

Prevention of Unplanned Extubation in Pediatric Intensive Care Units

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She has no known conflict of interest to disclose.

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Abstract

Objectives: This quality improvement project aimed to increase nurse and provider adherence to a sedation protocol and evaluate whether improved adherence impacts unplanned extubation (UE) rates in a pediatric intensive care unit (PICU).

Design: The Systems Accident Model was used to increase adherence with the current sedation protocol to reduce UE rate. A pre-post intervention design was used to assess changes in adherence and UE rates following structured staff education. Nursing adherence to sedation goal documentation and UE rates were analyzed pre- and post-nursing education, while provider adherence to ordering the protocol and UE rates were assessed pre- and post-provider education.

Setting: A PICU at a children's hospital in the Southwest United States.

Subjects: 262 intubated pediatric patients in the PICU; PICU nurses and providers.

Interventions: Staff education was implemented in two phases. Provider education emphasized patient eligibility and how to order the protocol, while nursing education focused on use of the protocol and documenting SBS goals. Education was provided in person, and PowerPoint presentations were sent to staff who did not attend. Human subjects were protected in this quality improvement project as confirmed by IRB approval.

Measurements and main results: The primary outcome was UE rates post-intervention. Secondary outcomes included adherence to sedation score documentation and protocol ordering. Data were collected two months before and after each educational intervention through chart reviews. No statistically significant changes in adherence or UE rates were observed.

Conclusions: While structured education on sedation protocol adherence did not yield significant improvements in UE rates, extended data collection periods may be necessary to detect meaningful changes.

Preventing Unplanned Extubation in Pediatric Intensive Care Units

Many patients in pediatric intensive care units (PICU) require intubation and mechanical ventilation for stabilization and recovery. Unplanned extubation (UE) may result in poor prognoses due to cardiopulmonary compromise, injury, and increased length of hospital stay. Addressing unplanned extubation in PICUs is imperative in improving quality care for critically ill children.

Background and Significance

Intubation is a life-saving intervention used to provide adequate oxygenation and ventilation to patients who are critically ill and unable to perform sufficient gas exchange without mechanical ventilation (Alibrahim et al., 2022). Unplanned extubation is defined as any unintentional endotracheal dislodgement, either due to patient self-extubation or patient handling by staff or family (Ferreira et al., 2023). National initiatives, such as The Children's Hospital's Solutions for Patient Safety, have significantly reduced UE rates by implementing care bundles targeted toward children requiring mechanical ventilation (Unplanned Extubations, 2022). Without initiation and adherence to care bundles that include standardized sedation protocols, patients may be at high risk for UE and associated morbidity and mortality.

Problem Statement

UE rates have been reported to affect between three to 16% of pediatric ICU patients globally (Mekonnen et al., 2023). Patients in PICUs may suffer cardiovascular collapse, hypoventilation, hypoxia, and injury after UE, resulting in increased hospital stay and significant morbidity and mortality (Ferreira et al., 2023; Klugman et al., 2020; Mekonnen et al., 2023). Additional complications of UE include ventilator-associated pneumonia (VAP) and requiring the use of mechanical circulatory support (Perry et al., 2023).

Modifiable risk factors for UE include inadequate sedation, intermittent sedation, improper use of physical restraints, uncuffed endotracheal tubes (ETT), improper cannula fixation, and a nurse-to-patient staffing ratio of 1:2 (Ferreira et al., 2023; Jayawardena et al., 2021; Mahaseth et al., 2020; Mekonnen et al., 2023). Unmodifiable risk factors for UE include night shift hours, younger patient age, underweight, and airway anomalies (Mekonnen et al., 2023; Perry et al., 2023). Quality improvement bundles vary between facilities and may include two-clinician assistance with patient repositioning and ETT manipulating, standardized ETT measurement method, sedation monitoring, using a sedation protocol, family and staff education, and the use of cuffed ETT's (Ferreira et al., 2023; Jayawardena et al., 2021; Klugman et al., 2020; Silva et al., 2022). The use of UE bundles that address sedation has demonstrated up to an 84% reduction in the rate of UE (Ferreira et al., 2023; Klugman et al., 2020; Melton et al., 2022; Silva et al., 2022). However, nonadherence to sedation protocols may increase risk of UE in this population.

Intubated Patients in the Pediatric ICU

Patients who have a critical illness requiring ICU management have a 1.79 times increased risk of mortality, and those requiring mechanical ventilation are placed at even further risk as one study demonstrated that over 10% of patients requiring mechanical ventilation suffered a ventilator-associated complication (Teshager et al., 2020). UE among ventilated pediatric patients is associated with increased overall duration of ventilatory support (Wollny et al., 2022). This ultimately increases patient morbidity and mortality. Factors associated with UE in this population include inadequate sedation, intermittent sedation, improper use of physical restraints, uncuffed ETT, improper cannula fixation, invasive bedside procedures, and a nurse-to-

patient ratio of 1:2 (Ferreira et al., 2023; Jayawardena et al., 2021; Mahaseth et al., 2020; Mekonnen et al., 2023).

Sedation Protocol

A lack of proper sedation and patient agitation contributes to the risk of UE among PICU patients (Anis et al., 2023; Mekonnen et al., 2023; Neves et al., 2023; Silva et al., 2022; Silva & Fonseca, 2020). A potential solution to the problem is a standardized sedation protocol (Hazwani et al., 2022; Mekonnen et al., 2023; Silva et al., 2022). Effective and evidence based standardized sedation protocols include a variety of strategies such as using a designated sedation regimen to reduce the need for intermittent sedation doses, setting a sedation target, education for nurses and physicians regarding the proposed algorithm, regular sedation assessments, and using a standard sedation scale (Anis et al., 2023; Hazwani et al., 2022).

To develop a sedation protocol, a standardized sedation scale should be established to assess sedation among intubated patients and should be valid and reliable for individual age groups (Giordano et al., 2019). Previous studies that demonstrated improved sedation management after using a sedation protocol utilized a standard sedation scale for all patients (Anis et al., 2023; Hazwani et al., 2022). Some scales that have shown validity and reliability for assessing sedation in pediatric patients include the Hartwig scale, Dartmouth Operative Conditions Scale, Ramsay Sedation Scale, Richmond Agitation-Sedation Scale, University of Michigan Sedation Scale, and the Vancouver Sedative Recovery Scale (Giordano et al., 2019). The State Behavioral Scale (SBS) is another sedation assessment tool that is particularly used in intubated infants and young children (Curley et al., 2006). This scale assesses sedation rather than pain, allowing clinicians to accurately assess and treat inadequate sedation levels. The SBS

is a valid tool for critically ill young children on mechanical ventilation and is commonly used in the PICU setting.

Decreasing UE in PICUs

Unplanned extubation occurs in PICUs due to the lack of standardized protocols when caring for critically ill patients requiring mechanical ventilation. In PICUs with pre-existing sedation protocols, adherence to these protocols is imperative in reducing UE rates and may require staff education to increase compliance. The desired outcome is a reduction in UE in PICUs. Reducing rates of UE can lead to decreased cardiopulmonary complications, shorter lengths of hospital stay, decreased morbidity and mortality, reduced resource utilization, and reduced hospital costs (Klugman et al., 2020; Mekonnen et al., 2023).

Unplanned extubation may result from the patient dislodging their ETT or from staff and caregiver manipulation. The literature suggests that UE in PICUs results in worse health outcomes. Incorporation of and adherence to sedation protocols may be a successful strategy in reducing UE rates in pediatric patients.

Internal Data

A children's hospital in the Southwest United States was examined for UE rates and initiatives to decrease rates of UE. After speaking with the hospital's clinical education specialist, potential associated factors have been identified. These include inadequate patient sedation and repositioning of intubated patients. This internal data supports the findings in the literature review identifying risk factors associated with UE in PICUs. After exploring the literature and internal data, sedation appears to be the most prevalent contributor to UE in the intensive care units as identified by bedside staff and is the focus for quality improvement efforts (Melton et al., 2022).

The hospital has already implemented a nurse-driven sedation protocol used to optimize sedation in mechanically ventilated patients (see Appendix A). This protocol was aimed to ensure a daily sedation score goal was determined among the healthcare team and that a sedation pathway was being utilized to ensure patients remain at their sedation goal. However, there has been poor adherence with daily ordering of the sedation protocol order set and with nursing documentation. Of all patients that met inclusion criteria, 50-60% of them had the sedation protocol ordered prior to intervention. With increased adherence of the sedation protocol and pathway, sedation may be optimized, and thereby reducing unplanned extubation rates. The PICU currently utilizes the state behavioral scale (SBS) to measure sedation in intubated pediatric patients. This scale allows for documentation of the patient's sedation status, identifying if they are unresponsive, responsive to noxious stimuli, responsive to gentle touch or voice, awake and able to calm, restless and difficult to calm, or agitated. Identifying a sedation score target for each patient using this valid and reliable tool could help decrease UE rates in this population.

Evidence Synthesis

Search Strategy

A literature search was performed using the following databases: PubMed, EBSCO Host, and The Cochrane Library. Key terms were selected based on the PICOT question and related terminology. Articles published more than five years ago were excluded from all databases, with a date limit set from 2019 to 2024. Studies that did not consider the role of sedation in unplanned extubation were excluded. Studies that included adults and that were conducted outside of the United States were included.

PubMed

Key terms used in this search included *PICU*, *pediatric*, *sedation*, *sedation score*, *sedation protocol*, *unplanned extubation*, and *extubation*. First, individual key terms were searched, then multiple combinations of two terms were searched, then multiple combinations of three terms related to the PICOT question were searched. The initial individual searches yielded between 3,302 to 7,846 results. After attempting to narrow down the search by using a variation of all three components of the PICOT question, between five and 116 articles were displayed. The combinations of key terms that yielded the most results included *pediatric*, *sedation score*, and *ventilation*, which yielded 116 results, and *PICU*, *sedation*, and *ventilation* which yielded 92 results. Based on this literature search, it was determined that the term *ventilation* yielded more results than *unplanned extubation* when combined with other key terms. However, while the combination of *pediatric*, *unplanned extubation*, and *sedation* only yielded 34 results, the articles were more directly related to the PICOT question.

EBSCO Host

EBSCO Host was also used to search key terms related to the PICOT question. These included *PICU*, *pediatric*, *sedation*, *sedation score*, *sedation protocol*, *extubation*, *unplanned extubation*, and *ventilation*. Key terms were searched individually, then in pairs, then by using variations of three terms to fully reflect the related PICOT question. The initial search with only one key term yielded between 275 and 32,907 results, with *unplanned extubation* having the least and *extubation* having the most. After narrowing down the search by using a variation of three specific key terms, seven to 300 resulted. In contrast to PubMed, the combination of *pediatric*, *sedation score*, and *ventilation* only yielded 30 results, while the combination of *pediatric*, *sedation*, and *ventilation* yielded 300 results. *PICU*, *sedation*, and *ventilation* also resulted in a significant result with 98 articles.

The Cochrane Library

A slightly different strategy was utilized in The Cochrane Library. Key terms of *PICU*, *pediatric*, *sedation*, *sedation score*, *agitation*, *pain*, *narcotics*, *benzodiazepines*, *extubation*, and *unplanned extubation* were used. More specific terms were utilized in this database due to the many results yielded from using the key terms. Furthermore, the “OR” function was utilized in this database to thoroughly exhaust the literature on this topic. For example, *PICU OR pediatric*, *extubation OR unplanned extubation*, and *sedation* yielded 1,164 results, while *PICU OR pediatric*, *extubation OR unplanned extubation*, and *sedation score* yielded 1,158 results. To attempt to further narrow this search, specific sedation agents were considered as key terms. *PICU OR pediatric*, *unplanned extubation*, and *narcotics OR benzodiazepines* were searched and resulted in a greater yield of 8,022. This attempt was unsuccessful in narrowing down the literature; therefore, the original literature searches were used for an in-depth review.

Ultimately, ten research articles were selected for critical appraisal and synthesis. All ten studies were retrieved from PubMed, while three overlapped in EBSCO Host and one in The Cochrane Library. Of the ten selected studies, two are observational studies, one is a case-control study, one is a retrospective study, two are quality improvement, one is a pre-and post-interventional study, and three are systematic reviews. In addition to the ten articles chosen for review, articles discussing different contributing factors to unplanned extubation and evidence-based sedation scoring methods were reviewed to increase understanding of the PICOT topic but were not included in the critical appraisal.

Critical Appraisal and Synthesis of Evidence

The quality of evidence was evaluated using the rapid critical appraisal (RCA) tool (Melnik & Fineout-Overholt, 2023). All studies were quantitative, which is considered a higher

level of evidence compared to qualitative studies (see Appendix B, Table 1). The strength of evidence was moderate, given that many articles were based on quality improvement interventions and observational studies. Some higher level of evidence was included using systematic reviews. Many studies utilized reliable sedation-scoring tools, including NPASS, RASS, and the CBS (see Appendix B, Table 2). The sample sizes of the studies ranged from 75 to 5,789 subjects. Most studies were conducted in pediatric ICUs (PICU, NICU, CVICU), with two including adult samples. Although this paper focuses on the pediatric population, the results from adult studies supplemented the findings of agitation being a risk factor for UE.

All primary studies that utilized UE bundles demonstrated decreased UE rates. Although many variables, including tube securement, nursing ratio, and restraint use, are included in UE bundles, most studies demonstrated sedation-related factors as contributing factors (see Appendix B, Table A2). However, considering these other variables is important in determining multifactorial causes of UE.

Purpose

UE in children results in adverse healthcare outcomes, leading to increased morbidity and mortality, length of stay, and hospital costs (Hatch et al., 2020; Klugman et al., 2020; Mekonnen et al., 2023). The purpose of this project is to optimize an existing sedation protocol by implementing structured staff education to increase adherence and thereby reduce UE rates. Objectives include increasing the adherence of providers ordering the sedation protocol for eligible patients, increasing the adherence of nursing staff documenting sedation score goals on patients who have the sedation protocol ordered, and reducing UE rates.

Frameworks

Theoretical Framework

The Systems Accident Model, also known as the Swiss Cheese Model (SCM) was used to increase adherence with the current sedation protocol to reduce UE rates. The SCM is used to influence root cause analysis of adverse events, and in this case, the adverse event of UE. The framework behind SCM was first proposed by James Reason, who described that accidents are commonly secondary to the lack of safety barriers across different levels of a system (Reason, 1990; Wiegmann et al., 2022). The SCM considers organizational influences, supervisory factors, preconditions for unsafe acts, and unsafe acts as the different system levels influencing errors (Reason, 1990; Wiegmann et al., 2022).

In reducing UE, organizational influences must first be addressed (Reason, 1990; Wiegmann et al., 2022). The organization must openly communicate the problem of UE and subsequently develop a plan to more effectively utilize the sedation protocol in efforts to reduce UE. Supervisory factors then aided in oversight of the protocol. This required further training of the medical staff on methods to increase ordering and documenting adherence (Reason, 1990; Wiegmann et al., 2022).

Preconditions for unsafe acts include environmental factors and team factors which are significant aspects of the SCM when considering UE (Reason, 1990; Wiegmann et al., 2022). Environmental factors include tools, technology, the physical environment, and the task itself. The use of a sedation protocol may require additional resources, including sedation agents and equipment to administer the medication, and a healthcare team member to administer the medication. It also requires nursing to complete the task of documenting the sedation score goal in the electronic medical record. Team factors include communication and coordination (Reason, 1990; Wiegmann et al., 2022). The use of a sedation protocol requires efficient communication between healthcare team members such as nurses, physicians and advanced practice providers to

determine patient sedation score goals daily, the need for sedation administration, and the proper timing for sedation administration. By addressing organizational influences, supervisory factors, and preconditions for unsafe acts, the SCM can be a helpful guide in reducing UE by implementing a sedation protocol.

Implementation Framework

The Rosswurm and Larrabee Model is a quality improvement model that is used to guide clinical changes based on evidence from quantitative and qualitative data (Rosswurm & Larrabee, 1999). This model has six main components, including assessing the need for change in practice, linking problem interventions and outcomes, synthesizing the evidence, designing practice change, implementing, and evaluating the change in practice, and integrating and maintaining the change in practice (Rosswurm & Larrabee, 1999). This model is effective for the proposed project. Internal data regarding UE has been collected and compared to external data, both demonstrating that sedation is a contributing factor to UE. Several potential interventions for the problem of UE have been identified, including sedation protocols, two-clinician assistance with transferring of patients, and standardized ETT measurement and securement. The evidence has been synthesized, which supports the use of a sedation protocol (see Appendix B, tables B1 and B2). Considering this evidence and internal data, the proposed change of optimizing a pre-existing sedation protocol has been defined. To further integrate this model, stakeholders must implement, evaluate, integrate, and maintain the change in practice.

Methods

Unplanned extubations (UE) of patients in pediatric intensive care units (PICU) are a critical challenge that poses a significant risk to patient safety, often leading to life-threatening complications. It is imperative to address this problem to minimize adverse outcomes in the

intensive care setting. Inadequate sedation can exacerbate the risk of UE by increasing patient agitation and susceptibility to excessive spontaneous movement, leading to unintentional tube removal. Adequate sedation plays a vital role in reducing UE by minimizing agitation.

Optimizing sedation protocols can ensure consistent sedation levels, standardize care practices, and is an evidence-based method to decrease UE rates in the pediatric population.

Setting and Stakeholders

A children's hospital in the Southwest United States was examined for UE rates and initiatives to decrease rates of UE. The hospital contains 465 licensed beds and 129 intensive care unit (ICU) beds within three ICUs: PICU, cardiovascular ICU (CVICU), and neonatal ICU (NICU). The quality leadership team at this hospital has a primary focus on reducing UE rates using a pre-existing sedation protocol in the PICU. In 2023, the PICU had 11 unplanned extubation events.

Stakeholders involved in the initiative to reduce the rate of UE at this hospital include a clinical education specialist, nursing ICU vice president, a quality consultant, PICU educator, PICU manager, PICU nurses, PICU providers, a PICU pharmacist, and a PICU fellow. The clinical education specialist is also the quality team lead and helped with the implementation of the project and the development of an effective intervention regarding what is needed for quality improvement at this institution. The nursing ICU vice president is a key stakeholder, as the implementation of this project affected the work requirements of staff. The quality consultant holds data on UE including documentation of trends and etiologies of UE. The PICU educator and manager are key stakeholders as this project involves implementation of staff education and affect the documentation requirements of nurses. PICU nurses and providers are directly involved in the implementation of this project, as they underwent specific education and were

asked to implement change in their daily practice. The providers underwent education intervention to increase their knowledge and adherence to ordering the sedation protocol for eligible patients, while nurses underwent education intervention to increase their adherence to documenting the sedation score goal. Both providers and nurses were be asked to add the topic of a sedation score goal to daily rounding. There is one lead physician and a PICU pharmacist who were already involved in the sedation protocol development, and they remained to be key stakeholders, as this pathway involves complex decision-making regarding patient selection, indications, and dosing of medications.

Participants

The population for this project includes PICU nursing staff and PICU providers, including physicians, nurse practitioners, and physician assistants. All nurses and providers in this PICU were included without exclusion. The education sessions provided to PICU staff are aimed to improve the adherence and use of the sedation protocol. The sedation protocol has already been implemented and has specific inclusion and exclusion criteria. Patients included in this protocol are mechanically ventilated patients located in the PICU and have an expected intubation duration of greater than 48 hours. Patients excluded are patients with acute brain injury, brain death candidates, end-of-life care, pre-existing continuous patient-controlled anesthesia, previous sedation tolerance in the ICU, continuous neuromuscular blockage, and extra-corporeal life support (ECLS). These inclusion and exclusion criteria have already been put into place for the existing sedation protocol and was determined by PICU medical providers. Recruitment of patients was be based on inclusion and exclusion criteria. Staff recruitment for the staff education sessions was be achieved by email notification and flyers posted in the PICU one month before the initiation.

Intervention

Evaluation of this quality improvement project involved determining if reinforcing provider and nursing education on the sedation pathway increases its utilization and adherence and how increasing adherence to ordering and documenting the sedation protocol affects UE rates in the PICU. The intervention was based on a pre-existing sedation pathway protocol developed by a PICU fellow (see Appendix A). This protocol involves the providers first ordering the sedation pathway for all eligible patients, and a sedation score goal for each patient is determined using the State Behavioral Scale (SBS) score. The nurses then use this order and sedation score goal to follow the protocol and administer specific medications to achieve or maintain the SBS goal.

As this pathway has already been established, the first step was to identify current rates of providers ordering the existing protocol and nurses documenting the sedation score goal. A chart review determined adherence of providers to identify the number of eligible patients, number of eligible patients who had the sedation protocol ordered, and the number of eligible patients who did not have the sedation protocol ordered. The nurses' adherence was determined by a chart review to identify the presence or absence of documented sedation score goals on all patients with the sedation protocol ordered. The documented sedation score goal was compared to the patient's documented true sedation scores to determine how often the goal was achieved. A chart review was also performed to identify UE rates in the PICU prior to intervention, SBS sedation scores during the time of UE, and if the sedation protocol was ordered for the patients who experienced UE.

Education material for providers and nurses was developed to help increase adherence. Provider education material included eligible patients for the sedation protocol, benefits of

utilizing the protocol, and how and how often to order the protocol. Nursing education material included benefits of utilizing the protocol, how to determine if the protocol is ordered for their patient, when and where to document sedation score goals. Both provider and nursing education included an overview of the protocol steps and the importance of daily team discussion of sedation score goal, re-assessing and reordering daily. Education was dispersed in two phases. The first phase was nursing education, which was provided at a regular monthly meeting. Nurses who did not attend the meeting were emailed the education material, and a clinical “Quick-Tip” was sent to all nursing staff. The education focused on adherence to documenting SBS goals as determined by the medical team. The second phase was for providers at a monthly division meeting two months after the nursing education. Education for providers focused on adherence to ordering the sedation protocol for eligible patients. Providers also received a “Quick-Tip” to summarize the education material. Both nursing staff and providers received education on updates to the sedation protocol in addition to emphasizing adherence. After education sessions were completed, the PICU staff were encouraged to continue to use the sedation protocol to increase its utilization.

Data Collection

A chart review before and after implementation of staff education was performed to determine its impact on UE rates and staff adherence. Prior to the staff education intervention, a chart review was done to identify UE rates in the previous two months, adherence rates of ordering the existing protocol for eligible patients, and adherence rates of nursing documentation of SBS score goals.

After the staff education intervention, data was collected to evaluate outcomes. To determine if implementing education to increase staff adherence reduces UE rates, the chart was

reviewed for the rate of UE occurring in patients who had the sedation protocol ordered and the rate of UE in patients who did not have the sedation protocol ordered. For every UE, the SBS score at the time of UE and SBS score goal was identified. To determine if implementation of structured education increases provider adherence, the chart was reviewed for the number of eligible patients, number of eligible patients who had the sedation protocol ordered, and number of eligible patients who did not have the sedation protocol ordered. To determine if the implementation of structured education increases nursing adherence, the chart was reviewed for the rate of documentation of sedation score goal on all patients with the sedation protocol ordered.

All three outcomes were determined using a chart review for data collection and documented on a chart audit form. The data items that were be extracted from the chart include patient age, patient sex, date of intubation, total ventilation days, eligibility for the sedation protocol, whether the protocol was ordered, if the SBS score goal was documented, and the SBS score goal at the time of UE. The data was be stored in a secure folder and was accessible only to project team members using password protection.

Instrument

In addition to a chart audit form for data collection, the SBS scoring tool was be used to evaluate patient sedation levels. This tool has already been implemented and used at the project site. The SBS tool was developed based on seven outcome variables. These include respiratory drive or response to ventilation, coughing, best response to stimulation, attentiveness to care provider, tolerance to care, consolability, and movement after consoled (Curley et al., 2006). These variables were used to develop different levels of sedation and were determined based on descriptors associated with agitation in prior literature (Curley et al., 2006). These levels of

sedation range from a score of -3 to +2, with +2 indicating that the patient is agitated (see Appendix C). There are detailed behaviors and descriptors listed under each of the levels of sedation to help more accurately identify the patient's sedation score.

To assess the reliability of the five different sedation states, patients were observed for one minute before incremental levels of stimulation was applied. Once there was a patient response, the patients were consoled for two minutes before identifying their SBS score (Curley et al., 2006). This consistent method of identifying SBS scores increases reliability of the tool. Some of the outcome variables such as consolability, however, may not be as reliably identified because each patient may console differently based on who is consoling them and how they are being consoled. Despite the variability of consolability, psychometric analysis revealed that the SBS tool had moderate to good inter-rater reliability (Curley et al., 2006).

The SBS tool was specifically developed and tested in pediatric ventilated patients. The validity of each of the seven variables were assessed using a one-way analysis of variance (ANOVA) and a post-hoc Tukey HSD test (Curley et al., 2006). The validity of the five different sedation states was evaluated by identifying a numeric rating scale for each patient along with the SBS score and comparing the results. Psychometric analysis demonstrated that the five different sedation states significantly differed from one another, which supports the validity of this tool (Curley et al., 2006).

The SBS tool is a valid and reliable tool for measuring sedation in intubated and mechanically ventilated children. Therefore, this is an appropriate tool for measuring sedation levels in patients undergoing a quality improvement project aimed at reducing unplanned extubation rates.

Outcome Measure and Data Analysis

The outcomes of this quality improvement project were to determine if nurse and provider education on an existing sedation protocol increases adherence to the protocol and if it reduces UE rates. These outcomes were measured by determining the percent change in UE rates before and after education, the number of eligible patients with the sedation protocol ordered, and the percent increase in documentation rates of SBS score goals.

Descriptive statistics were used to describe the demographics and outcome variables. Fisher exact tests were done to examine whether UE was independent of the pre- and post-intervention groups for nurse and provider education. Fischer exact tests were also done to examine whether the protocol ordering rate was independent of the pre- and post-provider intervention groups.

Adherence to documenting sedation scores and sedation score goals was calculated by determining how many times the value was required to be documented and calculating the percent that was documented.

Sustainability

There are two key stakeholders at the project site that are essential to the sustainability of this quality improvement project. A PICU physician and pharmacist have worked on this project for two years with a fellow physician who created the initial sedation protocol pathway. All stakeholders were crucial to the initial implementation of the protocol. The fellow physician is no longer at the project site, and a nurse practitioner student has taken her role in this project. The PICU physician is also a medical director of the quality department at the project site and continues to analyze the quality outcomes of using the sedation protocol.

While the PICU physician and pharmacist continue to implement the sedation protocol pathway, the sustainability of the staff education sessions must also be addressed to ensure that

staff continues to adhere to the sedation protocol. Another member of the PICU team must take the place of the nurse practitioner student to implement the education sessions and evaluate outcomes. This member can be a fellow physician, nurse practitioner student, medical student, or nurse practitioner at the project site. This team member will ensure sustainability by implementing the education sessions periodically for staff nurses and providers. Education sessions may be provided twice yearly, depending on staff needs and adherence rates. This team member will use the education material already developed but may adjust the education material according to staff needs and current gaps. The sustainability of this quality improvement project can be achieved by ensuring that the PICU physician and pharmacist continue the reinforcement and use of the sedation protocol and identifying a new team member to implement staff education.

Ethical Considerations

Human subjects were protected for this quality improvement project. The project did not require patient consent as it did not directly involve patients. This project entails staff education, chart reviews, and evaluation of a clinical protocol aimed at improving quality of care. In any patient who experiences a UE, their data was be extracted from the chart, but no patient identifiers were be disclosed in the study. Each patient with extracted data was de-identified with ID numbers. Patient data prior to the intervention were given ID's starting with 101, 102, and so forth. Data extracted after the intervention were given ID's starting with 201, 202, and so forth. This allows for a clear distinction between pre- and post-intervention data without disclosing patient identifiers. No patient contact information was obtained or stored for this project.

The data extracted from patient's electronic medical record was stored in a secured Microsoft excel file with password access for team members only. Team members include ASU

nurse practitioner student, ASU faculty mentor/Phoenix Children's Hospital Nurse Practitioner, Phoenix Children's Hospital lead physician for this project, and Phoenix Children's Hospital lead pharmacist for this project. Only these essential team members had access to the secured file, protecting human subject information. The institutional review boards at both the project site and Arizona State University reviewed the project methodology to ensure that ethical principles were followed, and that participants' human rights were protected.

Results

Intellectus Statistics software was used to store, manage, and analyze the data. There were a total of 262 patients. There were 68 patients in the two months prior to the nursing intervention and 97 patients in the two months after the nursing intervention, for a total of 165 patients. There were 97 patients in the two months prior to the provider intervention and 97 patients in the two months after the provider intervention, for a total of 194 patients. The two months after the nursing intervention and two months prior to the provider education were the same time period, and therefore, the patients were the same.

Nursing Intervention

There were 165 intubated patients in the PICU for the four months of pre and post-nursing intervention, 68 pre-intervention and 97 post-intervention. The average age was 6.14 years ($SD = 5.71$, $Min = 0.08$, $Max = 21.00$, $Mdn = 4.00$). The average days of ventilation was 6.57 ($SD = 10.47$, $Min = 0.02$, $Max = 68.00$, $Mdn = 3.00$). The summary statistics can be found in Table 1. Most of the sample was male ($n = 99$, 60%), and the remainder were female ($n = 66$, 40%) (see Appendix D, Tables 1 and 2).

Unplanned Extubation

In the two months before nursing education, 3% ($n=2$) intubated patients in the PICU experienced UE. One of the patients had two UE, for a total of three UE in the two months

before education. All patients who experienced UE were eligible for the sedation pathway, but none had the pathway ordered, and none of the patients with the sedation pathway ordered experienced UE. 67% of UE (n=2) were determined to be related to inadequate sedation. The other UE was attributed to patient transferring.

In the two months after the nursing education and before provider education, 2% (n=2) of all intubated patients in the PICU experienced UE. One of these patients were eligible for the pathway but neither of them had it ordered. All patients with the sedation pathway ordered did not experience a UE. None of the UE were reported to be attributed to inadequate sedation. The Fisher exact test was done to compare the rate of UE from pre- to post-nursing intervention. The results of the Fisher exact test were not significant based on an alpha value of .05, OR = 0.70, $p = 1.000$, suggesting that there was no significant change in UE from pre- to post-nursing intervention (see Appendix D, Table 3).

Adherence of Sedation Score Goal Documentation

The primary focus of the nursing education was to increase adherence to documenting sedation score goals for patients on the sedation protocol. For patients with the sedation pathway ordered, sedation scores are expected to be documented hourly and when the patient requires additional sedation. Additional sedation could be in the form of a PRN or bolus medication or an increase in an already infusing drip. It is also expected that SBS goals will be documented every shift.

Prior to nursing intervention, of the eligible patients with the sedation protocol ordered (n=2), none had SBS goals documented during protocol time period, but there was 92% adherence in documenting SBS scores. One patient reached their SBS goal 40% of the time, while the other patient reached their SBS goal 100% of the time while on the protocol. Although

there were six intubated patients with SBS goals documented, they were either not eligible for the protocol or did not have the protocol ordered.

After nursing intervention, of the eligible patients with the sedation protocol ordered ($n=2$), 50% had SBS goals documented ($n=1$) during the protocol time period, and there was 77% adherence in documenting SBS scores. One patient reached their SBS goal 80% of the time, while the other patient reached their SBS goal 60% of the time while on the protocol. Although there were 17 other patients with SBS goals documented, they did not have the protocol ordered (see Appendix D, Table 4).

Provider Intervention

There were 194 intubated patients in the PICU for the four months of pre- and post-provider intervention, 97 pre-intervention and 97 post-intervention. The average age was 6.61 years ($SD = 5.90$, $Min = 0.01$, $Max = 19.00$, $Mdn = 5.00$). The average days of ventilation was 6.26 ($SD = 9.45$, $Min = 0.04$, $Max = 68.00$, $Mdn = 3.00$). The summary statistics can be found in Table 4. Most of the sample was male ($n = 118$, 60.8%), and the remainder were female ($n = 76$, 39.2%) (see Appendix D, Tables 5 and 6).

Unplanned Extubation

The two months before provider education was the same time frame as the two months after nursing education. During this time, 2% ($n=2$) of all intubated patients in the PICU experienced UE. One of these patients were eligible for the pathway but neither of them had it ordered. All patients with the sedation pathway ordered did not experience a UE. None of the UE were reported to be attributed to inadequate sedation.

In the two months after provider education, 3% (n=3) of all intubated patients in the PICU experienced UE. Two of these patients were eligible for the pathway, but none had it ordered. All patients with the sedation pathway ordered did not experience a UE.

The Fisher exact test was done to compare the rate of UE from pre- to post-provider intervention. The results of the Fisher exact test were not significant based on an alpha value of .05, OR = 1.51, $p = 1.000$, suggesting that there was no significant change in UE from pre- to post-provider intervention (See Appendix D, Table 7).

Adherence to Ordering the Sedation Protocol

The primary focus of the provider education was to increase adherence to ordering the sedation protocol for eligible patients. Prior to provider education, 37% (n=36) of patients were eligible for the protocol. Of all eligible patients, 6% (n=2) had the protocol ordered. In the two months after provider education, 41% (n=40) of patients were eligible for the protocol. Of all eligible patients, 20% (n=8) had the protocol ordered.

The Fisher exact test was done to compare the rate of protocols ordered for eligible patients from pre- to post-provider intervention. The results of the Fisher exact test were not significant based on an alpha value of .05, OR = 3.26, $p = .065$, suggesting that there was no significant change in the ordering of the protocol for eligible patients from pre- to post-provider intervention (see Appendix D, Table 8).

Discussion

Summary

Research suggests that using a sedation protocol may help reduce UE rates in the PICU. The PICU at this organization already had a protocol aimed to be optimized by providing nursing

and provider education to increase adherence. Although the findings of this project were not statistically significant, adherence to a sedation protocol may help to reduce UE rates.

Strengths

Strengths of this quality improvement study include its cost-effectiveness, easy implementation of education interventions, and use of reliable tools for measurement. The use of a sedation protocol and adherence to it by nurses and providers requires no cost and negligible time from staff. Furthermore, the education sessions for nurses and providers are implemented during regular monthly meetings, requiring no additional time from staff. The SBS screening tool was used to assess patient sedation scores, and a chart audit was performed to determine adherence from staff. Both are valid and reliable tools for data collection. The sedation protocol was already in place before this intervention, making staff aware of the intervention and experienced with the protocol. This prior involvement from staff could have contributed to a smooth transition in implementing the protocol into their practice.

Limitations

There were several limitations to this quality improvement project. The sample size for patients who experienced UE was small, which limits the ability to adequately assess the impact of optimizing the sedation protocol. Furthermore, because of the small sample size of patients who received the protocol, statistical analyses could not be run for adherence to SBS goal documentation, as this data could only be analyzed by calculating percentages without testing significance. The sample of nurses and providers who attended was also small. Although education materials were dispersed to all nurses and providers, only 3% (n=6) of PICU nurses and 42% (n=21) of providers attended in person.

There were some limitations to the data collected. For example, 17% (n=44) of the patients who were admitted for less than a day were already intubated upon admission, so days of ventilation were based on days of ventilation only within the PICU. This may have resulted in inaccurate days of ventilation. Furthermore, 2% (n=6) of patients required tracheostomy placement within the data collection time. Although these patients were still being ventilated after tracheostomy placement, it is important to note that only days ventilated with an endotracheal tube were accounted for. Data collection was completed two months after provider education, and three patients were still intubated at this time. Therefore, the average days of ventilation account for the period data was collected and does not reflect the entirety of those patient's intubation period. In addition, of all eligible patients four months before and after provider education (n=76), 8% (n=6) later became ineligible due to exclusion criteria such as initiating a neuromuscular blockade or requiring ECMO support. When analyzing the percentage of patients who were eligible for the protocol, these patients were included, but their disqualification later on was not accounted for.

After implementation of the educational sessions for both nursing and providers, there were additional changes made to the protocol. The exclusion criteria were modified to include more patients, including those with pre-existing PCA, previous sedation tolerance, and those with deeper level of sedation required. These exclusion criteria were removed, and a note was added to encourage providers to use clinical judgement to determine appropriateness of following the pathway. Additionally, changes were made to ordering the order set from the provider's perspective. The ability to pre-select an SBS goal based on the patient's status – requiring heavy sedation, being weaned from the ventilator, or stable on the ventilator – was added as a guide for providers when deciding on an SBS goal. Since both changes were made

after education implementation, their effect on staff adherence or UE rates was not monitored. These changes could have contributed to changes not accounted for in this data collection process.

Implications and Future Recommendations

Data should be collected over a longer period to increase the sample size of patients who experience UE, thus allowing us to assess the impact of optimizing the sedation protocol more effectively. Gathering data using a larger sample size may allow for statistically significant results, suggesting using a sedation protocol to reduce UE rates in the PICU. Furthermore, all changes made to the protocol to optimize it should be made simultaneously to assess the impact better.

Sedation protocols can allow for optimal patient comfort. Increasing provider and nurse adherence using education sessions can help increase the ordering of the protocol for eligible patients and increase documentation of SBS goals. By adhering to sedation protocols, patient comfort may be optimized and thereby reduce UE rates in the PICU. Due to the small implementation time frame for this project, continued implementation and analysis are needed to determine its effectiveness.

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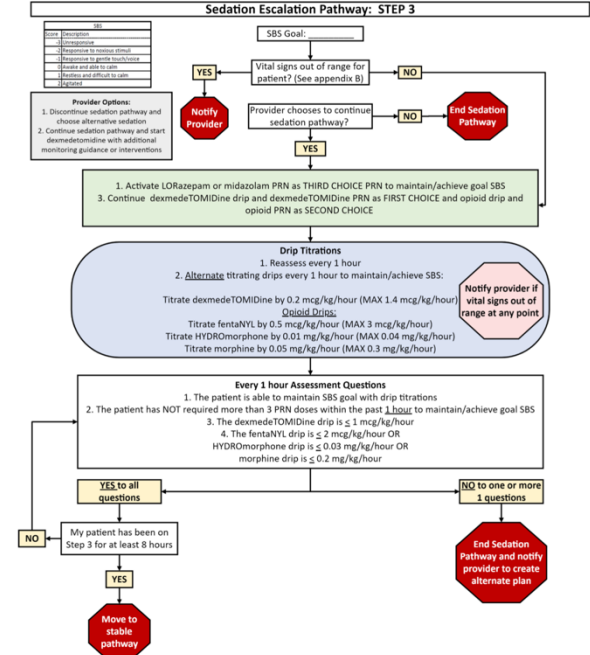
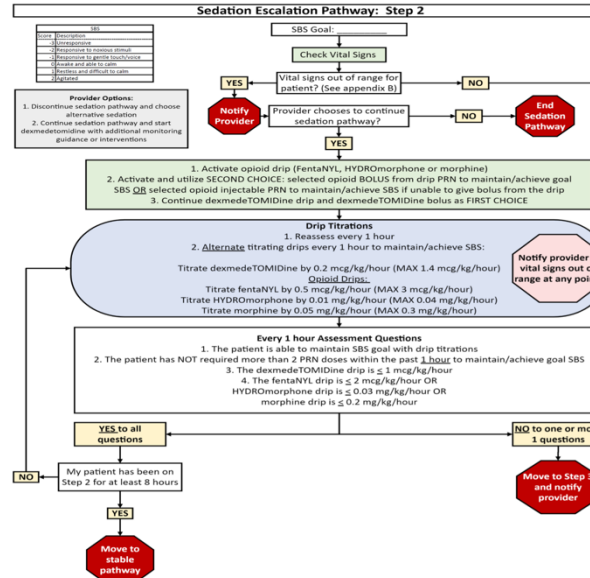
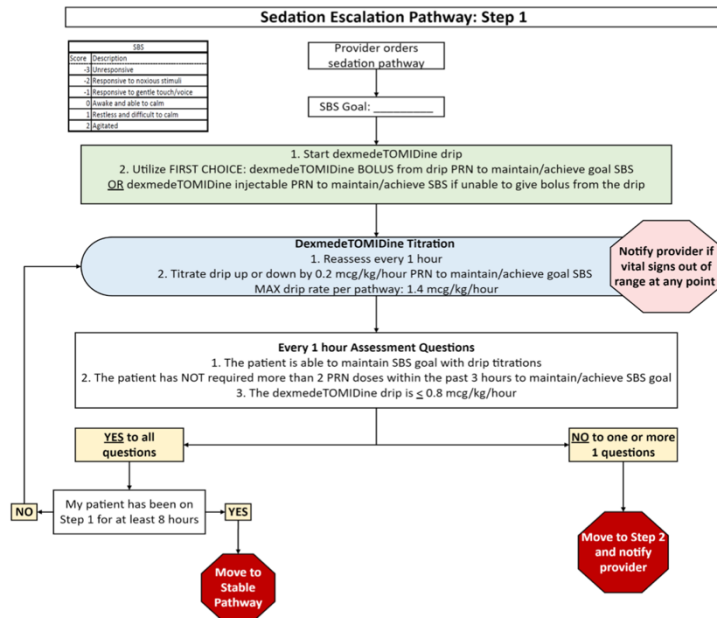
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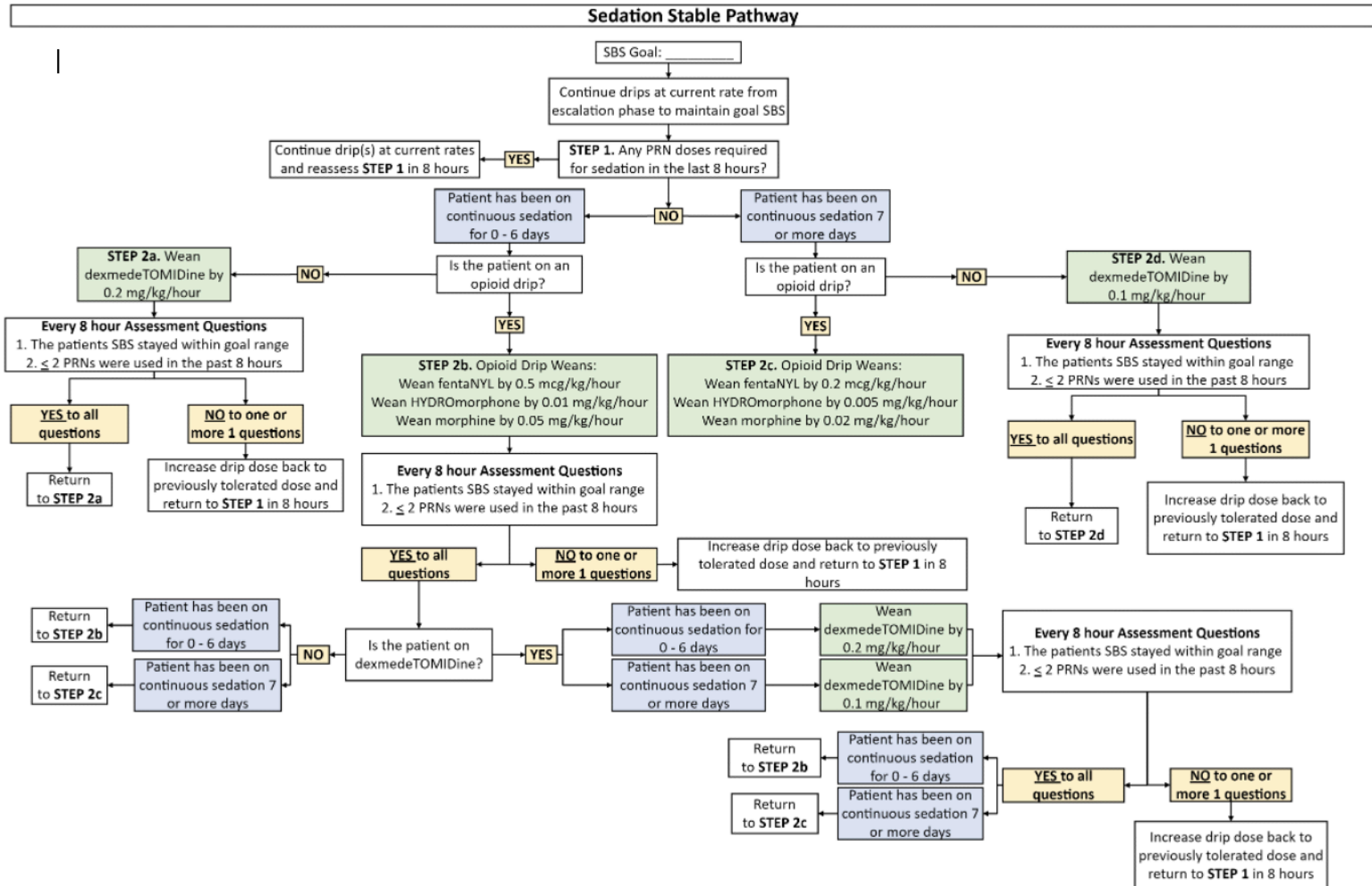
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Appendix A Pathways



Key: PICU Pediatric Intensive Care Unit, ICU intensive care unit, UE unplanned extubation, ETT endotracheal tube, CBS comfort behavioral scale LOE level of evidence, OR odds ratio, AOR adjusted odds ratio, CI confidence interval EMR: electronic medical record IV independent variable DV dependent variable RASS Richmond Agitation Sedation Scale



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Appendix B

Evaluation and Synthesis Tables

Table 1

Evaluation Table Quantitative Studies

Citation	Theoretical/ Conceptual Framework	Design/ Method/ Purpose	Sample/Setting	Variables	Measurement/ Instrumentation	Data Analysis	Results/ Findings	Level of Evidence; Application to practice; Generalization
<p>Neves et al., (2023), Pediatric unplanned extubation risk score: A predictive model for risk assessment.</p> <p>Country: Brazil</p> <p>Funding: None.</p> <p>Bias: None.</p>	<p>Pediatric Unplanned Extubation Risk Score Framework</p>	<p>Design: Single-center, observational study</p> <p>Purpose: The purpose of this study was to develop a predictive model to identify the risk of UE in a PICU (PUERS).</p>	<p>N= 2917 n = 73 UE</p> <p>Demographics: Intubated pediatric patients ages 28 days to 14 years old</p> <p>Setting: PICU of the Hospital de Clinicas Complex of the Federal University of Parana in Brazil</p> <p>Exclusion: Patients with a tracheostomy and patients who were extubated prior to</p>	<p>IV1: Inadequate ETT placement and fixation</p> <p>IV2: insufficient level of sedation</p> <p>IV3: < 12 months of age</p> <p>IV4: airway hypersecretion</p> <p>IV5: Inadequate family orientation or nurse-to-patient ratio</p> <p>IV6: Weaning period from mechanical ventilation</p> <p>DV1: UE</p> <p>Definitions: (PUERS) <u>Pediatric Unplanned Extubation Risk Score</u>: a model</p>	<p>Tools:</p> <ul style="list-style-type: none"> - Daily patient assessments - CBS <p>Validity/ Reliability: CBS is a reliable and valid tool to assess sedation in PICU patients ages 1 month – 18 years</p>	<p>Statistical Tests Used:</p> <ul style="list-style-type: none"> - t-test - Mann-Whitney test - Pearson’s chi-square test - Multivariate logistic regression - Receiver Operation Characteristic - Univariate logistic 	<p>DV1 affected by IV1: OR = 2, CI: 1.16-3.36</p> <p>DV1 affected by IV2: OR = 3, CI: 1.57-4.37</p> <p>DV1 affected by IV3: OR = 1.27, CI: 1.14-1.41</p> <p>DV1 affected by IV4: OR = 11, CI: 2.58-45.26</p> <p>DV1 affected by IV5: OR = 5, CI: 2.64-7.99</p> <p>DV1 affected by IV6: OR = 3, CI: 1.67-4.79</p>	<p>LOE: primary level III</p> <p>Strengths: PUERS scoring system was sensitive in estimating UE risk</p> <p>Can predict UE risk with 89% sensitivity and 62% specificity</p> <p>Study conducted over two years, increasing time of data collection</p> <p>Weakness: Recruitment from only one hospital decreases generalizability</p> <p>Feasibility:</p>

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			applying the risk score Attrition: 358 eligible patients with 286 who completed the study, resulting in a 20.1% attrition rate.	in the form of a checklist created based off this study to predict UE risk		regression - Multiple correspondence analysis		PUERS scoring system is cost-efficient Application: PUERS scoring system is generalizable across various PICU settings Systematic approach to evaluating UE risk
Mekonnen et al., (2023), Incidence, outcome and determinants of unplanned extubation among pediatric intensive care unit Addis Ababa, Ethiopia, 2023: Nested, unmatched case-control study design Country: Ethiopia Funding: Saint Paul’s Hospital, Millennium Medical College. Bias: None.	- Determinants of Unplanned extubated (UPEs) - The conceptual framework was developed by the researchers after a literature review.	Design: Nested unmatched case-control study Purpose: The purpose of this study was to determine the incidence, outcome, and determinant of unplanned extubating among children in the PICU.	N= 198 n = 66 UE Demographics: Intubated PICU patients ages 1 month to 14 years old, needing mechanical ventilation for at least 12 hours. Majority were less than six years old. Setting: Eight and four bedded PICUs in two hospitals, respectively, in Addis Ababa, Ethiopia Exclusion:	IV1: agitated patients IV2: working night shift hours IV3: use of plaster or roll bandages separately IV4: Nurse-to-patient ration 1:2 IV5: intermittent sedation IV6: physically restrained DV1: UE Definitions: <u>Planned extubation:</u> Admission to the PICU, intubation of at least 12 hours, and removal of the ETT after a	Tools: - Daily physician-revised notes, hourly nursing follow-up sheets - Questionnaire for every UE Validity/Reliability: Not evidence-based, variable dependent on physician/nurse, not standardized, unknown reliability and validity.	Statistical Tests Used: Chi-squared test Bivariate binary logistic regression Multivariate logistic regression analysis	DV1 affected by IV1: 3.7 times more likely for UE (p = 0.001, AOR = 3.708, CI: 1.401-9.81) DV1 affected by IV2: 8.8 times more likely for UE (p = 0.000, AOR = 8.789, CI: 2.37-32.58) DV1 affected by IV3: 4 times more likely for UE compared to both bandages together (p = 0.003, AOR = 4.12, CI: 1.215-13.96) DV1 affected by IV4: 6.65 times more likely for UE compared to 1:1 ratio (p = 0.000,	LOE: Primary level III Strengths: Comparison between groups of those with UE and planned extubation Low attrition rate Weakness: Did not include other confounding variables potentially affecting UE: presence of caregivers at bedside, nursing experience, nurses floating from other units. Feasibility:

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			<p>Patients with a tracheostomy and patients who died on a mechanical ventilator without planned or unplanned extubation.</p> <p>Attrition: 201 participants recruited, 198 completed, resulting in a 1.5% attrition rate.</p>	<p>physician's order, according to hospital policies and procedures.</p> <p><u>Unplanned extubation:</u> Premature removal of an ETT by healthcare professionals, caregivers, or the patient.</p> <p><u>Reintubation:</u> ETT placement within 24 hours of planned extubation of UE.</p>			<p>AOR = 6.65, CI: 1.87-23.698)</p> <p>DV1 affected by IV5: 3 times more likely for UE compared to continuous sedation (p = 0.005, AOR = 3.717, CI: 1.017-10.816)</p> <p>DV1 affected by IV6: 3 times more likely for UE (p = 0.009, AOR = 3.717, CI: 1.02-13.54)</p>	<p>Feasible, tools are low-cost and time-efficient. No cost to patient.</p> <p>Application: Observational study, can be conducted retrospectively.</p>
<p>Censoplano et al., (2020), Achieving sustainability in reducing unplanned extubations in pediatric cardiac ICU</p> <p>Country: United States</p> <p>Funding: Department of Quality and Patient Safety at Children's Hospital Colorado</p> <p>Bias: None</p>	<p>Systems Accident Model/Swiss Cheese Model (inferred)</p>	<p>Design: Retrospective chart review</p> <p>Purpose: To identify risk factors associated with UE</p>	<p>N = 2,067 total hospitalized patients</p> <p>n = 45 patients with UE</p> <p>Demographics: intubated and mechanically ventilated pediatric patients with congenital heart disease, those with UE</p>	<p>IV1: Poor ETT tape integrity</p> <p>IV2: inadequate tube securement</p> <p>IV3: inadequate sedation</p> <p>DV1: UE</p>	<p>UE events were recorded on the event record tracking system and verified with the EMR. Variables including sedation level are recorded by providers in the EMR.</p> <p>Validity/Reliability: ETT tape integrity, inadequate tube securement, and inadequate</p>	<p>Statistical Tests Used: Apparent cause analysis Chi-square test Mann-Whitney I test Two-tailed p value</p>	<p>DV1 affected by IV3: 39% of patients who experienced UE were inadequately sedated</p>	<p>LOE: Primary level IV</p> <p>Strength: Data was collected over a period of seven years total.</p> <p>Weakness: Small sample size of 45 patients that experienced UE Population is limited to the cardiac ICU and therefore is less generalizable to other ICU populations</p> <p>Feasibility: Feasible study as</p>

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			<p>with a median weight of 3 kg Setting The cardiac intensive care unit Children’s Hospital of Colorado on the Anschutz Medical Center of the University of Colorado. Exclusion: All patients that experienced UE were included Attrition: 45%</p>		<p>sedation are subjective, and therefore lack validity and reliability. Unspecified tool for sedation documentation.</p>			<p>it is a chart review and is at no cost to the patient or facility. Application: Easy to apply in various settings where UE are recorded in the EMR.</p>
<p>Ferreira et al., (2023), Quality improvement project to reduce unplanned extubation in a paediatric intensive care unit Country: United States Funding: Provided by institutional/departmental sources Bias: None</p>	<p>Improvement Model of methodology of the Institute for Healthcare Improvement</p>	<p>Design: Quality improvement intervention Purpose To reduce the rate of unplanned extubation in a PICU by 66%</p>	<p>N = 75 N = 15 with UE Demographics: Those with UE had a mean age of 28 months and were 53% female Setting: A PICU of a private hospital Exclusion: Tracheostomized patients</p>	<p>IV1: Sedation monitoring IV2: good practices of physical restraints IV3: evaluation of ETT positioning IV4: UE prevention checklist IV5: family engagement and education DV1: UE Definition:</p>	<p>Sedation measured using CBS Adherence to UE prevention practices was measured through a medical record audit and standardized checklist Validity/Reliability: Valid, reliable, evidence-based tool to monitor sedation</p>	<p>Statistical Tests Used: Control Uchart to plot UE Control Tchart to plot days between events</p>	<p>DV1: reduced UE rate by 100%, sustained during a 2-year period</p>	<p>LOE: Primary level IV Strength: Utilized a valid sedation monitoring tool Weakness: Evaluated adherence to the interventions through analysis of medical records rather than direct observation, potentially threatening the validity.</p>

Key: PICU Pediatric Intensive Care Unit, ICU intensive care unit, UE unplanned extubation, ETT endotracheal tube, CBS comfort behavioral scale LOE level of evidence, OR odds ratio, AOR adjusted odds ratio, CI confidence interval EMR: electronic medical record IV independent variable DV dependent variable RASS Richmond Agitation Sedation Scale

			Attrition: 20%	UE is any unexpected or UE due to patient agitation or patient handling by the medical team				Does not account for each of the IV independently, unknown which variable more significantly affects the DV Small sample size in a local area, decreases generalizability Feasibility: Feasible study as interventions entail monitoring and adherence to regular practices, not requiring additional costly resources
Minda et al., (2022), Magnitude and associated factors of unplanned extubation in intensive care unit: A multi-center prospective observational study Country: Ethiopia Funding: Not funded Bias: None	Systems Accident Model/Swiss Cheese Model (inferred)	Design: Prospective observational study Purpose: To assess the magnitude and associated factors of UE in ICUs	N = 314 N = 62 with UE Demographic s: 56% male, 44% female, primarily ages 15-47 with a median age of 40. Setting: Five ICUs in Addis Abada, Ethiopia Exclusion: all intubated patients with COVID-19 Attrition: 19%	IV1: agitation IV2: restraint use IV3: night shift DV1: UE Definition: UE is the removal of an ETT accidentally during procedural activities or by the action of a patient	RASS was used to measure sedation Validity/ Reliability: RAAS is a well-studied tool to evaluate sedation level	Statistical Tests Used: Bivariable and multivariable logistic analyses	DV1 affected by IV1: 10.82% of patients experiencing UE were agitated (AOR = 4.934, 95% CI: 1.934-12.586, p = 0.001) DV1 affected by IV2: 15% of patients experiencing UE had restraints (AOR = 4.352, 95% CI: 2.936-10.47, p = 0.001) DV1 affected by IV3: 12.42% of patients experiencing UE occurred during	LOE: Primary level III Strength: Multiple hospitals recruited Weakness: - includes patients of all ages, not just pediatrics - Small time period of 5 months

Key: **PICU** Pediatric Intensive Care Unit, **ICU** intensive care unit, **UE** unplanned extubation, **ETT** endotracheal tube, **CBS** comfort behavioral scale **LOE** level of evidence, **OR** odds ratio, **AOR** adjusted odds ratio, **CI** confidence interval **EMR:** electronic medical record **IV** independent variable **DV** dependent variable **RASS** Richmond Agitation Sedation Scale

							night shift (AOR 3.307, 95% CI = 1.97-6.27, p = 0.004)	
Jayawardena et al., (2021), A low-cost educational intervention to reduce UE in low-resources pediatric intensive care units. Country: El Salvador Funding: The Benjamin Harry Peikin Foundation Bias: None	Systems Accident Model/Swiss Cheese Model (inferred)	Design: pre-post interventional study Purpose: to determine if an educational intervention bundle regarding appropriate bedside care, sedation, appropriate use and securement of a cuffed ETT can reduce UE and mortality	N = 957 Pre-intervention N = 859 Post-intervention N = 98 Demographics: 44.5% female, mean age 3.02 years, mean weight 13.9 kg, most common diagnosis community-acquired pneumonia Setting: PICU at The Hospital Nacional de Niños Benjamin Bloom Exclusion: patients with existing tracheostomy	IV: Implementation of educational curriculum DV1: UE DV2: mortality rate Definitions: <u>Educational curriculum modules included the following:</u> - Care of the intubated patient (sedation, turning the patient, tubing, suctioning) - Cuffed ETTs (sizing, how to intubate, how to extubate, management) - Securing the ETT - Ensuring proper placement	Medical record documentation Validity/reliability: Subjective, not highly valid/reliable	Statistical tests used: Fisher's Exact Test Mantel-Haenszel test	DV1: decreased from 29.4% to 17.3% (CI: 0.28-0.88; p = 0.01) DV2: decreased from 26.7% to 22.4% (CI: 0.46-1.33; p= 0.40)	LOE: primary level IV Strength: Cost-effective, easily dispersible to other settings/hospitals. Weakness: Relies on data from a written medical record, not an RCT but could be designed as such, limited data from one hospital Feasibility: No cost of educational intervention. Materials such as ETT and ETT tape cost was \$3.18 per patient, in addition to the reusable Tri-anim cuff pressure manometer that cost 197.98. Cost-effective according to WHO guidelines. Application: Staff who created the educational materials were volunteers; requires willing staff, but

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				- Cuff inflation <u>UE</u> : any dislodgement of ETT from trachea that was not intentional while the patient was in the PICU				education material is freely available online.
Mahaseth et al., (2020), Reducing UEs in a level IV neonatal intensive care unit. Country: United States Funding: None Bias: None	Systems Accident Model/Swiss Cheese Model (inferred)	Design: Quality improvement intervention Purpose: To determine if a continuous quality improvement program reduces UE rates	N = 5,789 admissions n = 435 UE Demographics: Not provided Setting: Level IV NICU Exclusion: Patients with tracheostomy, patients where ETT was purposefully replaced despite correct placement	IV1: staff education IV2: Consistent standardized use of ETT securing device IV3: 2 providers during bedside activities IV4: Documentation of ETT position IV5: Targeted sedation scoring DV: UE Definitions: <u>Sedation medications used:</u> - Midazolam - Fentanyl - Morphine <u>UE apparent cause analysis components:</u> - staffing assignment	- Random audits - UE apparent cause analysis - N-PASS to monitor sedation Validity/reliability: N-PASS is a valid sedation screening tool in neonates. UE apparent cause analysis is subjective, may not be as valid	Statistical tests used: U charts Chi-square test	Decreased UE rates from 7.19 to 0.66 per 100 intubated days	LOE: Primary level IV Strength: 6-year study period Weakness: audits not done consistently, compliance with specific interventions varied, <i>did not measure individual IV effects on UE rates – instead used apparent cause analysis to determine effectiveness of IVs</i> Feasibility: cost of standardized ETT securing device not mentioned, other interventions are cost-effective. Application: requires significant staff training

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				<ul style="list-style-type: none"> - patient characteristics - procedures within 15 minutes prior - if sedation was ordered - description of UE - etiology 				
<p>Kambestad et al., (2019), The adverse impact of unplanned extubation in a cohort of critically ill neonates. Country: United States Funding: None Bias: None</p>	<p>Systems Accident Model/Swiss Cheese Model (inferred)</p>	<p>Design: Prospective cohort study Purpose: To identify significant risk factors of UE</p>	<p>N = 134 Demographics: average gestational age 27 weeks, average age 44 days, average weight 2.1 kg, 22 identified as having a critical airway Setting: 58-bed level-IV NICU in Los Angeles. Inclusion: All intubated patients with UE Exclusion criteria: subjects with incomplete data sets Attrition: Not disclosed</p>	<p>IV1: agitation IV2: Retaping ETT IV3: Routine care/bedside procedure DV: UE</p>	<p>RT performed real time documentation of details of UE</p> <ul style="list-style-type: none"> - brief description - airway information - sedation information - institutional factors - need for reintubation <p>Retrospective chart review for demographic data Data collected over 4 years NPASS to measure agitation</p> <p>Validity/reliability: Some documentation may be subjective</p>	<p>Shapiro-Wilk test</p> <p>Q-Q plots</p> <p>Paired t test or Wilcoxon signed-rank test</p> <p>Bivariate analysis: Student t test, Mann-Whitney U test, Chi-square test, Fisher exact test</p>	<p>DV affected by IV1: 20% of events were caused by agitation, which was the most common known cause. NPASS score within 4 hours prior to UE was higher in those noted to be agitated compared to those not noted to have agitation as the cause of UE (3.1 [2.6] versus 1.6 [1.7], p = 0.01) DV affected by IV2: 19% of events caused by IV2 DV affected by IV3: 14% of events caused by IV3</p>	<p>LOE: II Strength: Large sample size of patients with UE over a long period of time Weakness: No control group to compare risk factors Feasibility: documentation and chart review require no additional costs Application: requires accurate documentation from staff, may be subjective but applicable to various settings</p>

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					- Used NPASS to document agitation, which is less subjective and more reliable			
<p>Wolny et al., (2022), Quality improvement interventions to prevent UE in pediatric critical care: A systematic review Country: United States, Brazil, Argentina, Canada Funding: Alberta Children’s Hospital Research Institute Graduate Student Award, and an Alberta Health Services Critical Care Strategic Clinical Network Summer Studentship Bias: Potential publication bias –increased likelihood of publication of studies with significant results</p>	Behavior Change Wheel	<p>Design: Systematic review Purpose: To synthesize the literature on QI practices to reduce UE rates in critically ill children</p>	<p>N = 13 articles Database search: MEDLINE, Embase, CINAHL Exclusion criteria: not primary research, population not on pediatric critical care, did not include UE rates, presented as abstract Attrition:10%</p>	<p>IV: QI intervention DV: UE rates</p>	<p>QI-MQCS Validity/reliability: Includes 16 domains, which is considered a high quality tool to assess the reporting of the QI evaluation studies; used a validated evaluation tool specific to QI research</p>	<p>COM-B system: coding of QI interventions</p>	<ul style="list-style-type: none"> - 10 studies reported decreased UE rates, with 7 of them having statistical significance (p < 0.05) - Pre-QI intervention UE rates ranged from 0.44-6.40 events per 100 airway days, post-QI intervention UE rates ranged from 0-2.59 events/100 airway days. - 5 of the studies included sedation protocol as part of their QI intervention, which all demonstrated decreased UE rates 	<p>LOE: I Strength: first systematic review on QI interventions to decrease UE specifically in the pediatric population Weakness: Majority (76.9%) of studies were case reports, low level of evidence Conclusion: QI interventions decrease UE rates in pediatric critical care patients. QI interventions included guidelines (including sedation protocol), environmental restructuring, education, training, and communication.</p>

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<p>Wu et al., (2023), Prevention of unplanned endotracheal extubation in intensive care unit: An overview of systematic reviews. Country (various as it is a meta analysis, not specified) Funding: None Bias: Publication bias in 7 of the 13 studies</p>	<p>Systems Accident Model/Swiss Cheese Model (inferred)</p>	<p>Design: Meta-analysis and descriptive analysis of systematic reviews Purpose: To identify and summarize systematic reviews on prevention of UE in ICU's.</p>	<p>N = 13 systematic reviews N = 217 original studies Database search: PubMed, Cochrane Library, CINAHL, Embase, Web of science, SINOMED, PROSPERO Exclusion criteria: systematic review proposals, full text of literature not available Attrition: 2%</p>	<p>IV1: Psychological care and root cause analysis IV2: Restraints IV3: securing ETT with suitable fixation methods IV4: continuous quality improvement IV5: management of sedation and risk factors DV: UE rates</p>	<p>The Newcastle-Ottawa Scale, the Cochrane Collaboration Risk of Bias Tool, the Australian JBI literature quality assessment criteria scale. Validity/reliability: Methodological quality assessment tools</p>	<p>Meta-analysis of 6 of the 13 studies, descriptive analysis of 7 of the 13 studies</p>	<p>IV1: two meta-analyses (8 RCTs, 12 cohort studies) showed that root cause analysis decreased UE rates IV4: 2 studies showed that QI reduces UE in adults and children IV5: 4 systematic reviews showed that agitation and/or irritability contribute to UE</p>	<p>LOE: I Strength: Large number of primary studies, wide range of database searches Weakness: 9 of the 13 studies were on adults, limiting information on the population of interest, many of the original studies were from 2018 and earlier Conclusion: Level 3 evidence shows that agitation and irritability are risk factors for UE</p>
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Table 2
Synthesis Table

Study (Author, year)	Neves et al., 2023	Mekonnen et al., 2023	Censoplano et al., 2020	Ferreira et al., 2023	Minda et al., 2022	Jayawardena et al., 2021	Mahaseth et al., 2020	Kambestad et al., 2019	Wollny et al., 2022	Wu et al., 2023
Design LOE	Observational study III	Case-control III	Retrospective chart review IV	QI intervention IV	Observational study III	Pre-and post-interventional IV	QI intervention IV	Cohort study II	Systematic review I	Meta-analysis I
Sample										

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<i>n subjects</i>	2,917	198	2,067	75	314	957	5,789	134	n/a	n/a
<i>n with UE</i>	73	66	45	15	62	n/a	435	134	n/a	n/a
Setting										
<i>PICU</i>	X	X		X		X			X	X
<i>NICU</i>							X	X		X
<i>Pediatric CVICU</i>			X						X	
<i>Adult ICU</i>					X					X
Independent variables										
<i>Sedation-related factors</i>	X	X	X	X	X		X	X		
<i>Shift-time</i>		X			X					
<i>Nursing ratio</i>		X								
<i>Tube securement and positioning</i>	X	X	X	X			X	X		
<i>Restraint use</i>		X		X	X					
<i>Family engagement and support</i>	X			X						
<i>Age-related factors</i>	X									
<i>Airway mucus hypersecretion</i>	X									
<i>UE checklist or protocol</i>				X						
<i>Educational intervention</i>						X	X			
UE rates										
<i>Decreased</i>	X	X	X	X	X	X	X	X		
<i>Increased</i>										
<i>Unchanged/variable</i>									X	X

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Sedation scoring tool used										
<i>NPASS</i>							X	X		
<i>RASS</i>					X					
<i>Comfort Behavior Scale</i>	X			X						
<i>Unspecified/variable</i>		X	X			X			X	X

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Appendix C

Table 1*Nursing Intervention: Descriptive Statistics for Age and Days of Ventilation*

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	Min	Max	<i>Mdn</i>
Age	6.14	5.71	165	0.08	21.00	4.00
Days of ventilation	6.57	10.47	165	0.02	68.00	3.00

Table 2*Nursing Intervention: Frequency Table for Gender*

Variable	<i>n</i>	%
Gender		
female	66	40
male	99	60

Table 3*Unplanned Extubation Pre and Post-nursing Intervention*

group	UE		OR	<i>p</i>
	No	Yes		
Pre Nursing Intervention	66	2	0.70	1.000
Post Nursing Intervention	95	2		

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Table 4*Adherence to Documenting SBS Goals Pre and Post-nursing Intervention*

	Pre-Nursing Intervention	Post-Nursing Intervention
Total patients	68	97
Eligible patients on protocol	2	2
Patients with SBS goals documented	0 of 2 (0%)	1 of 2 (50%)
Total number of required SBS score documentation	67	51
Total SBS scores documented	62	39
Adherence in documenting SBS scores	92%	77%

Table 5*Provider Intervention: Descriptive Statistics for Age and Days of Ventilation*

Variable	<i>M</i>	<i>SD</i>	<i>n</i>	Min	Max	<i>Mdn</i>
Age	6.61	5.90	194	0.01	19.00	5.00
Days of ventilation	6.26	9.45	194	0.04	68.00	3.00

Table 6*Provider Intervention: Frequency Table for Gender*

Variable	<i>n</i>	%
Gender		
female	76	39.2
male	118	60.8

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Table 7*Unplanned Extubation Pre and Post-provider Intervention*

group	UE			<i>p</i>
	No	Yes	OR	
Pre Provider Intervention	95	2	1.51	1.000
Post Provider Intervention	94	3		

Table 8*Adherence to Ordering Sedation Protocol Pre and Post-provider Intervention*

group	Protocol Ordered for Eligible Patients			<i>p</i>
	No	Yes	OR	
Pre Provider Intervention	95	2	3.26	.065
Post Provider Intervention	94	8		

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