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Assessing Risk Factors for Pediatric Medical Injuries Using Nationwide Malpractice Data

THESIS

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MASTER OF SCIENCE

in Biomedical and Translational Science

by

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DEDICATION

To Dr. Kelly, for his continual support and mentorship

To Dr. Billimek, for teaching me everything I know about statistics

To Dr. Kaplan and Dr. Greenfield, for all they do for the MS-BATS program

I shall be telling this with a sigh

Somewhere ages and ages hence:

Two roads diverged in a wood, and I—

I took the one less traveled by,

And that has made all the difference.

Robert Frost

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ABSTRACT OF THE THESIS

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Pediatrics is considered a low-liability medical specialty with respect to the odds of facing a malpractice claim, yet indemnity payments made by pediatricians are among the most expensive of all physicians. Little is known about pediatric malpractice risks from a patient-perspective; especially non-obstetric risks in the infant population, and whether certain pediatric age groups are higher-risk for malpractice injuries. This study uses ten years of malpractice reports from the National Practitioner Data Bank (n = 70,441) to compare pediatric (infant, child, and teenage groups) to adult malpractice events. We compare the severity of injuries and the type of medical errors that were reported, and calculate rates for malpractice reports on a per capita (per 100K population) level for each age group. We found that the pediatric population is a heterogeneous patient population with unique age-specific risk factors. On a per-capita basis, non-obstetric infant malpractice claims were much more common than adult claims, whereas non-infant pediatric claims were less common than in adults. Devastating non-fatal permanent injuries such as brain damage and paralysis were exponentially more common in the infant

population across most non-obstetric medical error types. Overall, diagnostic and treatment-related errors were more common among pediatric claims than in adults, whereas surgical and medication-related errors were less common. While previous research has identified the significance of obstetric injuries in the infant population, future safety and training efforts should also focus on reducing the potential for negligence that can lead to non-obstetric paralysis or brain damage injuries in the infant population, particularly in the realms of diagnosis and treatment.

INTRODUCTION

Despite challenges associated with providing safe healthcare to children, pediatrics is usually considered an average to low-risk medical specialty with respect to malpractice liability.[1–3] According to a study that used data from the Physician Insurers Association of America (PIAA) between 1985 and 2005, pediatrics ranks 10th out of 28 specialties in terms of the odds of facing a malpractice claim.[1] A more recent analysis of a nationwide liability insurer found much lower odds: that pediatricians have a 3.1% chance of facing a malpractice claim every year, compared to 7.4% for all other physicians in the sample (n = 1630 and 40,916, respectively).[3] The study ranked pediatrics 23rd out of 24 specialties in terms of the annual rate of physicians facing a claim. Of note, the percentage of claims that actually result in indemnity payments is much lower at 0.5% and 1.6%, respectively.[3]

While the odds of facing a malpractice claim are low for pediatricians, indemnity payments made by them tend to be much higher than claims involving adult patients. The PIAA found that pediatrics has the 5th highest indemnity payments of 28 different medical specialties.[4] The explanation for this is multifactorial. For one, injured children often have a powerful emotional effect on juries that potentially influences the resulting settlement values.[5] Second, care for children with lifelong disabilities is more expensive than adults with equivalent injuries, simply because children require that care for a longer period of time. It is also possible that children are at an inherently higher risk for medical injury, or that when injuries do occur in the pediatric population, they tend to have more severe and long-lasting outcomes than with adults. In addition, the high payouts of medical

malpractice cases involving child injuries likely encourage excessive litigiousness, creating a potential selection bias for these types of claims. Some of the largest indemnity payments in the last decade have been made for pediatric injuries, a handful of which exceeded $20 million.[5]

1.1) Challenges in Pediatric Care

There are currently about 74 million children in the United States, comprising one-quarter of the population.[6] Healthcare concerns for this population are changing over time. Over the last decade the percentage of children with health insurance coverage has increased, facilitating healthcare delivery for pediatric patients.[5] Today over 91% of children aged 0-17 have some form of health insurance.[7] On the other hand, the modern pediatric patient population contains new challenges for practitioners, such as a large number of children with chronic diseases like obesity and type 2 diabetes.[8] According to 2012 data from the CDC, about 17% or 12.7 million children aged 2-19 years have obesity, and although these rates have been relatively constant over the last decade, there exist substantial racial disparities among children.[9]

Pediatric care continues to advance in terms of diagnostic, therapeutic, and technological sophistication. This has led to increased survival for neonates and children who were born prematurely or with complex diseases, such as genetic diseases like cystic fibrosis and muscular dystrophy.[10] In many cases, however, geographic regions and hospitals are lacking in pediatric subspecialists who can manage these patients. It is not uncommon to wait 3-6 months to see a pediatric subspecialist, and for children and their

families to travel out of state for this care. The long amount of time required for training and relatively low pay for pediatric subspecialists has led to a shortage of physicians that has been described as a crisis.[11]

Although modern practice faces a new range of challenges, pediatric care has always been inherently difficult. Children are unable to communicate to healthcare practitioners in the same manner as adults, making it more difficult to attain an accurate clinical history or to elicit and identify specific exam findings. It is impossible to ask an infant if they have a headache or stomachache, for example, and as a result pediatricians must often rely on suspicion, intuition, and experience to guide clinical decision making. Communication difficulties also make children fundamentally dependent on parents or a caregiver to relay their story, and are therefore perhaps particularly vulnerable to a caregiver's language barriers in healthcare settings.[5]

Complicating things further for pediatricians, children often present with signs and symptoms of an illness that are considered "atypical" compared to the common adult clinical manifestations.[5,12] Atypical signs and symptoms add to diagnostic challenges associated with pediatric healthcare and may also promote "defensive" healthcare practices. For example, due to anatomical differences in young children compared to adults (increased space between the brain and the skull), the hallmark signs of meningitis such as neck stiffness are often not present in children with the disease.[5,12] Not surprisingly, meningitis is one of the most common pediatric conditions to result in malpractice lawsuits.[12] At the same time, because of the long-term ramification of delays in diagnosis and treatment, it leads to some of the most expensive of all indemnity payments.[5,12] Appendicitis is another difficult diagnosis, with a large clinical overlap with other common

pediatric illnesses, such as viral illness and constipation.[12] It is estimated that 44% of children present with 6 or more atypical features,[13] and there also appears to be an inverse correlation between age and the likelihood of bowel perforation.[14,15]

1.2) Adverse Outcomes in Pediatrics

Slonim et al.[16] estimated national rates of hospital medical errors for inpatient pediatric cases using data from the Healthcare Cost and Utilization Project for 1988-1997. Over the various years of study, rates ranged from 1.81 to 2.96 per 100 discharges (1.81-2.96%). They also found that children requiring more specialized care such as dependence on medical technology had significantly higher rates of hospital errors. Urban hospitals reported higher error rates than small, for-profit hospitals. There was no difference in error rates based on gender, race, or household income, although there was a significant increase in the rate of errors for high-income households over the study period.

Using the same dataset from 1997 only, Miller et al.[17] found that children had similar inpatient adverse event rates to adults, with the most common pediatric injury being birth trauma. Birth trauma was associated with black and Hispanic ethnicity. Adverse events were associated with increased length of stay in the hospital and increased mortality. In a similar study, Meurer et al.[18] found a 3.4% rate of medical injury in discharge records from 318,000 hospitalized children in Wisconsin from 2000-2002. When stratified by the type of error, the rates were 1.5% for medications, 1.3% for procedures, and 0.9% for devices. In another study, Woods et al.[19] conducted a retrospective analysis of a sample of hospital discharge records from Utah and Colorado for

1992, finding that adverse events (injuries caused by medical management rather than the disease process) occurred in 1% of hospitalizations and that about 60% of these were preventable. Birth related and diagnostic errors were the most common causes of preventable adverse outcomes. The authors concluded that approximately 70,000 hospitalized children experience adverse events each year in the United States.

More recent research on adverse events seems to be increasingly tailored to address specific issues, such as preventing errors involving specific medications, protocols, and procedures. Although generalized adverse event studies are critical from an epidemiological perspective and for improving systems-level hospital safety, they are perhaps less informative for guiding the clinical practice of medical practitioners. One important reason for this is that discharge records miss the long-term outcomes associated with healthcare, and physicians are likely to already be aware of events when they occur immediately during an admission in the inpatient setting. Long-term adverse events associated with missed diagnoses, on the other hand, are not likely to be captured by discharge records. From a longitudinal perspective, malpractice claims data is in some respects more patient-centered in terms of guiding clinical practice, albeit this type of data has its own flaws in terms of serving as a representation of overall healthcare quality and safety. Malpractice claims data also has the advantage of quantifying the effect of damages from various medical errors on a patient-level.

1.3) Pediatric Malpractice Studies

Kain[20] used the National Practitioner Data Bank (NPDB) to compare malpractice claims (2004-2005) involving children at or under the age of 19 to those involving adult patients. This study did not look at pediatricians specifically and also included dentists and nurses. Median payments for children were significantly higher than for adults ($422,000 vs. $247,000), and pediatric payments varied significantly based on the severity of injury. Injuries involving quadriplegia, brain damage, or lifelong care had the highest median indemnity payment ($795,000), which was particularly common in children less than 1 year of age (25% of claims vs. 2.5% of adults aged 20-59). Diagnosis-related (27.9%) and obstetrics-related errors (27.6%) were the most common causes of pediatric injury.

Caroll and Buddenbaum[1] retrospectively analyzed 20 years of data between 1985 and 2005 from the PIAA database, a group of insurers representing about 25% of U.S. malpractice claims. The authors calculated that 2.97% of the claims involved pediatricians, making pediatrics the 10th most common out of 28 specialties in terms of claim frequency, and 16th in terms of indemnity payment (the frequency of claims which lead to an indemnity payment to the plaintiff). In terms of the size of indemnity payments, pediatrics ranked 7th, with a median payment $270,000 in 2005. The authors noted that payments were increasing over time, from a median of $65,287 in 1985 (adjusted to 2005). Errors in diagnosis were the most common causes of injury and represented 21.9% of claims.

Jena et al.[3] analyzed malpractice claims from a nationwide insurer made between 1991 and 2005 (n = 1630 pediatricians; 40,916 total physicians). The authors calculated an annual risk of facing a claim of 3.1% for pediatricians and 7.4% for other physicians. The rates of indemnity payment were 0.5% and 1.6%, respectively. Annual rates for payments greater than $1 million were not significantly different between pediatricians

and other physicians (0.13% vs. 0.11%, respectively; p=0.57). The mean payment was $562,180. Concordant with Kain's findings[20], claims involving permanent injury were the most expensive of all payments (Mean = $703,373). By comparison, the mean payment for claims involving patient deaths was $559,102. In a similar study using the same dataset, Jena et al.[2] compared 25 medical specialties and ranked pediatrics 24th in terms of the odds of physicians facing a malpractice claim annually.

McAbee et al.[12] analyzed data from the PIAA from the years 1985-2006. Although this study does not make a comparison to adult malpractice claims, it stands out in that it aims to identify the most common types of medical errors and illnesses that lead to diagnostic mistakes in pediatric care, as diagnostic errors are the most common error type leading to malpractice claims in pediatrics (and adult medicine[21,22]). The ten most prevalent conditions leading to malpractice lawsuits were, in order of decreasing frequency: brain-damaged infants, meningitis, routine health checks, respiratory problems in newborns, appendicitis, pneumonia, congenital anomalies, premature birth, birth, and asthma. The study also reports average indemnity payments for these claims. Of note, brain-damage and meningitis were not only the most prevalent conditions leading to lawsuits but were also the most expensive types of indemnity payments. Some of the most common specific conditions associated with errors in diagnosis were meningitis, appendicitis, congenital anomalies, pneumonia, and brain damage. Detailed information is provided on meningitis, such as the top misdiagnoses (ex, viral infection) and the frequency of presenting symptoms such as fever (74%), nausea/vomiting (49%), and lethargy (32%).

Greve's[5] article is an informative summary of the current state of pediatric demographics, malpractice, and risk-management in the U.S. The article discusses in detail

four important "low frequency/high severity" pediatric conditions, although it does not state the methodology used to select them. These conditions are: meningitis, volvulus/malrotation of the gut, retinopathy of prematurity (ROP), and kernicterus. The first two conditions are noted to be associated with diagnostic errors, while the second two usually involve system or communication problems, such as lack of follow-up.

1.4) Goals of this Study

The relationship between patient age and medical malpractice has the potential to elucidate risks for adverse medical outcomes in the pediatric population. This study uses malpractice reports from a comprehensive nationwide database to compare pediatric and adult malpractice events on the following levels:

(1) Clinical errors: What types of clinical mistakes most often lead to patient injury among reported malpractice events? To what extent do diagnostic, surgical, medication-related, and other types of clinical errors contribute to medical malpractice, and is there a difference in the representation of these errors based on patient age?

(2) Injury severity: What are the most common injuries among reported malpractice claims? Are certain types of injuries like brain damage or fatality more common among pediatric claims than adult claims?

(3) Subgroup analysis: Injury severity based on clinical error type. Is there a difference between various clinical errors in terms of injury severity? For example, are diagnostic errors more likely than surgical errors to involve devastating permanent injuries?

To answer the above questions, this study provides outcomes on both a claims-level and population-level. Claims-level outcomes simply report the percentage of malpractice claims that fall into various categories of patient injury and clinical error. For example, previous research suggests that the vast majority of pediatric malpractice claims involve diagnostic errors. It is still unknown if diagnostic errors are more common among pediatric claims than adult claims, however. Comparing the distribution of pediatric and adult malpractice claims according to error and injury type has the potential to identify pediatric-specific risk factors in medical practice.

Population-level outcomes are an attempt to quantify the burden of malpractice events on various age groups in the U.S. population. Previous studies have instead focused primarily on liability risk from a practitioner-level perspective. The calculation in this study is a measure of malpractice incidence: the number of malpractice claims involving various pediatric and adult patients, divided by population of each age group. The goal of this outcome is to provide a measure of overall patient risk from an epidemiological perspective. Quantifying rates of malpractice events in various patient age groups, and comparing pediatric and adult rates of various clinical errors and injury types, has the potential to guide future pediatric-specific risk reduction strategies.

A hypothesis of the study is that pediatric patients are heterogeneous and there may be a great degree of variability based on age within pediatric claims. For example, infant patients have unique risk factors compared to child and teen patients. As such, this study examines infant claims (<1 year) separately from other pediatric ages. This study also differs from previous research in that we examine only non-obstetric malpractice claims. Obstetrics-related malpractice events may obscure pediatric research findings because

they often involve devastating clinical outcomes, and make up a large percentage of adverse events among infants.[1,5,12,20] As such, by removing these claims, we hope to provide a more valid estimation of non-obstetric pediatric risk factors: Are infant malpractice claims still more likely to involve devastating injuries than adults (and other pediatric age groups) outside of the realm of obstetrics?

METHODS

2.1) Data Source

The National Practitioner Data Bank (NPDB) is a federal database managed by the US Department of Health and Human Services (HHS).[23] The data bank collects and shares information about adverse actions against and events involving healthcare practitioners in the United States.[24] Formed in response to the Health Care Quality and Improvement Act of 1986 and implemented in 1990, the NPDB facilitates the detection of potentially incompetent or unethical physicians, especially those who move state to state in order to avoid the consequences of malpractice or disciplinary actions against them.[23]

Hospitals are required to query the database when hiring new practitioners, and certain healthcare entities and medical boards have the option of querying – otherwise the data bank is confidential. In 2012 the data bank was queried 4.3 million times.[25] In 2007 the option to enroll a practitioner in a continuous query was introduced, in order to allow ongoing monitoring of practitioners. The number of continuous query enrollees grows substantially each year. In 2008 there were ~200,000 enrollees and in 2012 there were ~1.2 million.[25]

The NPDB also releases certain information as a Public Use Data File for researchers that is available for free download. Variables that allow for the identification of individual practitioners have been removed from the Public Use Data File. The file contains fifty-two variables for each malpractice report, including the type of allegation, severity of injury, the dollar amount paid, the date of payment, as well as demographic information about the

patient and the practitioner. The data file contains two general categories of reports: adverse actions, a generic term for disciplinary actions involving licensure or DEA actions against a practitioner, and reports on malpractice payments. Malpractice reports initially comprised 80-90% of reports in the data bank. As laws were passed requiring more stringent reporting of adverse action reports over time, the number of adverse action reports grew dramatically (from <10,000 prior to 2000 to >100,000 in 2010).[25] As a result, malpractice reports dropped to 16.4% of reports made in 2012, and now constitute about 40% of the complete data bank.

A report is required by law to be submitted to the NPDB whenever an insurer makes a payment on behalf of a physician, dentist, nurse, or other healthcare practitioner in response to any malpractice claim that resulted in a settlement or judgment.[23] Reports for malpractice payments made on behalf of medical residents are also required by law. Of note, the NPDB does not collect data about malpractice claims involving non-monetary settlements, claims when the defendant medical practitioner prevails, or claims that have been paid directly by the defendant.[26] Further, a corporation such as a hospital that accepts liability and pays on behalf of an employed practitioner is not required to report the payment to the NPDB.[21]

By law, all payments must be reported to the NPDB within 30 calendar days of payment.[23,24] However, while the NPDB reports the dates payments have been made on behalf of medical practitioners, it does not report when the actual malpractice event occurred. The average time to reach a resolution for pediatric malpractice claims is about 2 years, and also appears to be increasing significantly over time.[30] Since more severe clinical outcomes are likely to involve longer litigation times[2], there could also be a bias

towards underrepresenting more severe injuries in the dataset. These concerns primarily affect the validity of longitudinal analyses. This study does not attempt to track changes over time, or make associations between real-world events (such as changes in malpractice policy) and the incidence of malpractice claims – such studies would need to consider the lag time between malpractice events and various types of reported claim payments, in addition to potential longitudinal variations of litigation time.

2.2) Sample and Variables

This study uses an aggregated sample of medical malpractice reports made between 2005 and 2014. The start date was constrained by the availability of certain variables that were not added to the NPDB until January 2004.[31] All reports that were not defined as malpractice reports were excluded. Reports of payments made on behalf of physicians and residents (i.e., M.D., D.O.) were included while reports about all other practitioners (e.g., CRNA's, nurses, dentists) were excluded. The resulting sample serves as an approximation of all malpractice claims in the United States that were paid on behalf of physicians from 2005-2014.

The primary independent variable is patient age. This study categorizes claims as pediatric (0-19 years) and adult (19-59 years). To provide a more precise estimation of patient-level risk factors, we stratified patient age into 3 categories: infant (<1 year), child (1-9 years), and teen (10-19 years). These age ranges were constrained by the "patient age" variable in the data bank, which only provides 10-year age ranges for patients older than 1 year.

Claims involving fetal patients (<0 years) were excluded as these injuries are only pertinent to the field of obstetrics. Preliminary analysis revealed that the majority of claims in the infant age group were obstetrics-related (54.5%, n = 3,411). All adult and pediatric obstetrics-related claims in the sample (n = 6,180) were excluded, in order to specifically address injuries and medical errors pertaining to pediatric care and enhance the validity of comparisons between pediatric age groups. Similarly, all claims involving adults aged 60 and above were excluded, in order to eliminate data that is specific to geriatric medical practice. Although the age of 65 is universally used as an arbitrary cut-off for "geriatric," the adult group was constrained by the NPDB's alternative 10-year groupings for the patient age variable (i.e., 49-59, 59-69).

Other independent variables are injury severity and the type of medical error that lead to patient injury. For example, an injury may be "fatal" and the error type classified as "diagnosis-related." To simplify results in terms of outcome severity, this variable was collapsed into "minor temporary," "major temporary," "minor permanent," and "major permanent" groups, in addition to "paralysis/brain damage" and "fatality." These groups were guided by preliminary analyses that revealed similar outcomes and payment amounts between some of the pre-collapsed outcome variables. The finalized groups are similar to those used by previous NPDB studies[20,31] and showed consistent outcomes and payment amounts across all patient age groups.

2.3) Outcomes and Statistics

All outcomes are stratified by injury and error type for each patient age group. The primary outcomes of this study are claim distribution, claim incidence, and median payment amount. The claim distribution is the percentage of claims within a patient age group that fall into categories of a defined variable, such as clinical outcome. The incidence of malpractice claims is calculated within each age group by adjusting the number of claims in that group with the group's U.S. population (claims in age group/ 100,000 persons in that age group). Historical population estimates from the U.S. Census Bureau are used for population adjustments. For claim incidence, odds ratios are calculated with 95% confidence intervals, to compare each patient age group to the adult reference group. This calculation uses the 10-year probability of a claim occurring in an age group, given the average population of that group over the 10-year period.

To make payment amounts comparable across all years of the study period, all payments were adjusted to 2014 U.S. dollars using the Department of Labor Consumer Price Index (CPI-U). Pearson's Chi-Square test is used to compare the distribution of claims (according to an independent variable) between the pediatric age groups and the adult reference group. Standard methods are used to calculate percentages and 95% confidence intervals. Medians are used for reporting payment size in a group, as opposed to averages, as the size of malpractice payments is not normally distributed. The Mann-Whitney U test (Wilcoxon rank-sum test) is used as a nonparametric statistical measure for the comparison of payment amounts. All tests are 2-sided with $P<0.05$ considered significant. The analysis uses the Public Use Data File (Npdb1410.por) and IBM SPSS Statistics 22.0 software.

RESULTS

The final sample consisted of 70,441 non-obstetric medical malpractice reports filed against physicians during the 10 years between 2005 and 2014 (Table 1). Of these, 60,737 claims involved adult patients between 19-59 years (86.2%), and the remainder involved pediatric patients: 4,071 (5.8%) teens (10-19 years), 2,791 (4.0%) children (1-9 years), and 2,842 (4.0%) infants (<1 year of age). Adjusted using population data, there was an average annual claim incidence of 6.88 (infant), 0.75 (child), 0.99 (teen), and 3.66 (adult) claims per 100,000 population. Compared to the adult group, this translated to odds ratios of 1.88 (1.81-1.95) for infants, 0.21 (0.20-0.21) for children, and 0.27 (0.26-0.28) for teens. Payments differed significantly based on patient age within the pediatric group (P<0.001). Median payments were $269,870 (infant), $205,500 (child), $175,000 (teen), and $204,143 (adult). Infant (P<0.001) and child payments (P=0.04) were significantly more expensive than adults (although the difference was small between child and adult payments), whereas teen payments were less expensive than adults (P<0.001).

Table 1: Summary of Results by Patient Age

	Age Group (Yrs)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
N (% of total)	2,842 (4.0%)	2,791 (4.0%)	4,071 (5.8%)	60,737 (86.2%)
Annual incidence per 100K	6.88	0.75	0.99	3.66
Pop-Adjusted Odds Ratio (95%CI)	1.88 (1.81-1.95)	0.21 (0.20-0.21)	0.27 (0.26-0.28)	1.0
Median Payment	$269,870	$205,500	$175,000	$204,143
P-Value (Mann-Whitney)	<0.001	0.04	<0.001	

"Annual incidence" is the number of claims in the age group/year/100K persons in that age group in the U.S. population. Odds ratios report the odds of a claim in each group's population compared to the adult reference group. P-Values are for the non-parametric comparison test of payment amounts between each age group and the adult group.

3.1) Most Common Clinical Errors

Out of all claims in the sample, the most common error type was diagnostic (35.8%), followed by surgical (29.3%), treatment-related (20.2%), and medication-related (5.2%) errors (Table 2). For each pediatric age group, error type differed significantly when compared to adults (Pearson X^2, $P<0.001$). Diagnosis-related errors were more common among pediatric claims than adult claims (42.8% infant, 47.2% child, 43.4% teen vs. 34.4% adult). The proportion of diagnosis-related claims in the child group was significantly higher than infants and teens. Surgery-related errors were least common among infant claims (10.2%) and increased as a proportion of all claims with increasing age (12.7% child, 19.6% teen, and 31.6% adult). Treatment-related errors showed an opposite trend, becoming significantly more common with decreasing age (32.4% infant, 25.8% child, 21.7% teen, and 19.3% adult). Medication-related errors were least common among infant claims compared to the other age groups (3.2% infant vs. 4.3% child, 6.1% teen, and 5.3% adult). The proportion of errors that were medication-related may not be significantly different between child, teen, and adult groups (see Table 2 for confidence intervals and distribution of other error types).

Table 2: Distribution (%) of Claims by Error Type Within Patient Age Groups

Error Type	Age Group (Years)				
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	All Ages
Diagnosis Related	42.8 (40.9-44.6)	47.2 (45.3-49)	43.4 (41.9-44.9)	34.4 (34-34.8)	35.8 (35.4-36.1)
Anesthesia Related	2.3 (1.7-2.8)	3 (2.4-3.7)	2.4 (1.9-2.9)	2.9 (2.8-3)	2.9 (2.7-3)
Surgery Related	10.2 (9.1-11.3)	12.7 (11.4-13.9)	19.6 (18.4-20.8)	31.6 (31.3-32)	29.3 (29-29.7)
Medication Related	3.2 (2.5-3.8)	4.3 (3.5-5.1)	6.1 (5.3-6.8)	5.3 (5.1-5.5)	5.2 (5-5.4)
IV & Blood Products Related	0.8 (0.5-1.1)	0.5 (0.2-0.7)	0.1 (0-0.2)	0.2 (0.2-0.2)	0.2 (0.2-0.3)
Treatment Related	32.4 (30.7-34.2)	25.8 (24.1-27.4)	21.7 (20.4-23)	19.3 (19-19.6)	20.2 (19.9-20.5)
Monitoring Related	5.6 (4.8-6.5)	2.9 (2.2-3.5)	2.8 (2.3-3.4)	2.9 (2.7-3)	3 (2.8-3.1)
Equipment/Product Related	0.4 (0.2-0.6)	0.8 (0.5-1.1)	0.4 (0.2-0.6)	0.7 (0.6-0.7)	0.6 (0.6-0.7)
Other Miscellaneous	2.3 (1.7-2.8)	2.7 (2.1-3.3)	2.4 (2-2.9)	2.3 (2.2-2.4)	2.3 (2.2-2.4)
Behavioral Health Related	0 (0-0.1)	0.2 (0-0.4)	1 (0.7-1.3)	0.5 (0.5-0.6)	0.5 (0.5-0.6)
Total	100%	100%	100%	100%	100%
n	2842	2791	4071	60737	70441
P-Value (χ^2, vs. Adult)	<0.001	<0.001	<0.001		

Top errors are in bold, representing >90% of all claims. P-Values show the Pearson's Chi-Square result for comparisons of error type distribution between each pediatric age group and the adult group.

Regardless of error type, the population-adjusted odds of a paid claim were lower for children and teens compared to adults: all child and teen claim types were about 1/4 to 1/3 as frequent as adult claims (Table 3A). Claims involving behavioral health were about 50% as likely in teens compared to adults (OR = 0.53, 95%CI = 0.38-0.73), which was the highest per-capita odds ratio for teens. Infant claims, as opposed to other pediatric claims, had odds ratios >1 for almost all error types. The only error types that were less likely in infants compared to adults were surgery-related (OR=0.61, 95%CI=0.54-0.68) and behavior health related (OR=0.13, 95%CI=0.02-0.92). In addition, medication errors were not significantly different in infants compared to adults (OR=1.12, 95%CI=0.91-1.39). IV and blood products-related claims had the highest odds ratio among infant error types (OR 8.24, 95%CI = 5.26-12.9).

Table 3A: Odds Ratios (with 95% CI); Incidence of a Claim Compared to Adults, by Error Type

Pop. Adjusted Odds Ratios	Age Group (Years)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Diagnosis Related	2.34 (2.20-2.47)	0.28 (0.27-0.30)	0.34 (0.32-0.36)	1.00
Anesthesia Related	1.48 (1.15-1.89)	0.22 (0.17-0.27)	0.22 (0.18-0.27)	1.00
Surgery Related	0.61 (0.54-0.68)	0.08 (0.07-0.09)	0.17 (0.16-0.18)	1.00
Medication Related	1.12 (0.91-1.39)	0.17 (0.14-0.20)	0.31 (0.27-0.35)	1.00
IV & Blood Products Related	8.24 (5.26-12.9)	0.52 (0.29-0.92)	0.14 (0.05-0.39)	1.00
Treatment Related	3.16 (2.96-3.38)	0.27 (0.25-0.30)	0.30 (0.28-0.32)	1.00
Monitoring Related	3.70 (3.15-4.36)	0.21 (0.16-0.26)	0.27 (0.22-0.32)	1.00
Equipment/Product Related	1.10 (0.61-2.01)	0.25 (0.16-0.38)	0.18 (0.11-0.29)	1.00
Other Miscellaneous	1.88 (1.47-2.41)	0.24 (0.19-0.30)	0.29 (0.23-0.35)	1.00
Behavioral Health Related	0.13 (0.02-0.92)	0.09 (0.04-0.19)	0.53 (0.38-0.73)	1.00
Total	1.88 (0.81-1.95)	0.21 (0.20-0.21)	0.27 (0.26-0.28)	1.00

Bolded errors are most common, representing >90% of claims in the sample. Odds ratios report the odds of a claim in each group's U.S. population compared to the adult reference group.

Table 3B: Population-Adjusted Claim Incidence by Age Group and Error Type.

Claims/100K Pop	Age Group (Years)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Diagnosis Related	2.94	0.35	0.43	1.26
Anesthesia Related	0.16	0.02	0.02	0.11
Surgery Related	0.70	0.10	0.19	1.16
Medication Related	0.22	0.03	0.06	0.19
IV & Blood Products Related	0.06	0.00	0.00	0.01
Treatment Related	2.23	0.19	0.21	0.71
Monitoring Related	0.39	0.02	0.03	0.10
Equipment/Product Related	0.03	0.01	0.00	0.02
Other Miscellaneous	0.16	0.02	0.02	0.08
Behavioral Health Related	0.00	0.00	0.01	0.02
Total	6.88	0.75	0.99	3.66

Top errors are in bold, representing >90% of all claims. Values show the number of reported claims in each group/year/100K persons in that age group in the U.S. population.

Payment amounts varied based on error type and patient age (Table 4). In the full sample, the median payment for diagnosis-related errors ($257,849) was higher than surgery-related ($175,564), medication-related ($151,521), and treatment-related ($177,839) errors. The median payments for almost all types of errors in the infant group were significantly higher than in the adult group, whereas the reverse was true for teen claims which were less expensive than adults. For example, the median payment for diagnostic errors was $302,376 for infants, $199,849 for teens, and $265,988 for adults. As an exception, payments for surgery-related and medication-related errors were not significantly different between infants and adults. The only error type that was significantly higher for teens compared to adults was anesthesia-related errors ($401,408 vs. $252,621).

Table 4: Median Payment (P-Value) for Pediatric vs. Adult Claims, by Error Type.

Error Type	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Diagnosis Related	$302,376 (<0.001)	$236,372 (0.009)	$199,849 (<0.001)	$265,988	$257,849
Anesthesia Related	$415,716 (0.006)	$336,889 (0.008)	$401,408 (0.009)	$252,621	$264,214
Surgery Related	$163,749 (0.410)	$167,931 (0.818)	$165,590 (0.026)	$177,010	$175,764
Medication Related	$196,582 (0.439)	$145,000 (0.521)	$148,439 (0.901)	$151,521	$151,521
IV & Blood Products Related	$195,000 (0.963)	$146,786 (0.457)	$290,436 (0.410)	$157,867	$166,700
Treatment Related	$268,834 (<0.001)	$175,764 (0.351)	$135,708 (0.029)	$175,764	$177,839
Monitoring Related	$352,522 (<0.001)	$274,589 (0.001)	$214,795 (0.692)	$198,163	$214,412
Equipment/Product Related	$179,135 (0.013)	$31,952 (0.360)	$61,770 (0.710)	$52,322	$52,229
Other Miscellaneous	$195,000 (0.001)	$182,073 (0.002)	$90,713 (0.544)	$78,711	$85,175
Behavioral Health Related	$25,695 (0.340)	$197,453 (0.449)	$125,000 (0.850)	$116,866	$116,866
Total	$269,870 (<0.001)	$205,500 (0.039)	$175,000 (<0.001)	$204,143	$205,227

Parentheses have p-values for Mann Whitney U-test (comparison of payment amounts to adult group). Colored values are significantly different in size than adult payments (P<0.05). Red = more expensive; Green = less expensive; Black = No sig. difference.

3.2) Injury Severity

Fatal injuries were the most common of all injuries in the sample, constituting 29.4% of all claims. Major permanent injuries were the next most common (26.9%), followed by minor temporary (14.3%), minor permanent (13.5%), major temporary (11.5%), and paralysis or brain damage (4.3%). This distribution was similar for adult claims (see Table 5), although the proportion of paralysis/brain damage claims in the adult group was slightly smaller than average (3.2%). Injury distribution was significantly different for each pediatric group compared to adults (P<0.001). Paralysis/brain damage was increasingly common with decreasing age, comprising 4.5%, 9.4%, and 21.5% of teen, child, and infant claims, respectively. Major permanent injuries were also more common among infant claims (33.9%) compared to adult claims (26.7%). Fatalities were slightly less common among teen claims (27.2%) compared to adult claims (29.6%).

Table 5: Distribution (%) of Clinical Injuries by Patient Age.[1]

Injury Severity	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Minor Temporary	5.3 (4.5-6.1)	12 (10.8-13.2)	16.2 (15.1-17.4)	14.7 (14.5-15.0)	14.3 (14.1-14.6)
Major Temporary	4.3 (3.5-5.0)	7.5 (6.5-8.5)	10.7 (9.8-11.7)	12.1 (11.8-12.3)	11.5 (11.3-11.7)
Minor Permanent	7.1 (6.1-8.0)	12.5 (11.3-13.7)	15.5 (14.4-16.6)	13.7 (13.5-14.0)	13.5 (13.3-13.8)
Major Permanent	33.9 (32.1-35.6)	27.2 (25.5-28.8)	25.8 (24.4-27.1)	26.7 (26.3-27.0)	26.9 (26.6-27.3)
Paralysis/Brain Dam.	21.5 (20.0-23.0)	9.4 (8.3-10.5)	4.5 (3.9-5.1)	3.2 (3.1-3.4)	4.3 (4.1-4.4)
Fatal	27.9 (26.3-29.6)	31.4 (29.7-33.1)	27.2 (25.9-28.6)	29.6 (29.2-29.9)	29.4 (29.1-29.8)
Total	100%	100%	100%	100%	100%
n (% of total)	2842 (4.0%)	2791 (4.0%)	4071 (5.8%)	60737 (86.2%)	70441 (100%)
P-Value (χ^2 vs. Adult)	<0.001	<0.001	<0.001		

[1] Percentage of claims and 95%CI's within each age group. Colored values are significantly different than adult group (95%CI does not overlap). Red = More likely; Green = Less likely. X^2 compares overall distribution of injuries to adult group.

For all levels of injury severity, the population-adjusted odds of child and teen claims were less than the odds of adult claims (OR<1). With infant claims, more severe outcomes had greater odds than adults, whereas less severe outcomes had lower odds (Table 6A). The odds of an infant fatality was 1.78-times greater than in the adult group. The odds of paralysis or brain damage in infants was 12.5-times greater than adults, making this the leading outcome in terms of infant-specific risk compared to adults.

Table 6A: Odds Ratios (with 95%CI), Population-Adjusted Incidence of a Paid Claim Compared to Adults, by Pediatric Age and Injury Severity.

Pop. Adjusted Odds Ratio	Age Group (Years)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Minor Temporary	0.68 (0.58-0.80)	0.17 (0.15-0.19)	0.30 (0.27-0.32)	1.00
Major Temporary	0.66 (0.55-0.79)	0.13 (0.11-0.15)	0.24 (0.22-0.26)	1.00
Minor Permanent	0.97 (0.84-1.11)	0.19 (0.17-0.21)	0.30 (0.28-0.33)	1.00
Major Permanent	2.39 (2.24-2.55)	0.21 (0.19-0.22)	0.26 (0.24-0.28)	1.00
Paralysis/Brain Dam.	12.5 (11.4-13.7)	0.60 (0.52-0.68)	0.37 (0.32-0.44)	1.00
Fatal	1.78 (1.65-1.91)	0.22 (0.20-0.23)	0.25 (0.23-0.26)	1.00
Total	1.88 (1.81-1.95)	0.21 (0.20-0.21)	0.27 (0.26-0.28)	1.00

Odds ratios report the odds of a claim in each group's U.S. population compared to the adult reference group. Parentheses contain 95% confidence intervals.

Table 6B: Population-Adjusted Claim Incidence by Age Group and Injury Severity.

Claims/100K Pop.	Age Group (Years)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Minor Temporary	0.37	0.09	0.16	0.54
Major Temporary	0.29	0.06	0.11	0.44
Minor Permanent	0.49	0.09	0.15	0.50
Major Permanent	2.33	0.20	0.25	0.98
Paralysis/Brain Dam.	1.48	0.07	0.04	0.12
Fatal	1.92	0.24	0.27	1.08
Total	6.88	0.75	0.99	3.66

Values show the number of reported claims in each group/year/100K persons in that age group in the U.S. population.

The median payment for paralysis/brain damage claims was the highest of all injury types in the sample ($565,289). The next most expensive injury types were major permanent injuries ($325,525) and fatalities ($265,988). Payment amounts varied according to patient age (Table 7). Pediatric minor and major temporary injuries and minor permanent injuries were either less expensive or not significantly different than adult claims. On the other hand, major permanent and paralysis/brain damage claims were more expensive than the respective adult claims. Of note, all three pediatric age groups had significantly less expensive payments than adults when the injury was fatal.

Table 7: Median Payment (P-Value) for Pediatric vs. Adult Claims, by Injury Severity.

Injury Severity	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Minor Temporary	$27,500 (0.002)	$30,238 (<0.001)	$37,500 (0.414)	$40,712	$39,467
Major Temporary	$118,186 (0.177)	$116,535 (0.315)	$106,827 (0.004)	$131,330	$127,028
Minor Permanent	$113,995 (0.080)	$118,186 (0.013)	$107,589 (<0.001)	$131,556	$127,277
Major Permanent	$374,555 (0.002)	$336,560 (0.247)	$304,177 (0.231)	$325,525	$330,272
Paralysis/Brain Dam.	$687,244 (0.001)	$692,834 (0.006)	$624,258 (0.016)	$565,289	$581,271
Fatal	$194,702 (<0.001)	$228,986 (<0.001)	$236,372 (<0.001)	$265,988	$257,849
Total	$269,870 (<0.001)	$205,500 (0.039)	$175,000 (<0.001)	$204,143	$205,227

Parentheses have p-values for Mann Whitney U-test (comparison of payment amounts to adult group). Colored values are significantly different in size than adult payments (P<0.05). Red = more expensive; Green = less expensive; Black = No sig. difference.

3.3) Subgroup Analysis: Injury Severity by Clinical Error Type

Diagnostic errors were the most common error type in the sample (35.8%), comprising 42.8% of infant, 47.2% of child, 43.3% of teen, and 34.4% of adult claims.

Pediatric claims constituted 13.8% of the total sample, whereas 17% of diagnostic claims involved pediatric patients. The distribution of injury severity for diagnostic errors was very similar to the overall sample (Table 8). For example, 21.1% of infant diagnostic claims had paralysis/brain damage, compared to 21.5% of all infant claims. Adult diagnostic claims show more variation of injury type from the overall sample. Diagnostic errors in adults are more likely to lead to a fatality (38.9%) than the average adult claim (29.6%). As a result, among diagnostic errors, fatalities are less common in all three pediatric groups compared to adults.

Table 8: Distribution (%) of Clinical Injuries by Patient Age.[1] Diagnostic Errors Only.

Diagnostic Errors	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Minor Temporary	2.5 (1.6-3.3)	8.4 (6.9-9.8)	10.7 (9.3-12.1)	7 (6.6-7.3)	7.1 (6.8-7.4)
Major Temporary	4 (2.9-5.1)	8.3 (6.8-9.8)	9.6 (8.2-10.9)	7.6 (7.2-7.9)	7.6 (7.3-7.9)
Minor Permanent	5.3 (4-6.5)	11.7 (10-13.4)	15.7 (14-17.4)	10.1 (9.7-10.5)	10.3 (10-10.7)
Major Permanent	37.1 (34.4-39.8)	34.5 (31.9-37)	31.6 (29.4-33.7)	32.2 (31.5-32.8)	32.5 (31.9-33.1)
Paralysis/Brain Dam.	21.1 (18.8-23.4)	8.6 (7.1-10.1)	4.5 (3.5-5.4)	4.3 (4.1-4.6)	5.4 (5.1-5.7)
Fatal	30 (27.5-32.6)	28.6 (26.2-31.1)	28 (25.9-30.1)	38.9 (38.2-39.5)	37.1 (36.5-37.7)
Total	100%	100%	100%	100%	100%
n (% of total)	1215 (4.8%)	1317 (5.2%)	1767 (7.0%)	20892 (83%)	25191 (100%)
P-Value (χ^2, vs. Adult)	<0.001	<0.001	<0.001		

[1]Percentage of claims and 95%CI's within each age group. Colored values are significantly different than adult group (95%CI does not overlap). Red = More likely; Green = Less likely. X^2 compares overall distribution of injuries to adult group.

On a population-adjusted basis, diagnostic errors in infants are 2.34-times (95%CI = 2.20-2.47) as likely than in adults, compared to 1.88-times (95%CI = 1.81-1.95) for all infant claims. Child (OR 0.28, 95%CI = 0.27-0.30) and teen (OR 0.34, 95%CI = 0.32-0.36) diagnostic errors were less likely than adult diagnostic errors, but had higher odds ratios for diagnostic claims compared to the overall rate for child (OR 0.21, 95%CI = 0.20-0.21) and teen claims (OR 0.27, 95%CI = 0.26-0.28). The odds of diagnostic claims compared to adults were stratified by injury type and follow similar trends to the population-adjusted odds ratios for the complete sample (Table 9).

Table 9: Odds Ratios (with 95%CI), Population-Adjusted Incidence of a Paid Claim Compared to Adults, by Pediatric Age and Injury Severity. Diagnostic Errors Only.

Diagnostic Errors	Age Group (Yrs)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Minor Temporary	0.83 (0.58-1.19)	0.34 (0.28-0.41)	0.52 (0.45-0.61)	1.0
Major Temporary	1.24 (0.94-1.65)	0.31 (0.25-0.37)	0.43 (0.37-0.50)	1.0
Minor Permanent	1.22 (0.95-1.56)	0.33 (0.28-0.38)	0.53 (0.46-0.60)	1.0
Major Permanent	2.70 (2.45-2.97)	0.30 (0.27-0.33)	0.33 (0.31-0.36)	1.0
Paralysis/Brain Dam.	11.3 (9.85-13.0)	0.56 (0.46-0.68)	0.35 (0.28-0.44)	1.0
Fatal	1.81 (1.63-2.00)	0.21 (0.19-0.23)	0.24 (0.22-0.27)	1.0
Total	2.34 (2.20-2.47)	0.28 (0.27-0.30)	0.34 (0.32-0.36)	1.0

Odds ratios report the odds of a claim in each group's U.S. population compared to the adult reference group. Parentheses contain 95% confidence intervals.

Surgical errors were the second most common error type overall, making up 29.3% of the total sample and 31.6% of adult claims. They are less common among pediatric claims, making up 19.6%, 12.7%, and 10.2% of teen, child, and infant claims, respectively. Only 7% of all surgical claims were pediatric, compared to 13.8% of all claims (and 17% of diagnostic claims). Compared to other error types, surgical claims were less likely to involve severe injuries such as paralysis/brain damage (1.4%) or fatalities (10.9%) (Table 10). This was also true among the pediatric surgical claims. However, pediatric surgical claims were still more likely to involve severe injuries than adult surgical claims (although fatalities were not significantly different).

Table 10: Distribution (%) of Clinical Injuries by Patient Age.[1] Surgical Errors Only.

Surgical Errors	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Minor Temporary	18.3 (13.8-22.7)	20.6 (16.4-24.8)	23.9 (20.9-26.9)	20.1 (19.5-20.7)	20.2 (19.7-20.8)
Major Temporary	11.7 (8-15.4)	12.1 (8.7-15.5)	18 (15.4-20.7)	20.5 (20-21.1)	20.2 (19.6-20.7)
Minor Permanent	21 (16.3-25.7)	20.1 (15.9-24.2)	25.2 (22.1-28.2)	20.7 (20.2-21.3)	20.9 (20.3-21.4)
Major Permanent	29 (23.7-34.2)	27.7 (23-32.3)	21.9 (19-24.8)	26.5 (25.8-27.1)	26.3 (25.7-26.9)
Paralysis/Brain Dam.	5.2 (2.6-7.7)	6.5 (3.9-9.1)	2.1 (1.1-3.1)	1.3 (1.1-1.4)	1.4 (1.3-1.6)
Fatal	14.8 (10.7-18.9)	13 (9.5-16.5)	8.9 (6.9-10.9)	10.9 (10.5-11.3)	10.9 (10.5-11.3)
Total	100%	100%	100%	100%	100%
n (% of total)	290 (1.4%)	354 (1.7%)	799 (3.9%)	19210 (93%)	20653 (100%)
P-Value (χ^2, vs. Adult)	<0.001	<0.001	<0.001		

[1] *Percentage of claims and 95%CI's within each age group. Colored values are significantly different than adult group (95%CI does not overlap). Red = More likely; Green = Less likely. X^2 compares overall distribution of injuries to adult group.*

On a population-adjusted level, surgical errors were less likely to occur in the child population than any other age group (Table 11). Regardless of error type, surgical errors were much less likely in the child (OR 0.08, 95%CI = 0.07-0.09) and teen populations (OR 0.17, 95%CI = 0.16-0.18) compared to adults. This was also true for infant claims overall (OR 0.61, 95%CI = 0.54-0.68), although paralysis/brain damage (OR 2.49, 95%CI 1.48-4.19) was more likely than in adults. Infant fatalities were also not significantly different than the adult group in terms of population-adjusted incidence. Although all child surgical injuries were less common than with adults, compared to adults paralysis/brain damage had much higher odds than other injury types. The difference was much smaller in teens.

Table 11: Odds Ratios (with 95%CI), Population-Adjusted Incidence of a Paid Claim Compared to Adults, by Pediatric Age and Injury Severity. Surgical Errors Only.

Surgical Errors	Age Group (Yrs)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Minor Temporary	0.55 (0.42-0.72)	0.08 (0.07-0.11)	0.20 (0.17-0.23)	1.0
Major Temporary	0.35 (0.25-0.48)	0.05 (0.04-0.07)	0.15 (0.12-0.17)	1.0
Minor Permanent	0.62 (0.48-0.79)	0.08 (0.06-0.10)	0.20 (0.18-0.23)	1.0
Major Permanent	0.66 (0.53-0.82)	0.09 (0.07-0.11)	0.14 (0.12-0.16)	1.0
Paralysis/Brain Dam.	2.49 (1.48-4.19)	0.42 (0.28-0.65)	0.28 (0.17-0.46)	1.0
Fatal	0.82 (0.61-1.12)	0.10 (0.07-0.13)	0.14 (0.11-0.17)	1.0
Total	0.61 (0.54-0.68)	0.08 (0.07-0.09)	0.17 (0.16-0.18)	1.0

Odds ratios report the odds of a claim in each group's U.S. population compared to the adult reference group. Parentheses contain 95% confidence intervals.

Treatment errors were the third most common error type overall, making up 20.2% of the total sample. Like diagnostic claims, they are more common among pediatric claims, making up 21.7%, 25.8%, and 32.4% of teen, child, and infant claims, respectively. Whereas diagnostic errors were very common among all pediatric claims (and highest in the child group), treatment-related claims were increasingly common at younger ages. Therefore, they show an opposite trend with age than surgical errors. Just 13.8% of all claims in the sample were pediatric compared to 17.7% of treatment-related claims.

Treatment-related errors were also increasingly more likely to involve paralysis/brain damage in younger ages (25.4% infants vs. 3.5% adults; Table 12). Major permanent injuries were also more common in the infant age group (32.5%) compared to adults (23%), and were the most common treatment-related injury in the infant group. The most common injury for children (42.1%), teens (35.6%), and adults (37.6%) was fatality, with no significant difference between groups. Infant claims were less likely to involve fatalities than adults (30% of infant claims).

Table 12: Distribution (%) of Clinical Injuries by Patient Age.[1] Treatment-Related Errors Only.

Treatment Errors	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Minor Temporary	3.8 (2.6-5)	11.7 (9.6-13.8)	18.7 (16.2-21.2)	15.2 (12.9-17.5)	14.5 (12.2-16.8)
Major Temporary	2.1 (1.1-3)	4.3 (3-5.6)	8.4 (6.6-10.2)	8.4 (6.6-10.2)	7.8 (6-9.5)
Minor Permanent	6.2 (4.6-7.7)	12.1 (10-14.2)	11.7 (9.6-13.7)	12.3 (10.2-14.4)	11.9 (9.8-14)
Major Permanent	32.5 (29.5-35.6)	20.6 (18-23.2)	20.2 (17.6-22.7)	23 (20.3-25.7)	23.3 (20.6-26.1)
Paralysis/Brain Dam.	25.4 (22.6-28.2)	9.2 (7.3-11)	5.5 (4.1-7)	3.5 (2.3-4.6)	5.3 (3.9-6.8)
Fatal	30 (27.1-33)	42.1 (39-45.3)	35.6 (32.5-38.7)	37.6 (34.5-40.7)	37.2 (34.1-40.3)
Total	100%	100%	100%	100%	100%
n (% of total)	922 (6.5%)	719 (5.1%)	883 (6.2%)	11712 (82.3%)	14236 (100%)
P-Value (χ^2, vs. Adult)	<0.001	<0.001	0.001		

[1] Percentage of claims and 95%CI's within each age group. Colored values are significantly different than adult group (95%CI does not overlap). Red = More likely; Green = Less likely. X^2 compares overall distribution of injuries to adult group.

Among the four most common error types, treatment-related errors had the highest population-adjusted odds for infant paralysis/brain damage when compared to adults (OR 23.1, 95%CI = 19.7-27.3; Table 13).

Table 13: Odds Ratios (with 95%CI), Population-Adjusted Incidence of a Paid Claim Compared to Adults, by Pediatric Age and Injury Severity. Treatment Errors Only.

Treatment Errors	Age Group (Yrs)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Minor Temporary	0.79 (0.56-1.10)	0.21 (0.17-0.26)	0.37 (0.32-0.44)	1.0
Major Temporary	0.78 (0.49-1.22)	0.14 (0.10-0.20)	0.30 (0.24-0.38)	1.0
Minor Permanent	1.59 (1.22-2.07)	0.27 (0.22-0.33)	0.29 (0.23-0.35)	1.0
Major Permanent	4.47 (3.96-5.03)	0.25 (0.21-0.29)	0.27 (0.23-0.31)	1.0
Paralysis/Brain Dam.	23.14 (19.70-27.18)	0.73 (0.56-0.94)	0.48 (0.36-0.65)	1.0
Fatal	2.53 (2.24-2.85)	0.31 (0.27-0.35)	0.29 (0.26-0.32)	1.0
Total	3.16 (2.96-3.38)	0.27 (0.25-0.30)	0.30 (0.28-0.32)	1.0

Odds ratios report the odds of a claim in each group's U.S. population compared to the adult reference group. Parentheses contain 95% confidence intervals.

Medication errors were the fourth most common error type overall (5.2% of all claims). They were less common among infant claims (3.2%, 95%CI 2.5-3.8) than child (4.3%, 95%CI 3.5-4.1), teen (6.1%, 95%CI 5.3-6.8), and adult claims (5.3%, 95%CI 5.1-5.5). Only 2.5% of medication all errors involved infants, which comprise 4.0% of all patients in the sample. In terms of injury severity, there was no significant difference between adult medication errors and child and teen medication errors (P = 0.34 and 0.43, respectively). Infant claims had more major permanent and paralysis/brain damage injuries than adult claims, and a lower percentage of claims involving fatalities.

Table 14: Distribution (%) of Clinical Injuries by Patient Age.[1] Medication-Related Errors Only.

Medication Errors	Age Group (Years)				All Ages
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)	
Minor Temporary	14.4 (7.2-21.7)	22.5 (15-30)	21.1 (16-26.1)	19.3 (17.9-20.6)	19.4 (18.1-20.7)
Major Temporary	10 (3.8-16.2)	10 (4.6-15.4)	9.3 (5.7-12.9)	10.9 (9.8-12)	10.7 (9.7-11.7)
Minor Permanent	6.7 (1.5-11.8)	7.5 (2.8-12.2)	8.1 (4.7-11.5)	7.7 (6.8-8.6)	7.7 (6.8-8.5)
Major Permanent	25.6 (16.5-34.6)	14.2 (7.9-20.4)	22.3 (17.1-27.5)	17.9 (16.5-19.2)	18.2 (17-19.5)
Paralysis/Brain Dam.	16.7 (9-24.4)	5.8 (1.6-10)	2.8 (0.8-4.9)	2.7 (2.1-3.3)	3.2 (2.6-3.7)
Fatal	26.7 (17.5-35.8)	40 (31.2-48.8)	36.4 (30.4-42.4)	41.6 (39.9-43.3)	40.8 (39.2-42.4)
Total	100%	100%	100%	100%	100%
n (% of total)	90 (2.5%)	120 (3.3%)	247 (6.7%)	3213 (87.5%)	3670 (100%)
P-Value (χ^2, vs. Adult)	<0.001	0.338	0.429		

[1] *Percentage of claims and 95%CI's within each age group. Colored values are significantly different than adult group (95%CI does not overlap). Red = More likely; Green = Less likely. X^2 compares overall distribution of injuries to adult group.*

On a population-level, child and teen medication errors were much less likely than adult medication errors (Table 15). Among infant claims, most injuries caused by medication errors were not significantly more or less-likely to occur than with adults. Major permanent injuries were slightly more likely in infants than adults (OR 1.61, 95%CI = 1.06-2.44), and paralysis/brain damage was about 7-times more likely (OR 6.92, 95%CI = 4.0-12.0). Medication errors were more likely than surgical errors to cause paralysis/brain damage in infants compared to adults (OR 2.49, 95%CI = 1.48-4.19), but much less likely

than diagnostic (OR 11.3, 95%CI = 9.85-13.0) and treatment-related errors (OR 23.1, 95%CI = 19.7-27.2).

Table 15: Odds Ratios (with 95%CI), Population-Adjusted Incidence of a Paid Claim Compared to Adults, by Pediatric Age and Injury Severity. Medication Errors Only.

Medication Errors	Age Group (Yrs)			
	Infant (<1)	Child (1-9)	Teen (10-19)	Adult (20-59)
Minor Temporary	0.84 (0.49-1.46)	0.19 (0.13-0.29)	0.34 (0.25-0.45)	1.0
Major Temporary	1.03 (0.53-2.00)	0.15 (0.09-0.27)	0.26 (0.17-0.40)	1.0
Minor Permanent	0.98 (0.43-2.19)	0.16 (0.08-0.32)	0.33 (0.21-0.51)	1.0
Major Permanent	1.61 (1.06-2.44)	0.13 (0.08-0.21)	0.38 (0.29-0.51)	1.0
Paralysis/Brain Dam.	6.92 (4.00-11.97)	0.36 (0.17-0.78)	0.32 (0.15-0.70)	1.0
Fatal	0.72 (0.48-1.08)	0.16 (0.12-0.21)	0.27 (0.22-0.34)	1.0
Total	1.12 (0.91-1.39)	0.17 (0.14-0.20)	0.31 (0.27-0.35)	1.0

Odds ratios report the odds of a claim in each group's U.S. population compared to the adult reference group. Parentheses contain 95% confidence intervals.

DISCUSSION

4.1) Limitations

The NPDB is the largest, most nationally representitive database for physician malpractice in the U.S, and the Public Use Data File is easily accessable to researchers.[23] Because of its size, the NPDB has more statistical power than databases like the Closed Claims Project and other insurer databases. On the other hand, the NPDB was simply not designed to function as a research tool for improving medical care from a physician perspective. When evaluating the results of this study, it is critical to acknowledge several important limitations:

a) Specialty-specific conclusions are limited:

The NPDB does not list a physician's actual medical specialty such as "surgeon" or "anesthesiologist," but instead lists the type of medical error that occurred, such as "surgery-related" or "anesthesia-related." In the case of pediatrics, this does not create as large of a problem for drawing conclusions on a patient-level, because patient age is available as a variable. However, the NPDB cannot be used to compare pediatric errors made by family practitioners, obstetricians, emergency room physicians, and pediatricians. This study is not specific to pediatrics as a specialty.

b) Malpractice claims do not represent all adverse medical outcomes:

Woods et al.[19] estimated that 70,000 children experience preventable adverse outcomes in hospitals each year in the U.S. By comparison, there were less than 10,000 paid malpractice reports in the NPDB involving children in the 10-year sample used in this study, about 70-times lower than Woods' observation. Clearly, medical malpractice claims only represent a small minority of adverse medical events. The first explanation of this discrepancy is that this study only used malpractice reports involving physicians, so adverse events attributable to other types of medical practitioners are not represented. Another explanation is the required litigation process that leads to malpractice claims and payments: After an injury occurs, the victim must chose to make a malpractice claim, hire legal representation, and follow through on what is often a lengthy and expensive legal process. The average cost to defend a case prior to reaching a judicial verdict is about $27,000.[28] The average time to reach a resolution for pediatric malpractice claims is about 2 years,[30] and the majority of malpractice claims (approximately 80%[3]) do not lead to indemnity payments. To make a successful malpractice case it is necessary to prove that the medical practitioner not only made an error but that the error was negligent, and that negligence was the direct cause of the medical injury. Therefore, another reason for under-representation of preventable medical injuries in medical malpractice data is that not all adverse events are solely due to negligence.

c) The NPDB does not represent all paid malpractice claims:

Only claims made against individual practitioners are reported to the NPDB. Injuries involving institutional or hospital errors are not reported – a problem referred to as the "corporate shield."[21,23] Chandra et al.[21] addressed this source of bias by comparing

the NPDB to the Jury Verdict Database complied by the RAND Institute for Civil Justice. The authors found that while the NPDB underreports malpractice incidence by approximately 20%, the "magnitude of underreporting is remarkably consistent." Therefore, the NPDB can serve as a reliable tool for longitudinal trends and cross-sectional comparisons in most cases, although it should not be used as an absolute measurement of the incidence of malpractice in the U.S. In addition, since the NPDB does not require claims to be reported which are paid out-of-pocket by a practitioner, and there is an incentive to avoid NPDB reports, it is likely that the NPDB underreports lower-severity outcomes that lead to less expensive out-of-court settlements.[29]

d) This study does not quantify practitioner-level risk or adjust for medical utilization:

Medical utilization is a measure of quantifying the amount of care that practitioners provide and patients receive. It can be estimated using a variety of different methods: the number of patient encounters, time spent with patients, time spent in the hospital, and medical spending.[21] In theory, medical utilization is an ideal denominator when calculating medical risk. For example, our results show that infant claims are about 7-times more likely on a per-capita basis than teen claims. However, this does not necessarily mean than neonatologists (pediatricians who specialize only in infant care) are 7-times more likely to be implicated in medical malpractice lawsuits than other pediatricians: If infants receive 10-times more medical care than teens, neonatologists could theoretically have lower than average malpractice liability among pediatricians. Unfortunately for this study, comparisons of utilization between different medical specialties and types of practice are problematic. One type of practitioner might spend a month caring for a handful

of critically-ill patients in the hospital, while another might see 40 patients per day in an outpatient clinic. Adult patients may see 5 different doctors once annually, while infants may see one doctor 5 times per year. The range of potential variables involved with estimating medical utilization make it almost impossible to make practitioner-level liability estimates using nationwide data. Ultimately, the most precise estimates of risk from a practitioner perspective are generated using longitudinal samples with a known number of enrolled participants.

4.2) Most Common Clinical Errors

Four error types made up 90.5% of all errors in the dataset: Diagnostic (35.8%), surgical (29.3%), treatment-related (20.2%), and medication-related (5.2%) errors. On a population-level (adjusted per 100K), almost all error types were more common in infants compared to adults. The exceptions were surgical and behavioral-health-related claims. By contrast, for child and teen claims, all error types were less common than adults on a population level. Almost all infant errors had higher payment amounts compared to adults, but there was not a significant difference for medication-related and surgical errors. The reverse was true for teen claims (except for anesthesia-related errors, which were the only teen errors that were significantly more expensive than adult claims).

Previous research has highlighted the importance of medication-related errors as a major source of pediatric injuries.[32] We found that medication errors make up a lower percentage of infant claims than in other age groups, and there was no difference in payment size for these claims based on age (unlike most other error types). Moreover,

medication errors were equally likely on a per-capita basis between infants and adults, while almost all other error types were more common in the infant population. Medication injuries involve not only prescription mistakes but also errors with administering and dispensing medications[32], which are less likely to be solely attributable to a physician's negligence and therefore less likely to lead to reportable malpractice payments in this study's sample. This is one possible explanation for why we found medication-related errors are less likely among paid malpractice claims than other types of errors. However, since medication-related errors make up a lower percentage of pediatric claims than adult claims, it is possible that that for pediatricians, medication-related errors have lower relative liability risk than other types of errors. Since medication-related errors are common in pediatrics but do not represent a significant number of negligent errors that result in malpractice payments, the most effective target of policy measures for reducing medication errors is likely system and hospital-wide processes, rather than training and awareness measures for pediatricians.

Our results are consistent with previous research which has identified diagnostic errors as a major source of both pediatric and adult medical malpractice. Diagnostic error was the most common error type among all pediatric groups and the adult group. However, diagnostic errors make up a larger percentage of pediatric malpractice claims than adult claims. These claims are less likely to involve fatalities in the pediatric age groups compared to adults, but more likely to involve devastating injuries like paralysis and brain damage. Since devastating permanent injuries involving negligence are more common and more costly in pediatric patients compared to adults, these errors represent a major area of potential focus for training and awareness efforts involving physicians. As

discussed previously, meningitis is one specific diagnosis that has been identified by previous research to be relatively specific to pediatrics and a major contributor to catastrophic claims.[12]

Unlike diagnostic errors, treatment-related errors have not been heavily publicized as a major source of malpractice events involving pediatric patients. Our results show that for infants, errors involving delays in treatment or failure to treat are nearly as common among pediatric malpractice claims as diagnostic errors (32.4% and 42.8% of claims, respectively). Of note, among claims involving infant paralysis or brain damage, treatment-related errors represent a similar percentage of claims as diagnostic errors (38.2% and 41.8%, respectively). Additionally, in terms of population-adjusted risk in infants, treatment-related errors have the highest odds of paralysis or brain damage compared to adults of any error type. These injuries were 23-times more likely in infants compared to adults, whereas diagnostic errors were about 11-times more likely. Therefore, treatment-related errors are not only a leading contributor to devastating malpractice-related injuries in infants, they appear to be more specific to devastating pediatric injuries (compared to adults) than other types of malpractice errors.

Surgical errors stand out as being much less common among pediatric claims than adult claims, making up 10.2% and 29.3% of pediatric and adult claims in the sample, respectively. While pediatric surgical errors in the sample generally had worse outcomes than adult surgical errors (following a similar trends to all pediatric errors), it is interesting to note that among pediatric claims, surgical errors are much less likely to involve devastating outcomes than other error types. They were also less common than other pediatric error types on a per-capita basis and the only infant error type with population-

adjusted odds lower than adults. These results might be explained by the high degree of sub-specialization and training required of pediatric surgeons. By comparison, many of the diagnostic and treatment-related errors in the study could involve practitioners without pediatric-specific training, such as emergency room physicians, who may be more likely to see acute presentations of serious illnesses like meningitis. Future studies could compare diagnostic and treatment efficacy for high-risk pediatric conditions like meningitis across various practice settings and specialties, such as pediatricians versus emergency room and family practice doctors.

4.3) Injury Severity

Fatal injury was the most common of all injuries, making up 29.4% of all claims. There were less fatal injuries among teen claims than adult claims, but not a significant difference between infants, children, and adults. Overall, injury distribution was significantly different within each pediatric group compared to adults. For all levels of injury severity, the population-adjusted (per-capita) odds of child and teen claims were less than the odds of adult claims (OR<1). With infant claims, more severe outcomes had greater per-capita odds than adults, whereas less severe outcomes had lower odds. Median payment for paralysis or brain damage was the highest of all injury types in the sample ($565,289). This was the most expensive injury type in all age groups, but for all pediatric ages, paralysis/brain damage was significantly more expensive than adults. For most other injuries, including fatalities, pediatric payments were less expensive than adults.

While previous research has identified obstetric injuries as a major contributor to malpractice claims involving infants[1,5,12,20], our results confirm that non-obstetric injuries still represent a significant malpractice risk for physicians treating infant patients. Overall, claims involving infants are more likely to involve devastating outcomes like paralysis or brain damage than adult claims, while both pediatric and adult claims are about equally likely to involve fatalities. It is interesting to note that many of the trends observed for the infant age group are unique among pediatric claims. Pediatric patients are therefore a heterogeneous group in terms of malpractice risk and medical injury.

Major permanent injuries, paralysis, and brain damage involving infants represent the most expensive injuries of all claims in the sample. It is reasonable to assume that because of this, more attention and resources are invested in filing lawsuits after these injuries occur, which could result in over-representation of these types of claims in the sample used by this study. However, since adult claims of this type are also lucrative from a legal perspective, this selection bias most likely occurs to some extent across all age ranges. It is unlikely that such a bias alone could result the extreme extent to which these claims occur in the infant population when compared to the other age groups in the study.

Overall, the injury severity among malpractice claims is similar between teens and adults, and teens are the only pediatric subgroup to have a significantly lower percentage of claims involving fatalities than adults. This suggests that teens are a lower-risk patient population than other pediatric ages. The injury type with the strongest association with age appears to be paralysis/brain damage, which represents an increasing percentage of claims with decreasing age (4.5% of teen, 9.4% of child, and 21.5% of infant claims). Still,

this injury type is less common for child and teen groups on a per-capita basis than in the adult population.

Population-level (per capita) estimates of medical injury risk can be useful from an epidemiological perspective, as they determine the relative burden of malpractice events for certain patient populations. For example, while neonatologist liability is a product of utilization (i.e., how many patients they see) and inherent practice risks (i.e., risky medical procedures, underlying illness severity of individual patients), infants are nonetheless about 12.5-times as likely to experience paralysis or brain damage injuries than adults. It follows that interventions to minimize these types of injuries in infants should be emphasized, even if infants hypothetically receive more medical care than adults, and are therefore equally risk-prone from a practitioner-level perspective. In other words, even if infants were an at-risk population solely because of increased medical utilization, they are nevertheless an at-risk group. Since the most common malpractice-related injuries in this group are also the most expensive of all malpractice claims, interventions that reduced infant injuries as a whole would be extremely cost-effective.

Comparing relative rates of population-level risk is also informative, as it generally eliminates utilization-related issues. For example, paralysis and brain damage claims involving infants are 12.5-times more likely than in the adult population, but infant claims as a whole are only 1.9-times as likely. Moreover, minor injuries are less common in the infant population compared to adults. These within-group differences cannot be explained by utilization because the same denominator is used across each patient age group. With increases in utilization one would expect all injuries to be over-represented in the dataset. However, as discussed previously, such comparisons may be affected by sampling biases:

Infant claims involving devastating injuries may be more likely to generate malpractice lawsuits than the equivalent adult injuries. Keeping this in mind, it is unlikely that selection biases alone explain the extreme extent to which certain injuries are observed among pediatric claims compared to adult claims. This is especially true for the most severe injury types. One would assume that the majority of cases of paralysis, brain damage, or death caused by physician negligence would lead to malpractice claims whether they involve adult or pediatric patients.

4.4) Conclusion

The pediatric population is a heterogeneous patient population with unique age-specific risk factors. On a per-capita basis, infant malpractice claims are much more common than adult claims, whereas non-infant pediatric claims are less common. This study found significant differences in injury type and clinical errors among malpractice claims based on patient age. Four error types make up over 90% of all clinical errors among malpractice claims: Diagnostic, surgical, treatment, and medication-related errors. Diagnostic and treatment-related errors are more common among pediatric claims than in adults, whereas surgical and medication-related errors are less common. Several trends are extreme and robust throughout the entire sample, particularly the sheer number for claims involving infants with non-obstetric paralysis or brain damage injuries. Overall, devastating non-fatal injuries appear much more commonly among pediatric claims, and are more expensive for pediatric claims than adult claims. In addition, the per-capita risk of these injuries in the infant population is exponentially higher than in the adult population.

Future safety and training efforts should focus on reducing the potential for negligence that can lead to non-obstetric paralysis or brain damage injuries in the infant population, particularly in the realms of diagnosis and treatment.

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