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U.S. Trends in Computed Tomography Use and Diagnoses in Emergency Department Visits by Patients With Symptoms Suggestive of Pulmonary Embolism, 2001–2009

Lisa B. Feng, MPH, **Jesse M. Pines, MD, MBA, MSCE**, **Hussain R. Yusuf, MD, MPH**, and **Scott D. Grosse, PhD**
American Institutes for Research (LBF), Washington, DC; the Department of Emergency Medicine, George Washington University (JMP), Washington, DC; and the Centers for Disease Control and Prevention (HRY, SDG), Atlanta, GA.

Abstract

Objectives—Using computed tomography (CT) to evaluate patients with chest symptoms is common in emergency departments (EDs). This article describes recent trends of CT use in U.S. EDs for patients presenting with symptoms common to acute pulmonary embolism (PE).

Methods—The 2001–2009 National Hospital Ambulatory Medical Care Survey (NHAMCS), a nationally representative survey of U.S. ED encounters, was used for data collection. Patients with at least one of three complaints (chest pain, dyspnea, or hemoptysis) were categorized into the chest symptom study (CSS) group. The yearly increases in CT use for the complaints were tabulated first, then linear regression analysis was used to calculate average rates of increases in CT use between 2001 and 2007, the years where CT use increased, for the overall population and among specific subgroups. The ratios of the number of visits when CT was ordered and there was a target diagnosis relative to the total number of visits with CT in the CSS group (diagnosis/CT ratio) were calculated for PE and pneumonia.

Results—Annual CT rates for the CSS group increased from 2.6% in 2001 to 13.2% in 2007, subsequently leveling off at approximately 12.5% in 2008 and 2009. The average growth rate of CT use for the CSS group was 28.1% (95% confidence interval [CI] = 20.9% to 35.7%) per year between 2001 and 2007. Testing rates for all subgroups increased. The lowest growth rate was among Hispanic patients, whose CT rates grew 14.2% (95% CI = 5.7% to 23.5%) per year. The highest growth rate was in nonurban hospitals, at 43.1% (95% CI = 15.2% to 77.8%) per year. Patients triaged as nonurgent received the fewest CTs, compared to those who should be seen in 2 hours or less. With regard to sources of payment, the self-pay subgroup experienced the highest rate of increase at 35.1% (95% CI = 18.6% to 53.9%). The PE diagnosis/CT ratio from 2002 to 2009 was 2.7% for the CSS group. The pneumonia diagnosis/CT ratio grew from 5.8% in 2002 to 2005 to 7.8% in 2006 to 2009.

Address for correspondence and reprints: Lisa Feng, MPH; lfeng@air.org.

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Conclusions—Computed tomography use in ED visits by patients with chest symptoms increased dramatically from 2001 to 2007 and seems to have leveled off in subsequent years. The low PE diagnosis-to-CT ratio suggests that EDs may need to promote evidence-based use of CT.

Diagnosing pulmonary embolism (PE) in emergency department (ED) patients is challenging because the cardiopulmonary symptoms common to PE can mimic other clinical entities such as pneumonia, respiratory conditions such as asthma, and nonrespiratory conditions such as acute coronary syndrome.[1] D-dimer assays are highly sensitive but poorly specific initial tests for low-risk PE patients and may reduce the need for computed tomography (CT) pulmonary angiography; however, this is not always the case in practice.[2,3] Some physicians rely on CT as an initial test in cases of suspected PE. In addition, testing very low-risk patients with nonspecific D-dimer assays can lead to high rates of false-positive D-dimers, and ultimately negative CT scans. CT is the test of choice to diagnose PE in the ED, but overuse of CT is a concern because it can be associated with a small number of serious adverse events such as contrast-induced nephropathy, reactions to intravenous contrast dye, and radiation-induced cancer.[4–13]

Rates of CT use in U.S. EDs have risen dramatically over the past two decades, from 2.7 million in 1995 to 16.2 million in 2007.[10,14–17] A similar rise has been observed in ED patients with chest pain: in 1995, 1.2% received CTs; the rate increased to 13.7% by 2007.[14] Previous chart-based studies also reported up to 13-fold increases in use of PE-protocol CT scans over several years.[18,19] The benefits of the observed proliferation of CTs on PE care is mixed, however. One study of U.S. EDs found that increases in PE diagnoses did not coincide with increases in CT use, comparing 1997 through 1999 to 2005 through 2007.[20] “Overdiagnosis” is also a concern, as there is evidence of increased diagnosis of low-risk or asymptomatic PE, while absolute deaths have remained the same, resulting in a diminishing case fatality rate for PE.[21,22] Most recently, the American College of Physicians included CT use as an initial test for patients at low risk for PE on a list of low-value practices that should be discouraged.[23] Thorough understanding of these issues is critical during this period of health reform, as the nation is looking for ways to cut costs, reduce waste, and improve quality.

In this study, we explored longitudinal trends in the use of CT scans in U.S. EDs for three PE-related symptoms (chest pain, dyspnea, and hemoptysis) from 2001 through 2009 using a nationally representative sample: the National Hospital Ambulatory Care Survey. Recent studies have explored increases in CT use using national data, but our study is novel in several ways. First, we analyzed national trends in ED CT use beyond 2007, using data from 2008 and 2009. Second, we assessed the proportion of visits with PE diagnoses where CT may have contributed to the diagnostic process; for this we estimated the ratio of the number of visits with CTs and diagnoses, relative to the number of visits with CTs in our chest symptom study (CSS) group (diagnosis/CT ratio). This allowed us to compare the ratio for PE—a diagnosis that is usually sought on CT scans—with pneumonia, a diagnosis that can be captured on plain radiography but is sometimes found on CT in a search for suspected PE.[24]

METHODS

Study Design

This was a retrospective cohort study using the ED component of the National Hospital Ambulatory Medical Care Survey (NHAMCS) from 2001 through 2009. The institutional review board at the George Washington University found that this study was not human subjects research, as all data were from the NHAMCS.

Data Source

The NHAMCS is a nationally representative survey of hospital outpatient encounters in the United States administered by the National Center for Health Statistics, Centers for Disease Control and Prevention. NHAMCS uses a complex design to sample ED visits in noninstitutional general and short-stay hospitals in the 50 states and the District of Columbia, excluding federal, military, and Veterans Administration hospitals. Information collected includes patient demographics; hospital characteristics; times of arrival and seen by physician; expected sources of payment; the patient’s cited reasons for visit (RFV; up to three are recorded); whether selected imaging tests, including CT, were administered; and a principal and up to two additional International Classification of Disease, 9th revision; Clinical Modification (ICD-9-CM) diagnosis codes. Additional details of NHAMCS are described elsewhere.[25]

Inclusion and Exclusion Criteria

Patient visits with one or more RFV involving chest pain (RFV 1050.0–3), dyspnea (RFV 1415.0, 1420.0, 1430.0–2), or hemoptysis (RFV 1470.1) were categorized as the CSS group. The CSS group broadly captures possible PE cases. Patient visits for all other complaints were regarded as the non-CSS comparison group.

Primary outcomes of interest were CT use among ED visits for the two visit groups. Over the study period, there were some differences in the way that CT was coded in NHAMCS. From 2001 through 2004, CT and magnetic resonance imaging (MRI) were reported together; however, we assumed that CTs and MRIs for the CSS group were CTs. This assumption is likely valid in most cases because in 2005 and 2006 there were 12 and 18 MRI observations in our cohort, compared to 356 and 415 CTs, respectively. From 2007 through 2009, four categories of CT were available, “any [unspecified anatomic location] CT,” “CT head,” “CT other than head,” and “unknown.” Of all CTs from 2007 through 2009 associated with chest symptoms, approximately 50% were coded as any CT, 30% CT other than head, 13% CT head, and 5% unknown. There were no specific variables indicating chest or pulmonary CTs.

We may have overestimated CT use prior to 2007 as we excluded head CTs from 2007 through 2009. We also assumed all other CTs associated with the CSS group were chest CT. This is an assumption that has important implications for the analysis because we cannot determine whether CTs were used to diagnose or rule out PE, because NHAMCS does not report the test indication for CTs. We included all CTs to calculate the CT rate for the comparison group.

Variables

Emergency department visits were grouped by patient and hospital characteristics to enable stratified analysis of CT use. Visit categories by patient age group included <18, 18 through 39, 40 through 64, and ≥65 years. Race and ethnicity categories were non-Hispanic white, non-Hispanic black, and Hispanic; other groups were not reported separately due to small numbers. Expected payer statuses were private insurance, Medicare, Medicaid, and self-pay. Patient sex and the immediacy of the visit were also variables of interest. Hospital and regional characteristics included location in an urban setting and hospital ownership.

Visits with any diagnosis of PE were identified using ICD-9-CM codes 415.11 or 415.19. Diagnosis of pneumonia was captured using ICD-9-CM codes 480.9, 481.x, 482.9, and 486.x. Other potential alternative diagnoses that may be found on chest CT, such as aortic aneurysm or dissection, had insufficient numbers of observations to permit reliable estimates; therefore, we did not include them as alternative diagnoses that may have been detected on CT during the visit.

Data Analysis

Estimates were calculated using the weighting and sample design variables in NHAMCS. Annual estimates of total ED visits and percentage of visits with one or more of the complaints were derived. We calculated the percentage of CT use associated with visits with these complaints overall and stratified by patient, hospital, and geographic subgroups.

To assess the trend, we used linear regressions to determine the average rates of percentage increase of CT use between 2001 through 2007 (Equations 1 and 2). Visual inspection of the unadjusted annual data past 2007 suggests a plateau of CT rates, so 2008 and 2009 were not included in the regression. We chose to use a linear model to fit data from 2001 to 2007 because it allows for straightforward interpretation of differences in growth rates overall and for specific subgroups. A $p \leq 0.05$ was considered significant. The following formulas were used to report the average percentage increase per year:

$$\mathrm{Ln}\,(\mathrm{CT}\%) = \alpha + \beta\,(\mathrm{year}) + \varepsilon \quad (1)$$

Average rate of percent increase = $(\exp(\beta) - 1) \times 100$.

$$\text{Average rate of percent increase} = (\exp(\beta) - 1) \times 100. \quad (2)$$

The diagnosis/CT ratio from 2002 through 2009 was calculated using the number of visits where there was a CT and diagnosis of PE divided by the total number of visits where a CT was performed within the CSS group (Equation 3).

$$\text{Diagnosis/CT ratio in CSS groups} = \frac{\text{No. visits with CT and diagnosis}}{\text{No. visits with CT}} \quad (3)$$

Due to insufficient observations and complex survey requirements (i.e., 30 observations are required per cell to make a stable estimate), we were unable to examine values in separate periods. Observations from 2001 were not used because differences in sampling strategy from subsequent years made estimates of standard errors not comparable. The diagnosis/CT ratio for pneumonia in the same group was calculated for comparison. A sufficient number of observations in NHAMCS allowed us to pool pneumonia into two periods—from 2002 through 2005 and 2006 through 2009—and assess changes in the diagnosis/CT ratio over time. All data coding and analysis were conducted using Stata 11.1 (StataCorp, College Station, TX).

RESULTS

Sample Characteristics and Overall CT Use

There were 322,745 observations sampled during 2001–2009 that represented a weighted estimate of 1.05 billion ED visits (increasing from 107.5 million in 2001 to 136.1 million in 2009). About 12% of ED visits each year involved chest pain, dyspnea, or hemoptysis.

Figure 1 and Table 1 show CT use in all ED visits increased from 6.3% in 2001 to 13.9% in 2007 and then leveled off in 2008 and 2009 at approximately 14.5%. For the CSS group, CT use increased fivefold, from 2.6% in 2001 to 13.2% in 2007, and then plateaued at approximately 12.5%. Rates of CT use in the comparison group of non-CSS visits were very similar with rates in the overall ED population.

CT Use in the CSS Group Visits by Subgroups

CT use for the CSS group increased in all subgroups (Table 2). Use in white non-Hispanics increased from 2.6% in 2001 and leveled off at approximately 14% after 2007. However, not all subgroups had the same pattern of CT rate increase from 2001 to 2007 and plateauing afterward as did the overall ED or CSS groups. Rates of CT use in adults older than 65 years increased at 2.6% in 2001 to 14.7% in 2007 and then peaked at 17% in 2008, before decreasing to 15.6% in 2009. Among the race and ethnicity subcategory, Hispanics had the highest percentage of ED visits with CTs in 2001, 4.3%, but the lowest percent for most of the following years. Medicare patients had a low frequency of 1.9% CTs in 2001, peaking at 15.7% in 2008, and decreasing slightly to 14.6% in 2009, the highest among the payers subgroup. Midwest hospitals also experienced the same trend from a low percentage in 2001, 2%, to the highest in 2009, 14.3%. For most years, patients triaged to be seen within 15 minutes received more CTs than patients triaged to be seen more than 1 hour after arrival in the ED. Throughout the period, urban hospitals performed more CTs compared to hospitals in nonurban areas. Nonprofit hospitals had the greatest absolute increase between 2001 and 2009, 11.1%, compared to government-owned and for-profit hospitals.

CT in the CSS group increased by an average growth rate of 28.1% (95% confidence interval [CI] = 20.9% to 35.7%) per year. This rate of increase was higher than the rates for all ED visits, 13.8% (95% CI = 12.5% to 14.0%), and for visits without these complaints, 12.7% (95% CI = 11.0% to 14.3%; Table 1). Rates increased for every subgroup, but were lowest among Hispanics (Table 2). CT use grew more rapidly in nonurban hospitals, where rates of CT use were relatively low in 2001.

Diagnosis of PE and Pneumonia

There were an estimated 10,683,293 visits with CT for the CSS group in 2002 through 2009. Of the total, 291,642 had diagnoses of PE. The aggregate PE diagnosis/CT ratio over the 8 years was 2.7% in the CSS group. Further analysis stratifying the CSS group by RFV found the diagnosis/CT ratio was 2.0% for those with only chest pain and 3.7% for the CSS group once chest pain was excluded.

To investigate the potential alternate diagnoses, we examined the pneumonia diagnosis/CT ratio. Table 3 shows that the overall diagnosis rate of pneumonia of about 1.8% did not change from 2002 through 2005 to 2006 through 2009. However, pneumonia diagnosis/CT ratios in patients who underwent CTs were 5.8% in 2002 through 2005 and 7.8% in 2006 through 2009. Due to the limited number of PE diagnoses across the entire sample, we were not able to compare PE diagnosis/CT ratios for the same two periods. For a symmetrical comparison, we report the aggregate pneumonia diagnosis/CT ratio from 2002 through 2009 of 7.1%, more than twice that of PE.

DISCUSSION

CT Rates of Use

Our analysis shows dramatic increases in the use of CT in the ED from 2001 through 2007, as well as a leveling off after 2007. Average growth rate of CT use in the ED from 2001 through 2007 was 13.8% overall and 28.1% for the CSS group. By 2009, CT was used in 12.5% of CSS visits, up from 2.6% in 2001. The increase was seen in all subgroups, some more than others. Nonurban hospitals with low baseline rates experienced the highest rate of increase. Rates among Hispanics grew the slowest over time but had the highest 2001 baseline rate. Most other subgroups had average annual increases of approximately 20%, consistent with previous studies.[14,26] Notably, subgroups of older adults and Medicare beneficiaries experienced similar percentages and growth over the years, which is expected for these overlapping populations. Urban and nonprofit hospitals appear to order proportionately more CTs, which may point to a culture of teaching hospitals where less experienced trainees may favor objective testing.

Increases in CT use of this magnitude, while rates of symptoms largely remained constant, indicate a change in ED practice patterns. Determining whether these changes are specific to diagnosing PE requires important considerations. First, total CT use in the ED was greater than use for the subset of visits in the CSS group throughout the period, although the rate of increase was greater in the CSS group. This suggests that there would likely have been substantial increases over time in the use of CT for ED patients with chest symptoms even if physicians had not been using CT to specifically look for and diagnose PE. For the purposes of this analysis, it may be reasonable to assume the majority of the nonhead CTs in the CSS group were likely chest CTs. Consequently, we conclude that increased use of chest CT may be driving CT use for the CSS group.

Given limitations of the available data, we do not know what proportion of the CTs associated with one or more of these complaints were ordered to rule out PE, as these symptoms could also result from other conditions or diseases where CT might be used (i.e., a CT coronary angiogram, aortic dissection, or traumatic injury). We also do not know if CTs to diagnose PE were given to patients outside of our CSS group. Finally, it is entirely possible that someone with one or more of the chest symptoms received a CT for reasons unrelated to PE.

Diagnosis/CT Ratio

Accounting for the increases in CT use, the estimated PE diagnosis/CT ratio of 2.7% for PE was lower than the 7% to 10% previously reported diagnostic yields in chart review-based studies from single institutions.[18,24,27,28] Our estimate may be lower than actual diagnostic yield because specific CT indications were unavailable. Also, previously reported diagnostic yields might have been lower if representative samples of facilities were studied.

Although chest pain is one of the standard signs and symptoms of acute PE, the diagnostic yield for patients presenting with chest pain is low. Previous research has suggested that chest pain in isolation may not actually be as strong an indicator of PE as other symptoms, such as dyspnea. Specifically, among nine symptoms and clinical signs of PE or deep vein thrombosis reported for ED patients, two (chest pain and syncope) showed no significant positive likelihood for a diagnosis of PE.[29]

The effect of CTs for PE on alternative diagnoses such as pneumonia has been documented in previous studies.[30–33] Even though CT is not typically used to rule out pneumonia, the detection of pneumonia may be an ancillary benefit of using CT to rule out PE. A recent study found that 77% of CTs suspected but negative for PE had alternative diagnoses; pneumonia was present in 14% of the CTs.[30] We reported an increase in the pneumonia diagnosis/CT ratio from 5.8% in 2002–2005 to 7.8% in 2006–2009. Diagnoses of pneumonia may or may not have been incidental, as we do not know the indications for the CTs or if CTs accompanied chest x-rays. Future studies could determine if CTs are substituting for chest radiography or whether CT is increasing the detection rate for small pneumonias undetected on standard two-view chest x-rays.

LIMITATIONS

There are limitations to NHAMCS data that have important implications for our study. Although it is consistent with previous studies, the method we used to construct our cohort using RFVs and identified PE and pneumonia diagnoses have not been validated. In addition to combining CT and MRI data from 2001 through 2005, NHAMCS also did not specify the body region where the CT was performed until 2007. By excluding head CTs after 2007, we may have overestimated the number of CTs in the prior years. Further, it is possible that some of the CTs associated in the CSS population were not chest-related as we assumed.

We assumed that in a visit with a CT and a PE or pneumonia diagnosis, the diagnosis was based on the CT result, and that an absence of the diagnosis meant the test was negative for the two diseases. We may have undercounted PE, as we did not take into account diagnoses of deep vein thrombosis, which require the same treatment but can be diagnosed using ultrasound. While we reported a nationally representative estimate of the PE diagnosis/CT ratio, insufficient yearly observations made it impossible to analyze changes over time or compare directly with the pneumonia ratio. Further, NHAMCS data do not capture the patients' risk factors for PE or the physicians' decision-making processes.

Other limitations to this study are common to studies reliant on facility-based health care encounter data. However, ICD-9 diagnostic codes in NHAMCS are more standard than in hospital discharges because coding is done directly from abstracted charts by survey staff. The data also do not specify CT test indication, so we may have overestimated both the number of patients who received chest CTs and those at clinical risk for PE.

CONCLUSIONS

In ED patients with complaints of chest pain, dyspnea, or hemoptysis, this analysis documented dramatic increases in computed tomography use from 2001 through 2007, which leveled off in 2008 and 2009. We found increases in computed tomography use in our comparison group, patients without the chest symptoms in the chest symptom study group, although to a smaller extent. The more rapid increase in computed tomography use in our chest symptom study group could reflect increased awareness and vigilance for detection of pulmonary embolism. The best estimate for diagnostic yield, the diagnosis/CT ratio, for pulmonary embolism was low overall; however, this estimate should be interpreted in the context of how the chest symptom study group was defined and the survey limitations. We were unable to determine whether the diagnosis/CT ratio for pulmonary embolism changed over time. Higher test use and low diagnosis/CT ratios may suggest the need to promote more efficient and evidence-based use of CT in the ED.

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DR JEREMY BROWN TO DIRECT NIH OFFICE OF EMERGENCY CARE RESEARCH

The National Institutes of Health has announced in a press release that Jeremy Brown, MD, has been chosen to be the first permanent director of its Office of Emergency Care Research (OECR). Established in 2012 under NIH's National Institute of General Medical Sciences, OECR is a focal point for basic, clinical and translational emergency care research and training across NIH. It coordinates, catalyzes, and communicates about NIH funding opportunities in emergency care research and fosters the training of future researchers in this field. Dr. Brown is currently an associate professor of emergency medicine and chief of the clinical research section in the Department of Emergency Medicine at The George Washington University (GWU). He works clinically as an attending physician at the Washington D.C. VA Medical Center. His NIH appointment will begin in July. Dr. Brown will also represent NIH in government wide efforts to improve the nation's emergency care system. Alan E. Jones, MD, president of the Society for Academic Emergency Medicine, expressed the satisfaction of the emergency medicine community at the establishment of OECR and at Dr. Brown's selection as its first permanent director. "SAEM, along with other emergency medicine organizations, has been very involved in efforts to create a dedicated centralized national office for emergency care research. We are delighted at the progress that has been made since the announcement of OECR's creation last year, and congratulate Dr. Jeremy Brown on his well-deserved appointment as its first director." Dr. Brown is ready for the challenge of heading OECR. "I am excited to join this world-class institution and lead its efforts to improve emergency care in the U.S.," he says. "To pursue this goal, I look forward to partnering with all of the NIH institutes and centers, other government agencies, and a wide range of researchers and clinicians." Dr. Brown replaces Walter J. Koroshetz, M.D., deputy director of the National Institute of Neurological Disorders and Stroke, who had served as OECR's acting director since its inception.

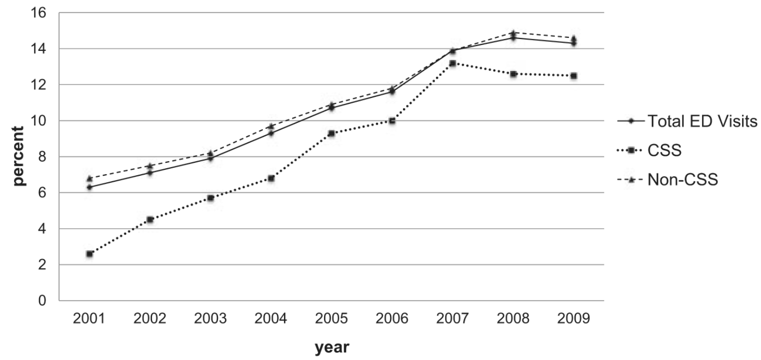

Figure 1.
Trend of CT Use for the CSS and comparison groups, 2001 through 2009. CSS = chest symptoms study.

Table 1

National Estimates of CT Use in EDs for the CSS and Non-CSS Comparison Groups, 2001 through 2009

	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average Rate of Percentage Increase, 2001–2007
Total ED visits, in millions	107.5	110.2	113.9	110.2	115.3	119.2	116.8	123.8	136.1	—
CSS group, in millions	12.6	13.0	13.9	12.9	13.6	14.2	13.3	15.2	16.5	—
Comparison group, in millions	94.9	97.1	100.0	97.3	101.7	105.0	103.5	108.6	119.6	—
% CTs out of total ED visits	6.3	7.1	7.9	9.3	10.7	11.6	13.9	14.6	14.3	13.8%* (12.5–14.0); SE 0.004
% CSS group with CT	2.6	4.5	5.7	6.8	9.3	10.0	13.2	12.6	12.5	28.1%* (20.9–35.7); SE 0.02
% Comparison group with CT	6.8	7.5	8.2	9.7	10.9	11.8	13.9	14.9	14.6	12.7%* (11.0–14.3); SE 0.006

CSS = chest symptom study; SE = standard error.

* Average rates of percent increase were significant at $p \leq 0.05$ level for all categories, reported with 95% CI.

Table 2

National Percent Estimates of CT Use for Subgroups of ED Visits in the CSS Group, 2001 to 2009

Subgroup	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average Rate of Percentage Increase,* 2001–2007
Age (yr) <18	0.7	0.3	0.9	1.7	4.8	1.5	2.4	4.4	2.5	35.7% (−2.4 to 88.6); SE 0.13
18 ≤ age <40	2.9	3.3	4.2	7.0	9.9	10.3	14.7	9.7	12.3	33.4%* (25.7 to 41.6); SE 0.02
40 ≤ age <65	3.1	3.8	7.1	8.1	9.2	10.7	14.5	13.8	13.7	28.1%* (19.3 to 37.6); SE 0.03
≥ 65	2.6	8.2	7.6	6.9	11.1	11.8	14.7	17.0	15.6	25.0%* (7.5 to 45.4); SE 0.06
Sex										
Male	2.6	3.6	6.1	6.5	8.8	8.9	13.0	11.4	13.5	28.5%* (20.1 to 37.6); SE 0.03
Female	2.7	5.2	5.5	7.0	9.7	10.9	13.3	13.7	11.8	27.9%* (19.4 to 37.0); SE 0.03
Race and ethnicity										
White, non-Hispanic	2.6	4.9	6.4	7.0	10.4	10.5	14.3	14.1	14.5	29.1%* (19.2 to 40.0); SE 0.03
Black, non-Hispanic	2.1	3.8	4.7	6.2	6.6	9.3	12.0	10.8	11.5	30.0%* (22.2 to 38.2); SE 0.02
Hispanic	4.3	4.1	4.3	5.6	8.4	8.3	7.4	7.3	8.2	14.2%* (5.7 to 23.5); SE 0.03
Source of payment										
Private	3.6	3.3	6.3	7.6	11.6	10.2	13.9	13.7	13.0	28.1%* (16.9 to 40.3); SE 0.04
Medicare	1.9	7.6	6.7	6.6	10.3	11.7	15.0	15.7	14.6	30.3%* (9.1 to 55.6); SE 0.07
Medicaid	1.5	4.0	4.2	5.6	5.9	8.0	10.2	10.3	10.1	30.5%* (15.9 to 47.0); SE 0.05
Self-pay	3.1	2.0	4.3	6.0	9.5	9.1	14.4	10.1	11.6	35.1%* (18.6 to 53.9); SE 0.05
Geographic region										

Subgroup	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average Rate of Percentage Increase,* 2001–2007
Northeast	2.3	5.2	6.2	5.2	9.3	9.0	11.2	12.4	8.8	24.9%* (10.9 to 40.6); SE 0.04
Midwest	2.0	5.2	6.3	9.0	9.5	10.9	16.6	12.0	14.3	34.1%* (18.5 to 51.8); SE 0.05
South	2.9	3.5	4.8	6.4	7.6	9.0	11.6	12.4	12.9	26.2%* (22.8 to 29.8); SE 0.01
West	3.3	5.1	6.4	6.3	12.1	12.7	14.7	14.1	13.1	28.0%* (19.1 to 37.6); SE 0.03
Location										
Urban	3.1	4.8	6.1	7.2	10.2	10.8	13.8	13.4	13.5	26.4%* (20.6 to 32.5); SE 0.02
Nonurban	0.6	2.7	3.8	3.8	4.0	5.9	9.5	8.9	7.9	43.1%* (15.2 to 77.8); SE 0.08
Hospital type										
Nonprofit	2.4	4.6	6.0	7.5	9.2	10.1	13.7	12.7	13.5	29.8%* (19.8 to 40.7); SE 0.03
For-profit	5.4	3.3	5.1	3.8	11.1	9.3	12.6	15.8	10.1	21.2%* (1.8 to 44.3); SE 0.07
Government, nonfederal	2.3	4.8	5.1	4.9	8.4	9.7	10.0	9.4	8.7	25.0%* (13.1 to 38.1); SE 0.04
Immediacy with which patient should be seen										
<15 minutes	3.0	5.8	6.1	8.7	9.8	10.9	12.8	10.6	14.6	24.3%* (14.5 to 34.9); SE 0.03
15–60 minutes	2.8	4.2	5.7	6.0	10.1	10.9	16.7	14.7	13.1	32.5%* (25.7 to 39.7); SE 0.02
>1–2 hours	1.7	2.1	6.1	7.8	7.1	9.5	13.3	13.7	9.5	39.6%* (20.4 to 62.0); SE 0.06
>2–24 hours	1.5	—	2.1	3.8	9.7	4.5	6.9	8.3	4.9	31.3%* (3.0 to 67.5); SE 0.09

CSS = chest symptom study; SE = standard error.

* Average rates of increase were significant at $p \le 0.05$ level for all categories, reported with 95% CI.

Table 3

Diagnostic Yield of Pneumonia for the CSS Group, 2002–2005 and 2006–2009

Diagnosis	2002–2005	2006–2009
No. total ED pneumonia diagnosis	8,452,423.2 (1.9% out of total visits)	9,123,219.4 (1.8% out of total visits)
No. CTs in CSS group	3,506,856.4 (0.8% out of CSS visits)	7,189,493.6 (1.5% out of CSS visits)
No. positive CTs for pneumonia	203,242.3	557,955.3
Diagnostic yield	5.8%	7.8%
Diagnostic yield 2002–2009	7.1%	

CSS = chest symptom study.