

# Decreasing the Rate of Unplanned Extubation in Neonates in the Neonatal Intensive Care Unit

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## Abstract

**Aim:** To reduce the unplanned extubation (UE) rate in neonates in the neonatal intensive care unit (NICU) by 20% from fiscal year (FY) 2015 to FY 2016 and sustain that decrease through FY 2017.

**Materials and Methods:** A multidisciplinary work group developed a classification system for causes of UEs based on post-UE event debriefings in the NICU from February 1, 2016, through September 30, 2016. Based on this classification scheme, targeted interventions were designed and sequentially implemented. Three interventions implemented were (1) an algorithm to address patients with questionable UE; (2) increasing frequency of staff assessment of endotracheal tube (ETT) depth; and (3) high-risk protocols to address patient–nurse interaction. The UE rate/100 ventilator days (VDs) in FYs 2016 and 2017 was compared with baseline data from FY 2014 and 2015 using a statistical process control chart.

**Results:** The UE rate/100 VDs in FY 2016 was 1.74 compared with a rate of 2.93 in FY 2015. This represented a 41% decrease in the UE rate/100 VDs. This improvement was sustained through FY 2017, where the UE rate was 1.03, which represented an additional 41% decrease compared with FY 2016. In total, there was a 65% decrease in the UE rate from FY 2015 to FY 2017. The highest ranked factor contributing to UEs was ETT depth.

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**Conclusions:** Staff training and application of interventions targeted at contributory factors identified through mini-root cause analysis of UEs successfully reduced the UE rate.

**Key Words:** Unplanned extubation, endotracheal tube, self-extubation, root cause analysis, postevent debriefing, bedside simulation

## Introduction

Unplanned extubation (UE) occurs frequently in neonatal intensive care units (NICUs) and is reported to be the fourth most common preventable adverse event.<sup>1</sup> Compared with children in the pediatric intensive care unit (PICU), UEs occur 2 to 3 times more frequently among neonates in the NICU, ranging from 0.14 to 6.6 per 100 ventilator days (VDs).<sup>2</sup> The causes of UEs are multifactorial, ranging from method of securement, endotracheal tube (ETT) manipulation, and self-extubation while coughing or pulling the ETT out.<sup>3</sup> UEs are associated with a wide range of complications, including rapid cardiorespiratory compromise, airway trauma, subglottic stenosis, increased intracranial pressure, and ventilator-associated pneumonia.<sup>3,4</sup> Up to 24% of neonates who have undergone an UE event may experience cardiovascular collapse requiring cardiopulmonary resuscitation (CPR) or epinephrine administration.<sup>5</sup> Furthermore, UEs result in increased healthcare costs, duration of stay in the hospital, and the number of VDs.<sup>5,6</sup>

There is a need for patient care practices to reduce the UE rate and the evidence available establishes care standards for preventing UEs.<sup>3,7-11</sup> However, most of the published literature has focused on strategies to decrease UE rates in adult and PICU populations.<sup>9-11</sup> The lack of a consistent definition for UE across NICUs may make designing interventions difficult to help decrease them.<sup>12</sup> In the adult ICU setting, implementation of a quality improvement program focused on standardizing procedures, improving communication, and identifying high-risk patients have been shown to decrease the overall incidence of UE.<sup>9</sup> Similarly, educational

sessions and introduction of care management protocols successfully decrease the UE rate from 1.5 to 0.8 per 100 VD in the PICU.<sup>10</sup>

Considering UE occurrences in the NICU and the associated complications neonates experience, there is a requirement for a well-defined, neonatal specific strategy to reduce the UE rate.

## Aims

The objectives of this quality improvement study were to (1) review UE events that occurred in NICUs over a period of time to identify common causes; (2) develop specific strategies that target the identified causes; (3) reduce the UE rate per 100 VDs by 20% from fiscal year (FY) 2015 to FY 2016; and (4) determine if a decrease in the UE rate could be sustained through FY 2017.

## Materials and Methods

This multidisciplinary quality improvement study was conducted to evaluate the efficacy of specific interventions to reduce the UE rate from FY 2015 to FY 2016 and maintain that reduction in FY 2017. We used root cause analysis (RCA) methodology to identify common causes and develop and implement targeted interventions. Solutions for Patient Safety's operational definition was used to define a UE as, "any dislodgement of an endotracheal tube from the trachea that is not intentional."<sup>13</sup> Approval was obtained for this study from the institutional review board.

## Study setting

The study was performed in the Newborn Center (Texas Children's Hospital, Houston, TX, USA), which

comprises 3 NICUs with 173 beds. This serves as a referral center for both inborn and outborn neonates with complex medical and surgical conditions. The Newborn Center manages approximately 30 intubated neonates per day. The center consists approximately 480 registered nurses (RNs), 150 physicians, 50 respiratory therapists (RTs), and 50 neonatal nurse practitioners (NNPs) who staff the NICUs. In FY 2016, there were 1880 admissions to the Newborn Center with an average daily census of 155 patients. In FY 2017, there were 1603 admissions with an average daily census of 147 patients.

## Study procedure

In the Newborn Center, UE data collection began in 2013. In 2014, a multidisciplinary UE work group was created. The group consisting of RNs, physicians, RTs, NNPs, clinical specialists, and a quality improvement specialist to review each UE event and develop strategies to reduce the occurrence. Each UE event was entered in a secure database in real time. However, there was no formal review process to determine the root cause of each event. In January 2016, the work group began to review the baseline UE data starting from FY 2014 and FY 2015. By February 2016, the work group instituted postevent debriefings with mini-RCAs for each UE using data from the safety event reporting system, charge nurse reports, electronic medical record (EMR) documentation, and a bedside debrief form. These forms were filled by the RN, RT, or physician caring for the neonate at the time of the UE and included events associated with or directly causing the UE. The forms consisted of open-ended questions developed by the UE work group and a mini-RCA portion developed by the Solutions for Patient Safety UE Pioneer Cohort.<sup>13</sup> This latter portion consisted of sections regarding factors that may have caused an UE event, including a table listing potential contributors to UE, activities at the time of extubation, level of sedation, and staffing ratio. The full debrief form is included in Appendix A. The data for each UE were organized in an advanced database collection tool called the Unplanned Extubation Tracker (UET). The UET contained information regarding patient demographics, events surrounding the UE, timing of the UE event, the day of the week it occurred, and

whether the neonate required reintubation or had a cardiorespiratory event requiring resuscitation after UE.

Using the data collected from the UET and from the postevent debriefings, causative factors for each UE were identified and used to develop formal categories to classify each event. These categories were used to develop targeted interventions designed to prevent UEs. These interventions were sequentially introduced and their effect on the UE rate was measured.

The hospital personnel were trained about the interventions through educational sessions, unit newsletters, flyers placed around the NICU and in break rooms, e-mails, and a nurse-led shared governance council. To ensure that both the day shift and night shift RNs and RTs received instruction regarding each intervention, it was made a part of their regular clinical competency training. Educational sessions were held quarterly throughout the year to sustain proficiency in each intervention. Attending physicians were also educated regarding the interventions through presentations given at mandatory department meetings.

## Categories of unplanned extubation

UEs were classified into 7 categories based on baseline data—ETT depth, patient agitation, securement device type, transfer/holding/weighting, repositioning/turning/therapy, vomiting, and unable to determine theme.

The transfer/holding/weighting category included transferring a neonate between the main incubator and a transport incubator, between the incubator and a caregiver, and caregiver holding or weighing the neonate. The repositioning/turning/therapy category included repositioning or turning of the neonate by healthcare personnel, for bedside imaging, and neonates undergoing invasive procedures. Invasive procedures included any procedure done at the bedside (eg, peripheral IV insertion and peripheral intravenous central catheter placement). An ETT was secured in 2 ways in the Newborn Center. Most ETTs were secured with a Neobar (Neotech, Valencia, CA, USA); however, in certain instances, tape was used.

## Interventions

As UE events were categorized, a variety of interventions aimed at preventing UE were sequentially introduced. In February 2016, initially, an algorithm was developed to address the uncertainty as to whether an intubated patient suspected to be extubated was truly extubated. A review of baseline data showed that in multiple instances, a neonate's ETT was withdrawn before confirming whether the patient had an UE. As a result, a 4-step process called PACE was introduced, which stands for Position, Assess, Chest rise and auscultation, and End-tidal CO<sub>2</sub>. In patients with a questionable UE, the staff were trained not to indiscriminately remove the ETT but to first assess the ETT position, auscultate for breath sounds and observe for chest rise, and use an end-tidal CO<sub>2</sub> detector. Only after completing these steps, if the patient was still thought to be extubated, then the ETT was removed.

The "Where is my ETT?" intervention, introduced in April 2016, was designed to increase staff awareness regarding what depth the ETT should be secured. Bedside staff were trained to estimate appropriate ETT depth for a given patient using the Neonatal Resuscitation Program (NRP) calculation, "patient weight in kilograms + 6." This calculation was performed weekly. In case of any discrepancy between the calculation and where the ETT was actually secured, the provider team was notified, a chest X-ray was performed, and the ETT was adjusted, if necessary. As the staff became more familiar in assessing ETT placement, it was incorporated into their daily assessment, starting from May 2016.

To incorporate the Solutions for Patient Safety, UE Pioneer Cohort recommendations and high-risk nursing protocols (HRPs) were implemented in September 2016.<sup>13</sup> This included a dedicated staff member to secure the ETT during any patient positioning, bedside imaging, holding, transport, or invasive procedure. Teams comprising RNs and RTs began bedside simulations, where nursing staff would practice maintaining securement of the ETT on a mannequin when transferring the patient to a caregiver and during repositioning of the neonate. All the staff completed the simulations,

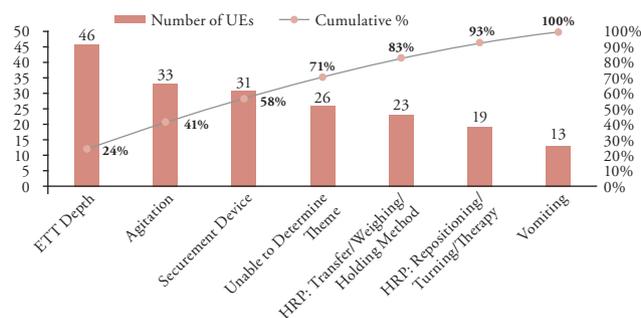
as it was a mandatory part of their clinical competency training.

## Data analysis

A Pareto chart categorized UE events that occurred from when the first intervention was implemented in February 2016 through September 2017. This chart helped in identifying the most common themes to develop specific interventions to reduce the incidence of UEs. The UE rate was calculated as the number of UEs per 100 VDs. The number of VDs was corrected by excluding VDs of patients with tracheostomies. At the end of FY 2016, the UE rate was compared with the rate in FY 2015. To determine if the decrease in UE rate was sustained through FY 2017, the UE rate from FY 2017 was compared with that in FY 2016 and also with that in FY 2015. Using statistical process control charts (Microsoft Excel, Redmond, WA, USA), it was determined if a shift in the number of UEs had occurred in FY 2016 and if it was sustained through FY 2017. The baseline data in the control chart was based on the UE rate calculated from FY 2014 and FY 2015.

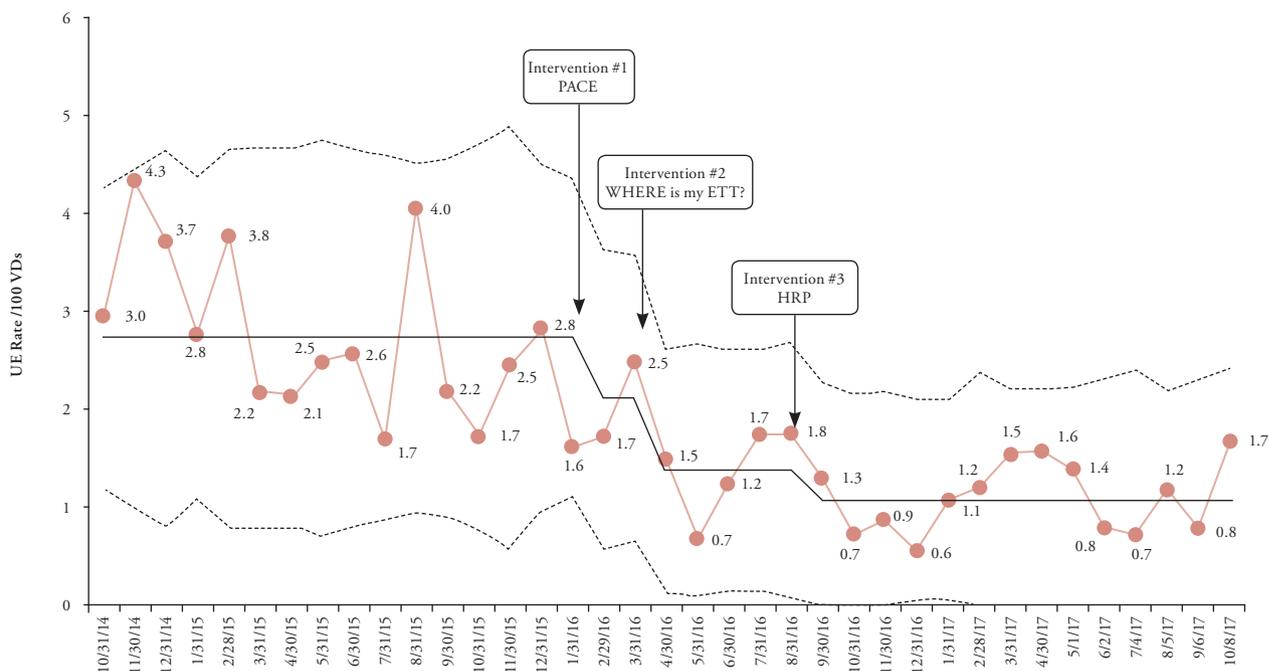
## Results

In FY 2016, there were 160 total UE events in the Newborn Center. From February 2016, when the first intervention was implemented, through September 2016, there were 99 UE events in the Newborn Center. In FY 2017, there were 92 UE events. The highest number of UEs occurred in the ETT depth category. As the



**Figure 1.** Pareto Chart Showing the Distribution of UEs by Category from February 2016 Through September 2017 (191 UE events)

ETT, endotracheal tube; HRP, high-risk nursing protocol; UE, unplanned extubation.



**Figure 2.** Control Chart Starting in FY 2013 through FY 2017 Showing the UE Rate/100 VDs on Monthly Basis in the Newborn Center

The arrows indicate introduction of each intervention. The decrease in UE rate began in February 2016 and continued to decrease with each intervention. The decrease in UE rate was sustained through FY 2017.

ETT, endotracheal tube; HRP, high-risk nursing protocol; PACE, Position, Assess, Chest rise and auscultation, and End-tidal CO<sub>2</sub>; UE, unplanned extubation; VDs, ventilator days.

Pareto chart in Figure 1 shows, other leading categories of UE were agitation and securement device.

Of the 160 UE events in FY 2016, 13% (21 UE events) did not require reintubation. Of the 92 UE events in FY 2017, 23% (21 UE events) did not require reintubation. These events occurred in equal frequency on both day and night shifts. Furthermore, there was no difference as to which day of the week these or any UE events occurred.

As the categories of UE were identified, sequential interventions were implemented. Figure 2 shows the statistical process control chart and when each intervention was implemented. After the first intervention, PACE, was introduced, the UE rate increased slightly from 1.6 to 1.7. After the implementation of the “Where is my ETT?” on a weekly basis, the UE rate decreased from 2.5 to 1.5 and once incorporated on a daily basis, the UE rate decreased to 0.7 and since then, the UE rate has not increased above 2.0.

Figure 2 shows a decrease in the mean UE rate after the introduction of each intervention. Following the last intervention, HRP, the mean UE rate was lowered further, where it has remained through September 2017. Overall, compared with the study period prior to the interventions in FY 2015, the UE rate in FY 2016 decreased from 2.93 to 1.74. This represented an overall reduction in the rate of UE per 100 VDs by 41%. The decrease in the UE rate from FY 2016 was sustained in FY 2017, where the UE rate per 100 VDs was 1.03. This was another 41% decrease compared with FY 2016 and a 65% decrease in the UE rate from FY 2015.

## Discussion

UE remains a significant adverse event in the NICU and can lead to a wide range of morbidities. This initiative shows that through staff training and application of interventions targeted at contributory factors, it is possible to effect a real change in practice and achieve a significant reduction in the UE rate, thus improving

patient safety. More importantly, after the interventions were implemented, the improvement in the UE rate was sustained and further decreased in FY 2017.

A major factor that helped achieve the reduction of UE was the development of the UET. This secure, comprehensive database served as a repository for information, where data could be extrapolated and analyzed at any time. It allowed a larger amount of data to be evaluated simultaneously by the UE work group so that trends could be identified more easily. The UET also aided in developing a comprehensive classification system and it continues to be updated to include new information for analyzing UE events. Continued use of this UET will help identify causes of UE events, so new interventions can be developed when needed.

Nursing and Respiratory Therapy leadership was vital in successfully reducing UE rates. Each department promoted an environment where change in practice was accepted. RN- and RT-led training sessions were held regularly several times throughout the year to educate the staff about each intervention. Learning the interventions was made part of the nursing clinical competency requirements, which further reinforced their successful implementation. Dissemination of education across such a large unit was a challenge but standardization of practice was achieved, thus reducing the odds of patient harm.

Most literature on UE has focused on adult and pediatric intensive care populations. Studies conducted on neonatal population also have reported similar UE categories, including poor securement of the ETT, lack of sedation, and unsafe handling of the neonate during ETT manipulations, bedside patient procedure, and kangaroo care.<sup>2-4,6-7,12</sup> A survey completed recently shows that the lack of a standard UE definition may affect the ability to decrease the UE rate.<sup>12</sup> The present and other studies show that targeted interventions based on identified causes successfully decrease UE rates.<sup>2,4</sup> In a study, UE rate was successfully decreased through similar methods in which 2 people were required to be involved in conducting procedures and using a real-time debrief form.<sup>2</sup> Another study, using a database approach, identified ETT securement as a

cause of UE. By standardizing their ETT securement method, they successfully decreased the UE rate.<sup>4</sup> Our study combined the aforementioned approaches and validated the concept of using a database approach to develop targeted interventions and reduce UEs.

In our study, the category in which most UE events occurred was ETT depth. Routine chest radiographs conducted to assess ETT position are not part of standard care in the Newborn Center. As routine X-rays are not performed, it could be posited that an intubated neonate may “outgrow” his/her ETT. By using the “weight + 6” calculation in each shift, this phenomenon was avoided. After the implementation of the “Where is my ETT?” intervention, there was a marked decrease in UE rate, which has been sustained. Other factors that are more likely to have led to an incorrect ETT depth include resecuring the ETT after the Neobar was changed, movement of the ETT during nursing interaction, or when caregiver is holding the neonate.

In our study, the agitation category had the second highest number of UE events. There is currently no sedation protocol for intubated neonates in the Newborn Center. However, there are policies in place to address patient agitation, including use of pain scores, developmental positioning, use of Z-Flo mattress (Medline Industries, Northfield, IL, USA), and use of specific swaddle blankets. The nursing staff receives formal training for assessing agitation. These policies were not developed by the UE work group and so were not included as an intervention for this study. One of the next steps will be to define sedation and develop a protocol for intubated neonates.

The UET proved to be useful in identifying trends regarding timing or causes of UE events. For example, the time of the day when UEs were occurring was analyzed. It was noted that there was an increase in UEs during bedside rounds and nursing change of shift. This was addressed with increased awareness and bedside simulations of the HRP interventions.

There was a relative increase in the percentage of patients with an UE who did not require reintubation from FY 2016 to FY 2017. This was brought to the attention of all the healthcare providers in an effort

to increase awareness of the importance of extubating a neonate as soon as the neonate is ready. To further address this, the UE workgroup, in collaboration with another multidisciplinary lung injury prevention group, has begun to develop early extubation guidelines. These guidelines provide clinical teams with a ventilator management protocol designed to wean patients safely and efficiently with an intention to increase the chances of early extubation.

## Study limitations

There are several limitations in this study. The lack of a true sedation protocol for intubated patients is the first one. While there are policies to address agitation listed earlier, it continued to be a major cause for UE.

Second, given the large size of the Newborn Center, a member of the UE work group was not always present for every UE event. Classification of the UEs relied on staff filling out the debrief forms and EMR documentation. In certain cases, there was no debrief form or there was a lack of adequate documentation in the EMR that resulted in categorizing events as “unable to determine.” To decrease the number of unable to determine UEs, each event was further reviewed by the UE work group. In cases where documentation was not adequate, individual care team members involved with the specific UE event were asked to recount events that may have been associated with the UE. Efforts were also made throughout the study period to reinforce the need to complete the debrief form.

Maintaining the reduction in the UE rate is a challenge. By including the interventions as part of the quarterly clinical competencies, RN and RT education is continually reinforced. To continue to adhere to the high-risk protocols, bedside teams routinely conduct additional training simulations in all shifts. As the Newborn Center often has float nurses from the PICU or the cardiovascular intensive care unit who may be unfamiliar with the current protocols for preventing UEs, future training sessions will include training for float staff also.

Further steps to reduce the UE rate in our institution involve continuing to develop and implement early extubation guidelines to decrease the number of VDs.

It has been shown that the duration of mechanical ventilation is a significant predictor of UE.<sup>14</sup> For each day on the ventilator, there is a 3% increase in the risk of UE.<sup>14</sup> To sustain the reduction in UE rate and improve upon it, further interventions will continue to be worked on while continuing to reinforce staff training of current strategies.

## Conclusion

Achieving a significantly lower UE rate in the NICU is possible with the creation of a dedicated work group, the use of standardized methodology, and diligent data tracking. The work group was successful in reviewing UE events, auditing circumstances surrounding an UE event, and creating a classification system that was then used to develop focused interventions to prevent UEs. Staff education, collaborative feedback, and frequent training sessions are essential. Furthermore, incorporating perspectives from staff members who will ultimately implement the interventions is crucial. A multidisciplinary approach involving all members of the care team is vital to help design effective targeted interventions.

## Acknowledgment

We thank all the nurses and respiratory therapists for their diligent efforts in following the interventions to help prevent UEs in our NICU.

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## Appendix A

**Sample of Debrief Form:** Refer pages 74 and 75

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### NICU Unplanned Extubation Data Collection

Please help us collect information about this event by answering the questions below.

**Date of UE Event:** \_\_\_\_\_

**Was this debrief performed immediately after the UE event?** Yes  No

**Severity of UE:** (check only one)

No reintubation within 1 hour

Reintubation within 1 hour

Reintubation and cardiovascular collapse requiring CPR and/or bolus epinephrine within 1 hour

**History of prior UE?** Yes  No

Airway/ETT

**Type of intubation:** Nasal  Oral

**HFOV:** Yes  No

Uncuffed/Cuffed:

Uncuffed

Cuffed-deflated

Cuffed-inflated

**Tape Secure:** Yes  No

ETT location:

Corner of mouth

Center of mouth

Nasal

**Inline (closed) suction apparatus present**

Yes  No  N/A

**Phase of Treatment**

Acute (care is escalating or stable vent settings)

Weaning ventilator settings

Weaning completed and awaiting planned extubation

**Sedation**

Continuous  Scheduled  PRN  None

**Agitation (inadequate pain control/agitation)**

Yes  No

**Staffing** 1:1  1:2  > 1:2

Contributors to UE

	Yes	No
Inadequate restraints		
Loose tape/loose Neobar		
Inadequate sedation		
Inadequate staffing		
Improper staffing handoff		
Within 1 <sup>st</sup> hour of NICU Admission		

Other contributor: \_\_\_\_\_

Activities occurring at time of extubation

	Yes	No
Kangaroo care or parent holding		
Radiology study (X-ray, U/S, echo, etc.)		
Respiratory treatment		
ETT adjustment/Re-taping ETT		
Weighing		
Position change		
Transport		
Suctioning		
< 2 caregivers for positioning or suctioning		
Bathing		
Line placement		
Blood draw		
Other bedside invasive procedure		

Other activity: \_\_\_\_\_

**Results of UE event**

	Yes	No
Arrhythmia		
BP change required intervention		
Need for increased vent support or FiO <sub>2</sub>		
Heart rate < 60 (verify in central monitor)		
Chest compressions		
Code medications given		