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Radiological Imaging of Patients with Suspected Urinary Tract Stones: National Trends, Diagnoses, and Predictors

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Abstract

Objectives—Overutilization of computed tomography (CT) is a growing public health concern due to increasing health care costs and exposure to radiation; these must be weighed against the potential benefits of CT for improving diagnoses and treatment plans. The objective of this study was to determine the national trends of CT and ultrasound (US) utilization for assessment of suspected urolithiasis in emergency departments (EDs), and if these trends are accompanied by changes in diagnosis rates for urolithiasis or other significant disorders, and hospitalization rates.

Methods—This was a retrospective cross-sectional analysis of ED visits from the National Hospital Ambulatory Medical Care Survey (NHAMCS) between 1996 and 2007. The authors determined the proportion of patient visits for flank or kidney pain receiving CT or US testing, and calculated the diagnosis and hospitalization rates for urolithiasis and other significant disorders. Patient-specific and hospital-level variables associated with the use of CT were examined.

Results—Utilization of CT to assess patients with suspected urolithiasis increased from 4.0% to 42.5% over the study period (p-value < 0.001). In contrast, the use of US remained low, at about 5%, until it decreased beginning in 2005 to 2007 to 2.4% (p-value = 0.01). The proportion of patients diagnosed with urolithiasis (approximately 18%, p-value = 0.55), other significant diagnoses (p-values > 0.05), and admitted to the hospital (approximately 11%, p-value = 0.49) did not change significantly. The following characteristics were associated with a higher likelihood of receiving a CT scan: male sex (odd ratio [OR] = 1.83, 95% confidence interval [CI] = 1.22 to 2.77), patients presenting with severe pain (OR = 2.96, 95% CI = 1.14 to 7.65), and those triaged in 15 minutes or less (OR = 2.41, 95% CI = 1.08 to 5.37). CT utilization was lower for patients presenting to rural hospitals (vs. urban areas) (OR = 0.34, 95% CI = 0.19 to 0.61), and those managed by a non-physician health care provider (OR = 0.19, 95% CI = 0.07 to 0.53).

Conclusions—From 1996 to 2007, there was a 10-fold increase in the utilization of CT scan for patients with suspected kidney stone without an associated change in the proportion of diagnosis of kidney stone, diagnosis of significant alternate diagnoses, or admission to the hospital.

INTRODUCTION

Urinary tract stones affect approximately 5% of the U.S. population,[1] with an overall incidence of about 1.0 to 2.5 per 1,000 persons per year in women,[2–5] and 1.4 to 3.8 per

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1,000 persons per year in men.[2,6,7] Many patients with stones develop renal colic and seek urgent care for pain relief.

In the United States, the American College of Radiology has recommended computed tomography (CT) as the first line of investigation for suspected urinary tract stones in the adult population (with the notable exception of pregnant women).[8] However, in some European and South American countries, ultrasound (US) is also considered an acceptable first line option.[9,10] This is particularly true for patients who have recurring episodes of renal colic, as repeat CT scans seldom change management.[11]

The main advantage of CT scan over US is its superior accuracy for detection of stones and alternate diagnoses that could account for the clinical presentation of the patient.[11–13] On the other hand, the main advantage of US over CT is lack of radiation exposure. Repeat CT scans in patients with known urolithiasis result in exposure to effective doses equivalent to that of 200 to 1,500 chest radiographs.[14] This is particularly salient given increased attention to the potential deleterious effects of excessive medical radiation.[15,16] The major disadvantage of US is its operator-dependency and decreased accuracy compared with CT.[17–20] US has poor sensitivity (24–60%), but high specificity (79–100%) for detection of urinary tract stones. It is important to note, though, that more than half of renal calculi missed by US are smaller than 5 mm, many measuring less than 3 mm,[18,20] a size that many consider clinically insignificant.[21,22] Finally, it is unknown if the improved detection of stones by CT is associated with improved outcomes for patients.

Considering the potential public health concerns related to cumulative patient radiation exposure, and the large and relatively young population affected by urinary tract stones, we conducted this study to determine: 1) the national trends and predictors of CT and US utilization for assessment of suspected urinary tract stones in emergency departments (EDs), and 2) if trends in imaging utilization have resulted in changes in the diagnosis rates of urinary tract stones and other significant disorders.

METHODS

Study Design

This was a retrospective cross-sectional analysis of ED visits from the National Hospital Ambulatory Medical Care Survey (NHAMCS) between 1996 and 2007.[23] This study received exempt certification from our institutional review board.

Study Setting and Population

The NHAMCS data were aggregated data into three-year intervals to provide a sufficient sample size for analyzing trends in ED visits for suspected urolithiasis. The NHAMCS is a publicly available sample of ED visits in the United States. Data are collected in non-institutional general and short-stay hospitals (excluding federal, military, and Veterans Administration hospitals) of the 50 states and the District of Columbia, using a four-stage probability sample. First, geographic units are sampled. This is followed by sampling of hospitals within geographic units and then ED within hospitals. In the fourth step, patients are sampled. For each hospital, data are collected during a random four-week period. A detailed description of the methods is provided by the National Center for Health Statistics.[23] Up to three coded “reasons for visit” and up to three International Classification of Diseases–Clinical Modification (ICD-9 CM) diagnoses are described in the NHAMCS. For the period of study, the NHAMCS survey includes 368,680 actual visits, which extrapolate to an estimated 1,289,500,000 ED visits.

For this study, we restricted the study population to non-pregnant adult patients (age ≥ 18 years) with the primary reason for visit of flank pain or kidney pain (based on reason for visit codes of 1055.2 and 1670.1, respectively). These symptoms were chosen because they are commonly associated with urinary tract stones, and they often lead to imaging evaluation in the ED. We opted for excluding pregnant women because CT scans are generally discouraged during pregnancy.

Study Protocol

The main outcome of this study was the proportion of visits for flank or kidney pain receiving CT and/or US testing. We also examined specific diagnosis rates and hospital admission rates as secondary outcomes. In the NHAMCS, magnetic resonance imaging (MRI) was grouped together with CT from 2001 until 2004. MRI, however, is rarely used in the ED for evaluation of abdominal conditions, and particularly not for assessment of patients suspected urolithiasis. To confirm this hypothesis, we verified the proportion of MRIs obtained in our study population in years in which CT and MRI were coded separately (1996 to 1999, and 2005 to 2007). MRI represented only 0.1% of the total number of imaging studies performed on adult ED patients with flank or kidney pain. US has always been coded separately from CT.

An ED diagnosis of urolithiasis was based on the primary diagnosis of ICD-9 CM codes 592.x (calculus of kidney and ureter) or 594.x (calculus of lower urinary tract). No patients in our cohort received a primary diagnosis of ICD-9 CM code 788.8 (renal colic). We also examined other primary diagnoses based on ICD-9 CM codes. Because many alternative diagnoses are rare, these were grouped into the following categories: acute infectious/ inflammatory processes (including pleural effusion), acute cardiovascular events, and malignant neoplasms. We opted for creating a classification system based on broad pathophysiologic processes to allow for improved interpretability of results. The ICD9 codes for each group are listed in Data Supplement 1. Two authors (ACW, RW) independently classified all alternative diagnoses into one of these categories, and a third author (RG) resolved discrepancies. The inter-rater agreement of our classification of alternative diagnoses was 81.9%, for a kappa of 0.76 (95% CI = 0.72 to 0.79; substantial agreement).[24,25]

We examined the variation of CT utilization during the most recent three-year period. Predictor variables were selected based on previous literature showing that the proposed variables are likely associated with different rates of imaging utilization.[26,27]

We evaluated patient characteristics of age (18–44, 45–64, and ≥65 years), sex, race/ ethnicity, insurance, presenting level of pain (mild, moderate, severe), and triage level, defined as the immediacy with which patient should be seen determined by triage nurse (< 15 min, 15–60 min, 1–2 hours, 2–24 hours). Race and ethnicity were combined into five categories: non-Hispanic white, non-Hispanic black, Hispanic, Asian, and other. Insurance was categorized as private insurance, Medicaid, Medicare, uninsured (self-pay and charity/ no charge), and other (e.g., worker's compensation, Veteran's Administration, CHAMPUS, or Tricare). The age categories we used are standard groupings from National Center for Health Statistics, and represent broad categories of patients as a function of age, likelihood of comorbidities, and work/insurance status.

We analyzed the following hospital-level variables: U.S. geographical region, as defined by the U.S. Census Bureau (Northeast, Midwest, South, and West); urban vs. rural institution; teaching vs. non-teaching hospital; and safety-net vs. non safety-net hospital. An institution was considered to be urban if present within a Standard Metropolitan Statistical Area (SMSA). A SMSA is defined as a federally designated geographical unit consisting of an urbanized area with a central city of at least 50,000 residents. The safety-net hospital status was determined based on the percentage of visits at each hospital in which the expected method of payment was either charity/no charge, self-pay, or Medicaid. Hospitals with 50% or more of patients falling in these payment categories were considered predominantly safety-net providers.[28,29] We arbitrarily defined a teaching hospital as an institution in which a resident or intern saw 25% or more of the patients.[29] We also examined the type of provider (physician, non physician clinician, resident/intern, other) for each visit.

Data Analysis

Considering the sampling structure of NHAMCS, means and proportions were calculated using visit weights provided by NHAMCS to describe the study population, and to generate national estimates of imaging utilization and diagnosis rates over time. Of note, any subgroups with fewer than 30 observations in the data set are considered unreliable for generating national estimates.

Multivariate logistic regression analysis was performed to investigate independent predictors of imaging utilization (CT vs. other) using data obtained from the last period of our study (2005 to 2007). We chose to limit this analysis to the last three years of the study in order to limit our results to current practice patterns. Binomial variables were analyzed by comparing point estimates, and categorical variables were analyzed using a weighted chi-square analysis. This was a fixed model based on a priori hypotheses about conditions that could influence test ordering (e.g. insurance status) and/or be associated with urolithiasis (e.g. sex).[27,30–32] All adjusted odds ratios (ORs) are presented with 95% CIs. Reference groups are noted in the text and tables.

A two-tailed *P* value of ≤ 0.05 was considered statistically significant. All analyses were performed using SAS statistical software (version 9.2, SAS Institute, Cary, NC) and SUDAAN, version 10.0 (Research Triangle Park, NC), to account for complex survey design.

RESULTS

During the study period, there were 3,818 actual sampled ED visits for flank or kidney pain by adults present in the NHAMCS, which represents an estimated 14.3 million visits (95% CI = 12.9 to 15.8) across the United States. Approximately 19% of these patients received a diagnosis of urolithiasis.

Our results show a substantial and persistent increase in the utilization of CT to assess patients with suspected urolithiasis, rising from 4.0% (95% CI = 2.0% to 6.1%) to 42.5% (95% CI = 37.5% to 47.4%). In contrast, the use of US was relatively low in 1996, and did not change until it decreased beginning in 2005 through 2007. Despite the large increase in CT use, the proportion of patients with a principal diagnosis of urolithiasis did not change. In addition, there was no change in the proportion of patients admitted to the hospital following imaging, remaining stable at about 10% to 11% for overall admissions (Table 1). Admissions of patients with urolithiasis also appeared to remain stable over time, but were too few to allow for reliable estimates.

Table 2 shows that there was no change in the proportion of ED patients with flank or kidney pain receiving a diagnosis of acute infectious or inflammatory processes. In addition, very few patients in the study population presented with an acute cardiovascular event or malignant neoplasms. These last two outcomes were so uncommon that estimates were unstable (ranging from 0.1% to 0.8%).

Multivariate analysis - patient characteristics

The multivariate analysis (Table 3) shows that CT utilization was higher for patients with severe pain (OR = 2.96, 95% CI = 1.14 to 7.65) and for those with a triage time of 15 minutes or less (OR = 2.41, 95% CI = 1.08 to 5.37). Similarly, men were more likely than women to receive a CT scan (OR = 1.83, 95% CI = 1.22 to 2.77). Patients of “other” race/ ethnicity, which excluded non-Hispanic black and Hispanic, were less likely to get a CT when compared to non-Hispanic whites (OR = 0.48, 95% CI = 0.23 to 0.98). Insurance type did not appear to be associated with differences in the likelihood of receiving a CT scan.

Multivariate analysis - hospital characteristics

Computed tomography utilization was lower for patients presenting to a rural hospitals (vs. urban areas) (OR = 0.34, 95% CI = 0.19 to 0.61) or those managed by a non-physician health care provider (OR = 0.19, 95% CI = 0.07 to 0.53). Patients seen in the South (OR = 0.50, 95% CI = 0.29 to 0.85) and West (OR = 0.38, 95% CI = 0.20 to 0.74) regions of the country were also less likely to receive a CT scan when compared to patients visiting EDs in the Northeast. We did not find an association between CT utilization and visits to either safety-net EDs or teaching hospitals.

DISCUSSION

We used the NHMACS survey to examine trends in radiological testing rates in patients presenting to EDs with flank or kidney pain. Over the study period, there was a marked rise in the utilization of CT scans; specifically, we found a greater than 10-fold increase from 1996–1998 through 2005–2007. During the same period of time, the proportion of patients who did not receive imaging and the proportion receiving US each decreased by half.

We can only hypothesize why US utilization has decreased over time, but this is likely a multifactorial process, including 1) the superior accuracy of CT scan, 2) resource availability, and 3) increased clinician intolerance for diagnostic uncertainty. CT scan has been shown to have near perfect accuracy, detecting even minuscule stones. Although the results of our study suggest otherwise, prior studies have found CT better than US for the diagnosis of alternate causes of symptoms. In many institutions, US are only available during certain hours. CT image acquisition is faster, and scanners are often continuously available in the ED. Finally, it has been shown that high-risk specialist physicians, such as emergency physicians, have identified ordering diagnostic imaging as a common act of defensive medicine.[33,34] Other factors (e.g., patient expectations, increasing radiologist preference for CT rather than US) may have also played a role in the decrease utilization of US in the United States.

Despite the superiority in accuracy of CT scan (vs. US) for urinary tract stones as well as significant thoracic and abdominal alternate diagnoses, we found essentially no change in the proportion of patients diagnosed with kidney stone, proportion of patients admitted to the hospital following imaging, or proportion of patients diagnosed with an alternative acute infectious or inflammatory diagnosis. These findings suggest that the increased utilization of CT scan in patients with suspected urolithiasis may not have had a significant effect on diagnosis or management of urolithiasis.

Because of the evidence suggesting that CT scans have not had a major clinical effect on the evaluation or management of adults with suspected urolithiasis, we explored whether non-clinical factors might be contributing or accounting for increased CT utilization rates. We found that there were a number of predictors for CT utilization in 2005 through 2007, including patient (male sex, severe acuity of pain, time in triage, other race/ethnicity) and hospital (northeast hospitals, urban hospitals, non-physician providers) characteristics. Some of these findings are expected; for example, acuity of pain and time in triage are patient factors that signal the need for and an increased urgency to correctly assess patients who are more ill-appearing. It is unclear why men were more likely than women to get a CT scan, but it is not uncommon to prefer an US in lieu of a CT scan for female patients, in particular, those of reproductive age. While for men the gonads can be easily shielded during acquisition of a CT scan, for women the ovaries are often directly exposed to the field of the radiation. Our results, however, showed that this difference persisted after controlling for age. Patients of other race/ethnicity were less likely to have a CT scan, but because this is a very heterogeneous group, it is difficult to find an explanation that is suitable for all patients within this category.

We attempted to explain differences in imaging acquisition based on hospital characteristics and geography given previous literature suggesting such variations. It is possible that urban EDs serve as referral centers and therefore provide service to more patients with more severe clinical findings, triggering a higher number of CT scans. Kirsch et al., in a study that investigated imaging utilization in EDs of 41 states, found that patients visiting higher-volume EDs were more likely to have CT scans.[35] Another potential explanation is that urban centers have a greater number of EDs with CT scanners, and a greater number of scanners per ED, compared to rural institutions.[36,37] Even after controlling for these factors, however, significant geographic variation in use of noninvasive diagnostic imaging, as shown in other studies, still persists.[38,39]

In the seminal study published in 1995, Smith et al. showed the superiority of CT scan for the identification of ureteric stones (comparing it to intravenous urography).[40] Since this time, CT scan has essentially replaced intravenous urography in patients with suspected kidney stone. In several subsequent studies, CT scan has also been shown to be more accurate than US in the detection of kidney stone, especially with small ones.[17,18,41] However, there is a dearth of evidence supporting the use of CT scan over US in terms of clinical efficacy or patient safety. This is in the context of growing evidence that CT scan utilization results in exposure to ionizing radiation (a known carcinogen),[42–45] increased detection of incidental findings,[46] and increased health care costs.

Our results are aligned with those reported by Pines.[27] In this recent study, it was shown that the utilization of imaging modalities to assess patients with abdominal pain in EDs has increased over time, in particular the use of CT. That study, however, excluded patients with urinary tract stones. One single-institution Canadian investigation that studied patients with suspected urolithiasis also suggested an increase in use of CT, which was not accompanied by a significant change in the rates of true renal stone disease or alternate diagnoses.[47] This study, however, did not address trends in utilization of alternative modalities such as US.

Our findings contribute to the literature by showing that the conventional argument for the choice of CT over US in the evaluation of flank or kidney pain in the ED is not supported by any evidence that increased use of CT scans have changed diagnosis or treatment rates. Some health care providers may assert that CT utilization is less critical for ruling-in nephrolithiasis and more critical for ruling-out dangerous alternative diagnoses. However, our results also do not support this contention; the percentage of alternative acute infectious or inflammatory diagnoses have not increased in parallel with CT utilization. Similarly, acute cardiovascular events and malignant neoplasms were uncommonly seen in our study population. These findings suggest that, at least if measured by alternative diagnoses or hospital admissions, CT imaging has not improved either of those goals.

LIMITATIONS

First, as the NHAMCS estimates are obtained using a staged sampling strategy, it is conceivable that the numbers reported may not represent true values in the population. It is very difficult to validate the NHAMCS data set, but to minimize the possibility of error, the survey follows a rigorous methodological structure. Second, as NHAMCS does not contain individual patient identifiers, it is not possible to determine if increases in imaging utilization are not due to repeated visits by individual patients. However, it is unlikely that a proportion of recurring patients large enough to explain the trends identified would visit the same ED during the short reporting period and would be randomly selected for inclusion in the study sample. In addition, our results suggest that a shift has occurred from US and/or no imaging to CT scan investigation.

We are unable to determine if the same patient visited numerous EDs in the area for the same complaint; the design of the NHAMCS, however, seeks to minimize oversampling in any single geographic region. Third, NHAMCS does not record the specific anatomical region examined by the imaging study, and we cannot be certain that all CT scans recorded for flank or kidney pain evaluation were abdominal scans; some could have been chest or head CTs. Fourth, it is possible that the diagnosis of urolithiasis is overestimated in patients who do not undergo imaging (e.g., muscle strain incorrectly diagnosed as urolithiasis), potentially affecting our results. However, in order to accept this fact as an explanation for the lack of difference in the proportion of patients diagnosed with stones over time, one would have to assume the prevalence of urolithiasis has increased over time at the same rate that our ability to detect stones has improved, which would be highly unlikely. This is illustrated when one compares the proportion of patients receiving the diagnosis in the first (1996 through 1998) to the second time periods (1999 through 2001). In 1996 through 1998, only 4% of patients had a CT scan (greatest potential for overestimation of urolithiasis). In 1999 through 2001, 18.3% of patients had a CT scan, a 4.5 fold increase. The proportion of patients diagnosed with kidney stones, however, remained stable (17.8% to 18.1%). If overestimation of urolithiasis in the first time period were to explain this finding, one would expect that at least 10% of patients were falsely diagnosed with urolithiasis between 1996 and 1998, and that the prevalence of the disease increased from about 8% to 18% between the first two time periods, as CT is over 90% sensitive for the detection of stones.

Finally, other well-known limitations of an administrative dataset are present. These include potentially lower accuracy of reason for visit, ICD-9 diagnoses, and procedure codes. To minimize this possibility, the U.S. Census Bureau field agents perform quality control reviews as the data are collected. NHAMCS may include inaccuracies in self-reported data fields, such as insurance status. However, we would not expect differential misreporting or misclassification to occur over time to bias our results. For the most part, this report provides a useful starting point of current imaging rates and a reference for further discussion.

CONCLUSIONS

Based on data from the NHAMCS survey over the time period of 1996 to 2007, there has been a 10-fold increase in the utilization of computed tomography scan for patients with suspected kidney stone. However, we did not find any appreciable change in the diagnosis of kidney stone, diagnosis of significant alternate diagnoses, or admission to the hospital over the same time period. The choice to utilize CT scan should be weighed against the known risks, particularly radiation exposure.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

NHAMCS ED 1996–2007 adult, non-pregnant visits, with primary reason for visit of flank pain/kidney pain

	1996–1998	1999–2001	2002–2004	2005–2007	p-values
Number of visits	1,629	868	1,176	1,145	-
Estimated visits[ϕ]	2,876,566 [2,418,161 – 3,334,971]	3,635,441 [2,964,892 – 4,305,990]	3,556,561 [3,110,189 – 4,002,933]	4,273,515 [3,490,287 – 5,056,743]	0.07
Imaging utilization[ϕϕ]					
None	2,601,160 (90.4) [2,173,276 – 3,029,044]	2,780,014 (76.5) [2,238,107 – 3,321,921]	2,253,311 (63.4) [1,942,812 – 2,563,810]	2,298,538 (53.8) [1,840,508 – 2,756,568]	<0.001
Ultrasound	153,236 (5.3) [94,291 – 212,181]	160,052 (4.4) [86,901 – 233,203]	163,426 (4.6) [106,929 – 219,923]	103,750 (2.4) [54,088 – 153,412]	0.01
CT	116,177 (4.0) [52,951 – 179,403]	665,344 (18.3) [474,001 – 856,687]	1,096,462 (30.8) [900,650 – 1,292,274]	1,814,727 (42.5) [1,411,353 – 2,218,101]	<0.001
Dx of urolithiasis	513,383 (17.8) [376,393 – 650,373]	657,236 (18.1) [472,228 – 842,244]	694,740 (19.5) [556,505 – 832,975]	812,213 (19.0) [598,736 – 1,025,690]	0.55
Admissions, any Dx	336,328 (11.7) [244,088 – 428,568]	409,503 (11.3) [274,259 – 544,747]	356,796 (10.0) [271,583 – 442,009]	451624 (10.6) [313,787 – 589,461]	0.49

Numbers in parentheses are percentages, numbers in brackets are 95% confidence intervals

CT = computed tomography; Dx = diagnosis; NHAMCS = National Ambulatory Medical Care Survey

[ϕ]Trend test performed on visits with weighted linear regression

[ϕϕ]Trend test based on percentages

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Table 2

Proportion of patients with a primary abdominal or thoracic diagnosis, stratified by diagnoses group; NHAMCS ED 1996–2007 adult, non-pregnant visits, with primary reason for visit of flank pain/kidney pain

		1996–1998 % [95% CI]	1999–2001 % [95% CI]	2002–2004 % [95% CI]	2005–2007 % [95% CI]	p-value $^{\phi}$
Diagnosis	1	17.9 [14.0, 21.7]	18.1 [14.6,21.5]	19.5 [16.5, 22.6]	19.0 [12.8, 25.2]	0.55
Group *	2	6.8 [1.2, 12.4]	9.3 [0.4, 18.1]	6.7 [0.4, 12.9]	6.7 [0, 14.8]	0.46

Group 1: urolithiasis; Group 2: acute infectious/inflammatory processes (including pleural effusion); Group 3: acute cardiovascular event; Group 4: malignant neoplasms

$^{\phi}$Trend test based on percentages

*For any given period, groups of acute cardiovascular events and malignant neoplasms had less than 30 visits (<0.8%), and not considered reliable by the NCHS.

Table 3

Multivariate logistic regression model of CT utilization

	Odds ratio	95% CI
Patient Characteristics		
Age, years		
18–44 (ref)	-	-
45–64	1.43	0.93, 2.21
> 65	0.88	0.32, 2.38
Sex		
Female (ref)		
Male	1.83	1.22, 2.77
Race/ethnicity		
Non Hispanic white (ref)	-	-
Non Hispanic black	0.67	0.38, 1.16
Hispanic	0.84	0.45, 1.58
Other	0.48	0.23, 0.98
Insurance		
Private (ref)	-	-
Medicare	0.73	0.33, 1.63
Medicaid	0.67	0.39, 1.14
Uninsured/self	1.16	0.68, 1.99
Other	0.30	0.07, 1.23
Presenting level of pain		
None	-	-
Mild	2.57	0.99, 6.65
Moderate	1.43	0.54, 3.81
Severe (ref)	2.96	1.14, 7.65
Triage		
<15 minutes (ref)	2.41	1.08, 5.37
15–60 minutes	2.01	1.01, 4.01
1–2 hours	1.91	0.88, 4.13
2–24 hours	-	-
Hospital Characteristics		
Region		
Northeast (ref)		
Midwest	0.71	0.42, 1.19
South	0.50	0.29, 0.85
West	0.38	0.20, 0.74
SMSA		
Rural	0.34	0.19, 0.61
Urban (ref)	-	-
Safety-net hospital		

	Odds ratio	95% CI
Yes	0.68	0.43, 1.07
No (ref)	-	-
Teaching hospital		
Yes	0.64	0.31, 1.31
No (ref)	-	-
Provider type		
Physician (ref)	-	-
Resident	1.38	0.60, 3.20
Other	0.19	0.07, 0.53

NHAMCS ED 2005–2007 adult, non-pregnant visits, with primary reason for visit of flank pain/kidney pain

HNAMCS = National Ambulatory Medical Care Survey; SMSA = Standard Metropolitan Statistical Area