REDUCING UNPLANNED EXTUBATIONS IN THE INTENSIVE CARE UNIT WITH EVIDENCE-BASED PRACTICE RECOMMENDATIONS

by

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THE UNIVERSITY OF ARIZONA

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THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the DNP Project Committee, we certify that we have read the DNP project prepared by Lauren Amie Lebowitz, titled Reducing Unplanned Extubations in the Intensive Care Unit with Evidence-Based Practice Recommendations, and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

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Final approval and acceptance of this DNP project is contingent upon the candidate's submission of the final copies of the DNP project to the Graduate College.

I hereby certify that I have read this DNP project prepared under my direction and recommend that it be accepted as fulfilling the DNP project requirement.

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We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui. Committed to diversity and inclusion, the University strives to build sustainable relationships with sovereign Native Nations and Indigenous communities through education offerings, partnerships, and community service.

DEDICATION

This DNP project is dedicated to my love, Matthew. While this manuscript is the result of my academic endeavors, his constant presence, care, and affection have been the anchor that kept me grounded and motivated to push forward. I am grateful for his belief in me, his sacrifices, and his unwavering commitment to our relationship. His love has been the driving force that enabled me to succeed in this academic journey. Thank you, Matthew, for being my rock and my inspiration. I love you.

TABLE OF CONTENTS

TABLE OF CONTENTS – Continued

TABLE OF CONTENTS – Continued

LIST OF FIGURES

ABSTRACT

Purpose: The purpose of the quality improvement (QI) project was to analyze a deidentified dataset of unplanned extubations (UEs) events throughout Banner Health's academic hospitals in 2021, complete a literature analysis, and provide evidence-based recommendations (EBR) to Banner Health.

Background: Mechanical ventilation through endotracheal intubation is a common intervention in intensive care units (ICUs) to address acute respiratory distress. UEs lead to complications and increased healthcare costs. The incidence of UE is associated with risk factors, including patient-related factors and clinical practice gaps. Within the context of Banner Health's academic medicine division, a needs assessment found addressing UEs is crucial.

Methodology: An extensive literature search and analysis on UEs in adult ICUs was completed. Once Banner Health's RDC was approved, data analysis was completed. Data was manually tallied on a dataset recording Excel document. A formal EBR was provided to the Banner Health system to improve UE incidence.

Results: Self-extubations (SEs) significantly outweigh accidental extubations (AEs), accounting for 97% of the 70 reported events. BUMCP reported the highest number of UEs. Night shift accounted for the majority of UEs, approximately 54%, with a substantial portion occurring within two hours of shift transitions. Concerns regarding physical restraint use, sedation, and staffing were prevalent in the data. Most UEs did not require immediate reintubation; one event resulted in a patient fatality.

Conclusions: The EBR to Banner Health is that current practices be evaluated -- including nurse staffing/characteristics, pain management, sedation/agitation management, and delirium management and education be delivered to nursing staff to address the risk factors. The ICU Liberation Bundle and PADIS guidelines guide these continuous quality improvement efforts.

INTRODUCTION

Endotracheal intubation is an invasive method of respiratory support crucial in managing critically ill patients. In intensive care units (ICUs) worldwide, a third of patients receive mechanical ventilation for at least 12 hours, with an average of 1.65 million adult patients receiving mechanical ventilation each year (Berkow & Kanowitz, 2020; Li et al., 2022). Nonetheless, mechanical ventilation is associated with many potential unintended complications. These include ventilator-associated pneumonia (VAP), sepsis, acute respiratory distress syndrome (ARDS), atelectasis, pulmonary edema, ventilator-induced lung injuries, gastrointestinal complications, vocal cord injuries, and agitation (Haribhai & Mahboobi, 2022; Li et al., 2022). However, unplanned extubations (UE) are among the most often reported unintended complications in patients with artificial airways (Zhang & Liu, 2022). The growing prevalence of UEs challenges the advanced practice nurse to translate research findings to understand the risk factors of UEs among the critically ill requiring mechanical ventilation to identify strategies to reduce the occurrence of this adverse event.

Background Knowledge and Significance

Mechanical ventilation through endotracheal intubation is a common intervention performed in ICUs to decrease patients' breathing and reverse acute life-threatening respiratory acidosis and hypoxemia (Guilhermino et al., 2018). The clinical management of mechanical ventilation is the responsibility of respiratory therapists in collaboration with providers and ICU nurses (Guilhermino et al., 2018). Managing a mechanically ventilated patient is complex and dynamic and requires accurate and prompt decision-making to provide safe patient care and reduce the risk of complications. Early on, liberation from mechanical ventilation is considered

and involves a three-step process, including daily readiness testing, weaning, and extubation (Epstein, 2022). Although extubation is not typically performed until the patient is in stable condition, passes a successful weaning trail, and maintains airway protection, UEs still occur (Hyzy, 2022).

UE refers to the premature removal of the endotracheal tube by the patient (self-extubation [SE]) or during patient care (accidental extubation [AE]) (Li et al., 2022). The incidence of UEs in adults ranges widely from 0.5 to 40.2 percent, with a projected increase since the outbreak of the coronavirus disease in 2019 (COVID-19) (Berkow & Kanowitz, 2020; Li et al., 2022; Zhang & Liu, 2022). Risk factors associated with UEs include male gender, confusion or delirium, suffering from physical restraint, method and level of sedation, age, high nurse-to-patient ratios, discomfort or pain, method of tube fixation, other comorbidities, and unclear extubation plan (Li et al., 2022). Complications associated with UEs include aspiration, vocal cord injury, respiratory distress, laryngeal edema, and death (Hyzy, 2022). In addition, possible gaps in clinical practice have led to persistent UEs, including a lack of nurse awareness, decision-making capabilities, and second-victim syndrome (Lin & Wu, 2019). The effects of the second-victim syndrome on healthcare professionals can result in significant psychological distress, profound guilt, and prejudice, and further compound emotional burden and impact clinical performance (Lin & Wu, 2019).

A systematic review found that of a total of 23 studies on UE, 82 percent of reported UEs were considered SEs (Li et al., 2022). Few SEs are reintubated and occur within one day of planned extubation, while approximately 50 percent of AEs require reintubation within 12 hours (Hyzy, 2022). Furthermore, the hazards of UE to patients can increase the in-hospital mortality

rate by up to 25 percent and expose patients to difficult reintubation, prolonged mechanical ventilation, prolonged ICU stay, prolonged hospital stay, and increased healthcare-associated pneumonia (Li et al., 2022). Ultimately leading to increased healthcare costs and an estimated overall cost burden in the ICU from UEs totaling nearly $5 billion in the United States (Berkow & Kanowitz, 2020). The research on UEs underscores the need to evaluate current practice knowledge, decision-making skills, and gaps in practice to reduce the incidence of UEs and, therefore, poor patient outcomes and healthcare costs.

Local Problem

Banner Health is one of the largest nonprofit hospital systems in the country and continues to evolve rapidly (Banner Health, 2021). This Phoenix, Arizona-based health system operates 30 hospitals, including three academic medical centers (Banner Health, 2021). Joint Commission International defines an academic medical center as "a tertiary care hospital that is organizationally and administratively integrated with a medical school" (Joint Commission International, n.d.). In addition, academic medical centers conduct medical, academic, and commercial human subjects research under approved protocols (Joint Commission International, n.d.). The academic medicine division of Banner Health includes Banner University Medical Center Tucson (BUMCT), Banner University Medical Center Phoenix (BUMCP), and Banner University Medical Center South (BUMCS) (Banner Health, 2021). As a part of Banner Health Research's commitment to clinical discovery and making the healthcare experience the best possible, data analysis helps guide the health system's needs to reduce variability and minimize patient safety risks (Banner Health, 2021).

All airway and anesthesia event data between January 1, 2021, and December 31, 2021, across Banner Health hospitals revealed a need to focus on the incidence of UEs across the health system. Banner Health hospitals involved in the data analysis included 13 non-academic hospitals – 11 in Arizona, 1 in Nevada, and 1 in Colorado – and three academic hospitals – BUMCT, BUMCP, and BUMCS. Through evaluation of the data, it was apparent that event entries provided by the academic hospitals provided more thorough descriptions of events and, therefore, insight to guide the needs assessment. 421 adult (18 years and older) airway management and anesthesia events were collected during 2021. Of these reported events, about 42% (177 events) were UE, and about 45% (79 events) of the UE occurred at an academic hospital – BUMCT (21 events), BUMCP (57 events), and BUMCS (1 event). This data emphasizes the need to address UEs in Banner Health's academic hospitals to disseminate findings to the rest of the hospital system and the healthcare community.

Intended Improvement

Project Purpose

This quality improvement project aimed to analyze a deidentified data set of UE events throughout Banner Health's academic hospitals in 2021, complete a literature analysis, and provide evidence-based recommendations to reduce UEs at Banner Health.

Project Question

Will analysis of Banner Health's UEs data set among academic hospitals facilitate an evidence-based recommendation to integrate into their intensive care units?

Project Objectives

1. Complete a literature analysis on UEs in adult intensive care units.

2. Analyze Banner Health's data set on UEs in their academic hospitals in 2021.
3. Develop an evidence-based practice recommendation that addresses the barriers identified to reduce UEs in the Banner Health system.

Theoretical Framework

The theoretical framework used to guide this project is the Diffusion of Innovation (DOI) Theory, first proposed by the sociologist Everett Rogers, which examines how innovations diffuse throughout a social system or organization (Rogers, 2003). Rogers was influenced by his research on agricultural extension, which involved working with farmers to encourage them to adopt new farming practices and technologies (Rogers, 2003). Through his research, Rogers observed that adopting new ideas and technologies was not a simple, linear process but was somewhat influenced by various factors (Rogers, 2003). These factors included the innovation, the communication channels used to promote it, and the characteristics of the individuals and social systems targeted (Rogers, 2003). Rogers published his findings in the book "Diffusion of Innovations" in 1962, which became a seminal work in innovation diffusion. Since then, other scholars have further developed and refined the theory and applied it to various contexts, including healthcare, education, and technology adoption (Rogers, 2003).

Healthcare is an industry that is constantly evolving with new technologies and practices. However, the adoption of these innovations is not always straightforward. The DOI theory provides a valuable framework for understanding the factors that contribute to UEs and how to promote the adoption of strategies to prevent them. Most importantly, Roger's theory supports that the likelihood of an innovation's effective adoption relies on the degree to which innovation, communication, time, and the social system are in harmony (Rogers, 2003). The theory guided

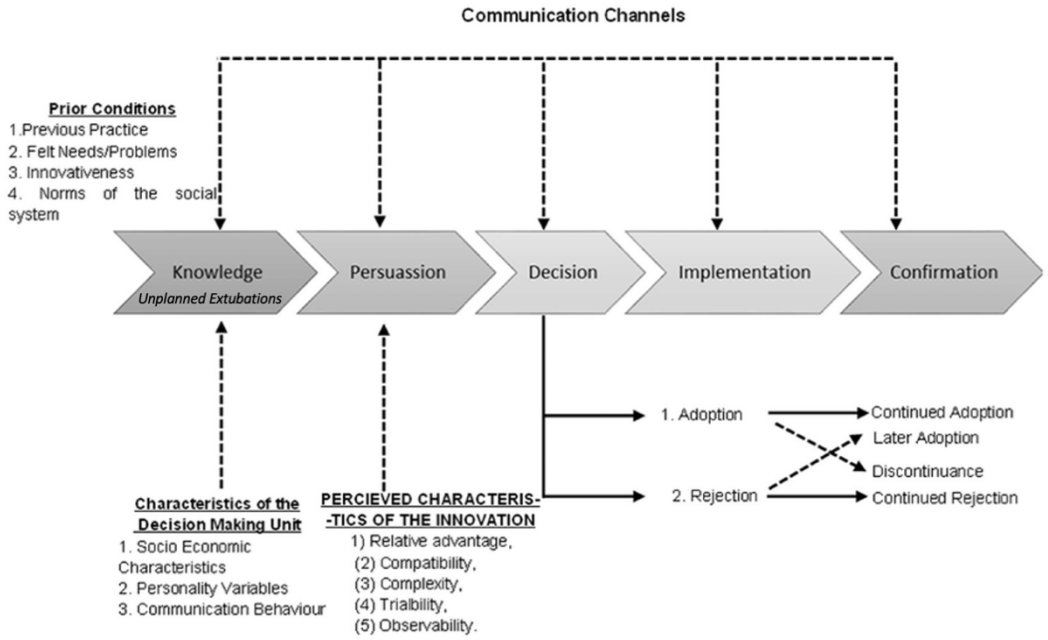
the project to clearly define an innovation and understand how the factors of communication, time, and the social system exist together. The characteristics of the strategies to reduce UEs in the Banner Health system can significantly impact their adoption. For example, strategies perceived as more effective, compatible with existing practices, and easy to use are more likely to be adopted (Rogers, 2003). In addition, effective communication channels through educational programs, training sessions, or clinical guidelines can help to build awareness of the problem of UEs and promote the adoption of preventative strategies (Rogers, 2003). When coming up with recommendations for Banner Health based on the UE data set, the DOI theory guides the decision of practical innovations into the system.

The adoption rate of preventive strategies for UEs can vary depending on the context, such that a hospital, like the Banner Health academic hospital, with an incidence of UEs may be more motivated to adopt preventive strategies than a hospital without an incidence of UEs (Rogers, 2003). Roger (2003) noted that the social system can influence innovation adoption. The characteristics of the hospital or broader healthcare system, such as the level of bureaucracy, the availability of resources, and the cultural norms, can all affect the adoption of preventive strategies for UEs (Rogers, 2003). Finally, healthcare providers, or the "adopters," may differ in their willingness to try new strategies or interventions depending on their experience level, attitudes towards risk, and belief about the efficacy of the strategies to reduce UEs (Rogers, 2003). Thus, there is a need to tailor adoption strategies for all adopter categories, including all ranges of healthcare providers, from new graduate nurses to respiratory therapists and intensivists. Overall, the Diffusion of Innovation theory can guide healthcare providers and policymakers in identifying factors that influence UEs and developing strategies to promote the

adoption of preventive strategies, reducing the incidence of UEs in Banner Health academic hospitals.

Figure 1

Innovation-Decision Process to Guide the Diffusion of Innovation to Reduce UEs



Literature Synthesis

Evidence Search

Literature analysis of UE involves examining the causes, consequences, and prevention strategies for this event. PubMed and Cumulative Index of Nursing and Allied Health Literature (CINAHL) databases were searched using key terms to identify literature relevant to this quality improvement effort. Eligibility criteria were consistent in both databases in which UEs were examined in the intensive care unit with participants over 18 years old. After screening the titles for relevance, an abstract review was conducted. The remaining articles were evaluated and included if they met the inclusion criteria.

The initial search was performed through PubMed using the MEDLINE database. Using the advanced search engine, the project coordinator identified keywords to guide the search. The Boolean operator "OR" broadened the search to include "self-extubation" *or "*unplanned extubation," and "AND" combined these terms with "intensive care." This search yielded 506 results. The filters were applied for the five-year publication date and article types, excluding books and documents, narrowing the results to 30 articles. Three of the remaining 30 articles met the inclusion criteria and were included in the literature analysis (Ai et al., 2018; Li et al., 2022; Wu et al., 2023).

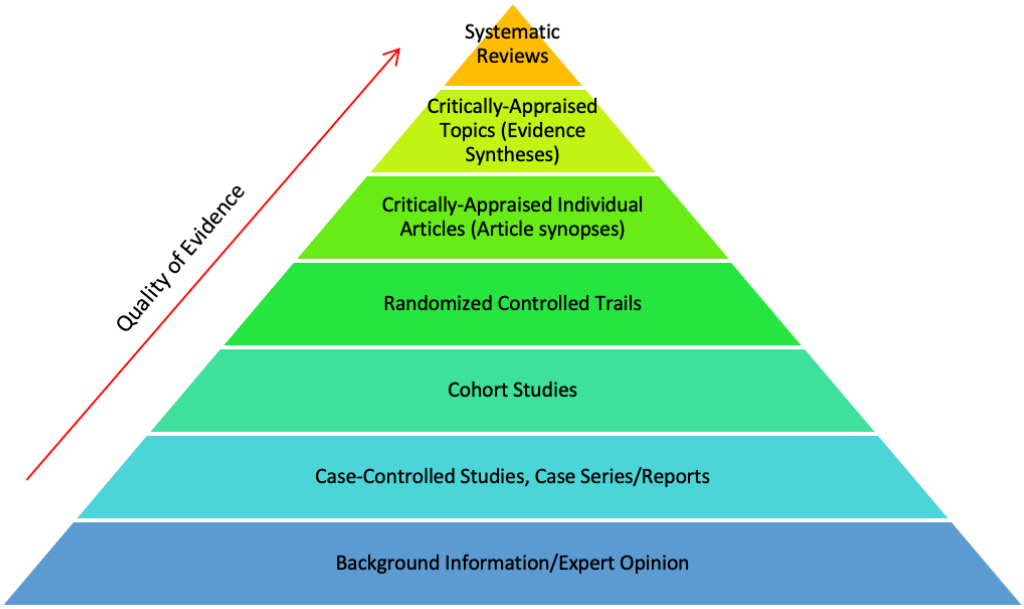
The second search was conducted in CINAHL using EBSCOhost. The advanced search option with the Boolean operator was utilized and included the terms "self-extubation," "OR," "unplanned extubation," "AND," "intensive care," "NOT "neonatal," "OR," and "pediatric." This query returned 201 results. Filters were applied, including the publication date in the last five years, academic journals, and English language, resulting in 59 articles. Articles found in the initial search were excluded; thus, of the remaining 56 articles, five articles satisfied the inclusion criteria and were included in the literature analysis (Chao et al., 2017; Gueret et al., 2020; Hur et al., 2021; Lucchini et al., 2018; Minda et al., 2022).

The methodological quality of the study designs, validity, and applicability to patient care varied among all eight articles. The eight articles ranked relatively high on the hierarchy of evidence pyramid, a visual representation used in evidence-based medicine and research to rank and organize studies and evidence based on their quality and reliability (Wallace et al., 2022). The hierarchy starts with the highest quality and most reliable evidence at the top and progresses to less reliable evidence at the bottom, as seen in Figure 2 (Wallace et al., 2022). Of eight, three

articles are systematic reviews or meta-analyses (Ai et al., 2018; Li et al., 2022; Wu et al., 2023). The remaining articles are retrospective studies, an observational study, and a case-control study (Chao et al., 2017; Gueret et al., 2020; Hur et al., 2021; Lucchini et al., 2018; Minda et al., 2022). The literature findings were derived from a wide range of evidence to provide a complete overview of the existing research on UE and are summarized in a table in Appendix D.

Figure 2

Hierarchy of Evidence



Comprehensive Appraisal of Evidence

Risk Factors Associated with UEs

The literature search revealed several risk factors associated with UEs. Five of the articles noted males having a higher risk of experiencing UEs in the adult ICUs (Ai et al., 2018; Hur et al., 2021; Li et al., 2022; Minda et al., 2022; Wu et al., 2023). Specifically, Ai et al. (2018) found

through meta-analysis that males had a statistically significant *(overall OR: 1.54, 95% CI 1.12-2.12, p=0.008)* higher risk of experiencing UEs than females. In addition, Hur et al. (2021), a retrospective study found that around three times more males than females experienced unplanned extubations *(76.6%, p < 0.001),* which can be attributed to males' larger body size and an overall increase of muscle mass (Minda et al., 2022).

Another significant risk factor noted in the literature review included Glasgow Coma Scale (GCS) scores, Acute Physiology and Chronic Health Evaluation (APACHE) II scores, and Richmond Agitation Sedation Scale (RASS) scores (Ai et al., 2018; Gueret et al., 2020; Lucchini et al., 2018; Minda et al., 2022; Wu et al., 2023). The GCS score is a neurological assessment used to evaluate patients' level of consciousness and neurological function. Two articles noted that a high GCS score, correlating to a more alert and responsive patient, has a statistically significant higher risk of UEs (p=0.008) (Ai et al., 2018; Wu et al., 2023). Minda et al. (2022), an observational study, noted a GCS of 9 in 40.4% of participants who experienced an UE. Moreover, confusion or delirium was noted as a risk factor contributing to a higher risk of UE (p < 0.00001) (Ai et al., 2018; Wu et al., 2023).

The APACHE II score assesses the severity and predicts the outcome of critically ill patients in which those with a lower score have a higher risk of experiencing UEs *(p < 0.0001)* (Ai et al., 2018). Gueret et al. (2020) explored the RASS score and its association with UEs. This case-control study found that RASS scores greater than -2, in which patients are drowsy to combative, are consistently associated with an increased risk of UEs in ICUs (Gueret et al., 2020). In Lucchini et al. (2018), the UE patients were found to have a median RASS of 0 while being sedated with propofol, midazolam, or fentanyl. Many studies found no statistically

significant correlation between specific sedation agents and UEs. Still, Gueret et al. (2020) noted that of those who experienced UEs, 34% had continuous sedation, 29% had intermittent sedation, and 37% received no sedation. These statistics emphasize the role of sedation management and enhanced monitoring of high-risk groups to reduce the incidence of UEs.

An additional factor commonly used in the ICU environment includes physical restraint as a patient safety measure. In Hur et al. (2021), a retrospective study on UEs found that a higher rate of physical restraints was used in the UE group *(61.3%, $p < 0.001$).* A factor attributed to this ironic result is physical restraints evoking delirium, discussed previously as a risk factor for UEs (Hur et al., 2021). In Wu et al. (2023), using restraints with a GCS greater than 9 increased the risk of UEs by 6.16 times, emphasizing that the intervention alone is ineffective in preventing UEs. In Ai et al. (2018), physical restraints use results in a higher risk of experiencing UEs *($p < 0.00001$),* and in a case-control study by Gueret et al. (2020) found that 87% of study participants that experienced UEs had restraints applied.

Several other risk factors are worth mentioning, although they were inconsistent in the literature review. Although the incidence of UEs is sometimes beyond the control of nursing staff, the incidence of UEs can be associated with poor nurse-to-patient ratios, lack of nurse experience, and the presence or absence of staff during extubation (Ai et al., 2018; Li et al., 2022; Minda et al., 2022). Lucchini et al. (2018) found that the incidence of UE in their retrospective study was 1.02%, at the lower end of the reported literature, expected to be due to the appropriate nurse-to-patient ratio of one nurse to two patients. Likewise, Minda et al. (2022) found that the night shift was 3.28 times more likely associated with UE occurrence due to several variables. Variables noted included staff exhaustion and staff and patient biological

sleep-awake dysregulation (Minda et al., 2022). Tube fixation is another factor noted among several articles with a notable lack of standardization and evidence (Chao et al., 2017; Gueret et al., 2020; Li et al., 2022; Wu et al., 2023). In the case-control study by Gueret et al. (2020), a higher positioned endotracheal tube tip to the carina distance increased the risk of self-extubation, possibly due to less excursion for removal and the position of the cuff triggering the Widdicombe cough receptors leading to more-intense irritation. These findings support recognizing risk factors in critically ill mechanically ventilated patients to reduce UE incidence.

Reintubation Rates

UEs are associated with a high risk of reintubation to adequately support and maintain proper ventilation (Lucchini et al., 2018). Unfortunately, reintubation following a UE is strongly associated with increased hospital expenses, ventilation days, and ICU length of stay (Lucchini et al., 2018). Between 2% to 90% of patients with UE require reintubation within the first hour, 0% to 63% of SEs, and up to 100% of AEs (Gueret et al., 2020; Hur et al., 2021; Lucchini et al., 2018). On the other hand, Lucchini et al. (2018) state that 71% of the patients who experienced UEs were not reintubated and only required respiratory support of an oxygen reservoir mask (4%), venturi mask (46%), and a helmet CPAP (46%). Although a large percentage are successful, oxygenation failure is the most common cause of UE failure (62% to 64.7%), followed by unstable hemodynamics (14.3%), secretions (12.6%), airway obstruction (12.7%), and encephalopathy (2.4%) (Chao et al., 2017; Gueret et al., 2020). The literature suggests that although reintubation rates are variable, reintubation is avoidable if clinicians are vigilant in reducing SEs and appropriately extubate when patients are ready.

Current Preventative Measures to UEs

The literature for current preventative measures for UEs in adult ICUs is limited but has been adapted from the pediatric population. Continuous quality improvement has proven an effective way to reduce UEs (Chao et al., 2017; Wu et al., 2023). Chao et al. (2017), a retrospective study over 15 years, approached UEs through continuing improvement interventions. The interventions resulted in a significant change in the trend analysis of UEs ($p < 0.0001$) and decreased UEs from 6.82/100 ventilated patients in 2001 to 0.95/100 ventilated patients in 2015 (Chao et al., 2017).

Interventions to reduce the incidence of UEs include standardizing procedures, improving communication skills, revising sedation and weaning protocols, changing strategies for restraints, establishing a task force for identifying and managing high-risk patients, encouraging accountability without assigning blame, and new endotracheal tube securing methods (Chao et al., 2017; Wu et al., 2023). Although noted earlier that physical restraints are associated with a higher risk of UE, a retrospective study found that appropriate physician-led restraint use and education can help reduce the rate of UE (Chao et al., 2017). In addition, setting up a task force for addressing UEs and using recording systems for real-time analysis can reduce UEs through understanding process improvement and increasing staff awareness (Chao et al., 2017). The findings of the retrospective studies to reduce UEs over several years indicate that a multidisciplinary quality improvement program is beneficial to reducing the incidence of UEs.

Strengths and Weaknesses of Evidence

While completing the search for evidence on UEs in intensive care units, the research findings were carefully evaluated for quality through understanding the validity, relevance,

consistency, and bias. Three studies involved in the literature analysis included systematic reviews and meta-analyses. These studies were comprehensive to identify all relevant studies to include all available evidence on UEs. Explicit and predefined methods for selecting studies, extracting data, and analyzing results helped to minimize bias and ensure transparency and consistency. These studies provided a rigorous and comprehensive approach to synthesizing and summarizing the available evidence on UEs in intensive care units to inform practice and policy decisions. Moreover, retrospective studies were included, which look back to analyze UE data already collected over time, rather than one instance or setting data collection. The retrospective studies allowed for the analysis of UEs from a more significant number of patients and reduced selection bias. Finally, observational studies were included, which allowed for identifying multiple potential risk factors and insights into UEs. All the evidence included in the literature analysis ranks high on the hierarchy of evidence, ensuring the relative strength of the evidence.

Unfortunately, although the studies were considered high on the hierarchy of evidence, there were still weaknesses. Although the systematic reviews and meta-analysis provide a comprehensive approach, small sample sizes were noted (Ai et al., 2018; Li et al., 2022; Wu et al., 2023). Small sample sizes can reduce statistical power, increase the risk of bias, increase variability, and limit generalizability (Biau et al., 2008). More extensive studies are warranted to identify risk factors and outcomes more precisely. In the systematic reviews, high heterogeneity was noted due to the potential of case-mix variations, follow-up protocols, staffing ratios, varying implementation of preventative interventions, and availability of resources (Ai et al., 2018; Lin & Wu, 2019; Wu et al., 2023). In addition, some of the studies did not adequately control for or noted confounding factors. In Minda et al. (2022), data were collected during the

COVID-19 pandemic, in which patients with COVID-19 were excluded, but confounding factors related to the pandemic were not noted. Failing to control these factors can result in spurious associations. Another weakness noted was the lack of a standardized definition of UEs, resulting in data being excluded and making it challenging to compare studies and synthesize findings. Psychological care for ET intubated patients is essential. However, the studies that note this care lack specificity and are not clinically actionable (Chao et al., 2017; Lucchini et al., 2018; Wu et al., 2023). Finally, due to limited evidence available on UEs in the adult population, the evidence provided a limited scope due to the small sample sizes and single-institution studies that may not represent the larger population. Larger samples and multi-center studies are needed to explore the association of UEs in patients older than 18 years old in intensive care units more comprehensively.

Gaps and Limitations

Various issues limit the evidence on UEs. The first factor is that there is no universally accepted definition for unplanned extubations leading to variations in the incidence, risk factors, and outcomes. In addition, it may be challenging to pinpoint particular risk factors and generalize findings across various patient groups due to the considerable variation in age, comorbidities, understanding of illness, and other factors among individuals at risk for UEs. There is a deluge of evidence for UEs in neonatal and pediatric intensive care environments. At the same time, there is a shortage of data for UEs in the adult intensive care environment.

Moreover, a uniform reporting system for UEs is also lacking, which may make it challenging to compare rates, outcomes, and confounding factors across different healthcare settings. These limitations highlight the gaps in research and practice related to UEs in the adult

population. Further research is needed to understand the various interventions on this quality indicator.

METHODS

Project Design

The design of this DNP project is a quality improvement (QI) effort that addresses UEs at this Arizona-based hospital system. QI projects strive to establish standard processes and structures to decrease variability, attain predictable outcomes, and enhance outcomes for patients, healthcare systems, and organizations (Centers for Medicare & Medicaid Services, 2021). An extensive literature search and analysis were completed to attain these aspects of the QI project. A data set regarding UEs in the academic medicine division of Banner Health, including BUMCT, BUMCP, and BUMCS, was analyzed. Finally, a formal evidence-based recommendation was formed to provide to the Banner Health system to improve the incidence of UEs.

Model for Implementation

This DNP project was guided by the Institute for Healthcare Improvement (IHI) Model for Improvement. This quality improvement framework provides a structured approach to improving healthcare processes and outcomes (IHI, 2023). The model consists of two parts. First, the three fundamental questions include: What are we trying to accomplish? How will we know that a change is an improvement? What change can we make that will result in improvement? (IHI, 2023).

Plan-Do-Study-Act (PDSA) Cycle

Second, the Plan-Do-Study-Act (PDSA) cycle, a low-risk four-stage iterative problem-solving approach that enables teams to test and refine changes on a small scale before implementing them more broadly (IHI, 2023). The four stages lay a framework for establishing a plan, implementing the plan, analyzing the data, and refining the change based on what was learned. The Model of Improvement guided this project to achieve the project's desired objectives previously noted.

Plan

The planning phase included developing a plan in which objectives are identified, predictions of outcomes are clearly stated, and tasks are assigned (Christoff, 2018). The Director of Nursing Research at Banner Health, Dr. Karen Johnson, Ph.D., RN, FAAN, obtained the data set of all airways events through Banner Health's event entry system, Verge. The complete data set included all airways management and anesthesia events during 2021 in the Banner Health systems – encompassing 16 hospitals. Dr. Johnson organized all the UE event data for 2021 on an Excel sheet with filters and categories noted in the event entry system. All data were deidentified to comply with the HIPAA Privacy Rule Standard for De-Identification and sent to the DNP project coordinator as a password-protected Excel Spreadsheet. The project coordinator stored the password-protected Excel Spreadsheet on a password-protected personal laptop. The project coordinator organized the data through filters to focus on the academic medicine division of Banner Health, including three Arizona hospitals. Project objectives were established and consisted of analyzing the data set, completing a literature analysis on UEs in adult ICUs, and

developing an evidence-based practice recommendation that addresses the barriers identified to reduce UEs.

Do

In this stage, the plan is carried out, and relevant data is documented that identifies the successes, problems, or unexpected outcomes (Christoff, 2018). At this point, a literature review and analysis were conducted to examine the causes, consequences, and prevention strategies for UEs in the adult ICU. PubMed and CINAHL databases were searched using key terms and criteria to find relevant, high-quality literature. Refer to the Appendix D for the Literature Review Grid.

Study

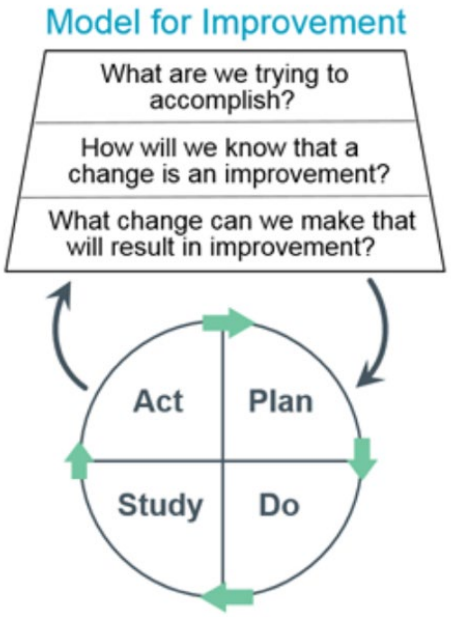
During the study phase, the project coordinator analyzed the data collected and identified areas for improvement (Christoff, 2018). The data set on UEs in 2021 that occurred at the academic hospitals, BUMCT, BUMCP, and BUMCS, was analyzed to determine areas for improvement and themes throughout. Results were compared to those predicted and previous learnings from the literature analysis.

Act

In the Act stage, the improvement team used the results from the previous stage to refine the change and implement it more widely (Christoff, 2018). Analysis of the literature and the data set informed the project coordinator to develop an evidence-based practice recommendation to provide to Banner Health to reduce the incidence of UEs in adult ICUs.

Figure 3

The Model for Improvement: Three Questions and PDSA Cycle



(Adapted from *Model for Improvement,* by the Institute for Healthcare Improvement, retrieved from http://www.ihi.org/resources/Pages/HowtoImprove/default.aspx, Copyright 2022).

Setting and Stakeholders

The setting of this QI project took place at the academic medicine division of Banner Health, including BUMCT, BUMCP, and BUMCS. The hospitals are affiliated with leading medical schools and research institutions and provide advanced medical care, education, and research (Banner, 2021). Among the three academic hospitals are 1,566 beds – BUMCP (755 beds), BUMCT (649 beds), and BUMCS (162 beds) (Banner, 2021). BUMCP is the flagship academic medical center for Banner Health located in downtown Phoenix, Arizona, and has four adult ICUs – Cardiovascular ICU, Neuro ICU, Medical ICU, and Surgical/Trauma ICU (Banner, 2021). In addition, two medical ICUs are intermittently open depending on the census. BUMCT

is located in Tucson, Arizona, and is a teaching hospital for the University of Arizona College of Medicine. It consists of four adult ICUs – Cardiovascular ICU, Neuro ICU, Medical ICU, and Surgical/Trauma ICU (Banner, 2021). Finally, BUMCS is located in Tucson, Arizona, and has one 12-bed adult ICU – Medical ICU.

This QI project involved several stakeholders in providing engagement and collaboration to ensure sustainable, impactful, and patient-centered improvements for UEs within the healthcare system. Key stakeholders for the QI project were Banner Health, Banner Health's Nursing Research Department, and the adult ICUs at BUMCP, BUMCT, and BUMCS. Successfully implementing the proposed practice recommendation depends heavily on the stakeholders' support, approval, and buy-in.

Planning the Intervention

The identification of the practice gap commenced in June 2022 with an intended completion date of December 2023 (Appendix B). The identified clinical problem was presented by the Director of Nursing Research at Banner Health, who offered the project team a valuable data set on UEs from 2020 to 2022 at Banner Health hospitals. A site authorization letter was obtained (Appendix C). The project team focused on the data set from January 1, 2021, to December 31, 2021, in the academic division at Banner Health, including three hospitals – BUMCP, BUMCT, and BUMCS. A literature search was conducted on UEs in adult ICUs, and relevant articles were compiled to complete an extensive literature analysis (Appendix D). In coordination with the project team, the project coordinator obtained the required approval from the Research Determination Committee (RDC) at Banner Health Research. After obtaining RDC

approval, the project coordinator analyzed the data set and prepared an evidence-based practice recommendation for Banner Health.

Participants and Recruitment

Banner Health provided the data set on UEs, which was drawn from Banner Health's event reporting system, Verge, by the Nursing Research Department. Banner Health Nursing Research Department permitted the use of the data set (Appendix A). Event reporting systems are frequently used for voluntary patient safety event reporting that relies on those involved in events to provide detailed information (Agency for Healthcare Research and Quality [AHRQ], 2019). Reports come from frontline personnel directly involved in an event to provide passive surveillance for near misses or unsafe conditions (AHRQ, 2019). The data set includes the ICU units, nurses, nurse managers, and deidentified patients.

Consent and Ethical Considerations

Data collected through event reporting systems can provide valuable insights into areas where improvements can be made, such as reducing UEs in the ICU. Employees and patients are guaranteed confidentiality when reports are submitted to voluntary event reporting systems (Fukami et al., 2020). However, ethical considerations must be considered when using event reporting system data from Banner Health. *Beneficence* is often understood as an obligation to promote patients' health and well-being and provide care that maximizes benefits and minimizes harm (Office for Human Research Protections [OHRP], 2018). Similarly, *non-maleficence* is an ethical principle encompassing the obligation not to inflict harm (Resnik, 2018). The primary goal of using this data set from Banner Health's event reporting system for the QI project was to

improve patient outcomes and cause no harm. However, considerations were made to ensure the data was used to benefit the patients and the healthcare system.

Several steps were taken to safeguard this beneficence and non-maleficence. First, privacy and confidentiality were maintained through data deidentification by Banner Health, proper data storage, and restricted access to authorized project committee members only. In addition, all components of the QI project went through a review by the project committee and Banner Health's RDC to ensure the project aligns with ethical guidelines. Finally, although the data set included many UE events, avoiding bias is critical. The bias in the data can be influenced by under-reporting or over-reporting events, subjective data input, and differences in reporting between hospitals, which can affect the analysis or conclusions drawn from the data (Fukami et al., 2020). The project team recognized the bias present in the data and noted them in the limitations.

Data Collection

The Banner Health Nursing Research Department completed the data collection for the data set. Data was derived through Banner Health's event reporting system, Verge, where employees are encouraged to report events to improve patient outcomes and ensure safety. Banner Health Nursing Research Department placed the data in an Excel document and included column headings based on the questions prompted in the event reporting system. Banner Health Nursing Research Department deidentified the Excel document to ensure HIPAA Privacy Rule Standard for De-Identification compliance. The password-protected Excel document was sent to the project coordinator. The project coordinator was responsible for safely storing the Excel document on a password-protected personal laptop and synthesizing the data set.

Data Analysis

Once Banner Health's RDC was approved, data analysis was completed on a password-protected Excel document provided by Banner Health Nursing Research Department. Twenty-one column headings organize the data, and the project coordinator applied filters to synthesize the data further. The data was filtered to include data from January 2021 to December 2021. Next, a filter was placed on the column heading "Organization" to include the academic divisions of Banner Health – BUMCP, BUMCT, and BUMCS. The "Age range at event date" filter excluded patients younger than 18 to focus on the adult population. The final filter under the column heading "Location of the event" ensured a focus on the ICUs at Banner Health, excluding Emergency Departments. Following data filtering through Excel, the project coordinator manually sifted through the remaining events to analyze the data set tallying events on the Banner Health Unplanned Extubation Data Set Recording on Excel (Appendix C). Events were manually tallied into the categories of self-extubation, accidental extubation, occurrence on day shift, occurrence on night shift, event occurrence within 2 hours of shift change, physical restraint concern, sedation concern, staffing concern, reintubation required, and no reintubation needed. The project coordinator summarized the data analysis findings and included them in the final DNP project paper in the Results and Discussion sections. Analyzing the data set assisted the project coordinator in uncovering critical themes to inform an evidence-based practice recommendation to provide to Banner Health.

RESULTS

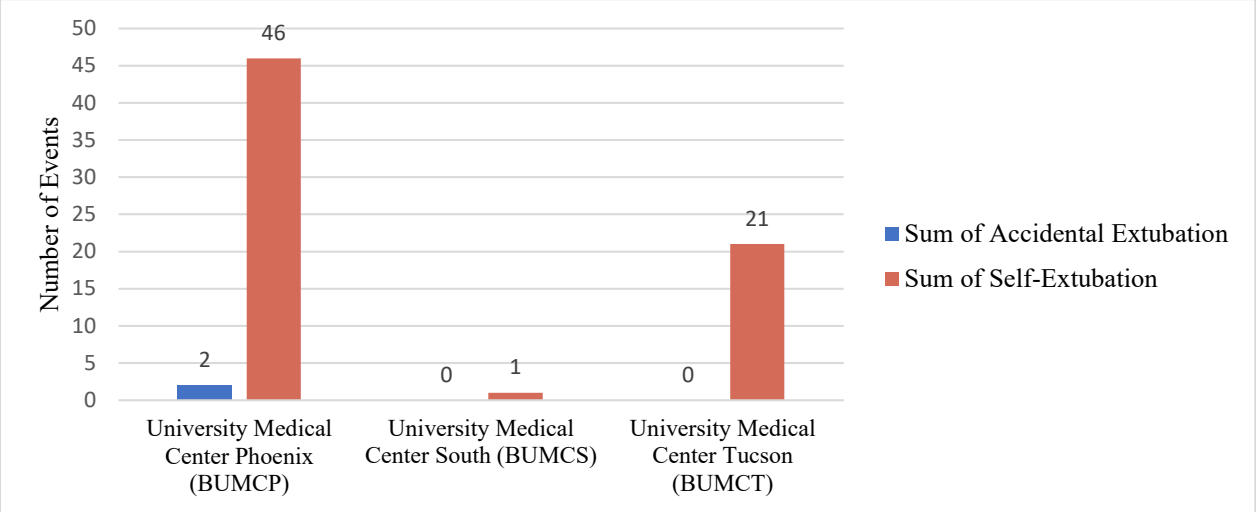
Banner Health's 2021 UE Data Set Analysis

Self-Extubations vs. Accidental Extubations

The data set results about UEs at Banner academic hospitals reveal a striking pattern, seen in Figure 4. In the data analysis, events were classified as self-extubations (SEs) when there was a premature removal of the endotracheal tube by the patient and accidental extubations (AEs) with the premature removal of the endotracheal tube during patient care (Li et al., 2022). Among the 70 total reported events, a staggering 68 of them were self-extubations, while only two were accidental extubations. This data underscores a critical finding: approximately 97% of the reported events were self-extubation. BUMCP is the only hospital that reported two AEs, in which both occurred while the patient was stretching their arms and got caught when lowering. BUMCS and BUMCT did not report any such incidents. BUMCP also had the highest number of UEs with 46 recorded events, followed by BUMCT with 21 UEs and BUMCS with just one. This variation in both the frequency of UEs and the presence of AEs among the different Banner academic hospitals emphasizes possible hospital-specific strategies and protocols to report such events and address patient safety.

Figure 4

Self-Extubation vs. Accidental-Extubation Events in 2021 at Each Banner Health Academic Hospital



Shift Occurrence of Unplanned Extubations

The dataset analysis aiming to assess UE occurrence during different shifts and within two hours of shift changes across the three academic hospitals reveals some compelling insights. Among the total reported occurrences, the night shift (1900-0700) accounted for the highest number of incidents, totaling 38 events, which constitutes approximately 54% of the total (Figure 5). Day shift (0700-1900) UEs were responsible for 32 events, making up about 46% of the total. Interestingly, a substantial proportion of these incidents, 33 in total, transpired within two hours before or after shift changes, occurring at 0700 or 1900, representing approximately 47% of the total occurrences.

Indeed, when examining the individual academic hospitals within Banner Health's academic division, the trend of UE occurrences appears to be consistent (Figure 6). At BUMCP, approximately 54% (26 events) occurred during the night shift, while 46% (22 events) occurred

during the day shift. Additionally, 46% (22 events) occurred within two hours of shift changes. Similarly, at BUMCT, the night shift experienced a higher occurrence rate, with 57% (12 events), while 43% (9 events) happened during the day shift, and 48% (10 events) within two hours of shift changes. BUMCS, with limited data, reported only one UE during the day shift, making it an outlier. This data suggests that specific challenges or factors may be associated with night shifts and shift transitions that contribute to a higher frequency of UEs.

Figure 5

Totals of Shift Occurrences of UEs in 2021 at Banner Health Academic Hospitals

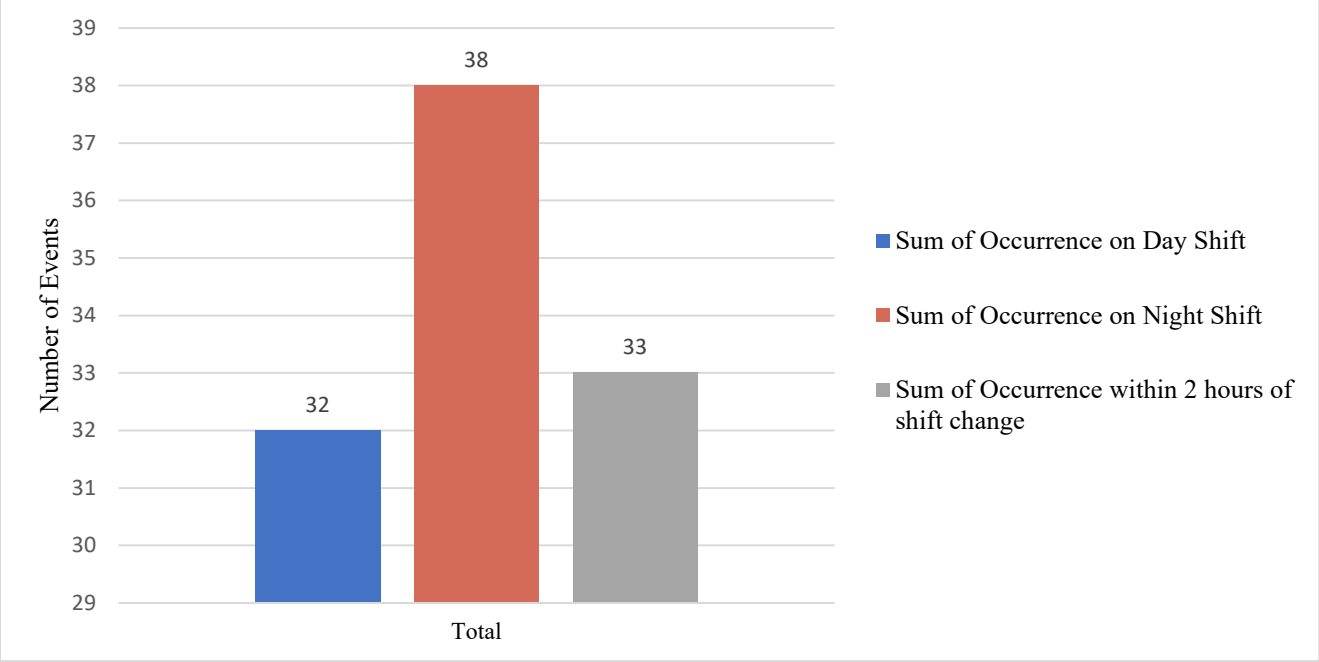
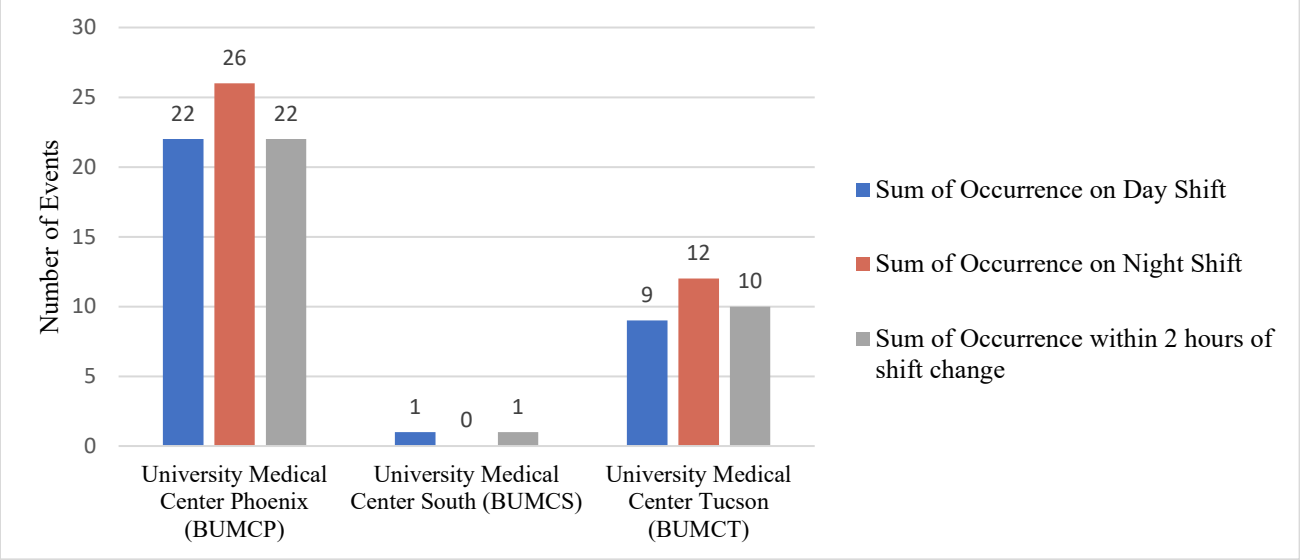


Figure 6

Shift Occurrences of UEs in 2021 at Each Banner Health Academic Hospital



Concerns Regarding Physical Restraint Use, Sedation, Staffing

The analysis of the data set of UEs at Banner Health's academic hospitals included focusing on concerns surrounding physical restraint use, sedation, and staffing (Figure 7 & Figure 8). The events qualified as a physical restraint use concern had to mention the use of physical restraints or lack in the event log. Physical restraints mentioned in the data set included hand mittens and soft wrist restraints. The examination of these events uncovered recurring themes. The most common theme included patients found to be wearing hand mittens bilaterally or unilaterally as the sole form of restraint. Other themes included cases where there was a failure to prevent UEs despite the use of soft wrist restraints, situations where restraints were not employed due to patient cooperation or agitation, shortages of soft restraints on the unit, and challenges in obtaining restraint orders from providers. Remarkably, out of the 70 UE events,

83% exhibited concerns related to physical restraint use, with 39 events occurring at BUMCP and 19 at BUMCT. At the same time, none met the qualification criteria at BUMCS.

In analyzing the data set, an important focus emerged regarding sedation concerns. The event logs with a sedation concern referenced concepts related to sedations, encompassing the use of sedation medication and the Richmond Agitation-Sedation Scale (RASS). The examination of these events unveiled several prominent themes. Inconsistencies in charting RASS scores were recurring issues, leading to discrepancies in determining whether patients were adequately sedated. Additionally, there were instances where no sedation was administered, often due to external factors not listed in the event logs. Notably, UEs occurred during sedation weaning in preparation for spontaneous breathing trials (SBT) or spontaneous awakening trials (SAT). Among the total of 70 events, 69% (48 events) met the criteria for sedation concerns, with 35 events at BUMCP and 13 at BUMCT. No events met the BUMCS criteria due to one logged event with limited detail.

Staffing concern appeared to be another critical area of focus when analyzing the data set. Staffing concerns were determined by event logs mentioning the absence of staff during the UE. Several key themes were uncovered in this context. Notably, registered nurses (RNs) were frequently unavailable in the patient's rooms at the time of the UE, often because they were attending to other patients or stationed at the nurse's station when the event occurred. The event log highlighted a delay in responding to ventilator alarms due to the patient being on airborne precautions, requiring the donning of personal protective equipment (PPE). Out of the total 70 UE events, 33 events, representing 47% of the events, met the criteria for staffing concerns. These concerns were particularly prevalent at BUMCP, with 35 events, and BUMCT, with 13

events. Conversely, the single UE at BUMCS did not provide sufficient detail to meet the criteria for staffing concerns.

Figure 7

Totals of Concerns Related to UEs in 2021 at Banner Health Academic Hospitals

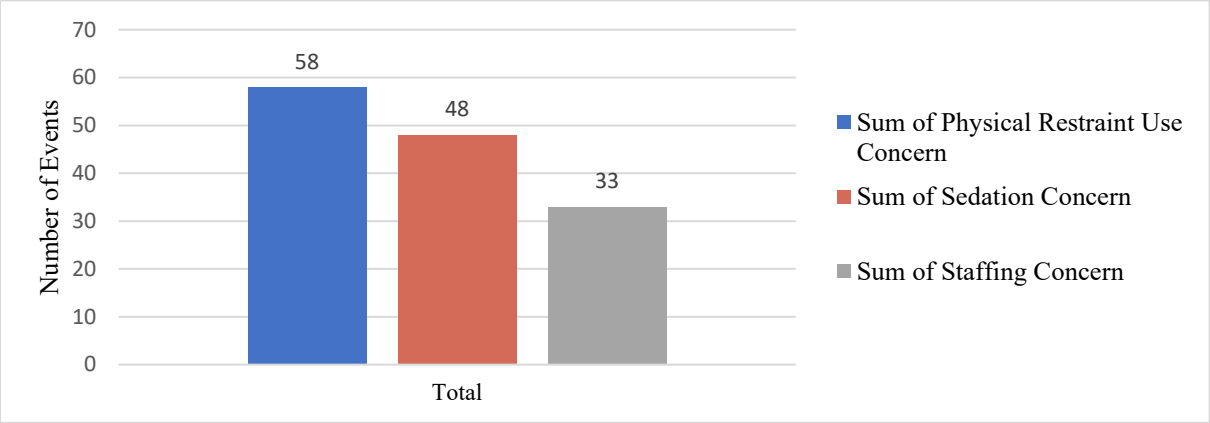
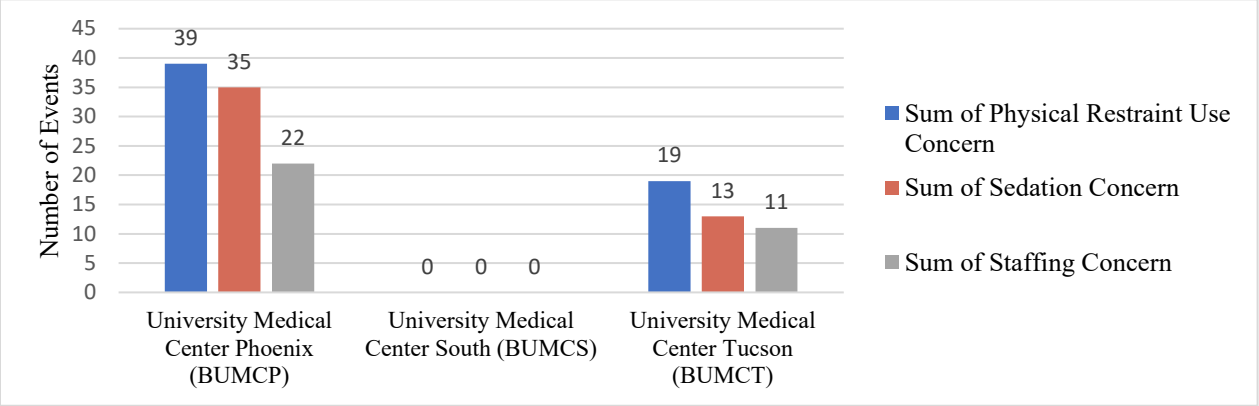


Figure 8

Concerns Related to UEs in 2021 at Each Banner Health Academic Hospital



Reintubation Rates

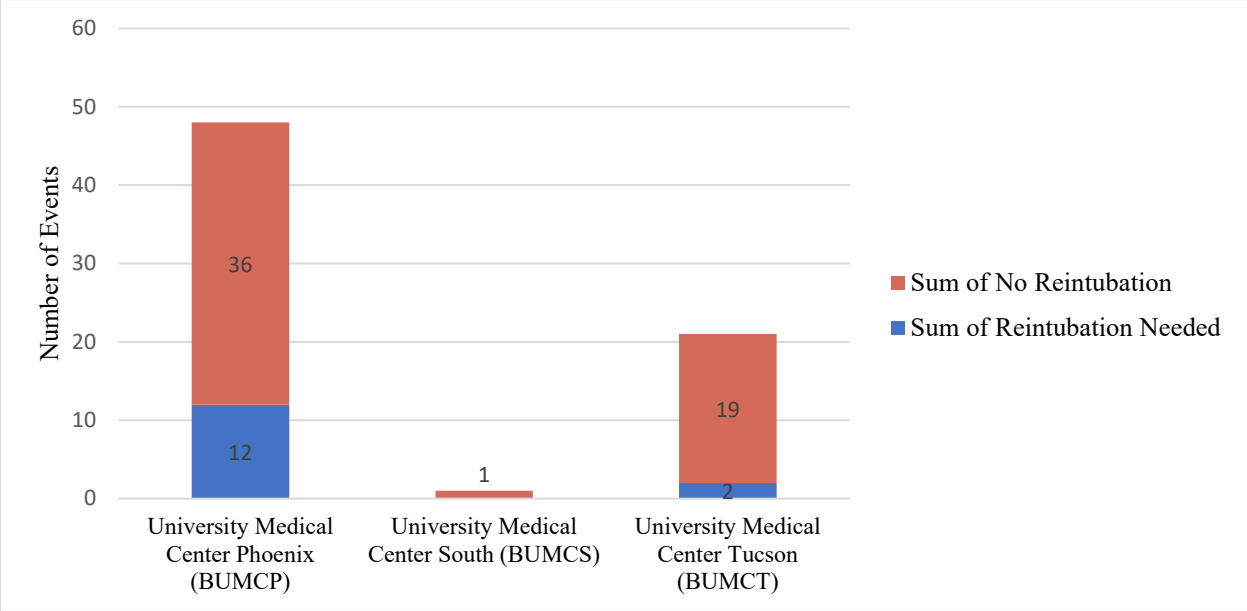
In analyzing UEs across Banner Health's academic hospitals, the need for reintubation was a factor to consider. The criteria for determining the need for reintubation were based on whether the event logs explicitly mentioned reintubation; cases without such mentions were

categorized as not requiring reintubation. Figure 10 illustrates that among all the UE events at the academic hospitals, 14 UE required reintubation, while 54 UE did not necessitate or mention it in the event log.

Specifically, at BUMCP, out of 48 UE events, 12 instances necessitated reintubation. It is essential to note that 2 of the UE events were AEs, which did not require reintubation (Figure 9). Therefore, the reintubation rate at BUMCP in 2021 following a UE was approximately 25%. In contrast, in BUMCT, only 2 UE events required reintubation. In comparison, the remaining 19 UE events did not (Figure 9), resulting in a reintubation rate at BUMCT in 2021 following an UE of approximately 10%. Unfortunately, the event at BUMCS lacked sufficient detail for adequate analysis and was marked as not requiring or mentioning reintubation.

Figure 9

Reintubation Rates with UEs in 2021 at Each Banner Health Academic Hospital



Summary of Academic Hospital UE Data Set

The analysis of UE data in 2021 across Banner Health's academic hospitals – BUMCP, BUMCT, and BUMCS – revealed several compelling trends and patterns. Figure 4 showcased that SEs far outnumbered AEs, with 68 SEs compared to just two AEs among the 70 reported events. This data underscores that approximately 97% of the events were SEs. It's worth noting that BUMCP reported two AEs, making it the sole hospital with such occurrences. BUMCS had a single UE-reported event in 2021 that did not provide sufficient detail and did not meet the criteria for most categories. BUMCP reported the highest number of UEs at 48 events, BUMCT at 21 events, and BUMCS with just one UE event, which may reflect varying event log entry cultures and recording practices among these academic hospitals' ICUs. Although there are varying events in each hospital, each hospital showed consistent trends.

Figure 5 demonstrated that night shifts were associated with the highest number of incidents among the shift occurrences of UEs, representing 54% of total UEs, while day shifts accounted for 46% of UEs. Additionally, 47% of UEs occurred within two hours before or after shift changes, emphasizing the vulnerability during these transitional periods. Figures 7 and 8 highlighted physical restrain use, sedation, and staffing concerns. In particular, physical restraint concerns were prevalent, with 83% of UEs presenting these concerns. Sedation concerns were also noteworthy, with 69% of events demonstrating inconsistencies in overall sedation management. Finally, staffing concerns affect 47% of UEs, indicating a need to explore staffing practices and guidelines to enhance patient safety at Banner Health's academic centers.

Regarding reintubation rates (Figure 10), it was evident that most UEs did not require reintubation when the event log was entered. Notably, one UE event across all hospitals resulted

in a patient death related to a PEA arrest without return of ROSC, underscoring the significance of preventing UEs.

In conclusion, this comprehensive analysis of UEs in 2021 across Banner Health's academic hospitals provides valuable insights into the prevalence of SEs, AEs, shift-related occurrences, concerns regarding physical restraint use, sedation concerns, staffing, and reintubation rates. All UE data are summarized in Figure 10 and Figure 11.

Figure 10

Summary of UE Data Set from 2021 at Banner Health Academic Hospitals

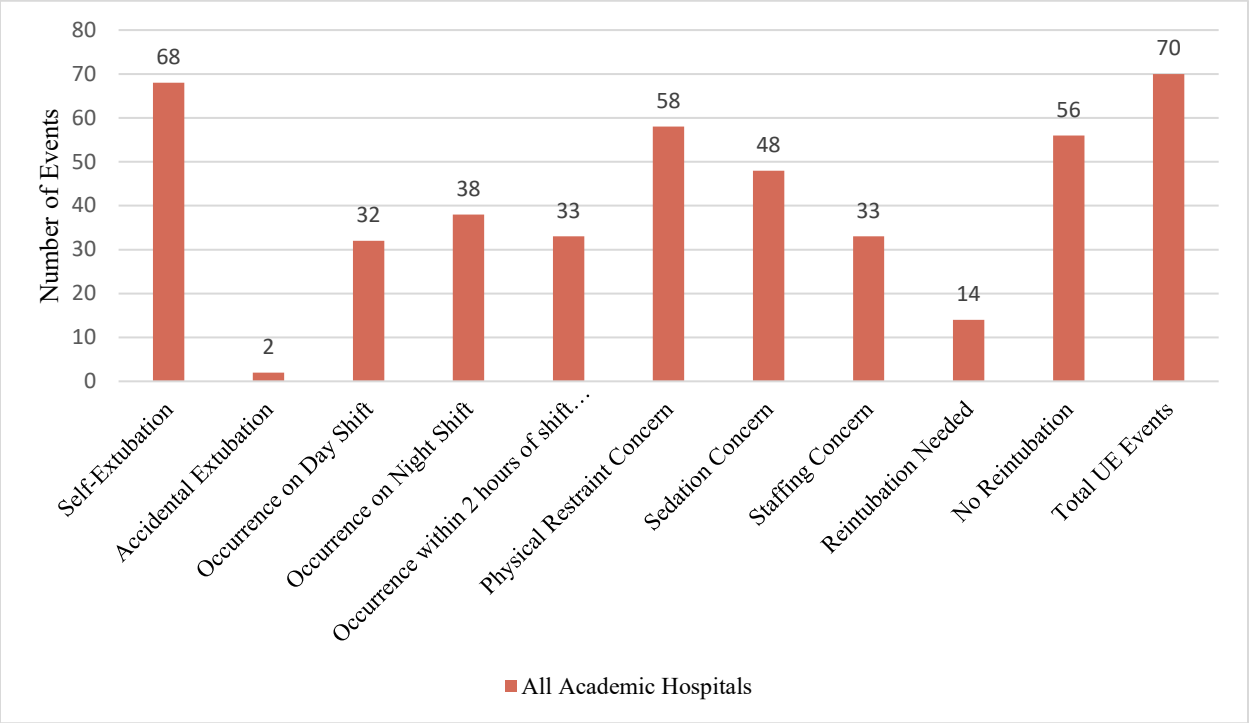
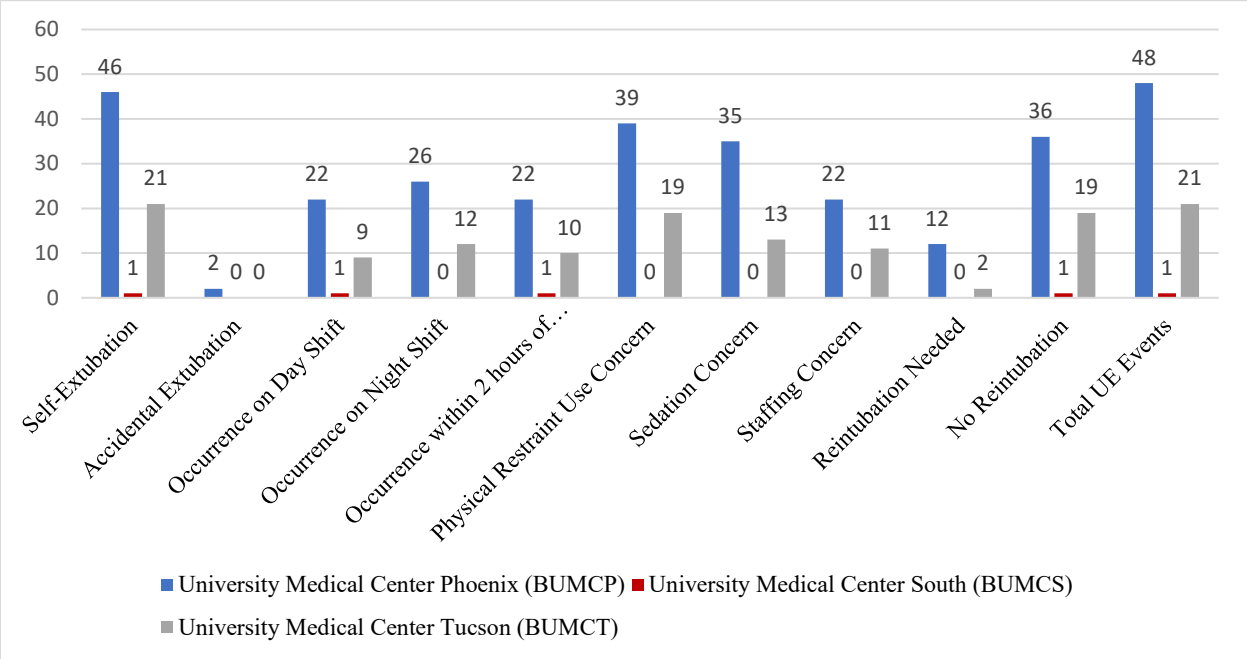


Figure 11

Summary of UE Data Set from 2021 at Each Banner Health Academic Hospital



Outcomes

The outcome of the DNP project, entailing the comprehensive analysis of Banner Health's Academic Division 2021 UE dataset, aims to furnish an evidence-based recommendation for the amelioration of UEs. A multifaceted, multidisciplinary strategy is recommended to tackle this challenge, particularly emphasizing identifying and mitigating risk factors associated with UEs. These risk factors encompass unmodifiable elements such as advanced age and male gender, alongside predominantly modifiable variables, notably those related to sedation, physical restraint use, and staffing/nursing characteristics (Ai et al., 2018). The path toward improvement necessitates a commitment to continuous quality improvement, in which a study by Chao et al. (2017) has illuminated the efficacy of continued quality improvement in this context that resulted in a significant reduction in UEs.

Evidence-Based Recommendations for Staffing and Nursing Characteristics

Variations in nursing care significantly impact the frequency of UEs. Extensive research consistently demonstrates that the level of nursing experience directly influences the occurrence of UEs, with an average critical care experience of 15.3 months associated with UEs (Anis et al., 2023). In addition, factors such as nursing workload and the nurse-to-patient ratio have been widely acknowledge as substantial risk factors for UEs (Anis et al., 2023). Lucchini et al. (2000) found that a nurse-to-patient ratio of 1:3 increases the risk of UEs, while a nurse-to-patient ratio of 1:2 or 1:1 improves outcomes related to UEs because healthcare providers can spend more time at the bedside. Although the dataset did not include such detail on the event logs regarding nurse experience and nurse-to-patient ratio, approximately 47% of UE events included staffing concerns. These events met the criteria for staffing concerns if the nurse was not present at the time of the UE, and most noted, the nurse occupied another patient room at the time of the event.

Notably, these UEs transpired during the zenith of the Coronavirus Disease 2019 (COVID-19) pandemic, a period characterized by nationwide staffing shortages and elevated nurse workloads. This situation was exacerbated by new graduate nurses and non-specialized nurses deployed to the ICU to assist, further amplifying the challenges. Regardless, studies done outside of the pandemic have shown that adding one extra nurse per patient day can result in a notable 51% reduction in UE rates, which reducing nursing workload can yield a substantial 45% decrease (Anis et al., 2023).

The timing of patient care throughout the day has been shown by studies and the data set as a significant contributor. UE occurrences are more frequent during nighttime shifts and shift changes when no nurse is at the bedside (Anis et al., 2023). Factors contributing to the higher

incidence of night shift include nursing load, experience, effects of shift work, and exhaustion or vigilance level to biological sleep-wake cycle (Anis et al., 2023). The nighttime effect on patients can also precipitate agitation or delirium (Anis et al., 2023). All factors related to staffing and nurse characteristics discussed above lead the project coordinator to make the formal recommendations below:

1. As part of new graduate orientation, educate new graduate nurses on risk factors associated with UEs.
2. Evaluate current staffing practices to ensure proper nurse-to-patient ratios and workload guided by evidence.
3. Explore strategies from supportive staff, such as certified nurse assistants, to assist in shift change surveillance of patients at high risk for UEs.

Evidence-Based Recommendations for Pain, Agitation/Sedation, and Delirium

A compelling pattern has emerged throughout this project, revealing a direct connection between insufficient sedation, patient agitation, and using physical restraints with an elevated risk of UEs (Anis et al., 2023; Ai et al., 2020). Physical restraints have been associated with a 3.1 times increased risk for UEs and have not been shown to prevent UEs (Anis et al., 2023). The elevated risk of UEs associated with restraint usage is more likely influenced by the presence of delirium, agitation, or inadequate sedation, as opposed to the result of agitation caused by the restraint (Anis et al, 2023). Delirium often results in heightened agitation, making patients more prone to inadvertently dislodging their endotracheal tube (Anis et al., 2023). Furthermore, untreated or inadequately managed pain and sedation can exacerbate this scenario, compelling patients to make forceful attempts to alleviate their discomfort and dislodge their endotracheal

tube. The recognition of these associations underscores the significance of robust sedation, delirium, and pain management and education that can be addressed with the implementation of the ICU Liberation Bundle (Appendix G), created by the Society of Critical Care Medicine (SCCM, 2020).

The ICU Liberation Bundle's adoption and integration into clinical practice offer healthcare practitioners a structured approach toward instigating a continuous quality improvement initiative to mitigate the incidence of UEs (SCCM, 2020). The ICU Liberation Bundle encompasses assessing and managing pain, spontaneous awakening and breathing trials, choice of analgesia and sedation, delirium assessment and prevention, early mobility and exercise, and family engagement/empowerment. It stands out as a comprehensive strategy to address UE risks (SCCM, 2020). Within the ICU Liberation Bundle, the 2018 Pain, Agitation/Sedation, Delirium, Immobility, and Sleep (PADIS) Guidelines provide a roadmap for developing evidence-based guidelines to be implemented through the bundle (Devlin et al., 2018). Evidence-based recommendations adapted from the ICU Liberation Bundle and PADIS Guideline for managing pain, agitation/sedation, and delirium to reduce UEs will be discussed further.

Effective pain management is a multifaceted challenge. Despite the communication limitations in this population, the patient's pain experience remains valid and necessitates appropriate management. Implementing assessment-driven and standardized pain management protocols has enhanced ICU outcomes and clinical practice (Devlin et al., 2018). Notably, carefully titrating analgesic dosages is crucial for balancing the advantages and potential risks associated with opioid exposure. PADIS suggests that protocol-based pain and sedation

assessment and management can reduce sedative requirements and pain intensity (Devlin et al., 2018).

Barriers to pain management and prevention include a lack of staff education, formal training on using appropriate assessment tools, and access to appropriate nonpharmacological strategies (SCCM, 2022). Therefore, this project recommends providing nursing staff with the proper education and training on pain management, including medications, age-appropriate assessment tools, and nonpharmacological strategies. The implementation team needs to evaluate current practices when developing the educational strategy.

For patients who can communicate effectively, various validated pain assessment tools are available, including the visual analog scale (VAS), the numeric rating scale (NRS), and the verbal rating scale (VRS) (Pandharipande & Hayhurst, 2023). Conversely, for semi-conscious or non-communicative patients, it is imperative not to assume the absence of pain. In such cases, validated tools are essential. Notably, the Behavioral Pain Scale and the Critical Care Pain Observation Tool have exhibited excellent validity and reliability (Devlin et al., 2018; Pandharipande & Hayhurst, 2023). In addition, it is essential to recognize that vital sign perturbations alone are not conclusive indicators of pain in critically ill adults. They should only prompt further assessment using these validated methods (Pandharipande & Hayhurst, 2023).

In critically ill patients, pain alleviation is predominantly accomplished with rapid onset and rapid recovery analgesic drugs. Opioids persist as a fundamental component of pain management in critically ill patients, endorsed by the PADIS guidelines (Devlin et al., 2018; Pandharipande & Hayhurst, 2023). However, these guidelines emphasize the prudent use of opioids at the lowest effective doses, and therefore, a multimodal approach is typically advocated

(Devlin et al., 2018; Pandharipande & Hayhurst, 2023). The comprehensive approach encompasses opioids, nonopioid intravenous agents like acetaminophen and ketamine, neuropathic pain medications, nonselective anti-inflammatory drugs (NSAIDs), nefopam, regional anesthesia, and adjunct therapies (Devlin et al., 2018; Pandharipande & Hayhurst, 2023).

Sedation strategies and the level of consciousness have been shown to impact the risk of UE, with lower sedation levels or restlessness increasing risk (Anis et al., 2023). As noted, the intricate interplay of pain and sedation factors in intubated patients can contribute to restlessness, elevating the risk of UEs. Therefore, the Society of Critical Care Medicine (SCCM) recommends a practice known as analgosedation, which encompasses two distinct approaches: the analgesia-first strategy and the analgesia-based approach (Devlin et al., 2018; Pandharipande & Hayhurst, 2023).

The analgesia-first strategy emphasizes assessing and addressing pain, typically administering opioids before sedatives (Pandharipande & Hayhurst, 2023). Conversely, the analgesia-based approach involves the utilization of opioids to achieve the desired level of sedation, effectively minimizing the need for sedative agents (Pandharipande & Hayhurst, 2023). It is worth noting that using opioids within analgosedation may raise the risk of delirium. Therefore, sedation titration should achieve a state of patient wakefulness and calmness, as indicated by the Richmond Agitation Sedation Scale (RASS) (Pandharipande & Hayhurst, 2023).

Appropriate sedative selection hinges upon sedation indication, therapeutic goals, clinical pharmacology, and acquisition costs (Devlin et al., 2018). Studies have shown the use of benzodiazepines for sedation increases the risk of UEs, and the recommended preference for

choice of sedative is for nonbenzodiazepine sedatives, such as propofol or dexmedetomidine (Anis et al., 2023; Devlin et al., 2018; Pandharipande & Hayhurst, 2023). Integrating multimodal pain medications and sedation strategies with current policies and engaging Banner Health pharmacists and providers can facilitate a more comprehensive investigation into intubated patient management practices, fostering interprofessional collaboration and promoting educational initiatives guided by the ICU Liberation Bundle.

Delirium is a critical factor in most UEs (Anis et al., 2023). Unfortunately, studies have illuminated a concerning gap that ICU nurses lack knowledge about ICU delirium, and when ICU delirium is encountered, they might lack evidence-based training and appropriate knowledge (Aldawood et al., 2023). In addition, it can be challenging to assess due to patients being sedated, on high dosages of analgesics, or intubated (Aldawood et al., 2023). The Confusion Assessment Method (CAM-ICU) is a valid objective screening tool to assess ICU patients' delirium (Aldawood et al., 2023; Devlin et al., 2018).

The PADIS guidelines recommend using a multicomponent nonpharmacologic intervention to reduce or mitigate delirium by improving wakefulness, immobility, and hearing and visual impairments (Devlin et al., 2018). Nonpharmacologic interventions are recommended over-treating with pharmacologic agents (Devin et al., 2018). It is important to note that no pharmacologic interventions to improve sleep are formally recommended. Instead, a sleep-promoting multicomponent protocol is preferred (Devlin et al., 2018). These interventions studied as part of the ICU Liberation bundle have significantly reduced delirium and mortality with no adverse effects (Devlin et al., 2018).

Pharmacological agents are not routinely recommended for delirium. Based on low-quality evidence of benefits, PADIS guidelines recommend against using an atypical antipsychotic, like haloperidol, or a stat to treat delirium due to lack of benefit (Devlin et al., 2018). Dexmedetomidine is recommended for delirium in intubated patients where agitation is evident (Devlin et al., 2018). Delirium requires prevention, early recognition, interdisciplinary and pharmacologic protocol, increased nursing presence, and short-acting sedation when appropriate (Anis et al., 2023). Education to ICU nursing staff on non-pharmacological interventions is recommended, as pharmacological agents are reserved for those who experience significant distress secondary to the symptoms of delirium.

Summary of Formal Recommendations Regarding Pain, Agitation, and Sedation:

1. Explore the ICU Liberation Bundle and current practices to understand gaps or areas of improvement.
2. Provide nursing staff with the proper education and training on pain management, including medications, age-appropriate assessment tools, and nonpharmacological strategies.
3. Provide nursing staff with the proper education and training on sedation strategies, including medication selections and proper assessment tools.
4. Provide nursing staff with the proper education and training on delirium management, including proper assessment tools, non-pharmacological interventions, and pharmacological options.

DISCUSSION

Summary

The project's primary focus was on addressing UEs, a critical and challenging complication discovered at Banner Health's academic medicine division, including Banner University Medical Center Tucson (BUMCT), Banner University Medical Center Phoenix (BUMCP), and Banner University Medical Center South (BUMCS). An extensive literature synthesis was undertaken to identify UE-associated factors and explore continuous quality improvement methods. This process aimed to understand the existing complexities and formulate strategies for improvement. Recognizing the need for a comprehensive approach to tackle this issue, Banner Health provided the project coordinator with a valuable dataset for in-depth analysis, which served as the foundation for developing evidence-based recommendations.

The comprehensive review of the existing literature, coupled with meticulous data analysis, underscores the multifaceted nature of factors contributing to an elevated risk of UEs within critical care. Given the data set analysis revealing a high incidence of SEs, occurrences during night shifts and within two hours of shift changes, and notable factors like physical restraint use, sedation management, and staffing concerns, addressing these identified risk factors is paramount.

The project coordinator formally presented the evidence-based recommendations to Banner Health's Nursing Research Department and discussed plans. The overall recommendation to Banner Health is that current practices be evaluated -- including nurse staffing/characteristics, pain management, sedation/agitation management, and delirium management -- and education be delivered to nursing staff to comprehensively address the risk

factors in a targeted and effective manner. These foundational elements will serve as cornerstones for identifying vulnerabilities and pave the way for ongoing quality improvement initiatives, which research recommends to reduce UEs. In light of these findings, the ICU Liberation Bundle emerges as an instrumental framework for implementation in addressing and proactively managing these modifiable risk factors (SCCM, 2020). Such a comprehensive approach, rooted in evidence-based practices, will testify to Banner Health's commitment to patient safety and the dedication to continuously enhance the quality of care within the ICU, ensuring optimal patient outcomes.

Implications

The literature synthesis and dataset analysis findings affirm the impact of practice improvements as a whole. These results underscore the need to implement educational initiatives for nurses, focusing on preventing UEs. Moreover, this project identifies a significant challenge for future research: the necessity for enhanced UE tracking methods, a broader research scope, and the cultivation of a just culture to report such events. Promoting a just culture and standardized UE tracking tool can ensure a more consistent and comprehensive collection of data across all hospitals, fostering a more robust foundation for research in the critical area. With concrete evidence of the success of continuous quality improvement projects in addressing UEs, it is strongly recommended that such an initiative be advocated for adoption at Banner Health.

Limitations

The project's aim to provide evidence-based recommendations to Banner Health for addressing UEs posed limitations. Several factors contributed to these limitations, affecting the scope and depth of analysis. First, the dataset evaluated was gathered during the COVID-19

pandemic, a period characterized by extraordinary healthcare challenges and dynamic circumstances that may not be fully generalizable to non-pandemic times. Recent studies have noted COVID-19 patients have a greater frequency of UEs, specifically SEs, with most events unwitnessed, where teams were altered via ventilator alarms (Chhina et al., 2019). In addition, the pandemic amplified the workforce shortage of registered nurses, placing strain on an already fragile healthcare system and leading to adverse patient outcomes, such as UEs (Kurtzman et al., 2022).

The limitations extend to the inherent subjectivity and inconsistency in reporting UE events to the Verge event log system. This lack of standardized reporting methods rendered the dataset's analysis a challenging task, as it necessitated the project coordinator to generalize data analysis categories, potentially leading to an oversimplification of the complex factors at play in UEs. Furthermore, specific known high-risk contributors to UEs, such as gender and comorbidities, were not documented in the dataset, rendering them unavailable for analysis.

A critical limitation arose from the lack of research on adult ICU UE events. The existing body of research predominantly pertains to neonatal and pediatric ICUs, which involve distinct patient populations and risks. Consequently, the generalizability of the findings to the adult ICU context was limited, and the direct applicability of specific recommendations became uncertain.

DNP Essentials Addressed

The quality improvement project effectively integrated several Doctor of Nursing Practice (DNP) Essentials, including Essential I, Essential II, Essential III, and Essentials VI, to conduct a comprehensive literature search and dataset analysis on UEs and subsequently offer evidence-based recommendations to Banner Health.

DNP Essential I: Scientific Underpinnings for Practice

Essential I, "Scientific Underpinnings for Practice," was diligently applied in conducting a thorough literature search and analysis (American Association of Colleges of Nursing [AACN], 2006). By meticulously reviewing the existing literature on UEs, the project incorporated this essential by ensuring that all recommendations were firmly rooted in scientific research and evidence (AACN, 2006).

DNP Essential II: Organizational and Systems Leadership

Essential II, "Organizational and Systems Leadership," played a pivotal role in obtaining the dataset from Banner Health (AACN, 2006). This project coordinator and collaboration with Banner Health were crucial in acquiring the necessary data based on a comprehensive needs assessment and serve as the foundation for evidence-based recommendations (AACN, 2006). Essential III, "Clinical Scholarship and Analytical Methods for Evidence-Based Practice," was central to the project's data analysis component (AACN, 2006). The project coordinator effectively employed analytical methods to assess the dataset's findings and derive evidence-based recommendations.

DNP Essential VI: Interprofessional Collaboration for Improving Patient and Population Health Outcomes

Essential VI, "Interprofessional Collaboration for Improving Patient and Population Health Outcomes," was interwoven throughout the project (AACN, 2006). The collaborative effort between the project coordinator, project committee, and Banner Health was instrumental in understanding the needs assessment, analyzing the dataset, and crafting recommendations that would benefit patient care and safety (AACN, 2006). The quality improvement project

thoughtfully incorporated DNP essentials, highlighting leadership in practice and scientific inquiry.

Conclusions

In conclusion, the evidence and results stemming from the literature and dataset analysis of the quality improvement project undeniably underscore the imperative need for continuous quality improvement initiatives aimed at reducing UEs within Banner Health's academic medicine division, including BUMCP, BUMCT, and BUMCS. The findings unequivocally demonstrate the existence of a pressing issue that necessitates attention and interventions. The ICU Liberation Bundle and PADIS guidelines offer invaluable guidance for these continuous quality improvement efforts, serving as comprehensive frameworks to enhance patient care and safety while minimizing UEs.

Equally significant is the role of education in this process. Ensuring nurses are well-informed and equipped with the best practices to prevent UEs is paramount. Supporting bedside nurses and engaging stakeholders in this shared mission will foster a culture of continuous improvement and ultimately reduce UEs. With a steadfast commitment to these principles and a dedication to evidence-based practice, Banner Health can take significant strides toward enhancing patient outcomes, promoting a safe healthcare environment, and contributing to research on UEs in adult ICUs.

Plan for Sustainability

The sustainability of this project hinges on Banner Health's strategic decisions regarding the recommendations provided. The organization can maximize the project's impact by sharing its findings with both academic ICUs and extending the knowledge to the non-academic ICUs

within the Banner Health network. This information can serve as a catalyst for future quality improvement initiatives, fostering a culture of continuous improvement. To ensure the project's integrity and data security, the project coordinator will keep the project paper and its supporting documents while responsibly deleting the original dataset provided by Banner Health, aligning with data protection principles and organizational best practices.

Plan for Dissemination

The results of this QI project were disseminated to Dr. Karen Johnson, the Director of Nursing Research at Banner Health, through email and through a formal presentation via a Zoom meeting. The project coordinator will disseminate findings at Banner Health's system wide Nursing Grand Rounds in December 2023. Dr. Johnson's critical role is to decide to further propagate these findings throughout the organization, considering the implications and potential impact they hold. Her decisions will encompass considerations for future QI initiatives within the Banner Health system, fostering a culture of continuous enhancements in patient care and healthcare practices.

APPENDIX A

BANNER SITE APPROVAL | BANNER HEALTH LETTER OF SUPPORT

Banner.
Research

Nursing Research
901 E. Willetta Street
Phoenix AZ 85006

April 12, 2023

University of Arizona Institutional Review Board
c/o Office of Human Subjects
1618 E Helen St
Tucson, AZ 85721

Please note that Lauren Lebowitz, UA Doctor of Nursing Practice student, has permission from Banner Health Nursing Research department to conduct a quality improvement project that seeks to analyze Banner Health's airway event data set, which includes events from our academic and nonacademic facilities.

Lauren Lebowitz will conduct an analysis of Banner Health's airway event data set and provide a formal report and evidence-based recommendations to the organization on how to improve aspects of these adverse events. These activities will be completed by Winter, 2023.

Lauren Lebowitz has agreed to work with Carla Clark PhD, RN Banner EBP Coordinator on the submission process to receive Banner Health Research Determination Committee approval. This process is outlined in the UA College of Nursing/Banner Health DNP student project approval process. As part of this process, Lauren Lebowitz has agreed to present aggregate results of the project and evidence-based recommendations to the Nursing Research Department to share with nurses across the Banner Health system.

If there are any questions, please contact me.

Signed,

Karen Johnson

Karen Johnson PhD, RN, FAAN
Director, Nursing Research
Banner Health
Karen.johnson2@Bannerhealth.com

Banner
Research

Date: 9/11/2023

To: Lauren Lebowitz, University of Arizona College of Nursing, DNP Student

cc: Allen Prettyman PhD, FNP-BC, FAANP, FNAP,
Clinical Professor University of Arizona, College of Nursing
Banner Health Research Determination Committee

From: Karen L. Johnson PhD, RN, FAAN, Director Nursing Research, Banner Health

Re: Reducing Unplanned Extubations in the Intensive Care Unit with Evidence-Based Practice Recommendations

I have assessed the above referenced project proposal for implementation potential and determined that the project is feasible and congruent with Banner Health initiative: Improve care efficiency and quality. It aligns with our goal: relentless improvement.

The resources needed: Access to de-identified system-level data on unplanned extubations 2021 in Banner Health's three academic medical centers, provided by Banner Quality Department, downloaded into an excel spreadsheet and reviewed by me. The student will analyze data and develop evidence-based strategies. I have been reviewed and determined necessary/acceptable.

The Banner Health Research Determination Process requires this letter of support along with the project application be uploaded into the IRIS electronic program. The Banner Research Determination Committee (RDC) will then review your initiative. This same committee will provide one final check for HIPPA compliance.

Following a determination of non-research, non-human subjects research, or exempt human subjects research that falls under one of the categories the RDC may grant approval for, you will be notified of approval to begin your project.

However, should the RDC determine your project constitutes human subjects research or involves protected health information (PHI), that requires Institutional Review Board (IRB) review, you will be notified and may begin the IRB review process. If your project will be reviewed by the Banner Health IRB, the Banner Research Regulatory Affairs team will also be notified to assist you with the submission process. You may not initiate the project until the IRB has granted approval.

Should you have any questions during the process, please contact Jane.Hoverson@bannerhealth.com. Upon completion of your project, we request that you disseminate your findings to Banner Critical Care Clinical Consensus Group or in another mutually agreed upon forum. Best wishes on the successful completion of your project.

Sincerely,
Karen Johnson
Karen Johnson PhD, RN, FAAN

X By checking this box, I attest to the project feasibility and confirm all necessary department/facility approval have been obtained.

APPENDIX B

EVALUATION INSTRUMENTS (BANNER HEALTH UNPLANNED EXTUBATION DATA SET RECORDING | 2021 DATA SET COLLECTION)

Banner Health Unplanned Extubation Data Set Recording

Organization	Self-Extubation	Accidental Extubation	Occurrence on Day Shift	Occurrence on Night Shift	Occurrence within 2 hours of shift change	Physical Restraint Concern	Sedation Concern	Staffing Concern	Reintubation Needed	No Reintubation	Total UE Events
University Medical Center Phoenix (BUMCP)											
University Medical Center Tucson (BUMCT)											
University Medical Center South (BUMCS)											

Unique ID	Self-Extubation	Accidental Extubation	Occurrence on Day Shift	Occurrence on Night Shift	Occurrence within 2 hours of shift change	Physical Restraint Concern	Sedation Concern	Staffing Concern	Reintubation Needed	No Reintubation
1										
2										
3										
4										
5										
6										

2021 Data Set Collection

Unique ID	Entry Month	Organization	Location of Event	Audit Title	Event or Unsafe Condition	Initial Severity	Describe what happened	Age range	Patient information: Age	What was the individual's pre-occurrence mental status?	Which of the following best describes the airway support provided?	Which of the following best characterizes the airway management problem?	Which of the following best characterizes the airway/anesthesia event?	What normally happens (i.e. what does everyone really do?)	What should happen (i.e. what does policy or prcedure require?)	Why did it happen, contributing, root causes	What was done to prevent it from happening again?	Severity	Safety Event Classification	Case Status
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				

APPENDIX C

PARTICIPANT MATERIAL (ICU LIBERATION BUNDLE


ICU Liberation
ICU Liberation is the overarching philosophy and practice directed at improving care by "liberating" ICU patients from pain, oversedation, delirium, mechanical ventilation, immobility and isolation, as well as from post-discharge sequelae that can be life-altering for many patients.
2018 Clinical Practice Guidelines for the Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption in Adult Patients in the ICU (PADIS Guidelines)
The PADIS Guidelines provide a roadmap for developing integrated, evidence-based, and patient-centered protocols which can be implemented through the ICU Liberation Bundle.
Assess, prevent, and manage pain
Both SAT and SBT
Choice of analgesia and sedation
Delirium: Assess, prevent, and manage
Early mobility and exercise
Family engagement and empowerment
The ICU Liberation Bundle
Represents the implementation strategy used to provide each of the recommendations in the PADIS guidelines to every ICU patient.
A
Assess, prevent, and manage pain
Understand pain and find tools for its assessment, treatment, and prevention
B
Both SAT and SBT
Use both spontaneous awakening trials and spontaneous breathing trials
C
Choice of analgesia and sedation
Understand the importance of the depth of sedation and choosing the right medication
D
Delirium: Assess, prevent, and manage
Understand delirium risk factors and find tools for its assessment, treatment, and prevention
E
Early mobility and exercise
ICU early mobility involves more than changing the patient's position
F
Family engagement and empowerment
Involving the family in patient care can help patients recover
Society of Critical Care Medicine
The Intensive Care Professionals
ICU LIBERATION
LIBERATION, ANIMATION, RESTORATION
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APPENDIX D

PROJECT TIMELINE

Completion Date	Planning	Pre-implementation	Implementation	Evaluation
June 2022	Discussion with DNP committee chair/advisor and Dr. Karen Johnson regarding project, data set, and tentative idea			
January 2023	Literature research conducted, relevant articles complied, and literature grid completed.			
March 2023	Drafted initial background/significance, theoretical framework, literature synthesis, and methods.			
April 2023	Iterative revisions of back/significance, theoretical framework, literature synthesis, and methods with chair. Drafted proposal define with continued iterative revisions with chair. Complete educational PowerPoint, presentation notes, site approval letter, and doodle poll for May DNP project proposal.			
August 2023		DNP Project proposal to committee via zoom by adhering to 10-business day rule. Proposal on 8/1/2023		
September 2023			Submit to Banner Health's RDC and await RDC approval.	
October 2023				Complete data set analysis. Evaluate results and determine EBP recommendation.

Completion Date	Planning	Pre-implementation	Implementation	Evaluation
				Draft results and discussion. Complete revisions of the final DNP project and prepare for final defense.
November 2023				Complete final DNP project defense.
December 2023				Graduate.
June 2022	Discussion with DNP committee chair/advisor and Dr. Karen Johnson regarding project, data set, and tentative idea			

APPENDIX E

LITERATURE REVIEW GRID

Project Question: How will an analysis of Banner Health's UEs data set, among their academic hospitals, facilitate the proposal of an evidence-based recommendation to integrate into their intensive care units?

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
2023, Wu et al.	Prevention of unplanned endotracheal extubation in intensive care unit: An overview of systematic reviews	Systematic Review	Risk Factors for UE: Male sex, delirium, restraint use, a higher GSC score, patient agitation, monitoring, the nurse-patient ratio, catheter fixation, irritability, poor fixation, bed-side handling, endotracheal extubation manipulation, APACHE II score, and times of high risk for UEE occurrence (at night, 1 hour before and after shift changeover, and during ventilator withdrawal stage) Preventative Measures - Psychological care and root cause analysis reduce the incidence of UE - Restrain use with a GCS score of > 9 increased risk of UE by 6.16 times. Restrain on its own was not effective in preventing UE and relevant nursing intervention in conjunction with restraint were more effective that restraint use alone - Lack of evidence to determining the most effective and safe method of stabilizing the tracheal tube - Continuous quality improvement has been proved an effective method to reduce the UE resulting in a 24.1% absolute	The findings in this review highlight the risk factors associated with UE and the effects of preventative measures on UE in the intensive care unit. Supporting the need for recognition of risk factors, the benefits of continuous quality improvement, and the need for addressing multiple measures to prevent UEs.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
			reduction rate in UE and a 36.6% absolute reduction rate in associated cardiovascular failure - Sedation management and enhanced monitoring of high risk groups and high-risk period can reduce the incidence of UE	
2022, Li et al.	Unplanned extubation among critically ill adults: A systematic review and meta-analysis	Systematic review and meta-analysis	Prevalence of unplanned extubations ranged from 0.5% to 40.2% in the included studies with a median of 6.4%. In studies that differentiated types of UE (SE or AE), pooled analysis showed that 84.2% of UEs were SEs. Ten studies investigated the reintubation rate after 48 hours, representing a rate of 33.3% to 81.4% with a median of 45.1%. Pooled prevalence of failed UEs was 50.2%. Meta-analysis showed that 6.6% of adult ICU patients receiving mechanical ventilation experience at least one episode of UE with a pooled incidence density of 1.06 UE events per 100 ventilation days. Male gender, confusion, suffering physical restrain, with higher GCS and lower APACHE II scores are significant risk factors for UE. Other risk factors such as patients' age, intubation route, use of sedative, and other comorbidities were noted. Literature supports that sufficient analgesia and sedation, optimal	The findings support the need to recognize important practical implications. Reintubation itself is independently associated with increased odds of healthcare-associated pneumonia and with increased length of hospital stay and in-hospital mortality. In addition, patients who experience UE were ready for planned extubations, and weaning from the ventilator should not have been delayed to avoid serious complications. Significant amount of UE (84.2%) were self-extubations highlighting the need to address discomfort or pain resulting from artificial airway, anxiety due to patients' inability to talk or breath on their own.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
			management of delirium, judicious use of restraints, increased staff surveillance, aggressive weaning, standardized tube fixation, and quality improvement initiative are all know interventions to assist in decreasing UE. Self-extubations occur mainly when nurse staffing is low. Surgical or mixed ICUs have lower UE prevalence.	
2022, Minda et al.	Magnitude and associated factors of unplanned extubation in intensive care unit: A multi-center prospective observational study	Observational Study	Risk factors for UE for study participant patients intubated in the ICU included 96.5% had no history of intubation, 40.4% were with GCS of 9, 34.4% were sedated with ketamine, 43.9% were physically restrained, and 38.5% UE occurred during night shift. Self-extubations occurred in 88.05% of all UE in this study. UE occurred when staff were at bedside (15%) and in the absence of staff (4.7%). 10.2% of UE occurred during MV weaning. Factors associated with UE included being male (55.7%), intubation duration < 5days (2 times more likely to experience UE), patients managed by a junior resident (more than 5 times more likely to experience UE than senior residents), agitation, being physically restrained (43.9%), and during night shift (38.5%).	The findings support the risk factors associated with UE suggesting the need to give special attention to early intubated patients, especially male individuals.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
2021, Hur et al.	Development and validation of unplanned extubation prediction models using intensive care unit date: Retrospective, comparative, machine learning study	Retrospective study	UE occurred in more males (76.6%, $p < 0.001$) than females. Higher rate in those with physical restraints (61.3%, $p < 0.001$). Occurred in fewer surgical patients (25.8%, $p < 0.001$). ICU mortality and hospital mortality were significantly higher in the UE group than in the planned extubation group. Reintubation rate within 24 hours was 39.9%, $p < 0.001$. UE was higher during the night shift as compared to planned extubation group. Superior net benefit was found when the best prediction model was used compared to the alternative approaches of predicting all or none as UE over a threshold probability range of 6% to 78%. The AUROC for RF was 0.787, for LR 0.762, for ANN was 0.763, and for SVM was 0.740.	These findings emphasize the risk factors associated with UE, especially highlighting the link between physical restraints and UE. - Developing an prediction model to screen and monitor ICU patients for UE shows promise and can allow clinical staff to take appropriate action to prevent UE.
2020, Gueret et al.	Self-extubation revisited: A case-control study	Case-control study	Restraint Use: 87% of UE had restraints applied Sedation: 34% had continuous sedation, 29% had intermittent sedation, while 37% received no sedation. Mechanical ventilation of less than 2 days was associated with a sensitivity of 44% and a specificity of 89% to predict self-extubation ($p = 0.004$) RASS score > -2 (subject drowsy to combative) was associated with a	The findings highlight that in the era of reduced use of sedatives in the ICU, clinicians must be vigilant of the risks factors associated with UE. In this study, risk factors identified included those who are agitated during the first 2 days of mechanical ventilation, especially when the ETT tip is far from the carina on chest radiograph.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
			high sensitivity (91%) but low specificity (58%) to predict self extubation (p <0.001) ETT tip to carina distance > 59mm had a specificity of 87.5% and sensitivity of 31% to predict self-extubation (p = 0.037) Reintubation after UE is more likely to occur at night (75%) and in subjects with hypoxic respiratory failure (62%). Reintubation was not associated with higher mortality in subjects who self-extubated.	
2018, Ai et al.	Factors associated with unplanned extubation in the intensive care unit for adult patients: A systematic review and meta-analysis	Systematic Review and Meta-Analysis	Males have a higher risk to experience UE in comparison to females in the ICU (overall OR: 1.54, 95% CI 1.12-2.12, p=0.008) Adult patients with lower APACHE II have higher risk to experience UE (overall OR: -2.26, 95% CI -3.35 to -1.16, p<0.0001) Physical Restraints have higher risk to experience UE than those without conducting physical restraint (overall OR: 3.10, 95% CI 2.21-4.24, p< 0.00001) Patients with confusion have a higher risk to experience UE than patient's without confusion (overall OR: 0.10, 95% CI 0.05-0.17, p < 0.00001) Patients with higher GCS have higher risk to experience UE (overall OR 1.23, 95% CI 0.32 -2.14, p = 0.008)	The findings highlight factors associated with UE which can facilitate future definitions of UE and factors association with UE in order to identify patients with high risk of UE and to take effective measures to prevent and reduce the rate of UE.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
			Patients with renal disease have a lower risk to experience UE than those without renal disease (overall OR: 0.32, 95% CI 0.15-0.70, p = 0.004) Duration of ventilation, smoking history, days of intubation, temperature, pCO2, BUN, medicine, BMI, pain score, Riker score, length of stay in the medical ICU, years of experience as nurse, level of education of nurse, work shift at time of UE, vital signs, and serum laboratory are remaining factors to UE	
2018, Lucchini et al.	Unplanned extubations in general intensive care unit: A nine-year retrospective analysis	Retrospective study	Self extubations account for 94%, while accidental extubations accounted for 6% of all UE At the time of UE, patients had a median RASS of 0, a mean propofol dosage of 84.2 to 140.9 mg/hr., a mean midazolam dosage of 2.1 to 1.1 mg/hr., a mean fentanyl dosage of 34.9 to 35 mcg/hr., physical restraints present in 48.6%. 71% of patients were not reintubated after UE. Patient not reintubated after UE, the respiratory supports used after included oxygen reservoir mask (4%), venturi mask (46%), and helmet CPAP (46%). UE incidence in this study was 1.02%, at the lower end in reported literature (0.5% to 35.8%). Expected to be due to appropriate nurse to	The findings support that the patient surveillance cannot be substituted by the utilization of physical restraints in order to prevent UE. In addition, the findings highlight that a low incidence can be related to standardized protocols in place and proper health care staff utilization.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
			patient ratio (1:2), and protocols for endotracheal tube management.	
2017, Chao et al.	Multidisciplinary interventions and continuous quality improvement to reduce unplanned extubation in adult intensive care units: A 15-year experience	Retrospective study	The overall rate of UE was 3.19/100 ventilated patients or 4.40/1000 ventilator days over a 15-year period Extubation failed in more than half of the episodes (50.1%) and required reintubation within 48 hours, with the annual rate of failed UE ranged from 38.7% to 65.1%. Oxygenation failure was the most common cause of UE failure (64.7%) followed by unstable hemodynamics (14.3%), secretions (12.7%), upper airway obstruction (12.7%), and encephalopathy (2.4%) Improvement interventions over a 15-year period included standardizing procedures; improving communication skills; revising sedation and weaning protocols; changing strategies for restraints; establishing a task force for identify and managing high-risk patients; using a new quality-improvement models as breakthrough series and team resource management; using the strategy of accountability without assigning blame; and new method to secure ETT. These interventions showed a significant change in the trend analysis of UE of $P < .0001$ while the rate of UE declined form 6.82/100 ventilated patients in 2001 to 0.95/100 ventilated patients in 2015.	These findings support the need for several preventive measures to avoid UE in the intensive care unit. This study provides clear evidence of ways to effectively reduce UE using a multidisciplinary and continuous quality improvement program.

Pub. Year; Author's Last Name	Title of Publication	Type of Study	Main Outcomes of Findings	Support for and or Link to Project
			Implementation of standardization of procedures (fixation of ET tube and restraints for patients) and improvement of communication skills with the use of simple cartoon cards led to a reduction of the rate of UE from 6.03/100 ventilated patients in 2002 to 4.84/100 ventilated patients in 2004 Revising sedation and weaning protocols reduced the rate from 4.84/100 ventilated patients in 2003 to 4.52/100 ventilated patients in 2004 Changing restraint strategy reduced the rate form 6.08/100 ventilated patients in 2005 to 3.48/100 ventilated patients in 2006 Implementation of event recording systems, BTS, and TRM reduced the rate of 3.82/100 ventilated patients 2006 to 2.03/100 ventilated patients in 2008 Implementing a new method of securing the ET tube decreased the rate to less than 1/100 ventilated patients in 2014	

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