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Delirium Screening in Critically Ill Children: secondary analysis of the multicenter *PICU Up!* pilot trial dataset, 2019–2020

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Abstract

Objective: To determine the patient-level factors associated with performing daily delirium screening in PICUs with established delirium screening practices.

Design: A secondary analysis of 2019–2020 prospective data from the baseline phase of the PICU Up! pilot stepped-wedge multicenter trial ([NCT03860168](#)).

Setting: Six PICUs in the United States of America

Patients: One thousand sixty-four patients who were admitted to a PICU for 3 or more days.

Interventions: None.

Measurements and Main Results—Out of 1064 patients, 74% (95% confidence interval [95% CI] 71–76%) underwent delirium screening at least once during their PICU stay. On 57% of the 8965 eligible patient days, screening was conducted. The overall prevalence of delirium was 46% across all screened days, and 64% of screened patients experienced delirium at some point during their PICU stay. Factors associated with greater adjusted odds ratio (aOR) of increased daily delirium screening included PICU stay longer than 15 days compared to 1–3 days (aOR 3.36 [95% CI 2.62 – 4.30]), invasive mechanical ventilation as opposed to room air (aOR 1.67 [95% CI 1.32 – 2.12]), dexmedetomidine infusions (aOR 1.23 [95% CI 1.04 – 1.44]) and propofol infusions (aOR 1.55 [95% CI 1.08 – 2.23]). Conversely, decreased adjusted odds of daily delirium screening was associated with female gender (aOR 0.78 [95% CI 0.63 – 0.96]), and the administration of continuous infusions of opioids (aOR 0.75 [95% CI 0.63 – 0.90]) or ketamine (aOR 0.48 [95% CI 0.29 – 0.79]). Neither patient age, the presence of family or physical restraints, or benzodiazepine infusions were associated with daily delirium screening rates.

Conclusions: In the 2019–2020 PICU UP! cohort, across six PICUs, delirium screening occurred on only 57% of days, despite the presence of established practices. Female gender,

patients in the early stages of their PICU stay, and patients not receiving mechanical ventilation were associated with lower odds of daily delirium screening. Our results highlight the need for structured quality improvement processes to both standardize and increase the frequency of delirium screening.

Keywords

children; delirium; screening; intensive care units; hospital; pediatric

Delirium in critically ill children is independently associated with increased ICU mortality, length of stay, and post-ICU morbidity(1–3). In meta-analyses conducted in 2020 and 2022, the pooled prevalence of delirium in PICUs was 34%, with point prevalences rising to 53% in pediatric cardiac ICUs(4, 5). Despite its high prevalence, in a 2012–2013 survey, universal screening for delirium was not uniformly adopted, and delirium was likely underdiagnosed(6). Several challenges exist in diagnosing pediatric delirium, including the perceived complexity of screening procedures, time constraints, as well as perceived challenges in evaluating intubated and sedated patients(3, 7–11).

Furthermore, pediatric delirium screening is complicated by the heterogeneous nature of verbal and cognitive skills, which vary widely across different developmental stages(12, 13). To overcome this challenge, several tools have been developed and validated for use in the PICU, including the Cornell Assessment of Pediatric Delirium (CAPD), the Pediatric Confusion Assessment Method for the ICU (pCAM-ICU), the Preschool Confusion Assessment Method for the ICU (psCAM-ICU) and the Sophia Observation Withdrawal Symptoms Pediatric Delirium Scale (SOS-PD)(14–18). These validated tools, alone or in combination, facilitate delirium screening for PICU patients of all ages and developmental levels. However, evaluation of PICU practices in 2016, 2017, and 2019 found that implementation of daily, routine screening was lacking(19, 20).

We know from studies carried out over 15 years ago that patient and clinical factors associated with routine delirium screening in adult populations include intubation status and sedation level(9, 10, 21). However, to our knowledge, no studies have focused specifically on the factors influencing delirium screening in the PICU. Our secondary analysis of the 2019–2020 PICU Up! multicenter pilot stepped-wedge trial dataset aimed to identify the patient factors associated with the use of delirium screening in six U.S. PICUs with established delirium screening practices.

METHODS

In this study, we performed a secondary analysis on prospectively collected data from the baseline phase of the PICU Up! multicenter pilot trial ([NCT03860168](https://clinicaltrials.gov/ct2/show/study/NCT03860168)). The trial included a total of 7 PICUs that completed data collection, out of which 6 were included in this analysis due to their established delirium screening practices before the baseline phase. Of the 6 units included in the study, 3 had formal protocols, all of which used the Cornell Assessment of Pediatric Delirium (CAPD). Units without formal protocols also used the CAPD. Our organizational survey did not collect data on the initiation of delirium screening. Positive screening results were defined per the CAPD instructions, with a score ≥ 9 being considered

positive (14). Notably, we also included units where delirium screening was commonplace but not protocolized (see Supplemental Digital Content [SDC] Table S1 for details regarding unit characteristics and screening practices).

In this stepped-wedge trial, each participating PICU represents a “cluster”, and baseline data represent each PICU’s usual care prior to the systematic implementation of a multifaceted intervention (PICU Up!) designed to promote early mobility(22). All participating PICUs were initially assigned to a baseline period ranging from 4.5 to 8.5 months and were then randomized to PICU Up! implementation.

The research was reviewed by the Johns Hopkins Institutional Review Board (IRB00199373; 02/25/2019, “PICU Up!: A pilot stepped-wedge quality improvement trial of a multicomponent early mobilization program”) and conducted consistent with the Helsinki Declaration of 1975. IRB approvals or determinations that the research did not qualify as human subjects research were obtained by all participating sites. De-identified data were collected with a waiver of informed consent. This study was conducted between May 2019 and March 2020.

Patient Selection

All patients admitted to participating PICUs for ≥ 3 days who did not have an active do-not-resuscitate (DNR) order were eligible for inclusion in this analysis. We excluded the following days from the analysis: 1) PICU discharge; 2) ICU days after the 28th day; 3) days on which the highest State Behavioral Scale (SBS) recorded was -3 or -2 (i.e., unable to screen for delirium); and 4) days on which the patient received a continuous infusion of a neuromuscular blocking agent for the entire day (see SDC Figure S1).

Data Collection

Baseline patient and clinical measures were collected and managed using the REDCap electronic data capture tools(23). They included demographics (age, gender, race, ethnicity), body weight, admission category (admission source and indication, medical vs. surgical admission), use of mechanical ventilation or respiratory support, and baseline Pediatric Cerebral Performance Category (PCPC) score(24). Daily data collection for each patient included delirium screening status (yes/no), the delirium tool used, medications administered, whether any benzodiazepines or opioids were administered that day, and whether family presence was documented in the medical record.

Statistical Analysis

The prevalence of delirium screening was defined as the number of patient days with at least one documented delirium screen performed, divided by the total number of eligible patient days during the study period. To account for within PICU correlation, we stratified the data by PICU, and variance was estimated using Taylor linearization. Categorical baseline patient characteristics were compared between screening status groups using the chi-square test, while continuous variables were expressed as medians [interquartile range (IQR)] and compared using the Mann-Whitney U test.

A multivariable logistic regression model with generalized estimating equations (GEE) was employed to calculate adjusted odds ratios and 95% confidence intervals (aOR [95% CI]) for the association between delirium screening and covariates of interest. The analysis was performed at the patient-day level, with each patient contributing multiple observations corresponding to their PICU days. The model accounted for data clustering within participating PICUs by modeling them as fixed effects and addressed potential correlations among repeated measures within individual patients using an exchangeable working correlation matrix and robust sandwich estimators. Multicollinearity was assessed using variance inflation factors, and no imputation was performed for missing data.

Covariates included in the adjusted regression model were determined *a priori* based on clinical relevance or prior literature(25). These included age, gender, race, daily respiratory support level, baseline PCPC score, admission reason, daily use of benzodiazepines, opioids, ketamine, propofol, and dexmedetomidine infusions, Glasgow Coma Scale (GCS) score, presence of physical restraints, family presence and PICU day, defined as the number of days since PICU admission and categorized into quintiles. Statistical significance was set at a two-sided P-value < 0.05. All analyses were performed using STATA/SE 18 (StataCorp, College Station, Texas).

RESULTS

Patient Baseline Characteristics

Of the 1066 screened patients with 10511 patient days in the 6 PICUs, 1064 unique patients with 8965 patient days met eligibility criteria (see SDC Figure S1). Overall, 43% of patients were female and 58% were <3 years old, with a median length of stay of 7 (IQR 5–12) days (see SDC Table S3). Baseline functional impairment (PCPC score ≥ 2) was present in 36% of patients. Respiratory disease was the most common admission diagnosis (41%), followed by medical cardiac (14%) and surgical cardiac (13%) diagnoses. More than half of patients (55%) were mechanically ventilated via endotracheal tube on the day of admission; 49% and 20% of all patients received an opioid and benzodiazepine infusion at any point during their stay, respectively. The mortality rate was 2.16%.

Daily Delirium Screening and Delirium Diagnosis

Overall, 74% (95% CI 71.4% – 75.7%, n=784) of patients received at least one delirium screen during their PICU stay, or the first 28 PICU days. Among all eligible PICU days, the prevalence of delirium screening was 57% (95% CI 54% – 59%). Patients received a median of 2 (IQR 1–2) screens per PICU day. Out of the 5091 days where delirium screening was performed, 2542 (46%) were documented as positive for delirium based on pre-established cutoffs for each score used. Among the 784 patients who were screened for delirium at least once, 64% had at least one positive result. The existence of a formal delirium screening protocol did not significantly influence the rate of delirium screening (56.3% with a formal delirium screening protocol vs. 57.4% without a formal delirium screening protocol; $\chi^2 = 1.0143$, p=0.314; after accounting for site-level clustering: z=0.08, p=0.938).

Risk Factors for Missed Delirium Screening

Table 1 summarizes the clinical characteristics for all eligible patient days. For multivariable regression analysis using complete case analysis, 1,061 patients with 8,943 eligible days had complete data for evaluation (see SDC Figure S1). Stepwise increases in odds of daily delirium screening were observed among later PICU days (Figure 1) during the stay (>15 days vs 1–3 days: aOR 3.36 [95%CI 2.62 – 4.30]) and physical restraints (aOR 1.25 [95%CI 0.99–1.59]). Most levels of respiratory support were associated with greater odds of delirium screening. Patients on nasal cannula or any respiratory support had greater odds of delirium screening compared to those on room air. Mechanically ventilated patients had the highest odds compared to those on room air (endotracheal tube aOR 1.67 [95%CI 1.32–2.12], or tracheostomy aOR 1.85 [95%CI 1.25–2.74]). Regarding oxygen administration via tracheostomy collar, we cannot exclude the possibility that this form of support was associated with up to 3.5-fold greater odds of delirium screening (aOR 1.54 [95%CI 0.67–3.53]).

Female gender was associated with fewer odds of delirium screening (aOR 0.78 [95%CI 0.63–0.96]). An associated lesser odds of daily delirium screening was present in patients receiving infusions of opioids (aOR 0.75 [95%CI 0.63–0.89]) or ketamine (aOR 0.48 [95%CI 0.29–0.79]). In contrast, an associated greater odds of daily delirium screening was present in patients receiving dexmedetomidine infusions (aOR 1.23 [95%CI 1.04–1.44], $p=0.015$) and propofol (aOR 1.55 [95%CI 1.08–2.23]). Regarding GCS scores, a score of 8 (aOR 0.22 [95%CI 0.16–0.28]) or undocumented scores (aOR 0.39 [95%CI 0.28–0.53]) were both associated with lesser odds of undergoing delirium screening when compared to patients with GCS scores of 14–15.

Figure 1 shows the aOR (95%CI) for variables in which we failed to identify an association with daily delirium screening (e.g., age, admission diagnosis, family presence, and the administration of benzodiazepine infusions). However, close inspection of the confidence intervals indicates what cannot be excluded.

DISCUSSION

In this secondary analysis of prospectively collected data from six U.S. PICUs in the 2019–2020 PICU Up! dataset, we identified patient-related factors that correlate with missed delirium screening across a wide spectrum of patient ages and diagnoses. Despite the presence of established delirium screening practices in the six PICUs, patients did not receive delirium screening on 44% of eligible days. Our results show that children earlier in their PICU stay, females, patients requiring lower levels of respiratory support, and those with decreased GCS scores had lesser odds of receiving delirium screening and identify patient subgroups most susceptible to undiagnosed delirium.

Recent systematic reviews have summarized risk factors for pediatric delirium, including younger age, need for mechanical ventilation, developmental delay, sedation, and use of opioids and benzodiazepines(4, 5). We hypothesized that that younger age, mechanical ventilation, and the use of sedative medications would be associated with a higher likelihood of delirium screening, as we expected that the presence of delirium risk factors would

lead to increased screening. While some known risk factors, such as sedative medications, respiratory support, physical restraints, and developmental delay, were associated with increased screening in our cohort, others such as age were not, which may be a consequence of sample size or confounding factors.

Interestingly, females had lower odds of delirium screening even after adjusting for clinical and demographic variables. This finding aligns with a 2017/2018 two-day point prevalence study in 82 PICUs, which reported that females received fewer early rehabilitation consultations(26). Even in the presence of established delirium and mobility practices, routine screening and rehabilitation consultation may be less used in female patients. Why? This observation could be due to clinical heuristics that perceive delirium as being more likely to occur in males, potentially leading to underdiagnosis and undertreatment of this condition in females(12).

Previous studies have found an association between delirium and increased length of stay in the PICU(27, 28). Our data suggests that increased length of PICU stay is associated with greater odds of screening. Several factors potentially contribute to this result. The focus on resuscitation and stabilization early in admission may initially overshadow delirium detection. As patients stabilize and staff become more familiar with them and their cognitive baseline, more attention may shift to delirium screening.

The negative association between sedative infusions, decreased GCS scores, and delirium screening likely reflects perceptions that assessing delirium is more difficult in heavily sedated patients. While screening tools are not designed for use in unrousable patients, reduced consciousness does not preclude their use if patients still meet screening criteria(14, 29, 30). This represents an area for potential clinician education. Notably, even children at high risk for delirium due to sedative infusions also had fewer screenings when their State Behavioral Scale (SBS) scores were ≥ 1 , levels considered appropriate for delirium screening (27, 31). Our data also illustrate challenges in recognizing hypoactive delirium, which may be confounded by sedation(32); however, our study did not analyze delirium subtypes.

Delirium screening was often overlooked in children not receiving respiratory support, suggesting a perception that less critically ill patients are at a lower risk. However, delirium can occur in the absence of mechanical ventilation(12, 33, 34). Children not receiving respiratory support warrant the same screening frequency as those who are; these screens are often straightforward and more efficient in communicative patients.

The low screening rate is concerning given the clinical relevance of pediatric delirium, the existence of screening resources, validated tools, and professional recommendations that emphasize the importance of routine delirium screening(35, 36). The PICUs included in our study all used the CAPD as a screening tool for delirium. However, both the pCAM-ICU/psCAM-ICU and CAPD are recommended as options in the PANDEM guidelines, and while perceptions of a tool's superiority may affect screening rates, there is no evidence to recommend one tool to the other. Regular screening with a validated tool is likely more important than the choice of tool itself. In a 2015 audit of three PICUs in Brazil,

relying solely on clinical suspicion led to significant under-recognition of delirium(37). The PANDEM guidelines carry strong recommendations for consistent, formal screening using validated instruments(36).

As this is the first study of its kind, further research is needed to validate these observations and assess their generalizability. However, we encourage clinicians to consider delirium as an important aspect of evaluating and managing all critically ill children(38). Our findings emphasize the need for replication and confirmation studies, not only in the USA but in diverse environments, as perceptions of delirium may vary across different settings.

There are potential limitations to our study. First, we could not conduct a detailed analysis of delirium incidence and risk factors due to the lack of consistent delirium screening; our estimates of delirium prevalence may be inaccurate due to a systematic bias in the patients who did not receive delirium screening. Second, we could not directly evaluate the severity of the illness; although respiratory status may serve as a proxy, future work should incorporate a validated measure. Third, our results may not generalize to PICUs lacking established delirium practices or smaller, resource-limited settings where screening rates may be even lower. Fourth, we observed an association between missing GCS scores and decreased odds of receiving delirium screens. While we believe the missing scores were the result of deferring GCS scoring in heavily sedated patients, it reflects the challenges associated with data collection in a study of this magnitude. Fifth, while we excluded patients with low SBS scores (-3 or -2) or receiving neuromuscular blockade, approximately 48% of observed days lacked SBS scores; if these mostly represented ineligible patients, it would inflate observed screening rates and potentially impact result validity. However, SBS score recording was not required in patients not receiving sedation. Among mechanically ventilated patients, 73% had a documented SBS score, indicating preferential recording in populations the score was developed for and possibly bias toward considering less acutely ill-appearing patients as lower delirium risk, contributing to their under-screening. Sixth, while our study focused on patient-level factors influencing delirium screening, institutional factors likely also play an important role. Unit-level factors such as staffing ratios, and delirium education may significantly influence screening practices. Our statistical methods attempted to adjust for unit effects, however uncontrolled confounding may exist.

CONCLUSION

In this multicenter dataset from six US PICUs with established delirium screening practices participating in the 2019–2020 PICU Up! pilot trial, we found that delirium screening was not completed on nearly half of the eligible patient days. Lesser odds of delirium screening were associated with several patient-related factors, including female sex, absence of respiratory support, decreased levels of consciousness, and receiving sedative infusions. Given the high prevalence of delirium in critically ill children and the risk of under-recognition, our findings underscore the importance of systematic delirium screening to ensure that delirium is adequately identified and promptly managed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Conflicts of Interest and Source of Funding:

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Research in Context

- Delirium in critically ill children is linked to increased ICU mortality, length of stay, and post-ICU morbidity, yet it often remains underdiagnosed due to inconsistent screening practices.
- Despite the development of validated screening tools for pediatric delirium, universal screening is not widely implemented in PICUs, leading to potential underdiagnosis, and missed opportunities for timely intervention.
- We used the 2019–2020 PICU Up! cohort dataset to evaluate the frequency of delirium screening in 6 PICUs with a screening protocol.

What This Study Means

- The findings in the PICU Up! 2019–2020 cohort challenge existing perceptions of delirium risk, especially regarding gender differences and sedative use.
- These results highlight the need for systematic screening across all patient categories to avoid underdiagnosis, particularly in hypoactive delirium cases.
- This study also underscores the importance of consistent delirium screening in all critically ill children, regardless of their respiratory support status, sedation level, or gender, to ensure timely identification and management of delirium in PICUs.

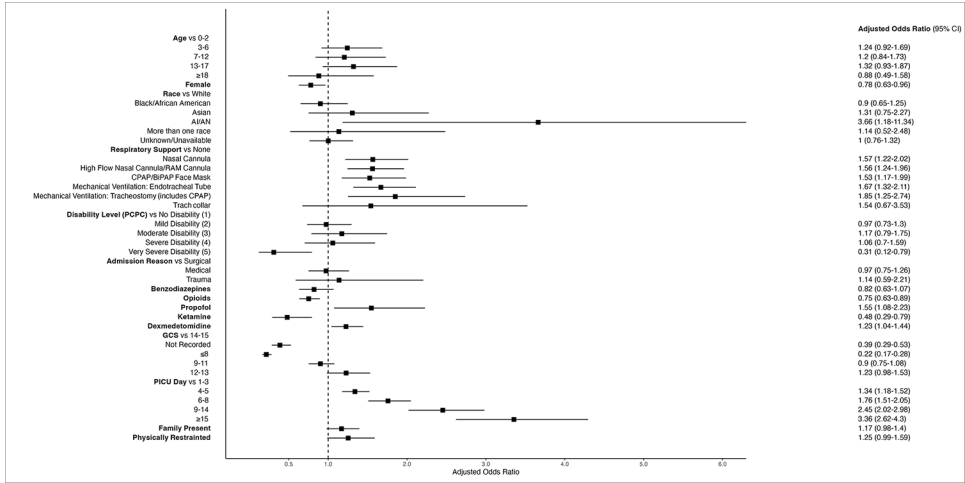


Figure 1. Adjusted Odds Ratios (ORs with 95% confidence interval) for delirium screening on the study day. ORs are adjusted for the variables shown, as well as PICU, age, race, baseline PCPC, the reason for admission, propofol, ketamine, and GCS. OR > 1 indicates greater odds of delirium screening. Abbreviations: AI/AN - American Indian/Alaska Native; BiPAP - Bilevel positive airway pressure; CPAP - Continuous positive airway pressure; GCS - State Behavioral Scale; PCPC – Pediatric Cerebral Performance Category Score; PICU – Pediatric Intensive Care Unit;

Table 1:

Patient Clinical Characteristics on Study Day, by Delirium Screen Status

Clinical Characteristics on Study Day	Total	No Delirium Screen	Delirium Screen
	N=8,964	N=3,873	N=5,091
Respiratory Support, <i>n</i> (%)			
None/RA	1,571 (18%)	588 (15%)	983 (19%)
Nasal Cannula	623 (7%)	199 (5%)	424 (8%)
High Flow Nasal Cannula/RAM Cannula	1,107 (12%)	508 (13%)	599 (12%)
CPAP/BiPAP Face Mask	891 (10%)	353 (9%)	538 (11%)
Mechanical Ventilation: Endotracheal Tube	3,578 (40%)	1,684 (43%)	1,894 (37%)
Mechanical Ventilation: Tracheostomy (includes CPAP)	1,137 (13%)	518 (13%)	619 (12%)
Trach collar	57 (1%)	23 (1%)	34 (1%)
Benzodiazepines, <i>n</i> (%)	980 (11%)	489 (13%)	491 (10%)
Opioids, <i>n</i> (%)	2,914 (33%)	1,416 (37%)	1,498 (29%)
Dexmedetomidine, <i>n</i> (%)	2,825 (32%)	1,203 (31%)	1,622 (32%)
Ketamine, <i>n</i> (%)	102 (1%)	61 (2%)	41 (1%)
Propofol, <i>n</i> (%)	270 (3%)	81 (2%)	189 (4%)
GCS, <i>n</i> (%)			
14–15	3,883 (43%)	1,473 (38%)	2,410 (47%)
12–13	412 (5%)	156 (4%)	256 (5%)
9–11	2,453 (27%)	911 (24%)	1,542 (30%)
<8	803 (9%)	544 (14%)	259 (5%)
Not Recorded	1,413 (16%)	789 (20%)	624 (12%)
Physical Restraints, <i>n</i> (%)	857 (10%)	294 (8%)	563 (11%)
Family Presence, <i>n</i> (%)	8,033 (90%)	3,429 (89%)	4,604 (90%)

Abbreviations: BiPAP – Bilevel Positive Airway Pressure; CPAP – Continuous Positive Airway Pressure; GCS – Glasgow Coma Score; RA – Room Air.