

# Trends in Diagnostic CT Among Fee-For-Service Enrollees, 2000-2011

Ghassan B. Hamra, PhD<sup>a</sup>, Richard C. Semelka, MD<sup>b</sup>, Lauren M. B. Burke, MD<sup>b</sup>,  
Virginia Pate, MS<sup>c</sup>, M. Alan Brookhart, PhD<sup>c</sup>

**Objectives:** To examine trends in the use of diagnostic CT in aggregate and for 4 major body regions (abdomen/pelvis, head/neck, chest, and spine) in an 11-year US nationwide analysis.

**Methods:** We summarize records from a large, mostly fee-for-service insurance claims database from 2000 to 2011.

**Results:** Rates of diagnostic CT have increased substantially from 2000 to 2011; however, changes in rates are disparate for different age groups and body regions. As others have shown, there has been a notable increase in use of diagnostic CT from 2000 to 2011. However, from 2009 to 2011, diagnostic CT studies of the chest, abdomen/pelvis, and head/neck have leveled off or decreased, whereas CTs of the spine show a continued increase in many groups.

**Conclusions:** In general, the increase in the rate of CT study performance has slowed, whereas spine CT continued to escalate. Future research should consider whether the increase in use of spine CT leads to a benefit that outweighs the risk associated with the increased population-level cancer risk.

**Key Words:** CT, diagnostic radiology, trends, radiation exposure

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## INTRODUCTION

The use of ionizing radiation as a diagnostic tool is an essential part of medicine. Of particular interest are diagnostic CT scans, the use of which has increased to an annual rate of 70 million scans [1,2]. The dramatic rise in use of CT scanners may be attributable to the fact that they are capable of providing clinicians with consistent image quality and high temporal resolution [3]. Indeed, rates of use have increased from 2.7 million scans in 1995 to 16.2 million in 2007, a 5.9-fold change [4].

Because CT scans expose patients to more radiation than traditional radiography, the sharp increase in CT

usage has translated into an increase in population exposure to ionizing radiation. In 2006, the collective doses due to traditional radiography and CT scans were estimated at 96,200 and 437,523 person-Sv, respectively [1]. On an individual basis, a patient undergoing a diagnostic scan may experience a benefit that outweighs the low risk of cancer associated with the exam [5]; on a population scale, a large number of individuals receiving low radiation dose will increase the population cancer risk [6,7].

In a recent study, Smith-Bindman et al examined the use of diagnostic imaging in a large, integrated health system and found that the use of diagnostic radiology has sharply increased over the past 15 years [8]. The authors showed that the use of CT scans had seen a greater increase relative to other forms of diagnostic radiology, such as x-rays [8]. Prior studies examining trends in CT use have evaluated fee-for-service insured populations [9,10]. These studies have focused on relatively homogeneous populations, such as single, private insurers [10] or Medicare populations [1,9], and often examine only trends of overall CT use.

Rates of diagnostic CT vary by body region. In 2006, head/neck, abdomen, chest, and spine diagnostic CTs represented about 28%, 16%, 32%, and 6% of total diagnostic CT scans used, respectively [1]. To the best of our knowledge, the analysis of heterogeneous payer aggregates and examination of trends in CT scanning of

<sup>a</sup>Section of Environment and Radiation, International Agency for Research on Cancer, Lyon, France.

<sup>b</sup>Department of Radiology, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

<sup>c</sup>Department of Epidemiology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Correspondence and reprint requests: Ghassan Hamra, Section of Environment and Radiation, International Agency for Research on Cancer, 150 Cours Albert Thomas, 69006 Lyon, France; e-mail: hamrag@fellows.iarc.fr.

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patients of differing age or individual body regions has been rarely studied; however, this type of analysis can provide a more accurate picture of the evolving use of diagnostic CT in the United States.

The purpose of our study is to assess trends in CT use from 2000 to 2011 in data from a geographically dispersed health care database that contains information from multiple, private employer-provided insurance and Medicare Supplemental insurance. We specifically analyzed trends in CTs performed based on patient age and anatomical region (head/neck, abdomen/pelvis, chest, and spine) to provide a more detailed understanding of changes in patterns of use.

## METHODS

This study utilized the MarketScan Research Databases (Thomson Healthcare, Inc), which includes insurance plan information and insurance claims for more than 100 million Americans who have private, employer-based insurance or Medicare Supplemental insurance. The majority of insurance plans represented in this database are based on a fee-for-service model.

Identification of diagnostic CT procedures was based on Current Procedural Terminology coding system as published by the AMA [11]. The coding system discriminates CT procedures used for diagnostic purposes from those used for treatment purposes. Procedures were only included in which CT was the exclusive imaging source; that is, codes for PET procedures with CT were excluded. In addition, codes were excluded for follow-up procedures (CPT code 74380) and nonspecific CT scans (CPT code 76497), the latter of which may indicate interventional purposes.

## Statistical Analyses

Rates of CT use are considered in aggregate and for 4 major anatomic sites: head/neck, abdomen/pelvis, chest, and spine. Groups were also divided by gender and age, where age was calculated as the age on July 1 of the given year. Age groups were: <1, 1 to 9, 10 to 17, 18 to 24, 25 to 34, 35 to 44, 45 to 54, 55 to 65, and 65+. For each year, only those enrollees who were continuously enrolled in the database for the entire year were included in the rate calculations. Codes that identify multiple scans performed on the same region are treated as a single diagnostic procedure. Similarly, to avoid over counting, multiple claims for diagnostic procedures performed on the same region on the same day were counted as single scan, as in previous work [8].

Rate of change is calculated as the percent change in the rate of use of diagnostic CT scans by age, gender, and body regions groups from 2000 to 2011. Although others have reported annual rate of change, we provide graphics of the rate of CT use by body region, age group, and gender group per year from 2000 to 2011 to provide a clear visualization of what is largely nonlinear changes over time. Rates are reported as

number of scans per 1,000 enrollees per year. All data were managed and analyzed in SAS, version 9.2 (SAS Institute Cary, NC).

## RESULTS

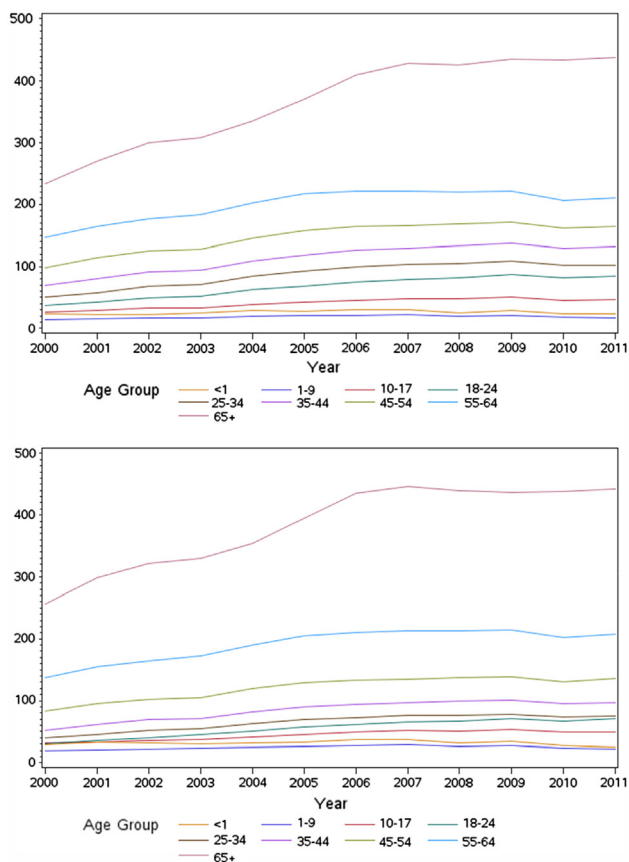
Over the time period from 2000 to 2011, there were a total of approximately 122 million enrollees. Of this number, approximately 84 million were continuously enrolled for at least one year; these individuals contributed approximately 257 million person-years of follow-up. Approximately 48% were male and 52% were female. There were a total of 35.6 million scans performed from 2000 to 2011. The 4 major body regions of interest account for 34.5 million, or 97%, of total diagnostic CT scans. Head/neck, abdomen/pelvis, chest, and spine scans represented 32.6%, 38.6%, 21.1%, and 4.8% of the 35.6 million total scans, respectively.

The MarketScan data show a clear increase in rate of CT use from 2000 to 2011. Figure 1 shows the trends from 2000 to 2011 for all diagnostic CT procedures collectively, separated by gender and age. Elderly subjects (65+) experienced the largest absolute increase in scans used; however, as a percentage change, evaluated by gender, the change from 2000 to 2011 for males and females aged 65+ was 72% and 87%, respectively. In comparison, males and females aged 18 to 24 saw a 135% and 129% increase in use of diagnostic CT from 2000 to 2011, respectively (Table 1). Male and female children <1 year old experienced a 4% and 3% decrease in overall diagnostic CT use from 2000 to 2011, respectively.

From 2009 to 2011, most age groups experienced a modest to substantial decrease in use of diagnostic CT. Both males and females in younger age groups, <1 and 1 to 9, experienced 17% to 25% decreases in the use of diagnostic CT, whereas most other age groups experience a 3% to 9% decrease from 2009 to 2011. The exception was the elderly, 65+ and males aged 18 to 24, who experienced little to no change (0%) in use of diagnostic CT from 2009 to 2011 (Table 2).

## Head and Neck

Rates of use of head and neck diagnostic CT scans showed a modest increase since 2000. Among males, the greatest relative change in use was among those aged 18 to 24, who showed an 88% increase in use from 2000 to 2011; females of the same age group showed a 50% increase in use. However, females aged 65+ experienced the greatest percent increase over the period 2000 to 2010, 65%, compared with males aged 65+, who experienced a 56% increase. From 2009 to 2011, rate of head and neck CT use decreased across all age groups; the decrease ranges from 21% and 25% for females and males aged <1, respectively, to 6% and 3% among 55- to 64-year-old females and males, respectively. The exceptions were males and females aged 65+ who experience a 3% and 2% increase in use from 2009 to 2011, respectively.



**Fig. 1.** Diagnostic CT use from 2000-2011 among females (top) and males (bottom).

**Abdomen/Pelvis**

Rates of diagnostic abdominal and pelvic CT use showed varying levels of change since 2000. Among both males and females aged 18 to 24, rates of use at least tripled, with a 197% increase for males and 240% increase for females. Similarly, large increases in use were seen for females aged 10 to 17 (154%), 25 to 34 (180%), and 35 to 44 (134%), and males aged 25 to 34 (146%) and 35 to 44 (136%). Trends among <1-year-old enrollees are disparate among males and females. Whereas males show an 14% decrease in the use of diagnostic abdominal/pelvic CT over the 11-year period, females experience a 41% decrease. Rates of diagnostic abdominal/pelvic CT largely decreased from 2009 to 2011, between 1% to 10% across age and gender groups, with the notable exception of <1-year-old males and females who saw a 37% and 26% decrease, respectively, in use from 2009 to 2011.

**Chest**

The use of diagnostic chest CT has increased since 2000 at different rates for gender and age groups. Across most age groups, females experienced a larger increase than males in use of diagnostic chest CT since 2000. This is especially true from years 2003 to 2009 (Figs. 2 and 3). Of particular note are females aged 18 to 24 and 25 to 34, who experienced a 283% and 217% increase in rates of use, respectively, from 2000 to 2011; males in the same age groups have seen a 161% (age 18 to 24) and 108% (age 25 to 34) increase in rates of use since 2000. Another group with a major increase in diagnostic chest CT use is females age <1, who experienced a 367%

**Table 1.** Percentage change in rates of diagnostic CT scans from 2000 to 2011

Age Group	Female				
	All	Head and Neck	Chest	Abdomen and Pelvis	Spine
<1	-3%	-2%	367%	-41%	47%
1-9	19%	1%	63%	96%	262%
10-17	81%	39%	138%	154%	258%
18-24	129%	50%	283%	240%	339%
25-34	102%	37%	217%	180%	120%
35-44	89%	44%	165%	134%	56%
45-54	66%	39%	116%	89%	45%
55-64	44%	28%	75%	51%	35%
65+	87%	65%	138%	71%	215%

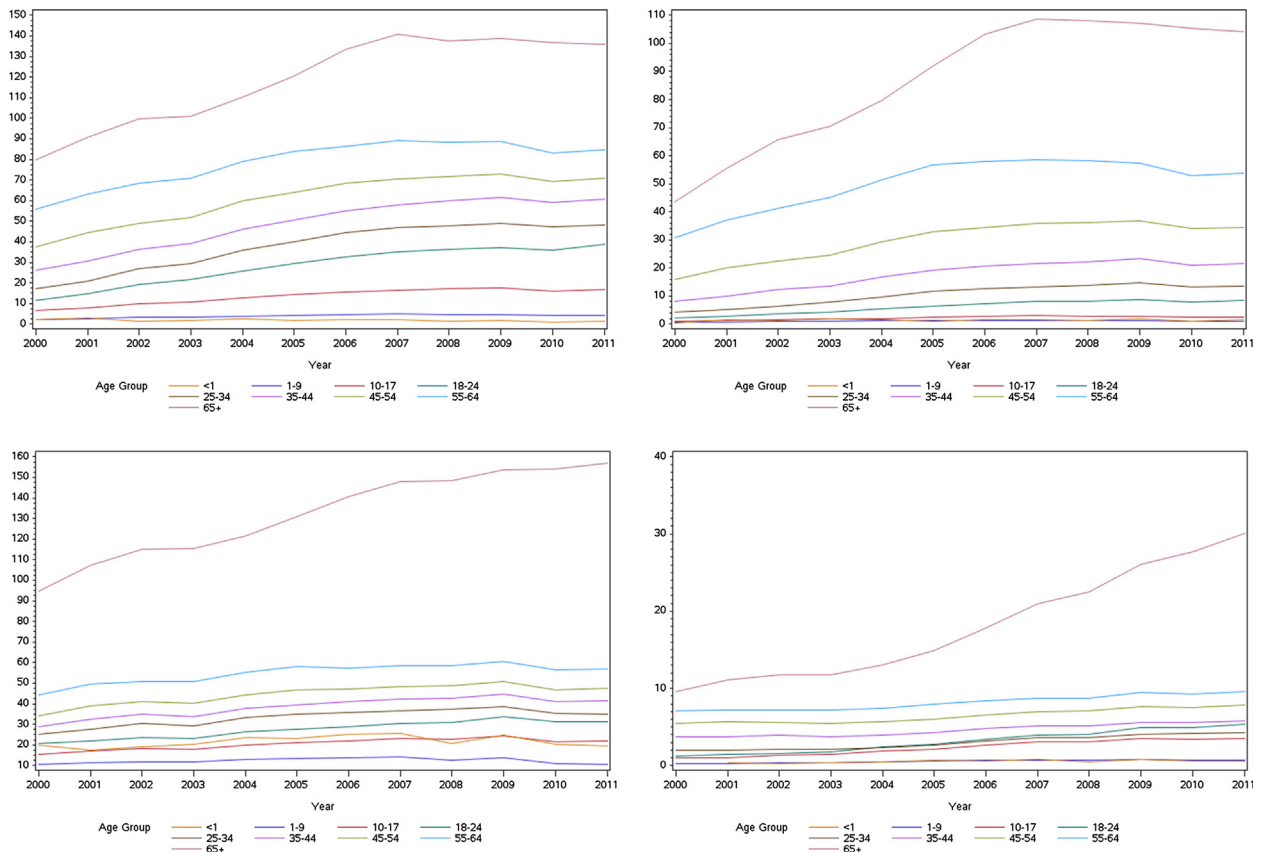
Age Group	Male				
	All	Head and Neck	Chest	Abdomen and Pelvis	Spine
<1	-4%	-15%	66%	-14%	30%
1-9	14%	-2%	48%	78%	211%
10-17	58%	37%	91%	81%	194%
18-24	135%	88%	161%	197%	321%
25-34	87%	44%	108%	146%	96%
35-44	86%	41%	116%	136%	56%
45-54	63%	35%	88%	82%	49%
55-64	52%	30%	70%	62%	58%
65+	72%	56%	101%	69%	141%

**Table 2.** Percentage change in rates of diagnostic CT scans from 2009 to 2011

Age Group	Female				
	All	Head and Neck	Chest	Abdomen and Pelvis	Spine
<1	-21%	-21%	-18%	-26%	-22%
1-9	-20%	-23%	-21%	-10%	-11%
10-17	-8%	-11%	-10%	-5%	0%
18-24	-2%	-8%	-4%	4%	9%
25-34	-6%	-10%	-8%	-2%	5%
35-44	-4%	-8%	-7%	-1%	4%
45-54	-4%	-6%	-6%	-3%	3%
55-64	-5%	-6%	-6%	-5%	1%
65+	0%	2%	-3%	-2%	16%

Age Group	Male				
	All	Head and Neck	Chest	Abdomen and Pelvis	Spine
<1	-25%	-25%	-12%	-37%	-15%
1-9	-17%	-21%	-17%	-5%	-9%
10-17	-9%	-11%	-10%	-7%	-3%
18-24	1%	-2%	0%	4%	12%
25-34	-3%	-7%	-5%	0%	5%
35-44	-4%	-6%	-5%	-2%	-1%
45-54	-3%	-4%	-2%	-3%	5%
55-64	-3%	-3%	-3%	-4%	4%
65+	1%	3%	0%	-1%	12%



**Fig. 2.** Rates of CT use from 2000 to 2011 among female enrollees of fee-for-service insurers. Rates are presented by region: abdomen/pelvis (top, left), chest (top, right), head/neck (bottom, left), and spine (bottom, right).

increase over the 11-year period; their male counterparts experience a much lower increase of 66% for the same period. However, these changes are based on relatively small numbers. There are 2 records for diagnostic chest CT among <1-year-old females out of 6,467 enrollees in 2000 (data not shown).

Rates of use for most age and gender groups dropped from 2009 to 2011. There is slight variation in these changes by age and gender group. However, male and female age groups each show a mostly similar rate of decrease in diagnostic chest CT use from 2009 to 2011.

### Spine

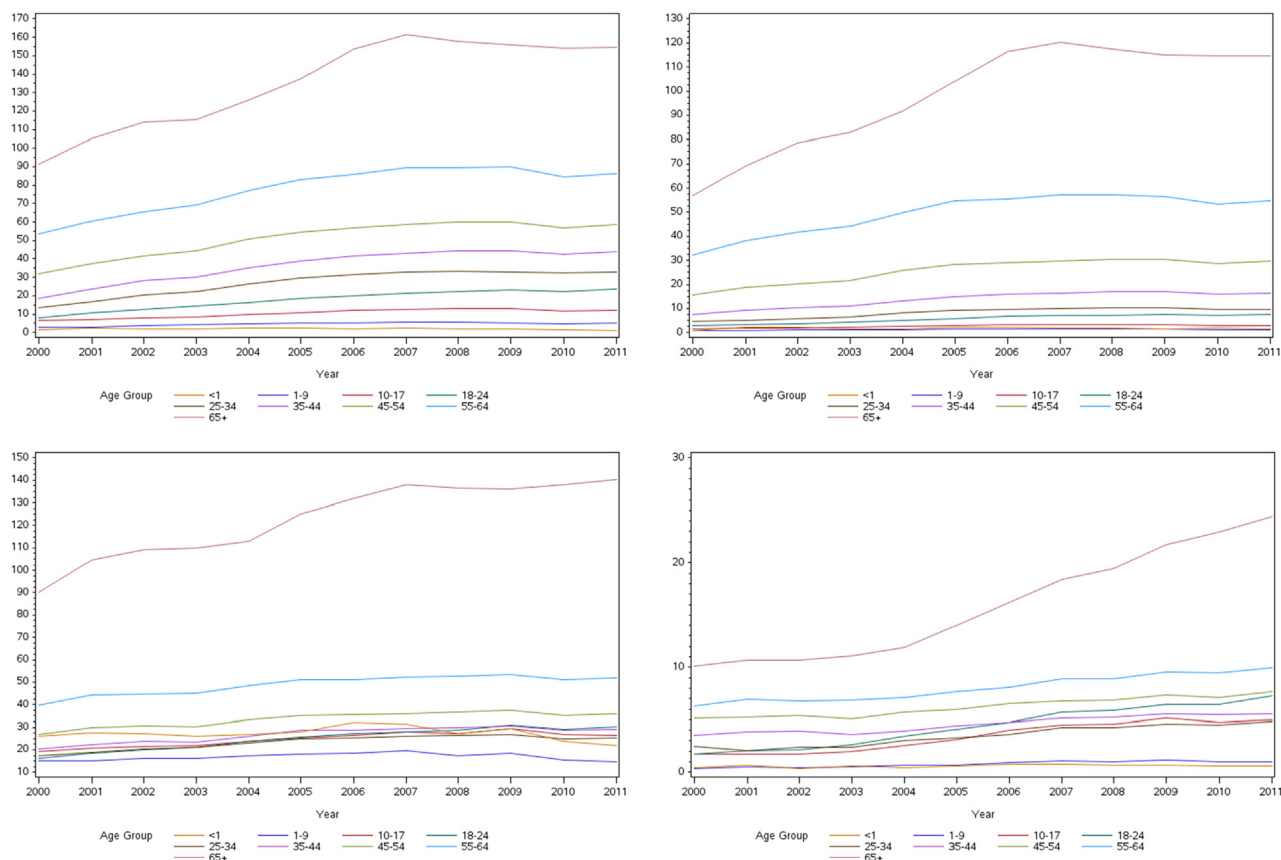
Spine CT scans were utilized at a lower rate than head/neck, abdominal/pelvic, or chest CT, comprising approximately 5% of the total scans among these 4 groups. Rates of use in this population never exceeded 11 scans per 1,000 enrollees per year among those <65 year of age (Figs. 2 and 3). However, spine CT use saw the greatest increase since 2000. Across most age and gender groups, the increase in rate of use exceeded that of abdominal/pelvic, head/neck, and chest scans. Similar to the other sites of interest, rates of use among 18- to 24-year-old males and females have seen substantial increase in use since 2000, 321% and 339%, respectively.

Spine CT usage showed a mixed change from 2009 to 2011, which is distinct from trends for age and gender

groups of other regions that show a mostly consistent decrease in use. Changes among female and male age groups <1, 1 to 9, and 10 to 17 and males aged 35 to 44 have ranged from a 0% to 22% decrease from 2009 to 2011, but all other groups showed a modest increase (up to 16%) for the same time period.

### DISCUSSION

We observed an overall increase in use of diagnostic CT scans from 2000 to 2011 in a large, fee-for-service insurer healthcare database. From 2009 to 2011, the rates of use decreased for most age and gender groups and across most body regions. Previous reports showing an increase in rates of use of diagnostic radiology are conducted among Medicare Parts A and B beneficiaries [12] and among members of an integrated health management organization group. To contribute to the body of knowledge on changes in CT utilization, rather than examining trends in use by type of scan (eg, CT, x-ray, nuclear medicine), which others have done [1,8], we studied the 4 body regions: head/neck, abdomen/pelvis, chest, and spine. These regions represent the tissue-interrogated organs of the highest risk for malignant degeneration from ionizing radiation (eg, thyroid, breast, gonads). Division by age, gender, and body region allowed us to document the variation in rates of increase from 2000 to 2011.



**Fig. 3.** Rates of CT use from 2000 to 2011 among male enrollees of fee-for-service insurers. Rates are presented by region: abdomen/pelvis (top, left), chest (top, right), head/neck (bottom, left), and spine (bottom, right).

The direction of change was largely consistent across age and gender groups; however, the magnitude of the increase varied by age groups and body region of interest. The age groups with the largest relative change in increased use of CT from 2000 to 2011 were 18 to 24, 25 to 34, and 35 to 44. Most radiation societies believe the risk of developing cancer from ionizing radiation exposure is less in adults than in adolescents and children, with that risk decreasing monotonically with increasing age at exposure [13,14]. Nonetheless, young adults still experience an appreciable risk of cancer induction from medical radiation, so the increased use of diagnostic CT in these younger adults over this time period may be of concern [15,16].

The National Research Council's report on the biological effects of low-level ionizing radiation (BEIR VII) estimate the lifetime attributable risk for 1,000 patients each receiving a 10 milli-Sieverts (mSv) effective dose as one cancer event [17]. One possible explanation for decreased use of CT from 2009 to 2011 may be an increased awareness amongst physicians of the hazards of radiation in young adults, in addition to children.

The concordance of our data with studies that have described utilization of CT for only 1 body region for specific age groups is good. For example, a number of studies have reported on the increased utilization of chest

CT for pulmonary embolism detection in young adult females [18], and we observed an increase in utilization of chest CT in females aged 18 to 24 and 25 to 34.

With regard to body regions, spine CT experienced a dramatic increase in use from 2000 to 2011. For many age and gender groups, the percentage increase in diagnostic spine CT was 2 to 3 times that of the other body regions. The increase in spine CT rates mirrors findings from other reports, one of which demonstrated a 435% increase in cervical spine CT rates in adolescents aged 13 to 17 between 2000 and 2006 [19]. This increase in the rate of spine CTs may be attributable to increased use in evaluating trauma patients in the emergency room setting. This is supported in recent work by Levin et al, which showed an overall decrease in CT use from 2009 in Medicare Part B participants, except in the emergency room, which has shown an increase in use [20]. Interestingly, Jindal et al [21] suggest that despite the increased rates of CT in evaluation of mild to moderate pediatric trauma, there was no change in injury detection or management. This is important to understand, as recent work suggests an increased radiation dose and cancer risk associated with spine CT scanning [22]. In those aged 65+, increased health care expenditures that may not translate into patient benefits would likely be of greater concern than

increased cancer risk from spinal CT. It is also possible that the need to follow up with additional testing to confirm a diagnosis provides a greater benefit than cost. Further research into this cost benefit comparison would be welcome.

The increasing use of CT has become an important subject of discussion and research in light of the need for health care reform. Many have termed this increased use of CT *overutilization*, meaning that CTs are obtained when they are unlikely to change patient outcome; it is estimated that as many as 20% to 50% of imaging tests fall under this category [23]. Although there may be clinical benefit to obtaining a negative CT scan, efforts are needed to reduce excessive CT use. Our results suggest that, beginning in 2009, there may be a community-wide recognition that CT use must be more carefully considered.

Our study does suffer from some limitations. Although MarketScan is a nationally representative sample of fee-for-service insurance holders, the data are not necessarily generalizable to all segments of the US population, such as the uninsured or those who utilize health management organization services for insurance. In addition, information for those with multiple sources of health care coverage may be missed, such as records of scans covered by different insurers [24]. However, we believe these results provide useful information regarding the differential rates of CT use from 2000 to 2011.

The results of our study have shown macro changes in the overall utilization of CT, which has paralleled findings from other studies. The separation into age and body region CT studies allowed us to observe changes in utilization that differ from what was expected, notably spine CT in young adults. Our findings draw attention to the fact that it may be important to understand the differences in rates of change by patient gender, age, and body region, as this may allow for targeted inquiry and targeted education both for health care practitioners and the public at large.

## TAKE-HOME POINTS

- Rates of diagnostic CT show wide variation across gender and age groups.
- Results suggest the need for examining the utility of diagnostic spinal CTs.
- Although the 11-year trend shows a general increase in CT utilization, recent years show a decrease in the use of most diagnostic CT scans.

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