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Increasing utilization of emergency department neuroimaging in Medicare beneficiaries from 1994 to 2015

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ABSTRACT

Objective: To assess for changes in emergency department (ED) utilization of neuroimaging in Medicare fee-for-service beneficiaries from 1994 to 2015.

Methods: Using Medicare Physician Supplier Procedure Summary Master Files, annual ED volumes of head computed tomography (CT), magnetic resonance (MR), and carotid duplex ultrasound (CDUS) were assessed from 1994 through 2015. Annual volumes of head CT angiography (CTA), neck CTA, head MR angiography (MRA), and neck MRA studies were assessed from 2001 (first year of unique reporting codes) through 2015. Longitudinal population-based utilization rates were calculated using annual Medicare Part B enrollment, and utilization rates were normalized annually per 1000 ED visits.

Results: From 1994 through 2015, ED neuroimaging utilization rates per 1000 ED visits increased 660% overall (compound annual growth rate [CAGR] 9%); 529% for head CT (CAGR 9%); 1451% for head MRI (CAGR 14%); and by 104% for CDUS (CAGR 3%). From 2001 to 2015, rates increased 14,600% (CAGR 43%) and 17,781% (CAGR 45%) for head and neck CTA, respectively, and 525% (CAGR 14%) and 667% (CAGR 16%) for head and neck MRA, respectively. Trends were similar when volumes were normalized for annual Medicare fee-for-service enrollment. Non-contrast head CT was the most common imaging modality throughout the study period (86% of annual neuroimaging volume in 1994; 89% in 2015).

Conclusions: In Medicare beneficiaries, neuroimaging utilization in the ED grew unabated from 1994 through 2015, with growth of head and neck CTA far outpacing other modalities. Non-contrast head CT remains by far the dominant ED neuroimaging examination.

1. Introduction

The ability of advanced neuroimaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) to rapidly and reliably evaluate the brain and associated vasculature has made these modalities a central component of neurologic workup in the ED. While neuroimaging in the acute setting demonstrably benefits clinical decision-making, recent literature addressing ED imaging use has raised concerns of increasing overutilization [1]. Prior studies have bolstered this assertion by demonstrating that rising overall advanced imaging use has not been met with a commensurate increase in actionable acute diagnoses [2]. Moreover, the unabated growth of such imaging in the ED contrasts with a recent trend of declining imaging utilization across other sites of care [1]. Implications of these findings include increased healthcare costs, greater ionizing radiation exposure, and the potentially harmful diagnostic cascade resulting from identification of incidental findings.

Efforts to understand the general evolution of imaging use in the ED setting would benefit from granular analyses of population based changes specific to individual anatomic regions (such as the brain) that are frequently imaged. Prior work revealed that rates of head CT use in the ED more than doubled from 1995 to 2007 for presentations related to head trauma or neurologic complaints [3]. However, little is known about how this trend has evolved over the subsequent decade, or whether the same trend applies to all neuroimaging modalities, including MRI and neurovascular imaging. Longitudinal analysis of overall neuroimaging use, partitioned by modality, could help better contextualize the relative changes across these modalities, with the ultimate aim of more appropriately directing the study of corresponding evidence-

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based clinical decision support tools and appropriate use criteria. Therefore, the aim of this study was to assess for overall and modality-specific changes in ED utilization of neuroimaging in the Medicare population from 1994 through 2015.

2. Methods

2.1. Study design, setting, and selection of participants

This study used aggregated Medicare claims data from Centers for Medicare and Medicaid Services (CMS) designated Public Use Files and was granted exempt status from our Institutional Review Board.

The data and methodology for using these claims data has been previously described [4,5]. Annual Medicare Physician Supplier Procedure Summary (PSPS) Master Files were obtained from CMS for years 1994 through 2015. These files contain aggregated Part B Medicare billing data for all claims submitted by physicians and other providers nationally. Fields include information on procedures by Current Procedural Terminology (CPT) code, billing provider specialty, and patient location at the time of service [6].

CPT codes for a variety of neuroimaging procedures throughout this time period were identified (Table 1). We focused on both neuroanatomical imaging (CT and MRI) and neurovascular imaging (ultrasound [US], CT angiography [CTA], and MR angiography [MRA]). CPT codes for MR angiography (MRA) and CT angiography (CTA) were first introduced in 2001, while other codes were available across the entire study period. We focused exclusively on services rendered in the emergency department (site code #23). Annual volumes of all targeted codes were ascertained for all noted years. Concurrent annual procedure counts for all billed emergency services evaluation and management (E&M) codes (99281 through 99285) were ascertained from PSPS Master Files and used to identify clinical ED encounters in the same population; these were used to normalize imaging frequency on an average per 1000 ED encounter basis. Annual Medicare fee-for-service (FFS) beneficiary enrollment for each year was separately obtained from CMS and used to calculate utilization on a per 1000 Medicare beneficiary population basis. During the study period, Medicare FFS enrollment increased from 32,305,000 in 1994 to 33,838,060 in 2015, representing approximately 12.4% and 10.5% of the United States population, respectively.

2.2. Outcomes

The primary outcomes were the total and annual growth for each neuroimaging modality in the utilization rate per 1000 ED visits in the Medicare fee-for-service population. Other outcomes included: growth in overall volume for each neuroimaging modality, growth in utilization per 1000 Medicare fee-for-service beneficiaries for each neuroimaging modality, and changes in the relative percentage of overall ED neuroimaging volume represented by each modality.

2.3. Analysis

Annual imaging volumes for each modality were tabulated and population- and encounter-based utilization rates were calculated. Compound annual growth rates (CAGR) were calculated where appropriate. Data analysis was performed using SAS 9.4 (SAS Institute, Inc., Cary, North Carolina) and Excel 2015 (Microsoft, Redmond, Washington).

3. Results

3.1. Overall neuroimaging use

Between 1994 and 2015, total ED neuroimaging volume in the Medicare fee-for-service population continuously increased from 350,721 to 3,649,072 examinations, representing 940% growth (CAGR 12%). Overall, ED neuroimaging utilization increased 660% (CAGR 9%) per 1000 ED visits and 993% (CAGR 12%) per 1000 Medicare enrollees from 1994 to 2015. Data on neuroimaging volume for specific modalities is further detailed in Table 1. Per 1000 ED visits and per 1000 Medicare beneficiaries, growth was similar (Figs. 1 and 2, respectively).

3.2. Head CT

Total ED head CT volume continuously increased from 330,296 in 1994 to 3,273,159 in 2015, representing 891% growth (CAGR 12%). Head CT utilization increased 529% (CAGR 9%) per 1000 ED visits and 846% (CAGR 11%) per 1000 Medicare enrollees from 1994 to 2015.

3.3. Head MRI

Total ED head MRI volume continuously increased from 5228 in 1994 to 127,836 in 2015, representing 2345% growth (CAGR 16%). Head MRI utilization increased 1451% (CAGR 14%) per 1000 ED visits and 2234% (CAGR 16%) per 1000 Medicare enrollees from 1994 to 2015.

3.4. Head and neck CTA

ED CTA volume demonstrated the largest relative growth of all neuroimaging modalities studied, increasing from 375 to 67,513 (17,903% growth, CAGR 45%) for head CTA and from 298 to 65,258 (21,799% growth, CAGR 47%) for neck CTA from 2001 to 2015. Utilization for

Table 1
Volume of specific ED neuroimaging modalities in the Medicare fee for service population (1994–2015), with associated Current Procedural Terminology (CPT) codes.

Modality	1994	2004	2015	% change	CAGR
CT head total	330,296 (94.2)	1,566,288 (94.8)	3,273,159 (89.7)	***891%***	***12%***
CT head without contrast (CPT 70450)	302,517 (86.3)	1,541,205 (93.3)	3,256,714 (89.2)	***977%***	***12%***
CT head with contrast (CPT 70460,70470)	27,779 (7.9)	25,083 (1.5)	16,445 (0.5)	***−41%***	***−2%***
MRI head total	5228 (1.5)	29,388 (1.8)	127,836 (3.5)	***2345%***	***16%***
MRI head without contrast (CPT 70551)	2606 (0.7)	13,567 (0.8)	89,883 (2.5)	***3349%***	***18%***
MRI head with contrast (CPT 70552,70553)	2622 (0.7)	15,821 (1.0)	37,953 (1.0)	***1347%***	***14%***
CTA head (CPT 70496)		2837 (0.2)	67,513 (1.9)	***17,903%***	***45%***
CTA neck (CPT 70498)		1915 (0.1)	65,258 (1.8)	***21,799%***	***47%***
MRA head total		11,547 (0.7)	40,907 (1.1)	***665%***	***16%***
MRA head without contrast (CPT 70544)		10,979 (0.7)	38,470 (1.1)	***678%***	***16%***
MRA head with contrast (CPT 70545,70546)		568 (0.0)	2437 (0.1)	***503%***	***14%***
MRA neck total		6319 (0.4)	25,629 (0.7)	***839%***	***17%***
MRA neck without contrast (CPT 70547)		3124 (0.2)	10,989 (0.3)	***419%***	***12%***
MRA neck with contrast (CPT 70548,70549)		3195 (0.2)	14,640 (0.4)	***2288%***	***25%***
Carotid US (CPT 93880,93,882)	15,197 (4.3)	33,761 (2.0)	48,770 (1.3)	***57%***	***6%***
Total neuroimaging exams	***350,721***	***1,652,055***	***3,649,072***	***940%***	***12%***

Note. Values in parentheses are percentages.
CAGR = compound annual growth rate.

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