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Variation in Advanced Imaging for Pediatric Patients with Abdominal Pain Discharged from the Emergency Department

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Abstract

Background—Pediatric abdominal pain visits to emergency departments (ED) are common. The objectives of this study are to assess variation in imaging [ultrasound (US) ± computed tomography (CT)] and factors associated with isolated CT use.

Methods—This was a retrospective cohort study of ED visits for pediatric abdominal pain resulting in discharge from 16 regional EDs from 2007–2013. Primary outcome was US or CT imaging. Secondary outcome was isolated CT use. We used multivariable logistic regression to evaluate patient- and hospital-level covariates associated with imaging.

Results—Of the 21,152 visits, imaging was performed in 29.7%, and isolated CT in 13.4% of visits. In multivariable analysis, black patients (OR: 0.4 (95%CI: 0.4, 0.5)) and Medicaid (OR: 0.6 (95%CI: 0.5, 0.7)) had lower odds of advanced imaging compared to white patients and private insurance, respectively. General EDs were less likely to perform imaging (OR: 0.6 (95%CI: 0.5, 0.7)) compared to the pediatric ED; however, for visits with imaging, 3.5% of visits to the pediatric ED compared to 76% of those to general EDs included an isolated CT ($P<0.001$). Low pediatric volume (OR: 1.8 (95%CI: 1.5, 2.2)) and rural (OR: 1.8 (95%CI: 1.3, 2.5)) EDs had higher odds of isolated CT use, compared to higher pediatric volumes and non-rural EDs, respectively.

Conclusion—There are racial and insurance disparities in imaging for pediatric abdominal pain. General EDs are less likely than pediatric EDs to use imaging, but more likely to use isolated CT. Strategies are needed to minimize disparities and improve the use of “ultrasound-first.”

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Keywords

Computed Tomography; Ultrasound; Radiation; Health Disparities; Abdominal Pain

1. Introduction

There are more than one million emergency department (ED) visits for pediatric abdominal pain each year.¹ Most pediatric patients presenting to the ED with abdominal pain have benign, self-limiting conditions, however, concern for appendicitis is often the impetus for advanced imaging.^{2,3} Appendicitis is the most common indication for acute abdominal surgery in pediatrics⁴ and the second most common cause of malpractice litigation in adolescents.⁵ Diagnosis of appendicitis can be challenging, and advanced imaging such as ultrasound (US) and computed tomography (CT) may be performed in order to assist with diagnosis. CT is the most accurate imaging modality⁶; however, there are risks involved with its use, including cost, increased length of stay⁷ and radiation exposure⁸. Given the concerns regarding radiation exposure in pediatric patients^{9,10} and in keeping with the As Low As Reasonably Achievable (“ALARA”) principle¹¹, ultrasound is recommended as first-line imaging for pediatric patients with abdominal complaints.^{5,12,13}

Previous studies suggest disparities in both access to and quality of healthcare for children of different races, ethnicities, and income levels regardless of presenting complaint.^{14–21} Additionally, there is unexplained variation in care between different hospital types.^{22,23} An evaluation of practice variation provides opportunities for optimizing resource utilization and quality improvement.^{24,25} Thus, the objectives of this study were to assess variation in advanced imaging use for pediatric patients with abdominal pain discharged from the ED and, to further assess factors associated with isolated CT use.

2. Methods

2.1 Study Design

We performed a retrospective observational study of visits to 16 EDs within a large, regional, integrated health network from January 1, 2007 through February 28, 2013. The institutional review board at our institution approved the protocol and deemed it exempt from written informed consent.

2.2 Study Setting and Population

The health network studied consists of 15 general EDs and 1 pediatric (academic) ED within a children’s hospital, and represents the largest health system in the region. Not all hospitals contributed data for the entire time period, depending on their adoption of the electronic medical record. We included visits by patients less than 19 years of age presenting with abdominal pain and discharged from the ED. Relevant visits were identified by electronic chart review by a single reviewer from a list of all chief complaints during the time period indicating abdominal pain such as: “abdominal” or “stomach ache”, “pain” or “cramps”, “rule-out appendicitis,” and “epigastric,” “right upper quadrant,” “left upper quadrant,” “right lower quadrant,” or “left lower quadrant pain.” We excluded pregnancy- and trauma-

related visits, as defined by a chief complaint or a primary *International Classification of Diseases, Ninth Revision, Clinical modification* (ICD-9-CM) diagnosis code related to pregnancy (640–649.4, V22, V23, V61.3–V61.9, V72.4, 633, 651, 659, and 779.6) or trauma (860–869, 902, 908.4, 958.93, and 959.12).

2.3 Study Protocol

We included the following patient-level variables: age, sex, race/ethnicity, and primary insurance. Race/ethnicity and primary insurance information are recorded in the electronic medical record by registration personnel upon ED arrival. We included those comorbidities hypothesized to be associated with the decision to perform advanced imaging as defined via ICD-9-CM coding (Crohn's disease-DX555, Ulcerative Colitis-DX556, transplant history-DXV42, and post-operative status-DXV45 or DXV58). We report primary discharge diagnoses except when the primary diagnosis was abdominal pain (not otherwise specified); in those cases we used the 2nd–4th diagnoses codes, when included, to further specify the discharge diagnosis. We evaluated the following ED-level covariates: ED type (pediatric vs. general), ED academic status, pediatric visit volume for non-pediatric institutions, and location (large urban, small urban or rural). An academic ED was defined as one in which emergency medicine residents rotated. We calculated the mean annual pediatric visit volume for each general ED and then defined those EDs as high volume if their mean annual volume was above the median for all EDs in the study. We categorized hospital location by metropolitan statistical area size (large urban, more than 1 million persons; small urban, 1 million to 100,000 persons; rural, less than 100,000 persons or nonmetropolitan statistical area).

2.4 Measurements

The primary outcome was advanced imaging use, defined as abdominal CT, abdominal US, and/or pelvic US performed during the ED visit as extracted from billed radiology procedures during that visit. The secondary outcome, among patients who had advanced imaging use, was isolated CT use (i.e. CT without having had an US).

2.5 Data Analysis

We used descriptive statistics to summarize patient, visit, and ED demographics as well as to report the frequency of imaging use. We compared proportions using the chi-squared test. Across the study period, approximately 14% of patients had multiple ED visits during the study period. Due to the potentially correlated nature of multiple visits by the same patient, we considered using a generalized estimating equations approach, which can help to deal with correlated data. We performed multivariable modeling with a generalized estimating equations model, as well as logistic regression, to evaluate the association of patient and ED covariates on imaging use. The differences between these two types of models were small (i.e. <10% difference in odds ratios (ORs) and 95% confidence intervals (CIs) without changes in statistical significance); therefore, we report the simpler logistic regression model, which treats each visit as an independent observation.²⁶

We constructed models for two distinct outcomes. In the first model, the dependent variable was any advanced imaging (vs. no advanced imaging) use among all EDs. To evaluate

factors associated with the outcome of advanced imaging, we included candidate covariates determined a priori to be associated with advanced imaging, either through previous work or scientific plausibility.^{17–19,27} Candidate covariates achieving p-values less than 0.2 on univariate analysis were included in multivariable models. Next, we sought to evaluate factors associated with isolated CT use (versus US $\pm$ CT), among those who received any advanced imaging. For this outcome, we further stratified the analysis by general EDs and pediatric ED given the differences in CT use.^{2,17,18} There were only 8 visits by patients < 3 years that involved an isolated CT in the general EDs and no such visits in the pediatric ED, therefore, we excluded the 285 visits by patients < 3 years from the analysis of this second outcome.

We report results as odds ratios with 95% confidence intervals (CI) and considered two-sided p-values less than 0.05 to be statistically significant. We used SPSS version 23 (IBM Corp, Armonk, NY) for all statistical analyses.

3. Results

Of the 437,167 pediatric visits to EDs during the study period, 173,756 visits (39.7%) were to the pediatric ED. After excluding for pregnancy or trauma, 5.7% (24,204) of these visits were for abdominal pain, of which, 87.4% resulted in discharge from the ED (Figure 1). The final cohort included 21,152 visits by 17,540 patients. Of these, 8,715 visits (41.2%) and 7,426 patients (42.3%) were to the pediatric ED (Table 1). The median age of all patients in the cohort was 12.3 years (interquartile range: 7.0–16.7 years). Most patients were female (61.3%), white/non-Hispanic (71.3%), and privately insured (58.5%) (Table 1). The most common discharge diagnoses were abdominal pain (not otherwise specified) (24.0%) followed by constipation (15.7%), urinary tract infection (6.2%), and nausea/vomiting (6.2%).

3.1 Advanced Imaging

Of the 21,152 visits for abdominal pain resulting in discharge, 29.7% (n=6,273) included advanced imaging. Isolated CT was performed in 13.4% of visits (n=2,842). US was performed in 16.2% of visits (n=3,431) and of those, 11.3% (n=389) included both an US and CT. Among the 12,437 visits for abdominal pain to general EDs, 29.2% (n=3,635) included advanced imaging. Isolated CT was performed in 22.2% of visits (n=2,759). US was performed in 7.0% of visits (n=876) to general EDs and of those, 22.9% (n=201) included both an US and CT. In multivariable analysis (Table 2), visits by Black and other minority patients and those without private insurance had lower odds of receiving advanced imaging compared to White/non-Hispanic patients. Visits to academic EDs were at lower odds of including advanced imaging compared to non-academic EDs, as were those to general EDs compared to pediatric EDs.

3.2 Isolated CT imaging

Evaluating the subset of visits with advanced imaging, 3.5% of those to the pediatric ED compared to 76% of those at general EDs included an isolated CT ($P<0.001$). Visits by adolescents had higher odds of receiving an isolated CT at the pediatric ED compared to

patients aged 3–11 years old. By contrast, adolescents had lower odds of receiving an isolated CT at general EDs compared to patients aged 3–11 years old (Table 3). Among general EDs, those with the lowest pediatric volumes and those classified as rural had higher odds of receiving an isolated CT, compared to higher pediatric volumes and non-rural location, respectively.

4. Discussion

Our regional, multicenter ED study of pediatric visits for abdominal pain demonstrates variation in ED advanced imaging utilization across patient race/ethnicity, insurance status, and ED type. Specifically, we found that minority patients and those not privately insured were less likely to receive advanced imaging for abdominal pain. Previous studies through 2009 regarding imaging disparities for pediatric abdominal pain vary in their findings, with some indicating racial and insurance disparities,^{2,17} and others in conflict with these results.³ Our data support those of other national studies and provide the most recent evidence to date.^{2,17}

The reasons for such variation in advanced imaging are likely multifactorial and due to patient and parent/guardian factors, system-level factors, as well as provider biases. For example, there may be stronger parental preference for advanced imaging among White, non-Hispanic parental/guardians. A study by Natale, et al,¹⁹ demonstrated parental anxiety/request for neuroimaging was more common for these patients. Similarly, in a survey of adult ED patients, white and privately insured patients preferred their acute problem was definitively diagnosed, such as with CT, even at the expense of more radiation.²⁸ Patients with private insurance may initially seek care at a primary care facility and be referred to the ED specifically for further evaluation with advanced imaging, making it difficult for ED physicians to avoid imaging. Numerous studies^{29–34} have elucidated physician implicit pro-White bias, which contributes to racial inequities in healthcare and may have played a role in provider imaging decisions in our study.

Interestingly, our study found general EDs had 40% lower odds of advanced imaging compared to the pediatric ED. This may be due to the around-the-clock diagnostic ultrasound services available at the pediatric ED. Further, the ease of obtaining this imaging modality may lower the provider-ordering threshold.³⁵ Although general EDs were less likely to perform advanced imaging, in cases where advanced imaging was utilized, we found these EDs were much more likely to perform an isolated CT. These findings may be the result of system-level factors that hinder or even preclude the use of an “ultrasound first” approach. Specifically, US is operator-dependent, with appendiceal visualization rates varying widely from 22%–98%^{36–40} and given that the majority of examinations in general EDs are performed on adult patients, it is possible that there is less accuracy and more technician discomfort with pediatric exams which would effect physician ordering practices. This notion is supported by our findings that adolescents treated at general EDs are less likely to have a CT as the primary imaging modality compared to younger patients. Our finding of higher odds of isolated CT imaging at low pediatric volume EDs further supports this notion. US availability, which may vary across hospitals³⁵, is also likely a factor in our study. In particular, rural hospitals may not have the ability to obtain US imaging around-

the-clock, and this may explain why these facilities were more likely to use CT as the primary imaging modality.

Physician-level factors likely also played a role in our findings. CT has superior accuracy compared to US and a preference for CT may indicate risk (of misdiagnosis) aversion by general emergency physicians.⁴¹ In addition, physicians may not be willing (or able) to tolerate the potential increase in lengths of stay associated with equivocal US results, in which the appendix is not visualized. In these cases, depending on the pre-test probability, physicians might order another imaging test (CT), a surgical consultation, and/or admission or transfer for observation, all of which would contribute to length of stay.

In adult patients with abdominal pain, CT is often used to evaluate for the many concerning etiologies⁴², however, with the exception of trauma, CT is uncommonly needed as the primary modality in the evaluation of pediatric patients.^{11,12} Hence, “Ultrasound First” is the recommended approach for the evaluation of pediatric patients with abdominal pain.^{5,12,43,44} Regardless of the reasons our data suggest that pediatric patients with abdominal pain are being evaluated in general EDs in much the same fashion as adults and given their increased radiosensitivity⁴⁵, indicates a need for improvement in the radiologic evaluation of these patients.⁴⁶

Mechanisms to optimize imaging strategies and decisions for pediatric patients deserve further evaluation and scrutiny. The limitations of US, such as availability and operator-dependence, deserve attention at the individual facility level and emergency physicians should advocate for improved US services for pediatric patients, as appropriate. Standardized clinical practice guidelines have been shown to reduce CT use while maintaining diagnostic accuracy.^{35,43,44} Several studies have investigated the use of non- and less-radiating alternatives to traditional CT imaging for pediatric appendicitis. For example, a recent study evaluated the use of MRI compared to CT after an equivocal US result and showed no difference in time to surgery, negative appendectomy rate, perforation, or length of stay.⁴⁷ However, the availability of MRI use in this scenario is a limitation for many EDs. Several other studies evaluated the use of a focused right lower quadrant CT in lieu of or following an equivocal US, but have had conflicting results in the sensitivity and specificity of the focused right lower quadrant CT.^{48–52} A final approach is in cases when decisions regarding transfer to a pediatric center have been made regardless of imaging findings (i.e. for pain management, hydration, parent/guardian request). In these cases it may be appropriate to forgo imaging and transfer to a pediatric center in order to perform advanced imaging studies.

Our study has certain limitations. First, our study used administrative data and therefore lacked clinical variables, such as measures of severity of illness. However, we limited our population to those visits resulting in discharge in order to assess a more homogenous, lower acuity population of patients with abdominal pain. Nonetheless, there may have been unmeasured confounders related to the decision to obtain imaging. The imaging data did not specify the exact indication for the radiologic test, and in some cases, the CT (or US) performed at the time of the visit may have been the more appropriate test. Our study, however, was not designed to evaluate appropriateness of imaging; rather, we sought to

explore variation in resource utilization across EDs. Additionally, visits with both US and CT imaging were not included in the isolated CT group; however, it is possible that the US was done to evaluate for ovarian pathology, specifically, and the CT to evaluate for appendicitis, which would be inconsistent with an “ultrasound-first” approach to the evaluation of appendicitis. This scenario would result in our underestimating actual CT practices. Also, given the retrospective nature of the data extraction, previous visits to facilities outside of the 16 ED network may not be reported. 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.

5. Conclusions

There are racial/ethnic and insurance disparities in advanced imaging use for pediatric visits for abdominal pain. General EDs are less likely than pediatric EDs to use advanced imaging overall, however, are more reliant on CT rather than US when imaging is utilized. Our findings highlight the need for increased attention to current ED imaging practices in an effort to reduce disparities in care and improve the use of “ultrasound first” in the evaluation of pediatric patients with abdominal pain.

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Abbreviations

CT	Computed Tomography
CI	Confidence Interval
ED	Emergency Department
OR	Odds ratio
US	Ultrasound

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Figure.
Flow Diagram of Study Cohort

Table 1

Patient and visit characteristics.

	All EDs n (%)	General EDs n (%)	Pediatric ED n (%)
Patient Characteristics	(N=17,540 patients)	(N=10,114 patients)	(N=7,426 patients)
Age			
< 3 years	1,042 (5.9)	362 (3.6)	680 (9.2)
3–11 years	7,485 (42.7)	3257 (32.2)	4228 (56.9)
12–18 years	9,013 (51.4)	6495 (64.2)	2518 (33.9)
Sex: Female	10,749 (61.3)	6,670 (65.9)	4079 (54.9)
Race			
White/non-Hispanic	12,498 (71.3)	6,989 (69.1)	5509 (74.2)
Black	4,396 (25.1)	2,731 (27.0)	1665 (22.4)
Other	646 (3.7)	394 (3.9)	252 (3.4)
Insurance			
Private	10,255 (58.5)	5,350 (52.9)	4905
Medicaid	6,421 (36.6)	4,083 (40.4)	2338
Self-pay	842 (4.8)	663 (6.6)	179
Missing	22 (0.13)	18 (0.18)	4 (0.05)
Comorbidity [†]	176 (1.0)	88 (0.9)	88 (1.2)
Visit Characteristics	(N=21,152 visits)	(N=12,437 visits)	(N=8,715 visits)
Academic ED	10,948 (51.8)	2,233 (18.0)	N/A
Pediatric Volume			
Low	6,607 (53.1)	6,607 (53.1)	N/A
High	5,830 (46.9)	5,830 (46.9)	N/A
Metropolitan location			
Large Urban	17,189 (81.3)	8,474 (68.1)	N/A
Small Urban	2,524 (11.9)	2,524 (20.3)	N/A
Rural	1,439 (6.8)	1,439 (11.6)	N/A
Repeat Visits	517 (2.4)	239 (1.9)	278 (3.2)
Discharge Diagnosis			
Abdominal pain, not otherwise specified	5073 (24.0)	2941 (23.6)	2132 (24.5)
Constipation	3311 (15.7)	1004 (8.1)	2307 (26.7)
Urinary tract infection	1307 (6.2)	1026 (8.2)	281 (3.2)
Nausea/vomiting	1310 (6.2)	750 (6.0)	560 (6.4)
Diarrhea	1138 (5.4)	286 (2.3)	852 (9.8)
Gastroenteritis	854 (4.0)	801 (6.4)	53 (0.6)
Viral infection	626 (3.0)	409 (3.3)	217 (2.5)
Menstrual /female genital organ-related	603 (2.9)	552 (4.4)	51 (0.6)
Acute gastritis	572 (2.7)	399 (3.2)	173 (2.0)

	All EDs n (%)	General EDs n (%)	Pediatric ED n (%)
Ovarian pathology	417 (2.0)	359 (2.9)	58 (0.7)
Pelvic inflammatory disease/ cervicitis/vaginitis	413 (2.0)	374 (3.0)	39 (0.4)
Fever	405 (1.9)	231 (1.9)	174 (2.0)
Pharyngitis	387 (1.8)	267 (2.1)	120 (1.4)
Gastroesophageal reflux	347 (1.6)	174 (1.4)	173 (2.0)
Upper respiratory infection	308 (1.5)	246 (2.0)	62 (0.7)
Other *	2141 (10.1)	916 (7.4)	1225 (14.1)
Missing	273 (1.3)	106 (0.9)	167 (1.9)

[†]Comorbidities include Crohn's Disease, Ulcerative Colitis, transplant history and post-operative status.

*"Other" diagnoses are those responsible for <1% of the visit cohort for all EDs and include but are not limited to: headache, otitis media, renal stone, pneumonia, chest pain, dehydration, and functional digestive disorders.

Not Applicable = NA

Table 2

Factors associated with any advanced imaging among visits to all EDs

Characteristics	All EDs (n=21,152)		
	Advanced Imaging (n=6,273)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio [†] (95%CI)
Age			
<3 yrs	285 (4.5%)	Reference	Reference
3–11 yrs	1,768 (28.2%)	0.7 (0.6–0.9)	0.6 (0.5–0.8)
12–18 yrs	4,220 (67.3%)	1.6 (1.4–1.9)	1.8 (1.5–2.1)
Gender			
Female	4,099 (65.3%)	Reference	Reference
Male	2,174 (34.7%)	0.9 (0.8–1.0)	1.0 (0.9–1.1)
Race			
White/non-Hispanic	5,094 (81.2%)	Reference	Reference
Black	1,002 (16.0%)	0.4 (0.3–0.5)	0.4 (0.4–0.5)
Other	177 (2.8%)	0.6 (0.5–0.8)	0.7 (0.5–0.9)
Insurance [^]			
Private	4,258 (67.9%)	Reference	Reference
Medicaid	1,773 (28.3%)	0.5 (0.4–0.6)	0.6 (0.5–0.7)
Self-Pay	232 (3.7%)	0.5 (0.4–0.7)	0.6 (0.5–0.7)
Comorbidity			
No	6,182 (98.5%)	Reference	Reference
Yes	91 (1.5%)	1.4 (1.0–1.9)	1.1 (0.8–1.5)
Repeat Visit			
No	6,076 (96.9%)	Reference	---
Yes	197 (3.1%)	1.5 (1.2–1.8)	---
Academic Hospital			
No	3,127 (50.0%)	Reference	Reference
Yes	3,146 (50.2%)	0.9 (0.8–1.0)	0.7 (0.6–0.8)
Hospital Type			
Pediatric	2,638 (42.1%)	Reference	Reference
General	3,635 (57.9%)	0.9 (0.8–1.1)	0.6 (0.5–0.7)
Pediatric Volume [*]			
High	1,698 (46.7%)	Reference	---
Low	1,937 (53.3%)	1.0 (0.9–1.1)	---
Location			
Large Urban	5,056 (80.1%)	Reference	---
Small Urban	779 (12.4%)	1.0 (0.9–1.2)	---
Rural	438 (7.0%)	1.0 (0.9–1.2)	---

[†] Adjusted Odds Ratio listed only for factors significant on univariate analysis ($p < 0.2$).

[^] Insurance information was missing for 10 visits with advanced imaging.

^{*} Pediatric volume number and percentages for general EDs only (advanced imaging N=3635) as there is only 1 pediatric ED

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Table 3
Factors associated with CT use, alone, among visits with advanced imaging to the pediatric ED and general EDs.

Patient Characteristics	Pediatric ED (N=2,367)			General EDs (N=3,621)		
	CT (N=83) n(%)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio [†] (95% CI)	CT (N=2,751) [‡] n(%)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio [†] (95% CI)
Age						
3–11 yrs	24 (28.9)	Reference	Reference	543 (19.7)	Reference	Reference
12–18 yrs	59 (71.1)	2.3 (1.4–3.8)	2.9 (1.7–4.9)	2,208 (80.3)	0.5 (0.3–0.6)	0.7 (0.5–0.9)
Gender						
Female	45 (54.2)	Reference	Reference	1,773 (64.4)	Reference	Reference
Male	38 (45.8)	1.4 (0.9–2.2)	1.9 (1.1–3.0)	978 (35.6)	3.1 (2.5–3.9)	2.9 (2.3–3.6)
Race						
White/non-Hispanic	75 (90.4)	Reference	Reference	2,233 (81.2)	Reference	Reference
Black	6 (7.2)	0.4 (0.1–1.1)	0.5 (0.2–1.2)	441 (16.0)	0.8 (0.6–1.0)	0.9 (0.7–1.2)
Other	2 (2.4)	0.8 (0.1–3.2)	1.0 (0.2–4.2)	77 (2.8)	1.1 (0.6–1.8)	1.2 (0.7–2.0)
Insurance [‡]						
Private	69 (83.1)	Reference	Reference	1,750 (63.6)	Reference	Reference
Medicaid	12 (14.5)	0.6 (0.2–1.1)	0.6 (0.3–1.2)	860 (31.3)	1.0 (0.8–1.3)	1.1 (0.9–1.4)
Self-Pay	1 (1.2)	0.9 (0.1–6.9)	1.2 (0.1–9.0)	137 (5.0)	0.7 (0.5–1.0)	0.8 (0.5–1.2)
Comorbidity						
No	75 (90.4)	Reference	Reference	2,711 (98.5)	Reference	NA
Yes	8 (9.6)	7.8 (3.4–17.5)	7.8 (3.2–18.6)	40 (1.5)	1.3 (0.6–2.6)	NA
Repeat Visit						
No	71 (85.5)	Reference	Reference	2,692 (97.9)	Reference	Reference
Yes	12 (14.5)	3.9 (2.0–7.5)	4.3 (2.1–8.6)	59 (2.1)	0.7 (0.4–1.1)	0.7 (0.4–1.2)
Academic Hospital [*]						
No	NA	NA	NA	2,369 (86.1)	Reference	NA
Yes	NA	NA	NA	382 (13.9)	1.0 (0.7–1.2)	NA

Patient Characteristics	Pediatric ED (N=2,367)			General EDs (N=3,621)		
	CT (N=83) n(%)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio [†] (95% CI)	CT (N=2,751) [‡] n(%)	Unadjusted Odds Ratio (95% CI)	Adjusted Odds Ratio [‡] (95% CI)
Pediatric Volume [*]						
High	NA	NA	NA	1,391 (50.6)	Reference	Reference
Low	NA	NA	NA	1,360 (49.4)	0.5 (0.4–0.7)	1.8 (1.5–2.2)
Location [*]						
Large Urban	NA	NA	NA	1,789 (65.0)	Reference	Reference
Small Urban	NA	NA	NA	643 (23.4)	1.7 (1.3–2.2)	1.2 (0.9–1.6)
Rural	NA	NA	NA	319 (11.6)	1.0 (0.7–1.3)	1.8 (1.3–2.5)

[†] Adjusted Odds Ratio listed only for factors significant on univariate analysis (p<0.2).

[‡] N excludes the 8 visits by patients <3 years who only received CT. Additionally, there were no visits by patients <3 years who only received a CT at the pediatric ED.

Given the small number of children <3 years with CT imaging, this age group (N=285) could not be included in these regression models

[‡] Insurance information was missing for 5 visits (1 at the pediatric ED, 4 at the general EDs) with isolated CT use

^{*} Academic hospital status, pediatric volume number and percentages are for general EDs only as there is only 1 pediatric ED which is academic, has 100% pediatric volume, and is located in a large urban area.

NA = Not applicable