RESEARCH ARTICLE

Variation in Pediatric Procedural Sedations Across Children's Hospital Emergency Departments

Andrew F. Miller, MD,[a,b] Michael C. Monuteaux, ScD,[a] Florence T. Bourgeois, MD, MPH,[a,b] Eric W. Fleegler, MD, MPH[a,b]

ABSTRACT

OBJECTIVES: Describe the trends in pediatric sedation use over time and determine variation in use of procedural sedation across children's hospital emergency departments (EDs).

METHODS: We analyzed ED data from 35 hospitals within the Pediatric Health Information System for patients <19 years old who received sedation medications and were discharged from 2009 to 2014. Patients with chronic comorbidities or undergoing intubation were excluded. We determined frequency and trends in use of sedation and compared these between EDs. Descriptive statistics with appropriate weighting were used.

RESULTS: Of the 1 448 011 patients potentially requiring sedation who presented to the ED, 99 951 (7.9%) underwent procedural sedation. Medication usage in 2014 included ketamine (73.7%), fentanyl and midazolam (15.9%), ketofol (7.3%), and propofol (2.7%). Use of fentanyl and midazolam increased, whereas use of ketamine, pentobarbital, etomidate, chloral hydrate, and methohexital decreased over time. Significant variation exists in the use of sedation across hospitals; in 2014, the sedation rate ranged 0.2% to 32.0%, with a median of 8.0%. The diagnosis with the largest variation in procedural sedation use was dislocation, with sedation rates ranging from 2% to 35%.

CONCLUSIONS: There is significant variability across pediatric EDs in the use of procedural sedation, suggesting sedations may be performed too often or too little in some hospitals.

www.hospitalpediatrics.org
DOI:https://doi.org/10.1542/hpeds.2017-0045

Address correspondence to Andrew F. Miller, MD, Division of Emergency Medicine, Children's Hospital Boston, 300 Longwood Ave, Boston, MA 02115. E-mail: andrew.miller@childrens.harvard.edu

HOSPITAL PEDIATRICS (ISSN Numbers: Print, 2154-1663; Online, 2154-1671).

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

Dr Miller conceptualized and designed the study, contributed to data acquisition, analysis, and interpretation, and drafted the initial manuscript; Dr Monuteaux conceptualized and designed the study and contributed to data acquisition, analysis, and interpretation; Drs Bourgeois and Fleegler conceptualized and designed the study, contributed to data interpretation, and critically reviewed the manuscript; and all authors approved the final manuscript as submitted.

[a]Division of Emergency Medicine, Boston Children's Hospital, Boston, Massachusetts; and [b]Department of Pediatrics, Harvard Medical School, Harvard University, Boston, Massachusetts

The initial guidelines for procedural sedation in pediatrics were developed and published by the American Academy of Pediatrics in 1985.[1] These guidelines have subsequently undergone numerous updates. There have been advances in the field of procedural sedation that have solidified this practice into a safe and reliable procedure that improves the care of tens of thousands of pediatric patients annually.[2–6] However, there are no guidelines on appropriate indications for sedation or recommended medications for particular patients or injury types.[7,8] There is scant information describing patterns and characteristics of pediatric sedation at a national level, and this information is limited to a single study in which researchers focused on procedural sedation around abscess incision and drainage procedures.[9] In smaller studies, researchers have suggested substantial variability in the frequency and type of pediatric procedural sedation provided in the emergency department (ED) and on hospitalist sedation services.[10,11]

Variation in pediatric care has been described across a number of patient groups and conditions, including the evaluation of febrile infants,[12] management of diabetic ketoacidosis,[13] and even admission rates for common pediatric illnesses.[14] It has been suggested that such variability should be reduced because it leads to increased health care costs and likely decreased quality of care.[15–17] In this study, we sought to describe trends over time in the administration of procedural sedation in the ED and to quantify the variation in procedural sedation in terms of rate of use, patient characteristics, indications, and choice of agents. We hypothesized that tertiary pediatric EDs exhibit wide variation in the use of procedural sedation, both across hospitals and over the study period.

METHODS

Study Design and Setting

We performed a retrospective, cross-sectional study using data obtained from the Pediatric Health Information System (PHIS), an administrative database that contains ED, inpatient, ambulatory surgery, and observation encounter–level data on every patient from 45 not-for-profit, tertiary care pediatric hospitals in the United States. Participating hospitals are tertiary care institutions located in 17 of the 20 major metropolitan areas, representing 85% of all dedicated children's hospitals within the United States[18] and accounting for 13% of all inpatient pediatric discharges with the exception of newborns (S. Reid, PHIS Analytics Department personal communication, 2017). These hospitals are affiliated with the Children's Hospital Association (Overland Park, KS). Data quality and reliability are assured through a joint effort between the Children's Hospital Association and participating hospitals. Portions of the data submission and data quality processes for the PHIS database are managed by Truven Health Analytics (Ann Arbor, MI). For the purposes of external benchmarking, participating hospitals provide discharge or encounter data, including demographics, diagnoses, and procedures. Nearly all submit data on resource use (eg, pharmaceuticals, imaging, and laboratory). Data are deidentified at the time of data submission and are subjected to reliability and validity checks before being included in the database. We limited our analysis to the 37 hospitals with comprehensive data in the PHIS data set since 2009.

Study Population

Children younger than 19 years of age who presented to the ED of a participating PHIS institution between January 1, 2009, and December 31, 2014, were eligible for inclusion. On the basis of previous studies in which researchers delineated the most common indications for pediatric procedural sedation,[10,19] we identified patients who would potentially receive procedural sedation using their ED visit diagnoses. These diagnoses were identified by using the following *International Classification of Diseases, Ninth Revision, Clinical Modification* codes for the principal diagnosis in the PHIS: fracture (810.0–829.1), dislocation (830.0–838.19), laceration (870.0–884.2; 890.0–894.2), abscess/pilonidal cyst (681.0–682.9 or 685.0–685.1), external burn (940.0–946.5 948.0–949.5), septic joint/effusion (711.0–711.99; 719.0–719.3), and partial finger amputations (885.0–886.1). For analytical purposes, diagnoses were classified into the categories of fracture, laceration, abscess, dislocation, and other (external burns, septic joint or effusion, and partial finger amputations).

Children were excluded if they had a chronic comorbid condition (eg, cerebral palsy, cystic fibrosis, congenital heart disease, etc) as defined by Feudtner et al[20] because the considerations and indications for sedation may be different in these populations. Because sedation medications are also used for intubation, we excluded patients who were given the following neuromuscular blocking agents: succinylcholine, rocuronium, vecuronium, cisatracurium, and/or pancuronium. Lastly, given that the PHIS does not account for whether medications were administered in the ED or in an inpatient setting, we excluded patients admitted to the hospital or the operating room to guarantee that these medications were not given outside of the ED.

To determine which patients underwent procedural sedation, we used the PHIS data in which medication administration was captured. This methodology has been used in a previous PHIS study in which researchers described procedural sedation.[9] The administration of the following medications or combinations of medications in conjunction with the above diagnoses was considered to constitute procedural sedation on the basis of current literature[21,22]: propofol, ketamine, ketamine and propofol, midazolam and fentanyl, dexmedetomidine, etomidate, chloral hydrate, pentobarbital, methohexital, and meperidine, promethazine, and chlorpromazine. Single-agent use of opiate or benzodiazepine was not considered procedural sedation but rather analgesia and anxiolysis, respectively. Although other opiates and benzodiazepines exist, the combination of midazolam and fentanyl are most cited given their inherent short-acting qualities, providing ideal short-term procedural sedation. The combination of meperidine, promethazine, and chlorpromazine was not found in our query

during the study period and therefore was excluded from our analysis.

Data on the administration of nitrous oxide are not available in the PHIS database because it is typically administered by the treating provider and not ordered and billed through the pharmacy. This might lead to an underestimation of patients who underwent procedural sedation in the PHIS. To address this issue, we conducted a survey on the use of nitrous oxide at each of the 37 hospitals. We decided a priori that institutions that used nitrous oxide for 15% or more of procedural sedations in the ED would be excluded from the study so as to prevent misclassification about the rate of procedural sedations. We also gathered data on whether sedations are routinely performed in the ED or if procedural sedation for certain indications is performed in other settings, such as the operating room or in a procedural unit by a sedation service. The survey was sent via e-mail to the division chiefs of the EDs at each institution, with follow-up telephone inquiries to nonresponsive institutions. We obtained a 100% response rate. Most hospitals did not use nitrous oxide or used it minimally; only 2 hospitals used nitrous for 15% or greater of their sedations, and therefore the number of eligible institutions was reduced to 35. None of the EDs surveyed transferred patients outside the ED for routine procedural sedation with the exception of obtaining MRI. The institutional review board at Boston Children's Hospital approved this study with a waiver of informed consent.

Statistical Analysis

Descriptive statistics were used to describe the use of procedural sedation overall and by indication across hospitals. To test if the use of sedation medications changed over time, we estimated a logistic regression model with sedation medication use as the dependent variable and time (coded in years) as the independent variable as a test of linear trend. A multivariable logistic regression model was estimated to test the association between the administration of procedural sedation and patient demographic characteristics, including sex, age, race (white versus people of color), ethnicity (Hispanic versus non-Hispanic), and payment source (private versus public insurance). The sedation rates by indication were compared across age groups, defined as 0 to 4, 5 to 11, and 12 to 18 years of age. These age groups were chosen on the basis of preschool age, school age, and adolescent child, respectively.

Given that data were taken from several hospitals representing thousands of patients each, the assumption of independent observations may not hold. To accommodate these data, we used regression models with clustered sandwich SE estimates to allow for intrahospital correlation, relaxing the assumption that observations from the same hospital are independent. A sensitivity analysis was performed to compare the data with the full 37 hospitals to the data without the 2 hospitals that were excluded because of their frequent use of nitrous oxide for sedations. All statistical tests were 2-tailed with an α set at .05 and were performed by using the software package Stata 13.0 (StataCorp, College Station, TX).

RESULTS

There were 1 448 011 ED encounters by patients <19 years of age with diagnoses of interest during the study period. Of these, we excluded 23 345 (1.6%) because of complex chronic conditions, 30 522 (2.1%) for receiving neuromuscular blockade, and 128 758 (8.9%) for undergoing a surgical operation or admission to the hospital. This left 1 265 386 (87.4%) patients who met study criteria, of which 99 951 (7.9%) received procedural sedation medications. The number of patients seen at a hospital level with each given diagnosis throughout our study period is represented in Supplemental Table 2.

Patient and Procedural Characteristics

The total rate of procedural sedation was 7.9% across all ages and diagnoses, with a rate of 7.4% in ages 0 to 4, 9.3% in ages 5 to 11, and 6.3% in ages 12 to 18 years. Compared with school-aged children (ages 5–11), there was a lower rate of procedural sedations in adolescents (ages 12–18) and infants (ages 0–4) (adjusted odds ratio [aOR] 0.65 [95% confidence interval (CI) 0.61–0.70] and aOR 0.78 [95% CI 0.68–0.90], respectively). Fractures made up 54.5% of all procedural sedations, followed by lacerations (23.4%), abscess or pilonidal cyst (16.4%), and dislocations (3.2%), with external burns, septic joint or effusions, and partial finger amputations making up the final 2.5%. In the most recent year of the study (2014), ketamine was used 73.7% of the time, followed by fentanyl and midazolam at 15.9%, ketofol at 7.3%, and propofol at 2.7%, with the rest of the medications used <1% of the time.

Patient demographic characteristics are shown in Table 1. In a multivariable logistic regression, we found that patients with public health insurance had decreased odds of receiving procedural sedation medication (aOR 0.82 [95% CI 0.70–0.97]) compared with those with private insurance. All other patient characteristics in the multivariable logistic regression were not significant.

Trends Over Time

In Fig 1, we show the distribution of sedation medications used by year to demonstrate medication trends over time by using a logarithmic scale. A test of linear trend was performed on each medication (or combination of medications) as well as on all medications combined to assess how preferences in the choice of agent(s) changed over the study period. Only the combination of fentanyl and midazolam increased, with an OR of 1.39 (95% CI 1.12–1.72) and an absolute rate increase of 12.6%. Other medications decreased in relative use over the study period, including ketamine (OR 0.81 [95% CI 0.67–0.98]), pentobarbital (OR 0.73 [95% CI 0.62–0.86]), etomidate (OR 0.78 [95% CI 0.65–0.92]), chloral hydrate (OR 0.37 [95% CI 0.32–0.43]), and methohexital (OR 0.58 [95% CI 0.46–0.75]). The absolute rate of use for these medications also decreased (−9.5% for ketamine, −0.14% for pentobarbital, −0.48% for etomidate, −0.43% for chloral hydrate, and −0.16% for methohexital). Use of all other medications did not change over time.

Variability

Figure 2 reveals the variation in procedural sedation at the hospital level in the earliest

TABLE 1 Hospital-Level Demographic and Procedural Sedation Characteristics for Pediatric Patients With Select Diagnostic Codes Treated in the ED From 2009 Through 2014

	All Included Patients (N = 1 265 386)	Nonsedated Patients (n = 1 165 435)	Sedated Patients (n = 99 951)	Multivariate Logistic Regression OR (95% CI)
Median age, y	6 (IQR 3–11)	6 (IQR 3–11)	6 (IQR 3–10)	0.99 (0.98–1.00)
Boys, %	60.4	60.4	60.0	1.00 (0.96–1.05)
Race, %				
White	55.4	55.0	60.0	Comparison
African American	24.6	24.9	21.2	0.81 (0.64–1.02)
Other	20.0	20.1	18.8	0.99 (0.77–1.29)
Ethnicity, %				
Non-Hispanic	65.6	65.0	71.7	Comparison
Hispanic	21.4	21.7	17.8	0.77 (0.55–1.09)
Other	13.1	13.3	10.5	0.64 (0.38–1.1)
Payment source, %				
Private	37.7	37.3	43.3	Comparison
Public	52.1	53.6	46.3	0.82 (0.70–0.97)
Other	10.2	10.2	10.4	0.95 (0.67–1.35)

The category "Other" includes missing variables; however, missing values were excluded from the multivariate logistic regression.

and the most recent year of our study. The median sedation rate in 2009 was 6.9% (interquartile range [IQR]: 3.5–9.8) and ranged from 0.03% to 15.1%. During 2014, the median sedation rate was 8% (IQR: 3.2–12.3) with a range of 0.21% to 32%. At the hospital level, the change over time (2009–2014) in sedation rate varied from a decrease of 9% to an increase of 26%. Similar figures for each diagnostic category are represented in Supplemental Figs 4–7.

Figure 3 reveals the variation in the rate of procedural sedation across institutions by diagnoses in the most recent year (2014). The diagnoses with the largest variation were in the grouped category that included external burns, septic joint or effusion, and partial finger amputations (with a range from 0%–43%), followed by dislocations (with a range of 1.9%–34.5%) and abscess (with a range of 0%–32.3%).

DISCUSSION

Our results demonstrate substantial variability across pediatric EDs in the use of procedural sedation for children. There was substantial variability in procedural sedation rates both across institutions and within institutions over the study period. Medication preferences changed, with the combination of fentanyl and midazolam increasing and staple medications such as ketamine decreasing.

Overall procedural sedation rates show an absolute rate range of ∼30% between institutions. Even after removing the outlier hospitals that constituted the uppermost 25th and lowermost 25th percentiles, there remains approximately a threefold difference in the rate of sedations. Within the diagnosis of dislocation, there is a >15-fold difference in the rate of sedation across the hospitals. For fractures, lacerations and abscesses, we found a >30-fold difference in procedural sedation rates between institutions. Variation across pediatric hospitals in the rate of procedural sedation may be related to various factors, including but not limited to local and individual practice patterns,[23] staffing models, and available resources. Practice patterns, including patients receiving pain control with regional anesthesia by using techniques such as hematoma blocks, nerve blocks, or Bier blocks in addition to anxiolysis but no formal procedural sedation, could also be a source of variability in some of the diagnoses, such as fractures. Although transfers out of the hospital are also a possibility, PHIS institutions are tertiary care centers that likely serve as referral centers for pediatric-specific interventions such as procedural sedation. PHIS data do not allow for a detailed exploration of hospital-specific factors, but the degree of variation is striking, and we argue for measures to standardize pediatric procedural sedation practices.

We did find a significant change in the use of specific medications. Ketamine was the most frequently used medication, making up approximately three-quarters of all pediatric procedural sedations, but it has decreased in use over recent years. We found increasing use of fentanyl and midazolam, especially within the last year of our study period. We were not able to identify any published evidence that would support this recent increase. In fact, many other drugs, such as propofol, ketofol, and dexmedetomidine, have had a significant uptick in the pediatric ED literature over the last 15 years, with providers reporting favorably on their use in the ED setting.[24–26] We did not find a significant increase in the use of propofol, which may reflect the challenges in securing approval for use by nonanesthesiologist providers in some institutions.[24,27] There was an increase of >10-fold in the use of dexmedetomidine in 2014, although this is not statistically significant and overall use remained <1%. On the other end of the spectrum, medications such as pentobarbital, etomidate, chloral hydrate, and

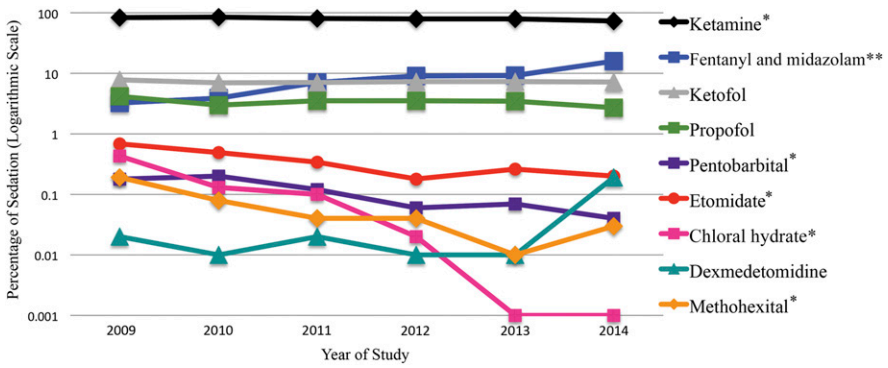

FIGURE 1 Procedural sedation medication trends over time (2009–2014) using a logarithmic scale. * Decreasing over time; $P < .05$. ** Increasing over time; $P < .05$.

methohexital are becoming less popular in the procedural sedation armamentarium. This may reflect the fact that these medications have suboptimal side effect profiles and are perhaps less effective than medications that are now more routinely used.[28–31]

We cannot ascertain what the correct rate of procedural sedation should be and whether certain hospitals are performing too few or too many sedations. On the one hand, rates approaching 0 likely reflect underuse: sedation is frequently required to provide optimal conditions of pain control and safety during closed reduction, complicated sutured repair, or incision and drainage of large abscesses. On the other hand, overuse of sedation may unnecessarily expose patients to medications that carry low but inherent risks such as hypoxia, laryngospasm, and aspiration.[32,33] Consensus statements outlining when and how to perform procedural sedation could help ensure that sedations are being performed for the appropriate patients and indications.

Evidence-based guidelines (EBGs) have been a successful strategy to enable pediatric EDs to provide more consistent care to patients.[34] These have been used for many indications in pediatrics, including bronchiolitis[35] and head injury,[36] leading to a reduction in the amount of variability in management of children. Authors of EBGs for the use of procedural sedation should outline inclusion and exclusion criteria, taking into account the type and severity of injury as well as patient-specific medical and psychosocial factors. There have been other studies in which researchers demonstrated differences in cost-effectiveness[37] and length of stay[38] in the use of procedural sedation; these factors likely contribute to physician decision-making and should be incorporated. Finally, authors of EBGs should provide guidance on the specific medications to be considered for different types of injuries and patients. Although EBGs allow for deviation at the providers' discretion, they would likely lead to more consistent (and perhaps more optimal) care across institutions.

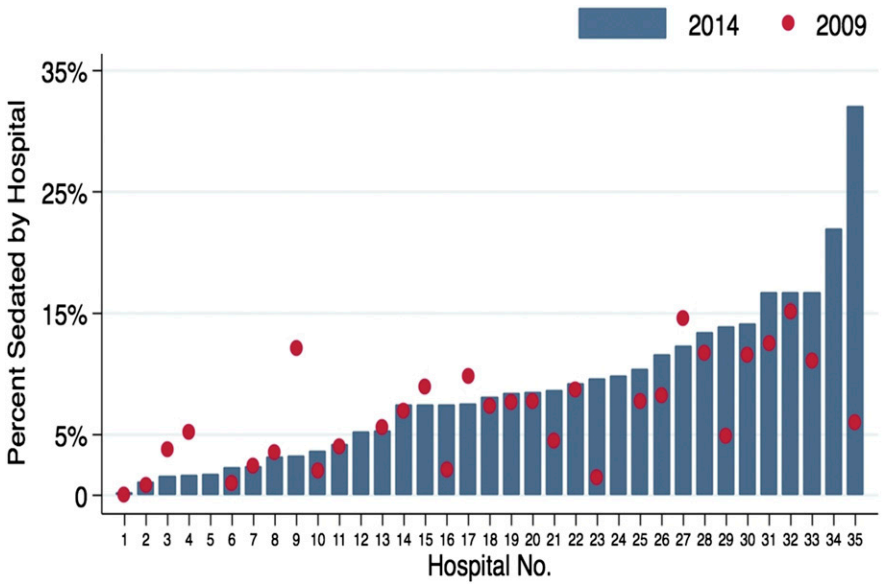

FIGURE 2 Hospital-level procedural sedation rates among pediatric patients in the earliest year, (2009, red circle) and the most recent year (2014, blue bar). Each number represents a hospital. Four hospitals did not provide complete data in 2009 and therefore do not have a data point diagramed as a red circle.

Of note, public insurance was the only demographic factor that decreased the likelihood of a patient receiving procedural sedation for the indications we studied. Disparities in pediatric care related to insurance status have been previously documented for multiple aspects of care.[39,40] With regard to analgesia and sedation, insurance status has been shown to affect opioid prescribing practices[41] and the provision of procedural sedation for abscess drainage in the ED.[9] Procedural sedation and analgesia overlap on the spectrum of pain control; therefore, the etiology may be similar. In previous studies, researchers have hypothesized that these differences may be related to parental request but acknowledge the possibility of provider bias.[39,40] This lower sedation rate for patients with public insurance is concerning and merits further investigation.

We used a database of tertiary care children's hospitals throughout the United States, and our results may not be generalizable to all EDs. Given the wide variability in sedation practices in tertiary care centers, one would expect variation in other settings as well. Diagnostic codes were used to identify the study cohort, which are reliant on the provider billing for

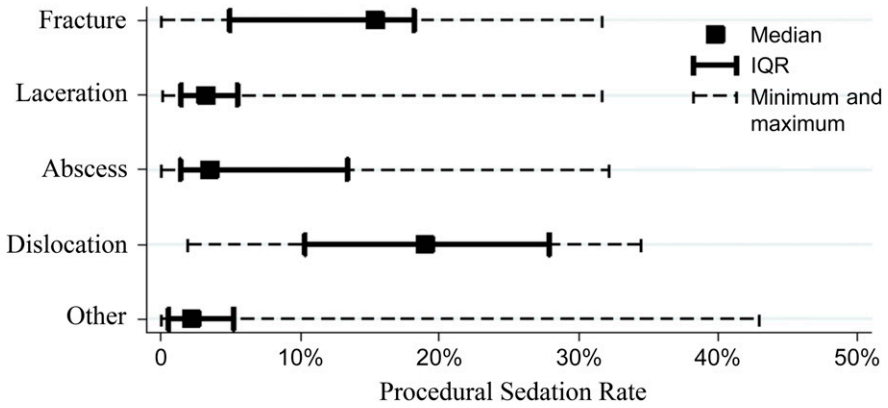

FIGURE 3 Hospital-level procedural sedation rates among pediatric patients in the most recent year (2014), evaluated by diagnostic group. This figure reveals the variability of procedural sedation given the diagnostic group.

the appropriate condition. However, this is a standard methodology for identifying specific patient cohorts.[12–14,42] Some of the included procedure codes likely captured patients who either did not undergo a procedure or did not require procedural sedation. As a result, our reported rates of procedural sedation cannot be extrapolated to absolute rates of procedural sedation for specific procedures. Although we could not investigate this further because the PHIS does not categorize the severity of injuries, we assumed the rate of misclassification would be the same across the EDs in our samples given that they are all tertiary pediatric centers. Although we cannot determine the absolute rate of patients requiring procedural sedation, our methodology allows us to compare the relative rates of sedation between institutions. We recognize that unadjusted confounding is another explanation of our result. There is also the possibility of some spectrum bias: for example, patients without public insurance may be more likely to have presented with conditions that do not require procedures, and those with conditions that do require a procedure may be less likely to require sedation. Because *Current Procedural Terminology* codes are not used consistently in the PHIS database, we chose to identify procedural sedations on the basis of the medications administered because medication data are highly reliable in the database. With regard to nitrous oxide, this methodology is not reliable because it is not a routinely billed agent. To address this, we performed a survey to exclude hospitals that are frequent nitrous oxide users. By using PHIS alone, it is not clear if patients were discharged to settings outside of the ED for procedural sedation, but this survey also revealed that this was not occurring for these acute diagnoses. Although this survey helped us clarify some aspects of our study, it was not specific enough for us to be informed on all possible factors that could affect variability.

CONCLUSIONS

Our findings demonstrate tremendous variation in the use of procedural sedation for similar indications across pediatric EDs in the United States as well as changing preferences in agent selection for procedural sedation. Standardized guidelines could provide assistance in identifying appropriate candidates for procedural sedation in the pediatric ED. With our findings about variability in the performance of procedural sedation, we suggest the need to develop and implement guidelines on procedural sedation, including recommendations on the types of patients who should receive sedation and the specific medications to consider.

REFERENCES

1. Committee on Drugs, Section on Anesthesiology. Guidelines for the elective use of conscious sedation, deep sedation, and general anesthesia in pediatric patients. *Pediatrics*. 1985;76(2):317–321
2. Krauss B, Green SM. Procedural sedation and analgesia in children. *Lancet*. 2006; 367(9512):766–780
3. Mace SE, Brown LA, Francis L, et al; EMSC Panel (Writing Committee) on Critical Issues in the Sedation of Pediatric Patients in the Emergency. Clinical policy: critical issues in the sedation of pediatric patients in the emergency department. *Ann Emerg Med*. 2008;51(4): 378–399, 399.e1–399.e57
4. Coté CJ, Wilson S; American Academy of Pediatrics; American Academy of Pediatric Dentistry; Work Group on Sedation. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update. *Pediatrics*. 2006;118(6): 2587–2602
5. Roback MG, Wathen JE, Bajaj L, Bothner JP. Adverse events associated with procedural sedation and analgesia in a pediatric emergency department: a comparison of common parenteral drugs. *Acad Emerg Med*. 2005;12(6): 508–513
6. Havidich JE, Cravero JP. The current status of procedural sedation for pediatric patients in out-of-operating room locations. *Curr Opin Anaesthesiol*. 2012;25(4):453–460
7. Langhan ML, Mallory M, Hertzog J, Lowrie L, Cravero J; Pediatric Sedation Research Consortium. Physiologic monitoring practices during pediatric procedural sedation: a report from the Pediatric Sedation Research Consortium. *Arch Pediatr Adolesc Med*. 2012;166(11):990–998
8. Hostetler MA, Auinger P, Szilagyi PG. Parenteral analgesic and sedative use among ED patients in the United States: combined results from the National Hospital Ambulatory Medical Care Survey (NHAMCS) 1992-1997 [published correction appears in *Am J Emerg Med*. 2002;20(5):496]. *Am J Emerg Med*. 2002; 20(3):139–143
9. Uspal NG, Klein EJ, Tieder JS, Oron AP, Simon TD. Variation in the use of procedural sedation for incision and

drainage of skin and soft tissue infection in pediatric emergency departments. *Hosp Pediatr*. 2015;5(4):185–192

10. Bhargava R, Young KD. Procedural pain management patterns in academic pediatric emergency departments. *Acad Emerg Med*. 2007;14(5):479–482
11. Srinivasan M, Bhaskar S, Carlson DW. Variation in procedural sedation practices among children's hospitals. *Hosp Pediatr*. 2015;5(3):148–153
12. Jain S, Cheng J, Alpern ER, et al. Management of febrile neonates in US pediatric emergency departments. *Pediatrics*. 2014;133(2):187–195
13. Tieder AJS, Mcleod L, Keren R, et al; Pediatric Research in Inpatient Settings Network. Variation in resource use and readmission for diabetic ketoacidosis in children's hospitals. *Pediatrics*. 2013; 132(2):229–236
14. Bourgeois FT, Monuteaux MC, Stack AM, Neuman MI. Variation in emergency department admission rates in US children's hospitals. *Pediatrics*. 2014; 134(3):539–545
15. Neuman MI, Chiang VW. Variation in pediatric care at US hospitals. *Pediatrics*. 2013;132(2):369–370
16. Fisher ES, Bynum JP, Skinner JS. Slowing the growth of health care costs–lessons from regional variation. *N Engl J Med*. 2009;360(9):849–852
17. Soni SM, Giboney P, Yee HF Jr. Development and implementation of expected practices to reduce inappropriate variations in clinical practice. *JAMA*. 2016;315(20):2163–2164
18. Wood JN, Feudtner C, Medina SP, Luan X, Localio R, Rubin DM. Variation in occult injury screening for children with suspected abuse in selected US children's hospitals. *Pediatrics*. 2012; 130(5):853–860
19. MacLean S, Obispo J, Young KD. The gap between pediatric emergency department procedural pain management treatments available and actual practice. *Pediatr Emerg Care*. 2007;23(2):87–93
20. Feudtner C, Hays RM, Haynes G, Geyer JR, Neff JM, Koepsell TD. Deaths attributed to pediatric complex chronic conditions: national trends and implications for supportive care services. *Pediatrics*. 2001;107(6). Available at: www.pediatrics.org/cgi/content/full/107/6/e99
21. Sahyoun C, Krauss B. Clinical implications of pharmacokinetics and pharmacodynamics of procedural sedation agents in children. *Curr Opin Pediatr*. 2012;24(2):225–232
22. Gozal D, Gozal Y. Pediatric sedation/ anesthesia outside the operating room. *Curr Opin Anaesthesiol*. 2008;21(4): 494–498
23. Kamat PP, Hollman GA, Simon HK, Fortenberry JD, McCracken CE, Stockwell JA. Current state of institutional privileging profiles for pediatric procedural sedation providers. *Hosp Pediatr*. 2015;5(9):487–494
24. Bassett KE, Anderson JL, Pribble CG, Guenther E. Propofol for procedural sedation in children in the emergency department. *Ann Emerg Med*. 2003;42(6): 773–782
25. Andolfatto G, Willman E. A prospective case series of pediatric procedural sedation and analgesia in the emergency department using single-syringe ketamine-propofol combination (ketofol). *Acad Emerg Med*. 2010;17(2):194–201
26. McMorrow SP, Abramo TJ. Dexmedetomidine sedation: uses in pediatric procedural sedation outside the operating room. *Pediatr Emerg Care*. 2012;28(3):292–296
27. Mallory MD, Baxter AL, Yanosky DJ, Cravero JP; Pediatric Sedation Research Consortium. Emergency physician-administered propofol sedation: a report on 25,433 sedations from the pediatric sedation research consortium. *Ann Emerg Med*. 2011;57(5):462–468.e1
28. Nordt SP, Rangan C, Hardmaslani M, Clark RF, Wendler C, Valente M. Pediatric chloral hydrate poisonings and death following outpatient procedural sedation. *J Med Toxicol*. 2014;10(2): 219–222
29. Schenarts CL, Burton JH, Riker RR. Adrenocortical dysfunction following etomidate induction in emergency department patients. *Acad Emerg Med*. 2001;8(1):1–7
30. Moro-Sutherland DM, Algren JT, Louis PT, Kozinetz CA, Shook JE. Comparison of intravenous midazolam with pentobarbital for sedation for head computed tomography imaging. *Acad Emerg Med*. 2000;7(12):1370–1375
31. Austin T, Vilke GM, Nyheim E, Kelly D, Chan TC. Safety and effectiveness of methohexital for procedural sedation in the emergency department. *J Emerg Med*. 2003;24(3):315–318
32. Peña BM, Krauss B. Adverse events of procedural sedation and analgesia in a pediatric emergency department. *Ann Emerg Med*. 1999;34(4, pt 1): 483–491
33. Biber JL, Allareddy V, Allareddy V, et al. Prevalence and predictors of adverse events during procedural sedation anesthesia-outside the operating room for esophagogastroduodenoscopy and colonoscopy in children: age is an independent predictor of outcomes. *Pediatr Crit Care Med*. 2015;16(8): e251–e259
34. Akenroye AT, Stack AM. The development and evaluation of an evidence-based guideline programme to improve care in a paediatric emergency department. *Emerg Med J*. 2016;33(2):109–117
35. Akenroye AT, Baskin MN, Samnaliev M, Stack AM. Impact of a bronchiolitis guideline on ED resource use and cost: a segmented time-series analysis. *Pediatrics*. 2014;133(1). Available at: www.pediatrics.org/cgi/content/full/133/1/e227
36. Nigrovic LE, Stack AM, Mannix RC, et al. Quality improvement effort to reduce cranial CTs for children with minor blunt head trauma. *Pediatrics*. 2015;136(1). Available at: www.pediatrics.org/cgi/content/full/136/1/e227
37. Pershad J, Todd K, Waters T. Cost-effectiveness analysis of sedation and analgesia regimens during fracture

manipulation in the pediatric emergency department. *Pediatr Emerg Care*. 2006; 22(10):729–736

38. Godambe SA, Elliot V, Matheny D, Pershad J. Comparison of propofol/fentanyl versus ketamine/midazolam for brief orthopedic procedural sedation in a pediatric emergency department. *Pediatrics*. 2003;112(1, pt 1):116–123
39. Amanullah S, Linakis JG, Vivier PM, Clarke-Pearson E, Steele DW. Differences in presentation and management of pediatric facial lacerations by type of health insurance. *West J Emerg Med*. 2015;16(4):527–534
40. Skinner AC, Mayer ML. Effects of insurance status on children's access to specialty care: a systematic review of the literature. *BMC Health Serv Res*. 2007;7:194
41. Pletcher MJ, Kertesz SG, Kohn MA, Gonzales R. Trends in opioid prescribing by race/ethnicity for patients seeking care in US emergency departments. *JAMA*. 2008;299(1):70–78
42. Florin TA, French B, Zorc JJ, Alpern ER, Shah SS. Variation in emergency department diagnostic testing and disposition outcomes in pneumonia. *Pediatrics*. 2013;132(2):237–244

Variation in Pediatric Procedural Sedations Across Children's Hospital Emergency Departments

Andrew F. Miller, Michael C. Monuteaux, Florence T. Bourgeois and Eric W. Fleegler

Hospital Pediatrics 2018;8;36
DOI: 10.1542/hpeds.2017-0045 originally published online December 12, 2017;

Variation in Pediatric Procedural Sedations Across Children's Hospital Emergency Departments

Andrew F. Miller, Michael C. Monuteaux, Florence T. Bourgeois and Eric W. Fleegler

Hospital Pediatrics 2018;8;36
DOI: 10.1542/hpeds.2017-0045 originally published online December 12, 2017;