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Incidence and between-center heterogeneity of anesthesia-related complications in pediatric populations documented in administrative data: A retrospective study

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Though not its primary intended purpose, administrative data collected from hospital billing and discharge records are used widely in anesthesia research, including in studies of pediatric populations.¹ Owing to their sheer size, these databases are well-suited to monitoring rare complications. However, the recording of complications has been shown to exhibit substantial between-center heterogeneity in adult populations.² The primary objective of this study was to measure the incidence of complications due to anesthesia during an inpatient admission in which an operative procedure was performed using a large, geographically diverse database. The secondary objective was to assess the between-hospital variability in the incidence of complications.

We queried all records of pediatric inpatient hospital admissions in the State Inpatient Databases from the Healthcare Cost and Utilization Project (HCUP)³ from Q4 2015–2018 for the following regions in the United States: Florida, Kentucky, Maryland, New York, and Washington. The State Inpatient Databases approximate a census of inpatient admissions ascertained from nearly all hospitals in the included geographic areas. Inclusion criteria were inpatient admissions to patients aged 0–18, non-missing patient sex, containing at least one operating room procedure (either “major therapeutic” or “major diagnostic”), and the Major Diagnostic Category (MDC) was not: pre-MDC; pregnancy, childbirth, and puerperium; mental diseases & disorders; factors influencing health status & other contacts with health services; other; or missing. We calculated the incidence of anesthesia complications using International Classification of Diseases, 10th Revision, Clinical Modification (ICD) codes marked as not present on admission, indicating that they developed during the hospitalization. Per HCUP reporting requirements, cells with

1–10 observations were masked. Study activities were approved by the Institutional Review Board at Weill Cornell Medical College (#1308014181).

After applying inclusion criteria, there were 124 877 inpatient admissions clustered in 568 hospitals. The incidence of any anesthesia complication was <191 (<0.15%) (Table 1). The most prevalent reported individual complications were failed or difficult intubation ($N=39$), overdose of other and unspecified general anesthetics ($N=38$), overdose of unspecified anesthetics ($N=35$), and hypothermia ($N=30$). There were no recorded instances of adverse effects of anesthesia in therapeutic use, and the overall rate of anesthetic overdoses amounted to 0.09%. Only 59 of 568 hospitals (representing 76.2% of cases in the dataset) reported at least one anesthesia complication; of the 59 hospitals reporting complications, rates varied widely (independent of the number of cases), with the majority reporting complication rates of less than 0.3%: median: 0.3% (IQR 0.1% to 0.8%), range 0.03% to 10.0% (Figure 1). The corresponding absolute number of complications reported by these hospitals ranged from <11 to 20.

To contextualize our findings, we compared the observed incidence of complications to roughly equivalent measures from previous studies (Table 2). Our results diverged from previous studies which reported rates of complications in pediatric anesthesia from a variety of sources. These sources included a meta-analysis of medication errors, multicenter registries, and data from a single center.^{4–7}

Are administrative data suitable for studying the incidence of anesthesia-related complications in pediatric populations? The incidences observed in this population are indeed different from those previously reported in other studies, though without a

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ICD-10 code and category	ICD-10 Description	Incidence in SID (N = 124 877)
Overdose of anesthetics		111 (0.09%)
T41.0	Inhaled anesthetics	12 (<0.01%)
T41.1	Intravenous anesthetics	12 (<0.01%)
T41.2	Other and unspecified general anesthetics	38 (0.03%)
T41.3	Local anesthetics	14 (0.01%)
T41.4	Unspecified anesthetics	35 (0.03%)
Adverse effects of anesthesia in therapeutic use		0 (0.00%)
Y45.0	Opioids and related analgesics	0 (0.00%)
Y47.1	Benzodiazepines	0 (0.00%)
Y48.0	Inhaled anesthetics	0 (0.00%)
Y48.1	Parenteral anesthetics	0 (0.00%)
Y48.2	Other and unspecified general anesthetics	0 (0.00%)
Y48.3	Local anesthetics	0 (0.00%)
Y48.4	Unspecified anesthetics	0 (0.00%)
Y55.1	Skeletal muscle relaxants (neuromuscular blocking agents)	0 (0.00%)
Other complications of anesthesia		<80 (<0.06%)
T88.2	Shock due to anesthesia in which the correct substance was properly administered	0 (0.00%)
T88.3	Malignant hyperthermia	<11 (<0.01%)
T88.4	Failed or difficult intubation	39 (0.01%)
T88.5	Other complications of anesthesia, hypothermia following anesthesia	30 (0.02%)
Y65.3	Endotracheal tube wrongly placed	0 (0.00%)
Total	Any anesthesia complication	<191 (<0.15%)

TABLE 1 Incidence of not present on admission anesthesia-related complications – State Inpatient Databases (SID) Q4 2015–2018.

reference standard we cannot conclude that these results exhibit either inferior or superior validity. Differences in study methodology, inconsistent definitions of complications or critical incidents (both in terms of clinical definitions and requirements for ascertainment in the administrative record), and differences in study populations could all contribute to the observed variability in estimates.

Perhaps most concretely, our study suggests that most hospitals (representing approximately a quarter of cases in our dataset) are either not recording these complications as ICD codes in administrative records, or that these hospitals may not experience any complications related to anesthesia. One potential explanation of the low observed incidence of complications on the administrative record is because rectifying adverse effects of anesthesia complications often does not require procedures which are billed separately. Furthermore, the observed between-hospital heterogeneity of complication rates and the simultaneous lack of any recorded incidence of certain complications of anesthesia may call into question the validity of these administrative data. The heterogeneity may also be suggestive of systematic site-based reporting

errors. However, bereft of a reference standard, we are unable to draw conclusions about potential biases. The ramifications of reporting estimates of complications from administrative data without acknowledging the potential biases are vast: ranging from the development of imprecise clinical prediction models to setting baseless benchmarks.

Researchers should proceed with caution when using multicenter administrative data to measure the incidence of complications in pediatric anesthesia unless they are aware of the idiosyncrasies of coding practices of each contributing center. Though this study does not bring us closer to identifying the true incidence of these anesthesia complications in pediatric populations, it highlights the between-hospital heterogeneity in incidence and limitations that need to be considered when using administrative data to study clinical outcomes. Finally, this study underscores the need for a set of standardized core outcome measures in pediatric anesthesia to ameliorate the conduct and reporting of research across contexts. While ICD coding is indeed standardized, its use in the reporting of inpatient complications in pediatric anesthesia may not be.

FIGURE 1 Hexagon plot of $N = 568$ hospitals showing the percentage of total anesthesia complications by hospital plotted against the total number of cases contributed by each hospital (log₁₀ transformation).

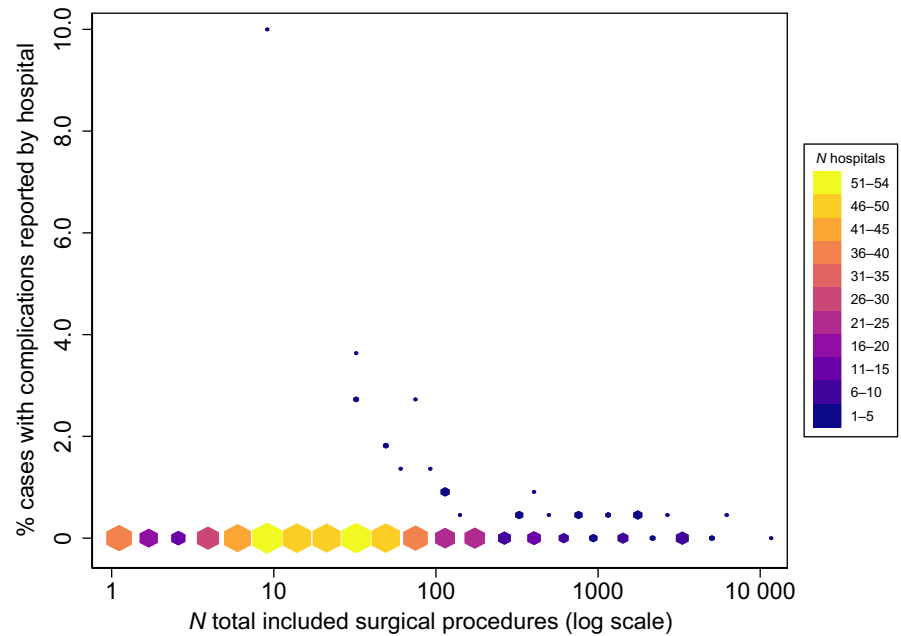


TABLE 2 Comparisons of findings with previous studies.

Source population from previous studies	Findings from previous studies	Current study
Meta-analysis of medication errors in pediatric anesthesia (including data ascertained through audit, voluntary reporting, and monitoring every anesthetic event) ⁷	Rate of medication errors: 0.08% (1 in 1250 anesthetics)	Anesthetic overdoses: 0.09% No records with ICD-10 codes for adverse effects of anesthesia in therapeutic use
Multicenter registry of difficult pediatric intubations: Pediatric Difficult Intubations (PeDI) ⁵	Failed intubations: 2% (of 1018 difficult pediatric tracheal intubations)	Failed or difficult intubations: 0.01%
Multicenter APRICOT registry of severe critical incidents ⁶	Anaphylaxis due to anesthesia present in three cases (of 31 127 anesthetic procedures in 30 874 children)	No recorded instances of 'shock due to anesthesia in which the correct substance was administered'
Anesthesia-related critical incidents in a single-center study ⁴	Critical incidents: 3.4% of 35 190 anesthetics, nearly half of which involved the respiratory system, including: <ul style="list-style-type: none"> • 33 (0.09%) anaphylactic reactions • 85 (0.24%) difficult or failed intubations 	No recorded instances of 'shock due to anesthesia in which the correct substance was administered' Failed or difficult intubations: 0.01%

CONFLICT OF INTEREST STATEMENT

Dr. Jurgen C. de Graaff and Dr. Sanne E. Hoeks serve on the Editorial Board at *Pediatric Anesthesia*. Dr. Robert S. White is supported by the Foundation for Anesthesia Education and Research (Award Number: MRTG-15-2021-White).

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality (AHRQ). Restrictions apply to the availability of these data, which were used for this study following HCUP approval. Data are available from https://hcup-us.ahrq.gov/tech_assist/centdist.jsp with the permission of the Healthcare Cost and Utilization Project (HCUP).

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