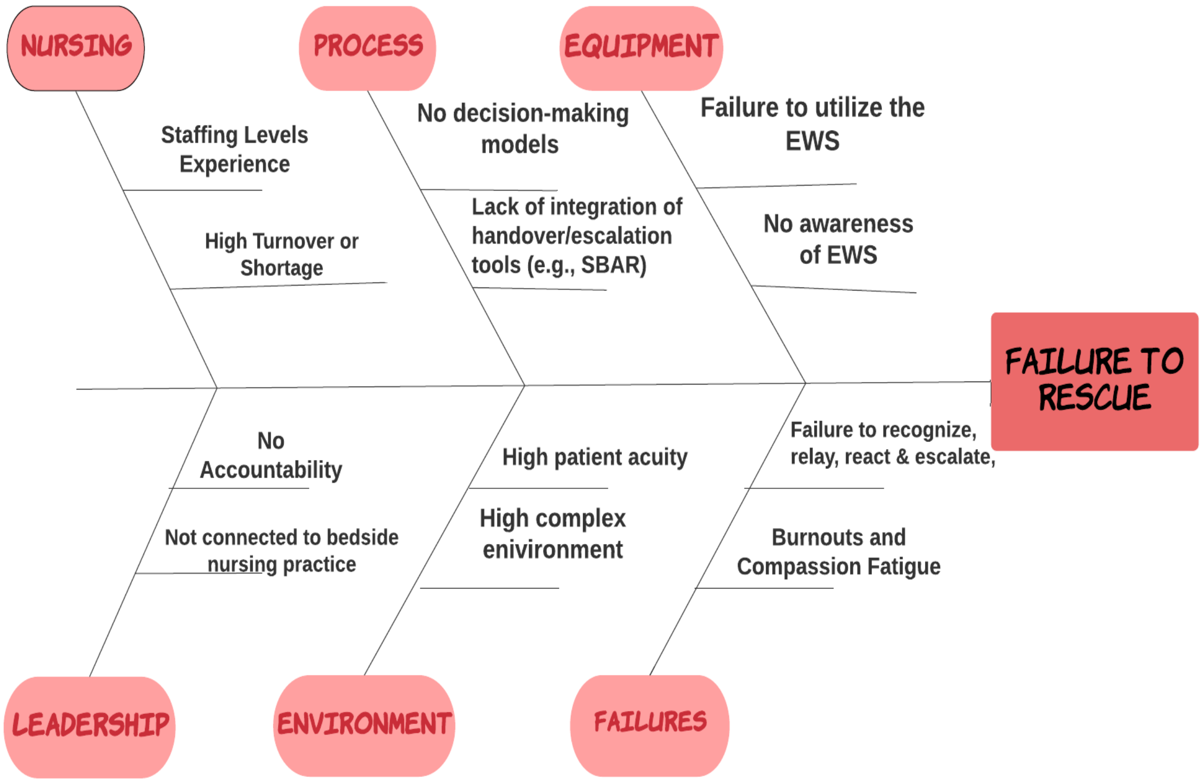


Figure 1

Intubation rates/Unplanned transfers to ICU

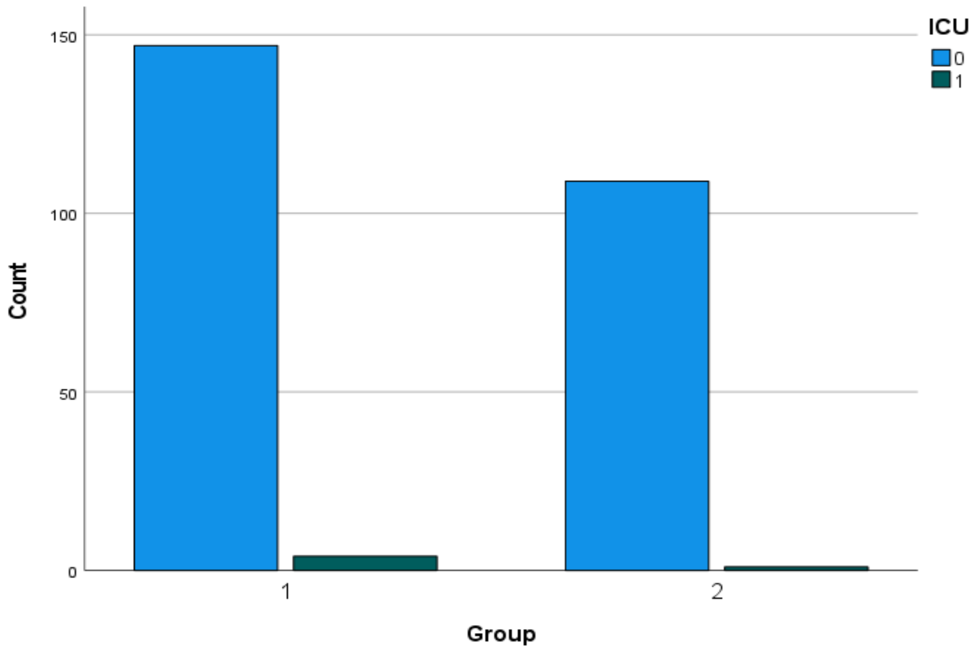


Figure 2

IMU staff compliance with reporting EWS

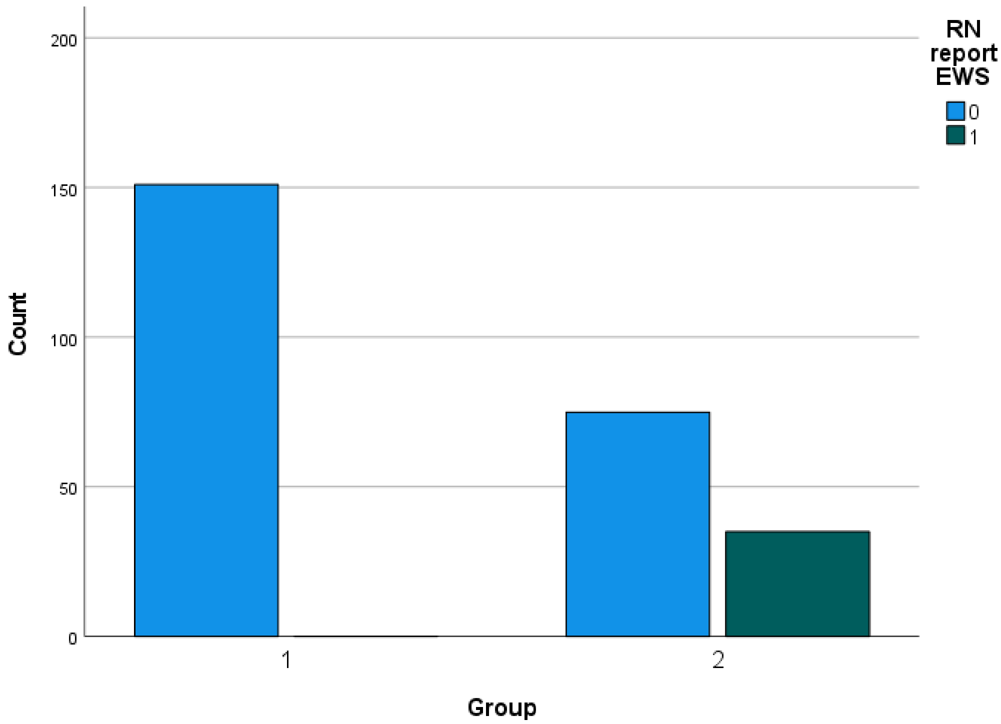


Figure 3

Weekly Run charts

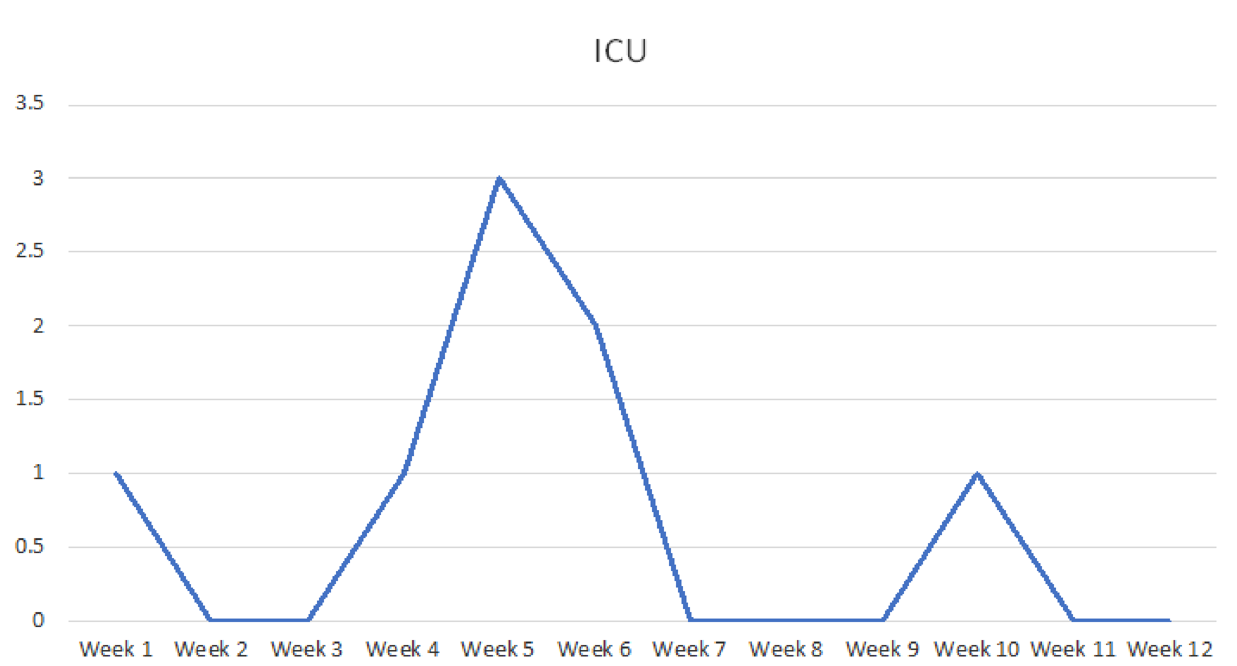


Figure 4

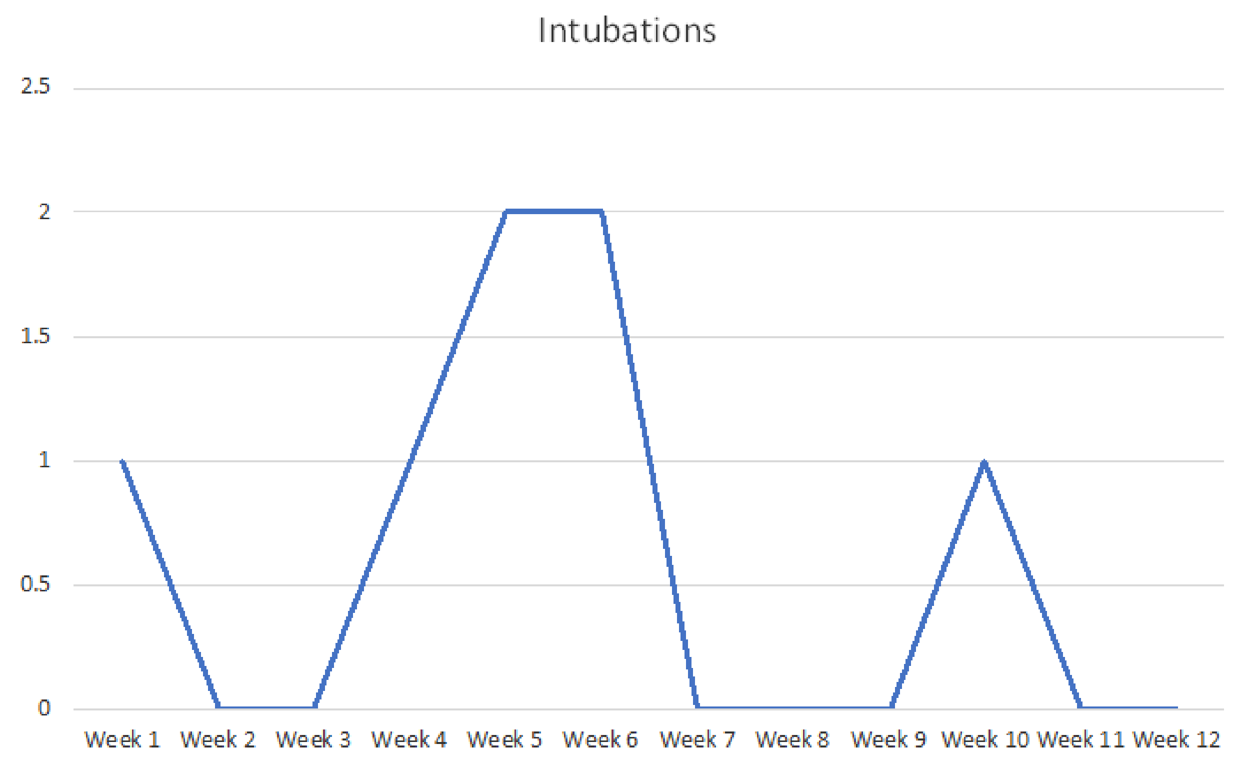

Intubations
2.5
2
1.5
1
0.5
0
Week 1 Week 2 Week 3 Week 4 Week 5 Week 6 Week 7 Week 8 Week 9 Week 10 Week 11 Week 12

Figure 5

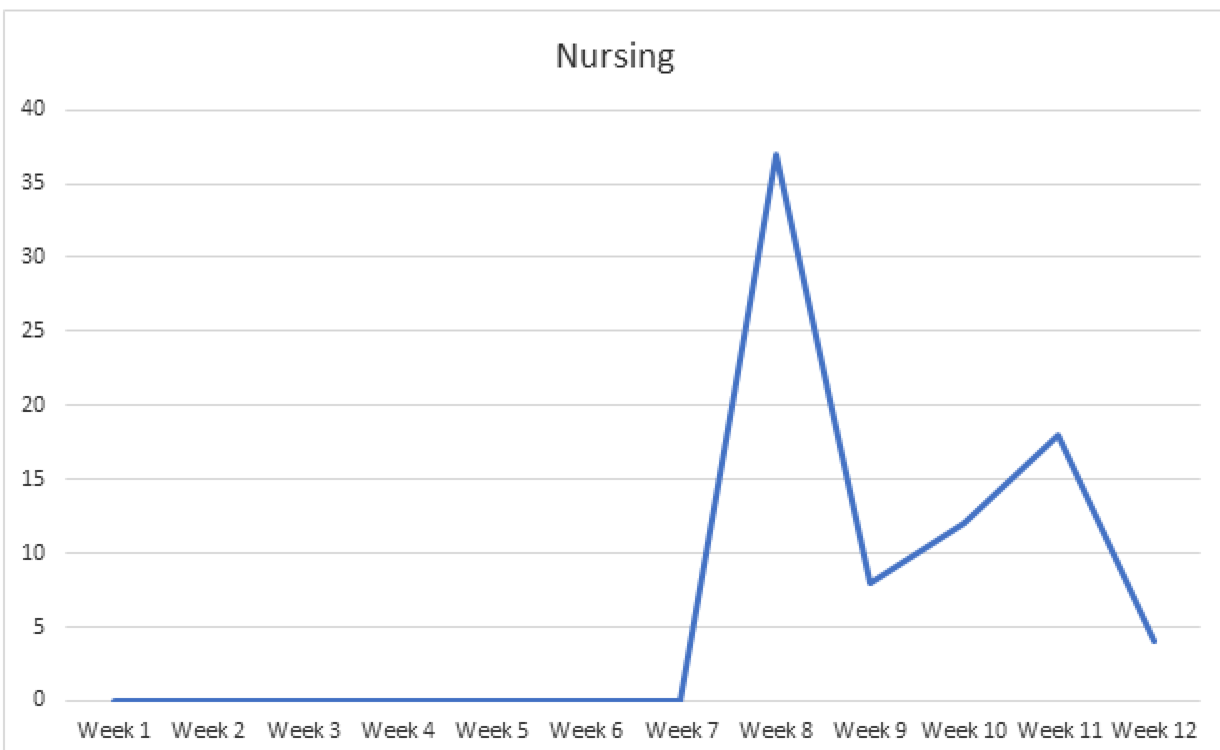
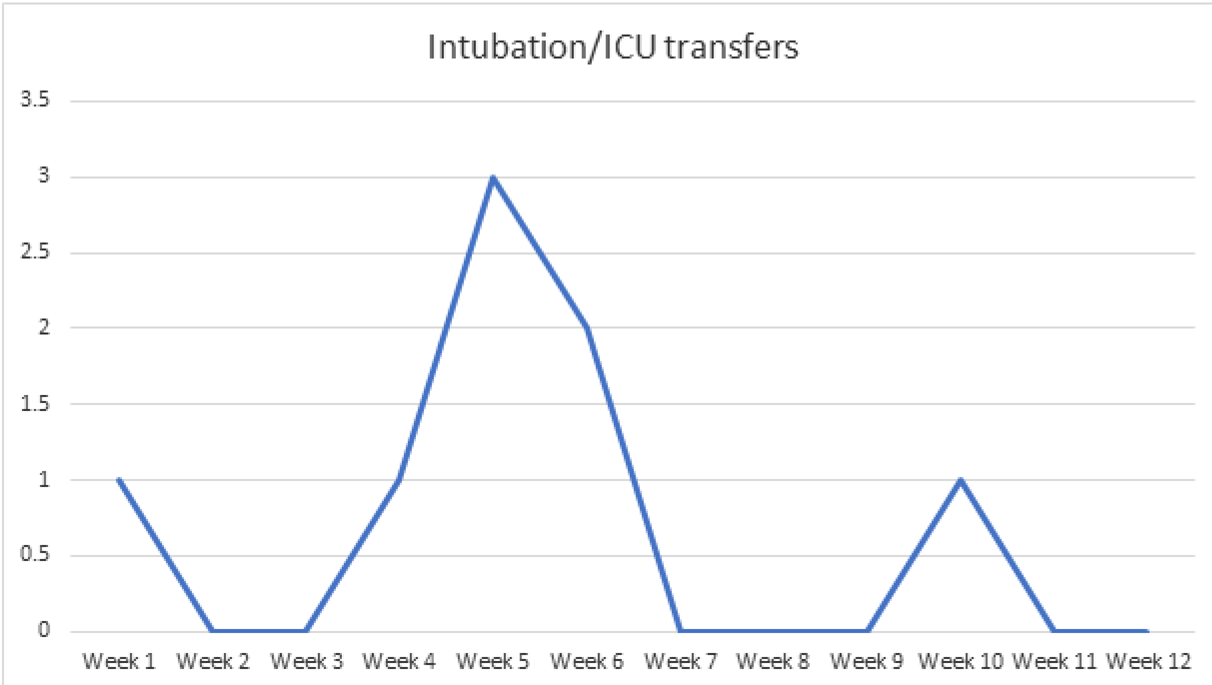

Nursing
40
35
30
25
20
15
10
5
0
Week 1 Week 2 Week 3 Week 4 Week 5 Week 6 Week 7 Week 8 Week 9 Week 10 Week 11 Week 12

Figure 6


Intubation/ICU transfers
3.5
3
2.5
2
1.5
1
0.5
0
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12