Published in final edited form as:

J Pediatr. 2015 October ; 167(4): 897–904.e3. doi:10.1016/j.jpeds.2015.06.052.

Variation in computed tomography imaging for pediatric injury-related emergency visits

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Abstract

Objectives—To assess variation in the use of computed tomography (CT) for pediatric injury-related emergency department (ED) visits.

Study design—Retrospective cohort study of visits to 14 network-affiliated EDs from November 2010 through February 2013. Visits were identified by *International Classification of Diseases, 9th revision, Clinical Modification* diagnosis codes. Primary outcome was CT use. We used descriptive statistics and performed multivariable logistic regression to evaluate the association of patient and ED covariates on any and body region-specific CT use.

Results—Of the 80,868 injury-related visits, 11.4% included CT, and 28.4% of those had more than one study. Across EDs, CT use ranged from 7.6%–25.5% of visits and did not correlate with institutional injury severity score ($P=0.33$) or admission/transfer rates ($P=0.07$). In multivariable analysis of non-pediatric EDs, trauma centers and non-academic EDs were associated with CT use. Higher pediatric volume was associated with any CT use, however, there was an inverse relationship between volume and non-head CT use. When the pediatric ED was included in multivariable modeling, the effect of level 1-3 trauma center designation remained, and the pediatric level 1 trauma center was less likely to use most body region-specific CTs.

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The authors declare no conflicts of interest.

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Conclusions—There is wide variation in CT imaging for pediatric injury-related visits not solely attributable to case mix. Future work to optimize CT utilization should focus on additional factors contributing to imaging practices and interventions.

Keywords

emergency department; injury severity score; trauma

Injuries are the leading cause of morbidity and mortality among children in the United States.(1) Computed tomography (CT) is the most sensitive modality to evaluate for acute traumatic injuries.(2) In general, advanced imaging for injury-related diagnoses has increased over time without comparable increases in the severity of diagnoses or changes in management.(3,4) CT-associated radiation as a cause of future cancers, particularly in the radiosensitive pediatric population, has been a topic of high concern, specifically in light of recent epidemiologic data.(5-7) The increase in CT use has led to concerns from the public, policy makers, and patients regarding cost, resource utilization, radiation risk, and overall appropriateness of use.(8-10) The increase in use is not uniform across all diagnoses and institutions,(11-13) and identification of significant variation in CT use presents an opportunity for practice improvement and the potential for optimizing CT utilization. Our objective was to assess ED-level variation in CT utilization for pediatric injury-related visits.

Methods

We performed a retrospective observational study of visits to 14 EDs within a large, regional, integrated health network from November 2010 through February 2013. The health system represents the largest in the area and receives transfers from within and outside of the network. Transfers from within the health system to an ED outside of the network are rare. We included visits by patients less than 19 years of age with at least one final injury-related *International Classification of Diseases, 9th revision, Clinical Modification* (ICD9-CM) diagnosis(14) (of 25 possible diagnosis positions in the medical record) (Table I). In cases of transferred patients, we included imaging at the transferring institution, and excluded the visit to the receiving ED in order not to underestimate CT use at the receiving ED. We defined transfers as those visits to a second ED that were within 1 calendar day of the index visit. We also excluded those visits with only an ICD9-CM diagnosis code related to a burn as the Injury Severity Score (ISS), which was used as a measure of injury severity in our study, is not applicable to burn patients. The institutional review board at our institution approved the protocol with a waiver of informed consent.

We collected the following demographic variables: age, sex, race/ethnicity, primary insurance, and final disposition. We defined age based on clinically significant categories, specifically including those 15-18 years of age in a separate category, as some of the non-pediatric EDs preferentially care for this group of patients (i.e. in many cases, patients <15 years of age who are designated as trauma patients prior to arrival to the ED, will be taken to the pediatric trauma center). We defined injury severity based on the ISS. Scores of 1 through 8 were considered minor, 9 through 15 were considered moderate, and scores greater than 15 were considered severe.(15) We used the ICD Programs for Injury

Categorization,(16) a validated method to translate ICD9-CM diagnosis codes into ISS scores.(15,17) Some ICD9-CM codes (N=5961) were translated into ISS scores of 0 (905-908, 909.2, 909.4, 909.9, 920-924, 930-939, 958-959, 960-979, 980-994, 995.5, 995.80-995.85) and were included in the “minor” ISS category. We collected the following ED-level covariates: trauma center designation, academic status, and annual pediatric visit volume. Pediatric annual visit volume was categorized by quartiles based on the mean annual volumes of pediatric patients across the years of the study for each ED. Trauma center designation was defined according to the accreditation assigned by the state Trauma Systems Foundation and level I trauma centers were further categorized as pediatric and non-pediatric. An academic ED was defined as one in which emergency medicine residents rotated.

The primary outcome was whether CT was performed during the ED visit, as extracted from the documented radiology procedures performed during the patient's visit. We consolidated CTs into 8 meaningful categories: head, cervical spine, abdomen, chest, face, spine (non-cervical), extremity, and neck (eg, pelvis CT was included as an abdomen, orbit CT was included as a face CT, neck CT were those CTs not of the cervical spine, including neck CT angiography and neck soft tissue CT).

We used descriptive statistics to summarize patient, visit, and ED demographic data as well as for reporting the frequency of imaging use. We calculated the visit-level proportions of CT use, ISS>8, and admissions/transfers for each ED and used Spearman's rho to evaluate the correlation between CT use and both ISS and disposition from the ED. Across the study period, approximately 20% of visits involved patients with multiple ED visits during the study period, with most of those patients appearing only twice. We, therefore, considered using generalized estimating equations, a method for dealing with correlated data while accounting for case-mix. We performed multivariable modeling with generalized estimating equations with various correlation structures, as well as logistic regression, to evaluate the association of patient and ED covariates on any CT use as well as on the most common body region-specific CT types. The differences between the two types of models were small (ie, <10% difference for odds ratios and confidence intervals without changes in statistical significance); therefore, we report the logistic regression model, which treats each visit as an independent observation. We used the Hosmer-Lemeshow goodness-of-fit test to assess the calibration of the model.

We included covariates in the model that were determined a priori to be associated with CT use, either through previous work or scientific plausibility.(12,18) When constructing the logistic regression model, we noted an age-related referral trend, with most visits by those in the youngest age group being treated at the pediatric ED and most visits by those in the oldest age group being treated at non-pediatric EDs. Given that CT imaging utilization patterns are significantly different in infants than older children,(19) likely due to several factors including difficulty in clinical evaluation and concern for non-accidental trauma, we developed logistic regression models as follows. For the first model, we included only non-pediatric EDs and evaluated the effects of trauma center designation, academic status and annual pediatric volume as ED-level covariates, as well as patient-level covariates on any and body region-specific CT use. For the second model, we included all EDs and evaluated

the effects of trauma center designation and patient-level covariates (including a diagnosis of abuse) on any and body region-specific CT use. There was neither sufficient variation of academic status nor of pediatric volume within trauma center type; therefore, these variables could not be included in the second model. In addition, the variable indicating a diagnosis of abuse could not be included in the first model, given the low prevalence of abuse in the non-pediatric EDs.

We report results as odds ratios (ORs) with 95% confidence intervals (CIs). We considered P values <0.05 significant. We used SPSS, version 21, (IBM Corp, Armonk, NY) to perform all statistical analyses.

Results

There were a total of 287,409 pediatric visits to network EDs during the study period. After excluding visits by transferred patients to receiving EDs, visits without injury-specific ICD9-CM diagnosis codes, and those for isolated burns, there were 80,868 visits by 64,474 individual patients in the final cohort (Figure 1; available at www.jpeds.com). The median patient age was 10.5 years (interquartile range: 4.6-14.9); and more than half of patients were male (57.9%), White, non-Hispanic (74.4%), and had private insurance (57.2%; Table I). The vast majority of visits resulted in discharge from the ED. Of visits resulting in admission (3.7%), 18.1% required management in the intensive care unit. Most visits were by patients with injuries of minor severity, with 98.2% having an ISS $\leq$ 8. The most common injury diagnoses were contusion, sprains and strains, and open wounds of the head, neck, and trunk (Table I). The diagnoses resulting in the highest proportion of CT use were intracranial injury, skull fracture, and spine fracture. Of all injury-related visits, 11.4% (N=9213) had at least one CT performed. Of those visits in which a CT was performed, 28.4% were associated with more than one CT, 8.0% with more than 2 CTs, and the maximum number of CTs performed during a visit was 7 (n=10 visits).

The proportion of injury-related visits resulting in CT across the 14 EDs varied from 7.6% to 25.5% (Figure 2). Proportions of visits resulting in either admission or transfer ranged from 1.3% to 15.3% and the proportion of visits with ISS>8 was 0.3% to 8.1%. There was neither a correlation between ED CT use and the proportion of patients with ISS>8 (Spearman rho= 0.28, P value= 0.33) nor ED CT use and the proportion of patients admitted/transferred (Spearman rho= 0.51, P value= 0.07).

Across all EDs, head CTs were the most commonly performed CTs, and for 10 EDs, cervical spine CTs were the second most frequent type (Figure 3). Three EDs (numbers 1, 5, and 7) performed more than 2 CTs for more than 20% of their visits (Figure 4; available at www.jpeds.com). These EDs also had the highest utilization of chest and abdomen CT imaging (Figure 3), with similar utilization patterns within each of these institutions for chest and abdominal imaging, suggesting the two CTs were most often ordered together in these institutions.

In multivariable analysis of the non-pediatric EDs (Table II), the trauma centers and non-academic EDs had higher odds of using CT for injury-related visits. In addition, EDs with

larger volumes of pediatric visits were found to have higher odds of using any CT. However, when evaluating the relationship between volume and the most common CT types, we found that for c-spine, chest, and abdomen CTs, compared with the smallest volume EDs, those with higher volumes of pediatric patients had lower odds of performing these types of CTs (Figure 5; available at www.jpeds.com). Compared with infants, patients between 1 and 9 years of age were at lower odds of CT; adolescents older than 15 years of age were at higher odds of having CT performed. Patients who were male, white, or had private or “other” insurance had higher odds of having CT during a visit for injury-related diagnoses. In addition, those with a higher ISS had higher odds of having CT performed.

In a second multivariable model (Table III; available at www.jpeds.com) which included the pediatric ED, we found a slightly higher odds of performance of any CT at the pediatric Level 1 trauma center compared with non-trauma centers, though Level 1 and Level 2 trauma centers had up to a 42% higher odds of CT use compared with non-trauma centers. However, when evaluating the body region-specific CTs, the pediatric level I trauma center had significantly lower odds of imaging compared with non-trauma centers for head, c-spine, and chest CTs, and level 1, 2, and 3 trauma centers had substantially higher odds (Figure 6; available at www.jpeds.com). The diagnosis of abuse was associated with increased odds of imaging compared with other diagnoses. In this model, compared with infants, all age groups had decreased odds of any CT and head CT specifically.

Discussion

We demonstrate wide variation in CT utilization for pediatric injury-related visits across various types of EDs within a health network. Case mix, as measured by ISS and disposition, did not account for the variability in CT use, which raises the possibility that non-clinical factors influence the decision to obtain imaging in these patients. Understanding factors associated with CT utilization in injured children could be important to both limit exposure to unnecessary radiation as well as contain costs in this setting.

We found that non-pediatric trauma centers and non-academic EDs had higher odds of using CT during injury-related visits. We hypothesize that trauma centers may not distinguish between pediatric and adult trauma patients when evaluating injured patients. This may explain the high use of multi-scanning protocols (ie, chest, abdomen, and other CTs done concomitantly) at several EDs in our study. This finding also may reflect adherence to a protocol, consistent approach to the care of injured patients at trauma centers. Previous national data suggests that trauma centers are more likely to perform head CT imaging for pediatric head trauma(11) and our study further supports these findings. Non-academic EDs, specifically, may not have the personnel or space to engage in a period of observation, which in select patients can be used in lieu of CT imaging. In addition, these EDs compared with academic medical centers, may not engage in the same evidence-based protocols designed to optimize CT usage, and therefore, employ more liberal scanning practices. Among the non-pediatric EDs, there was an inverse relationship between annual pediatric patient volume and c-spine, chest, and abdominal CTs. One possible explanation for this finding is that physicians in EDs with higher pediatric volumes are more comfortable in their clinical assessment and management of injured children and do not rely as heavily on CT imaging.

We found that injured infants have higher odds of receiving any CT imaging compared with other age groups and this finding was largely driven by use of head CT, specifically. Patterns of CT utilization in this age group may reflect difficulty in relying on the physical examination, especially in the youngest of infants. Another possible explanation for the increased odds of imaging in infants may be the concern for non-accidental trauma in this population. Most children <1 year of age are non-ambulatory, and therefore, physicians may be more vigilant in their diagnostic evaluation of an injured infant in the absence of a plausible mechanism. Guidelines for evaluations in suspected abuse often include screening with head, in particular, and abdominal CT imaging.(20-22) It should be noted that although only <0.1% of our population had an ICD9-CM diagnosis code of abuse, this does not reflect the true prevalence of physician suspicion for abuse. For example, a physician may evaluate for findings of abuse, however, if the diagnostic work-up is negative, the visit would not be coded with an ICD9 code to reflect the initial concern. Our finding of lower odds of CT imaging in racial and ethnic minorities is consistent with that found by others and may reflect disparities among parental preferences versus physician biases.(12,18)

In addition to patient- and ED-level characteristics associated with CT utilization across institutions, we found increased CT utilization was consistent across imaging subtypes within individual institutions. Several EDs in our study demonstrated high utilization across several different types of CT, specifically, head, cervical spine, chest, and abdomen, suggesting the practice of “pan scanning.” In adult trauma patients this has been suggested to be an effective and safe method in which to evaluate for injuries.(23) However, this liberal approach to CT scanning in pediatric trauma patients has come into question for several reasons.(24,25) First, injury patterns in pediatric patients are different from those in adults. Specifically, routine chest CT in the setting of high-speed deceleration injuries is advocated in adult patients regardless of chest radiograph results, given the high incidence risk of aortic injuries.(26) However, the prevalence of pediatric aortic injury is exceedingly low (0.1%) (27) and one study found that chest radiograph alone had a negative predictive value of up to 98% for diagnosing these injuries.(28) In addition, pulmonary contusions in children do not yield the high morbidity seen in adult patients, who have higher risks of respiratory failure and acute respiratory distress syndrome.(29) Although chest CT is more accurate in diagnosing rib fractures(30) and pulmonary contusions,(31) these findings don't translate into clinical interventions not otherwise made based on radiographs and clinical monitoring. (31,32) Second, ISS in the adult trauma population is generally much higher than in most pediatric populations, including ours; therefore, increased CT evaluation may be warranted to assess for these more severe injuries.(23,33) Third, as part of the list of “Five things physicians and patients should question” for the Choosing Wisely campaign, the American College of Surgery recommends against the routine performance of whole-body CT in patients with minor or single system trauma.(34) Finally, pediatric trauma patients are subjected to high levels of CT radiation(35), and given the increased susceptibility of children to the effects of diagnostic radiation, it is prudent for physicians to be judicious in their approach.

The second most common CT performed in our study was that of the cervical spine. This is particularly noteworthy, as the incidence of cervical spine injury is very low in pediatric patients. In our study, there was a 0.3% incidence of any spinal fracture or spinal cord injury,

meaning an even lower incidence of injuries involving the cervical region, specifically, which has been previously described.(36) Decision rules are designed to minimize unnecessary use of imaging, and there are several related to pediatric cervical spine injuries. (37) In addition, plain radiographs are highly sensitive (up to 94%)(38) for diagnosing cervical spine fractures in pediatric patients, and in many cases, may obviate the need for more advanced imaging.(39) Moreover, the pediatric thyroid gland is among the most radiosensitive organs, and a cervical spine CT exposes the thyroid to 90-200 times more radiation than a plain radiograph.(40) Therefore, use of cervical spine CT imaging in children should be done with caution.(41) We found that the pediatric trauma center was at much lower odds of performing c-spine imaging than non-trauma centers and trauma centers had up to double the odds of using this imaging modality for pediatric patients, even when adjusting for relevant confounders. Cervical CT utilization patterns outside the pediatric trauma center setting may reflect protocols derived from adult-based decision rules(42,43) and guidelines(44) that may not be appropriate in the pediatric setting. However, because the majority of children are cared for in general emergency departments, further attention to pediatric-specific radiation-sparing protocols is warranted.

Our study has certain limitations. First, our data were derived from administrative billing data and therefore, we were unable to assess specific clinical factors, such as the Glasgow Coma Score, which is commonly used as a marker of injury severity. However, we used ISS and disposition as markers of injury severity, with the assumption that those who were discharged were not significantly injured. Second, we report visits with ICD9-CM injury codes and whether a CT was performed, however, a CT may have been ordered for a non-injury related issue despite having an injury-related diagnosis as well. Third, in the case of transferred patients, we included imaging utilization from the transferring facility only. It is possible that imaging was withheld at the initial ED with the expectation that it would be most appropriately performed at the referral ED. However, because only a small percentage of visits in this study resulted in transfer (1.1%), including visits to accepting facilities would be unlikely to alter the results substantively. Fourth, there may be unmeasured confounders related to the decision to obtain a CT. Our study did not attempt to assess the appropriateness of CT use at each visit but rather explore the variation across EDs. Finally, this study was performed within a single, regional health system and the results may not generalize to all EDs. However, our study includes 14 different EDs, which serve a large catchment area.

We demonstrate wide individual ED variation in CT imaging for injured pediatric patients not attributable to injury severity. The speed, accuracy, and noninvasiveness of CT scanning make it an attractive modality in pediatric trauma. However, several lines of evidence suggest that practice patterns regarding evaluation of adults by CT are not appropriate in the pediatric setting. Understanding system-level as well as individual physician factors that lead to wide practice variation in CT utilization in pediatric patients could lead to targeted initiatives to optimize utilization.

Acknowledgments

Supported by the National Institutes of Health (UL1TR000005). J.M. received support from the Agency for Healthcare Research and Quality for a conference on diagnostic imaging (R13HS023498).

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Abbreviations

CT	Computed tomography
ED	emergency department
ICD9-CM	<i>International Classification of Diseases, 9th revision, Clinical Modification</i>
ISS	injury severity score
OR	odds ratio
CI	confidence interval

Figure 1. online- Visits included in the cohort

Figure 2. Proportions of visits with a CT, admitted or transferred, and with ISS>8

Horizontal red line represents the proportion of visits with ISS>8 at each ED

¹Transferred refers to patients transferred into that hospital

Figure 3. Types of CTs across EDs

Figure 4. online- Frequency of multiple CTs in patients who underwent at least one CT
 *If a patient received more than one CT of the same type (e.g. head CT and head CT angiogram), it was counted as 2 CTs

Figure 5. online- Proportions of body region-specific CTs by annual pediatric volume quartile

Figure 6. online- Proportions of body region-specific CTs by trauma center designation

Table 1
Characteristics of visits by discharge diagnosis codes (N= 80,868)

	Number of visits (%)	Number of visits with CT performed (%) ^I
ICD9-CM diagnosis²		
851-854 Intracranial injury, excluding skull fracture and concussion	203 (0.3)	142 (70.0)
800-804 Fracture of skull	1233 (1.5)	851 (69.0)
805-806 Fracture of vertebral column with or without spinal cord injury	188 (0.2)	118 (62.8)
860-869 Internal injury of thorax, abdomen, and pelvis	382 (0.5)	203 (53.1)
807-809 Fracture of bones of the trunk (e.g. ribs, pelvis)	247 (0.3)	130 (52.6)
850 Concussion	5135 (6.3)	2565 (50.0)
950-957 Injury to nerves and spinal cord	83 (0.1)	30 (36.1)
900-904 Injury to blood vessels	54 (0.1)	16 (29.6)
958-959 Certain traumatic complications and unspecified injuries	9497 (11.7)	2677 (28.2)
905-908, 909.2, 909.4, 909.9 Late effects of injuries, poisonings, toxic effects, and other external causes	285 (0.4)	77 (27.0)
920-924 Contusion with intact skin	16350 (20.2)	2571 (15.7)
995.5, 995.80-995.85 Child and adult maltreatment, neglect, or abuse	644(0.8)	101 (15.7)
990-994.9 Other and unspecified effects of external causes	245 (0.3)	33 (13.5)
996-999 Complications of surgical and medical care, not elsewhere classified	2622 (3.1)	312 (11.9)
910-919 Superficial injury	8162 (10.1)	935 (11.5)
870-879 Open wound of head, neck, and trunk	12096 (15.0)	1152 (9.5)
820-829 Fracture of lower limb	3204 (4.0)	295 (9.2)
840-848 Sprains and strains of joints and adjacent muscles	14557 (18.0)	1066 (7.3)
810-819 Fracture of upper limb	7912 (9.8)	340 (4.3)
960-979 Poisoning by drugs, medicinal and biological substances	1366 (1.7)	59 (4.3)
830-839 Dislocation	1738 (2.1)	72 (4.1)
890-897 Open wound of lower limb	2340 (2.9)	78 (3.3)
880-887 Open wound of upper limb	3506 (4.3)	86 (2.5)
980-989 Toxic effects of substances chiefly nonmedicinal as to source	1127 (1.4)	21 (1.9)
925-929 Crushing injury	271 (0.3)	5 (1.8)
930-939 Effects of foreign body entering through body orifice	2833 (3.5)	33 (1.2)
Age		
<1 year	2733 (3.4)	579 (21.2)
1-4 years	19017 (23.5)	1354 (7.1)
5-9 years	16592 (20.5)	1294 (7.8)
10-14 years	22954 (28.4)	2567 (11.2)
15-18 years	19572 (24.2)	3419 (17.5)
Sex- Male	46847 (57.9)	5768 (12.3)
Race/ethnicity		

	Number of visits (%)	Number of visits with CT performed (%) ¹
White, non-Hispanic	60198 (74.4)	7426 (12.3)
Black, non-Hispanic	18302 (22.6)	1539 (8.4)
Other ³	1181 (1.5)	119(10.1)
Missing	1187 (1.5)	129 (10.9)
Insurance		
Private	46230 (57.2)	5251 (11.4)
Medicaid	29453 (36.4)	2836 (9.6)
Self-pay	2829 (3.5)	255 (9.0)
Other ⁴	2350 (2.9)	871 (37.1)
Missing	6 (0)	0 (0)
Disposition		
Discharged	76995 (95.2)	7770 (10.1)
Transferred	866 (1.1)	195 (22.5)
Admitted (floor)	2464 (3.0)	930 (37.7)
Admitted (ICU)	543 (0.7)	318 (58.6)
Number of injuries⁵		
1	68580 (84.8)	5735 (8.4)
2	9757 (12.1)	2338 (24.0)
3	1734 (2.1)	712 (41.1)
4	507 (0.6)	257 (50.7)
5	164 (0.2)	86 (52.4)
6	71 (0.1)	45 (63.4)
7	55 (0.1)	40 (72.7)
ISS		
Mild 1-8	79416 (98.2)	8501 (10.7)
Moderate 9-15	1125 (1.4)	506 (45.0)
Severe >15	3247(0.4)	206 (63.0)

¹ Percentages represent proportion of visits that included at least one CT

² Each visit could be associated with more than one injury-related ICD9-CM diagnosis code

³ Asian (N=721), Hispanic (N=338), American Indian/Native Hawaiian (N=122)

⁴ Auto accident insurance (N=2087), worker's compensation(N=260), other not specified (N= 3)

⁵ Number of ICD9-CM injury diagnosis codes for an individual visit

Table 2
Multivariable regression model of ED and patient factors associated with performance of CT among non-pediatric EDs

	Any CT Adjusted OR (95%CI)	Head CT Adjusted OR (95%CI)	C-spine CT Adjusted OR (95%CI)	Chest CT Adjusted OR (95%CI)	Abdomen CT Adjusted OR (95%CI)
<i>ED characteristics</i>					
Trauma designation					
Not a trauma center	Referent	Referent	Referent	Referent	Referent
Level 1	1.54 (1.18, 2.00)	1.49 (1.11, 2.00)	3.43 (2.10, 5.58)	75.62 (10.49, 545.00)	20.94 (6.60, 66.37)
Level 2 or 3	1.31 (1.15, 1.49)	1.34 (1.17, 1.54)	3.47 (2.65, 4.54)	2.06 (1.23, 3.44)	2.79 (1.77, 4.39)
Non-academic ED	1.51 (1.16, 1.96)	1.54 (1.15, 2.06)	1.84 (1.12, 3.02)	4.62 (0.62, 34.49)	3.88 (1.20, 12.54)
Annual pediatric volume					
1 st quartile	Referent	Referent	Referent	Referent	Referent
2 nd quartile	1.03 (0.91, 1.16)	1.05 (0.93, 1.20)	1.05 (0.87, 1.28)	0.92 (0.55, 1.53)	0.82 (0.59, 1.14)
3 rd quartile	1.33 (1.19, 1.48)	1.39 (1.23, 1.56)	1.10 (0.93, 1.30)	0.37 (0.29, 0.49)	0.54 (0.43, 0.68)
4 th quartile	1.28 (1.11, 1.48)	1.20 (1.03, 1.41)	0.68 (0.51, 0.92)	1.67 (0.91, 3.09)	0.72 (0.45, 1.18)
<i>Patient characteristics</i>					
Age					
<1 year	Referent	Referent	Referent	Referent	Referent
1-4 years	0.41 (0.31, 0.53)	0.40 (0.30, 0.52)	0.69 (0.31, 1.54)	0.45 (0.05, 3.93)	0.67 (0.08, 5.45)
5-9 years	0.59 (0.46, 0.76)	0.49 (0.38, 0.64)	1.43 (0.66, 3.09)	0.85 (0.11, 6.66)	2.94 (0.40, 21.59)
10-14 years	0.93 (0.72, 1.19)	0.77 (0.60, 1.00)	2.81 (1.31, 5.99)	1.89 (0.26, 13.92)	4.52 (0.63, 32.68)
15-18 years	1.60 (1.25, 2.05)	1.23 (0.98, 1.61)	5.95 (2.80, 12.65)	6.46 (0.90, 46.69)	11.12 (1.55, 79.77)
Male	1.23 (1.15, 1.31)	1.18 (1.10, 1.26)	1.09 (0.98, 1.21)	1.40 (1.12, 1.75)	1.26 (1.05, 1.51)
Non-White or Hispanic ¹	0.75 (0.68, 0.82)	0.69 (0.62, 0.76)	0.61 (0.52, 0.72)	0.69 (0.52, 0.90)	0.63 (0.50, 0.81)
Insurance status					
Private	Referent	Referent	Referent	Referent	Referent
Medicaid	0.81 (0.76, 0.88)	0.80 (0.74, 0.87)	0.79 (0.69, 0.90)	0.91 (0.69, 1.20)	0.86 (0.69, 1.08)
Self-pay	0.80 (0.68, 0.94)	0.84 (0.70, 1.00)	0.92 (0.70, 1.21)	0.52 (0.26, 1.04)	0.92 (0.58, 1.47)
Other	3.33 (2.97, 3.73)	3.45 (3.06, 3.88)	6.80 (5.91, 7.83)	9.60 (7.43, 12.40)	7.14 (5.76, 8.86)
ISS					

	Any CT Adjusted OR (95%CI)	Head CT Adjusted OR (95%CI)	C-spine CT Adjusted OR (95%CI)	Chest CT Adjusted OR (95%CI)	Abdomen CT Adjusted OR (95%CI)
8	Referent	Referent	Referent	Referent	Referent
9-15	9.48 (7.45, 12.06)	6.51 (5.13, 8.26)	7.89 (5.96, 10.44)	19.03 (13.33, 27.17)	14.93 (10.85, 20.56)
>15	9.50 (5.99, 15.05)	9.06 (5.80, 14.16)	8.74 (5.31, 14.39)	11.19 (6.47, 19.35)	8.93 (5.29, 15.08)

Non-White defined as Black, non-Hispanic, or Other compared with White as the referent group

Table 3
Multivariable regression model of ED and patient factors associated with performance of CT among all EDs

	Any CT Adjusted OR (95%CI)	Head CT Adjusted OR (95%CI)	C-spine CT Adjusted OR (95%CI)	Chest CT Adjusted OR (95%CI)	Abdomen CT Adjusted OR (95%CI)
<i>ED characteristics</i>					
Trauma designation					
Not a trauma center	Referent	Referent	Referent	Referent	Referent
Pediatric level 1	1.15 (1.09, 1.21)	0.93 (0.88, 0.98)	0.23 (0.19, 0.27)	0.43 (0.29, 0.64)	1.23 (1.01, 1.50)
Level 1	1.17 (1.07, 1.28)	1.11 (1.01, 1.22)	2.03 (1.77, 2.32)	11.25 (8.65, 14.62)	5.38 (4.41, 6.56)
Level 2 or 3	1.42 (1.30, 1.54)	1.33 (1.22, 1.46)	2.36 (2.07, 2.70)	4.1 (2.96, 5.69)	2.69 (2.11, 3.42)
<i>Patient characteristics</i>					
Age					
<1 year	Referent	Referent	Referent	Referent	Referent
1-4 years	0.30 (0.27, 0.33)	0.26 (0.23, 0.29)	1.12 (0.56, 2.26)	2.05 (0.26, 16.30)	1.09 (0.47, 2.51)
5-9 years	0.32 (0.29, 0.36)	0.23 (0.21, 0.26)	1.93 (0.97, 3.85)	2.88 (0.37, 22.58)	3.15 (1.41, 7.02)
10-14 years	0.48 (0.43, 0.54)	0.34 (0.31, 0.38)	4.21 (2.15, 8.25)	6.39 (0.85, 48.16)	4.60 (2.09, 10.11)
15-18 years	0.77 (0.69, 0.85)	0.53 (0.47, 0.59)	8.41 (4.30, 16.46)	19.87 (2.66, 148.71)	8.66 (3.94, 19.04)
Male	1.25 (1.20, 1.31)	1.20 (1.14, 1.26)	1.10 (0.99, 1.21)	1.45 (1.18, 1.80)	1.34 (1.15, 1.55)
Non-White or Hispanic ¹	0.70 (0.66, 0.75)	0.67 (0.63, 0.72)	0.56 (0.48, 0.64)	0.66 (0.51, 0.85)	0.57 (0.47, 0.69)
Insurance status					
Private	Referent	Referent	Referent	Referent	Referent
Medicaid	0.90 (0.86, 0.95)	0.89 (0.84, 0.95)	0.80 (0.71, 0.90)	0.89 (0.79, 1.15)	0.94 (0.79, 1.12)
Self-pay	0.78 (0.68, 0.89)	0.81 (0.70, 0.93)	0.93 (0.71, 1.21)	0.57 (0.29, 1.10)	0.86 (0.56, 1.33)
Other	3.50 (3.18, 3.85)	3.73 (3.38, 4.12)	6.38 (5.58, 7.29)	8.52 (6.70, 10.84)	7.81 (6.52, 9.37)
ISS					
8	Referent	Referent	Referent	Referent	Referent
9-15	5.88 (5.19, 6.67)	4.92 (4.31, 5.62)	6.89 (5.46, 8.70)	20.17 (14.88, 27.32)	12.56 (10.04, 15.71)
>15	10.31 (8.10, 13.10)	9.52 (7.51, 12.07)	12.90 (8.89, 18.72)	30.27 (18.95, 48.34)	21.36 (15.15, 30.10)
Diagnosis of abuse ²	1.30 (1.03, 1.67)	1.52 (1.18, 1.96)	1.94 (0.84, 4.44)	3.06 (0.72, 13.08)	2.14 (0.98, 4.71)

¹Non-White defined as Black, non-Hispanic, or Other compared to White as the referent group

ICD9-CM diagnosis codes: 995.5, 995.59, 995.596, 995.596+85

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