Introduction
Respiratory distress is the most frequent cause of admission to the neonatal intensive care unit (NICU). Airway management in neonates begins immediately after delivery, with 19% of preterm newborns requiring mechanical ventilation. The goal of airway management in the NICU is to ensure the neonate is properly ventilated while minimizing long-term damage to the lungs.

While mechanical ventilation does reduce mortality in critically ill neonates, it is still associated with adverse events, such as endotracheal tube (ETT) misplacement and unplanned extubation (UE). Complications with ETTs include misplacement in 35%-50% of patients, which when malpositioned or deeply positioned, are associated with neonatal morbidity. Importantly, UEs that require reintubation are the fourth most common adverse event in United States NICUs. Unplanned extubations and reintubations can be caused by many factors, including restlessness and agitation, poor fixation, tube manipulation, and performance of a bedside procedure. In addition, difficult reintubations may be associated with the need to administer CPR, and often result in longer mechanical ventilation time and length of stay. Veldman et al. found that UEs were associated with a 12-day longer ventilation time per 100 ventilator days and a 42-day longer length of stay. This was confirmed by other recent studies, which found that patients with UEs had 14-16 days of ventilation time per 100 ventilator days, compared to patients without UEs who had 3-5 days of ventilation time per 100 ventilator days. In addition to longer length of ventilation and length of stay, UEs are also associated with increased costs. Among pediatric patients, those with UEs had $36,692 higher hospital costs compared to pediatric patients without UEs (p<0.001), including significantly increased charges for the pharmacy, respiratory therapy, blood bank, radiology, and laboratory services.

We performed a survey of United States NICU healthcare professionals to characterize current airway management practices, including a focus on UEs and its impact on clinical care. This report summarizes the survey results.

Survey Design and Methodology
This survey was sponsored by Medtronic (Boulder, CO, US) and conducted by Ipsos (Paris, France). The survey research was conducted in two phases. The first phase of research consisted of web-assisted telephone interviews among neonatologists and NICU department heads/chiefs in the United States between August 19, 2020 and September 8, 2020. The second phase was a double-blinded online survey among administrators and purchasers, NICU physicians, and NICU nurses in the United States between October 21, 2020 and December 9, 2020. A total of 90 United States healthcare professionals (HCP) participated in the survey, and were selected using the following criteria: 1) Neonatologist, Pediatrician, Neonatal Nurse, or Respiratory Therapist who works in the NICU; 2) has been in the role for ≥3 years; 3) works primarily in a public or private hospital, academic or non-academic; 4) has worked at the primary facility for ≥1 year; 5) NICU is Level II, III, or IV; 6) ≥10 NICU
and ≥10 critical care NICU beds; 7) have ≥1 NICU IMV patients in a typical 12-month period; 8) clinicians provide input to the team that makes purchase decisions; and 9) administrators help make decisions to purchase equipment and supplies for the NICU and understand the cost of NICU equipment. Healthcare professionals were excluded if they were not eligible for market research compensation and if they had any conflicts of interest.

Overview of Healthcare Professionals Surveyed

Ninety United States HCPs were included in the survey, including 24 neonatologists, 22 NICU nurses, 19 NICU Medical Directors, 10 Respiratory Therapists, 9 NICU Chief Nursing Officers, 4 Intensivists, and 2 Neonatal Nurses. The HCPs had spent an average 14.0 years in the role, with 12.4 years at the current facility. HCPs were distributed across the United States, including 37% in the South, 28% in the North East, 21% in the Midwest, and 14% in the West (Table 1). The primary facilities represented in the survey included public non-academic hospitals (24%), private non-academic hospitals (32%), and academic hospitals (43%), with 62% of surveyed HCPs affiliated with a network hospital. Medium-size hospitals (100-500 beds) were most common, representing 62% of facilities, with 37% working at large hospitals (≥501 beds) and 1% working at small hospitals (≤100 beds).

A majority of the NICUs represented were Level III (50%) or Level IV (41%), with 9% Level II. The NICU patient volume varied from 1-100 patients in 12 months to >1000 patients in 12 months, with relatively even distribution (Table 1). All facilities had at least 10 NICU beds, with 26% containing 21-30 beds and 34% containing >50 beds. It was most common for the NICU to contain 10-20 critical care beds (Table 1).

Current Airway Management Practices

Use of Invasive Mechanical Ventilation

Across an average 610 NICU patients during a 12-month period per facility, clinicians reported that 55% of NICU patients received noninvasive ventilation. In addition, 32% of NICU patients received IMV for ≥24 hours, with clinicians reporting a mean of 12 days on IMV.
Suctioning

For patients on IMV, 79% of respondents reported suctioning when the patient clinical condition or any patient monitoring system indicated a need for suctioning (Figure 1). In addition, 47% of respondents reported suctioning after the patient was moved, and 52% reported routine suctioning according to the facility protocol, which was most frequently advised every 2 hours (53% of respondents) or every 4 hours (40% of respondents) (Figure 2).

Chest X-rays

Patients receiving IMV for ≥24 hours were reported to undergo a median 2 X-rays to confirm initial placement of the ETT, 3 X-rays to evaluate the ETT after initial placement, and 2 X-rays for other reasons during the NICU stay (Figure 3).

Unplanned Extubations

UE tracking varied across respondents: 71% of respondents reported to ‘always’ track UEs, while 25% only tracked ‘sometimes,’ and 4% of respondents declared that they ‘never’ track UEs (Figure 4). Of the 69 respondents who were aware of their facility’s UE rate, there was a median 5 UEs per 100 ventilator days (Figure 4). The median number of UE occurrences in a 12-month period was 20.

Figure 1. Type and percentage of healthcare professionals included in the survey.

Figure 2. Percent of respondents who report suctioning, with the frequency of routine suctioning among respondents who reported following routine suctioning protocols.

Figure 3. Reason for chest X-rays among patients receiving IMV for ≥24 hours. A median three out of seven chest X-rays (43%) are attributed to evaluating the ETT after initial placement.

Figure 4. Assessment of UEs among patients receiving IMV for ≥24 hours. A) Frequency of UE tracking by NICU healthcare professionals. B) Median UE rate per 100 ventilator days, among the 77% of respondents who reported the facility rate.
When asked about the impact of UEs on clinical care, 81% of respondents agreed or strongly agreed that UEs are a critical quality of care or safety metric at the facility, with 77% agreeing or strongly agreeing that UEs are a top clinical or safety concern. Moreover, 71% of respondents agreed that reducing UEs would lead to a reduction in patient length of stay, and 64% agreed that it could lead to significant cost savings in the NICU. Sixty-three percent of respondents indicated that the facility is focused on UEs to improve hospital reviews, rankings, or competitive positioning amongst other NICUs (Figure 5).

**Figure 5.** NICU healthcare professional attitudes toward unplanned extubations.

Finally, when asked to imagine an airway management solution, respondents indicated that reducing UEs and enabling accurate troubleshooting at the bedside would be the most valuable benefits, with a reduction in chest X-rays and optimizing suctioning practices as moderately valuable benefits.

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