ORIGINAL ARTICLE

Computed Tomography Utilization in the North Carolina Medicaid Population With a Focus on "High Exposure" Patients, 2007–2012

Lauren M. B. Burke, Holly Biola, Linda Grey, Rita M. Lahlou, Randall M. Best, Richard C. Semelka

PURPOSE We examined trends in utilization of computed tomography (CT) among Medicaid enrollees in North Carolina, the clinical setting in which those CT scans were performed, and the number of enrollees known to have undergone 10 or more scans in a given year.

METHODS North Carolina Medicaid claims were analyzed to determine the number of CT studies performed between January 1, 2007, and December 31, 2012. We assessed the number of "high exposure" patients—those who received 10 or more CT scans in a given calendar year—and divided this group into patients with a diagnosis of cancer and patients without a diagnosis of cancer. We also determined the type of site at which each CT scan was performed.

RESULTS Over the 6-year period 2007–2012, the percentage of all enrollees who underwent any CT study ranged from 8.0% to 9.6% (126,082–177,425 enrollees). The number of CT scans performed annually increased from 2007 to 2009 and then plateaued. The number of high-exposure patients increased gradually, from 2,171 in 2007 to 4,017 in 2012. The majority of CT scans of high-exposure patients—150,241 of 251,052 (59.8%)—were performed in nonoffice outpatient settings, such as emergency departments or urgent care centers.

CONCLUSIONS Although the number of CT scans performed annually in the North Carolina Medicaid population stabilized in the late 2000s (as did CT use nationally), the percentage of high-exposure patients has continued to rise. Physicians and patients need to be further educated in order to promote radiation safety and to decrease unnecessary radiation exposure.

Computed tomography (CT) has become an invaluable imaging tool for the diagnosis or further evaluation of various medical conditions. With evolving technology, decreasing acquisition times, and improving resolution, the use of CT has increased dramatically in recent years [1, 2]. It is estimated that more than 85 million CT scans were performed in the United States in 2011 [3]. Although the clinical utility of CT evaluation is undeniable, medical expenses for advanced imaging (including CT, magnetic resonance imaging, and positron emission tomography) rose from $3.6 billion in 2000 to $7.6 billion in 2006 and have continued to rise [4]. The increasing use of CT has been documented by a number of investigators [5-7].

Although the financial impact of CT imaging is substantial, a greater concern is that overuse of CT scans will adversely impact patient safety [8-12], because greater exposure to radiation is thought to be associated with a greater risk for the development of cancer, especially in younger patients [2, 8, 13, 14]. A large, retrospective study of patients in Quebec province who were hospitalized for myocardial infarction during the period 1996–2006 found that exposure to low-dose ionizing radiation during cardiac imaging and therapeutic procedures was associated with an increase in the risk of cancer [8]. In this study population, each 10-millisievert (mSv) increase in exposure to medical radiation was associated with a 3% increase in the risk of cancer [8]. Of course, calculations of additive risk for cumulative doses across populations cannot be used to estimate an individual patient's cancer risk. A 2006 report prepared for the US government by the National Research Council [13] points out that an individual's risk will vary with age at exposure, underlying health conditions, genetic predispositions, and other factors. Although the exact dose that significantly increases cancer risk in a given individual is unknown, Birnbaum and colleagues [15] stated that patients should be counseled about the risks of further exposure to ionizing radiation if they have had a total of 10 CT studies of the neck, chest, abdomen, and/or pelvis.

In the early 2000s some large insurers (including North Carolina Medicaid) partnered with radiology benefits management (RBM) firms in an attempt to mitigate the risks and costs associated with the rapid growth in the utilization of CT and other imaging modalities [16]. Growth in utilization of CT scans has slowed nationally in recent years among various major insurers, including Medicare [17, 18], although the latter does not use an RBM firm. A recent study of imaging records at 6 large integrated health systems during the period 1996–2010 [17] reported that growth in utilization of CT slowed from 2008 to 2010. A report prepared by the med-

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Address correspondence to Dr. Lauren M. B. Burke, University of North Carolina at Chapel Hill, Department of Radiology, 101 Manning Dr, Chapel Hill, NC 27514 (lauren_burke@med.unc.edu).

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ical market research firm International Marketing Ventures (IMV), Limited, found that growth had leveled off in recent years, with only 4% growth in utilization of CT scans nationally from 2010 to 2011, compared with annual growth rates of 10% or more in the early 2000s [3, 19]. Even more recently, IMV reported that the national CT utilization rate peaked in 2011 and actually declined 5.5% per year in 2012 and 2013 [20]. A recent review of claims from Medicare and several commercial multistate insurers documented a slowing of the growth in CT utilization rates between 2007 and 2009 [16]. The authors of this review provided erudite speculation regarding nonmedical factors that might have contributed to the slowing of the growth in CT utilization, but other sources have cited the growing concern about radiation exposure as a significant contributing factor [21-24].

The intent of the current study of the North Carolina Medicaid population was to evaluate trends of CT utilization, to identify the clinical settings of CT scans, to calculate the number of high-exposure enrollees with and without a diagnosis of cancer, and to further describe the population at greatest risk of radiation-induced injury.

Materials and Methods

This study was approved by the Institutional Review Board of the University of North Carolina at Chapel Hill, the Health Insurance Portability and Accountability Act (HIPAA) privacy officer at the North Carolina Division of Medical Assistance (DMA), and a review panel at the DMA. The DMA Medicaid claims database was queried to enumerate all North Carolina Medicaid enrollees who underwent diagnostic CT scans during the calendar years 2007–2012. CT scans were identified through current procedural terminology (CPT) codes derived from the American Medical Association's 2011 CPT codebook [25] and included all CT studies of the brain, neck, chest, abdomen, pelvis, or extremity. Each imaging session was counted as 1 study. CPT codes for treatment-related procedures such as CT-guided biopsies and CT-guided joint injections were excluded. Codes relating to post-processing of CT data were also excluded, because they did not represent services that delivered additional ionizing radiation.

Variance in Medicaid billing formats complicated our analysis of the data. Medicaid billing formats vary by facility type (critical-access hospital, non–critical-access hospital, or free-standing imaging center) and by whether the radiologist is an employee of the facility or an external contractor. In some settings, the technical code for performing the CT scan is the only way to identify the scan; in other settings, the claim for the reading of the CT scan is the only way to identify the scan.

Another complication is that a combined abdomen/pelvis CT code was added to the 2011 CPT codebook [25]; this code prevented a CT scan of the abdomen and a CT scan of the pelvis from being billed separately if they were performed on the same day. Given that the new code counted as 1 CT study what would have been counted as 2 studies in previous years, these new codes had to be pulled out, reverted to their pre-2011 codes, and recounted.

Because of these complexities, our queries were repeated and cross-checked by 2 investigators to assure that we were not double-counting or missing any identifiable CT claims. After running a query, we reviewed a sample of CT claims histories and actual medical records to validate the accuracy of the counts. Iterations of this process were performed between May 1, 2011, and May 8, 2012, using SAS version 9.2 software and structured query language (SQL), and adjustments were made in the SAS/SQL logic until it could be confirmed that all scans had been identified and counted appropriately. A scan was identified as a unique CT procedure code claim for a unique individual (identified by his or her Medicaid identification number) on a unique date of service at a unique imaging facility. Once we were sure that the count was accurate, we determined the number of recipients who underwent 10 or more CT scans in a given calendar year; these individuals were assigned to the high-exposure group.

The high-exposure patients were further subdivided into 2 groups: patients with a diagnosis of cancer (CPT codes 140.0–208.9) on any claim within that calendar year or the prior calendar year, and patients without a diagnosis of cancer on any claim during that time period [25]. These groups were analyzed separately to try to find out what proportion of the high-exposure group consists of patients who might be undergoing imaging for cancer surveillance and treatment. Among the high-exposure patients without a diagnosis of cancer, the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes associated with their CT studies were categorized based on common chief complaints: headache (784.0), respiratory complaints such as shortness of breath or chest pain (786.00–786.9), abdominal pain (789.00–789.09), back pain (724.0–724.9), and injury or trauma (800–959) [26]. We then calculated the percentage of studies associated with each chief complaint category.

The type of clinical setting in which the imaging study was performed was also identified. North Carolina Medicaid records classify CT scans as inpatient, outpatient, or office visit scans. Outpatient scans consist mostly of scans ordered in an emergency department (ED) or an urgent care setting, but they may also include scans performed in a hospital outpatient scanner following referral from a physician office.

Because of month-to-month fluctuations in Medicaid's enrolled population, the number we used to represent the annual number of enrollees is not the number of enrollees at a particular point in time; rather, it is the sum of each month's enrollment for that year (taken from the DMA Web site [27]) divided by 12.

Using SAS/SQL, logistic regression was performed to determine whether there were statistically significant upward trends in the percentage of patients who underwent

at least 1 CT scan, the percentage of patients in the high-exposure cancer group, or the percentage of patients in the high-exposure noncancer group.

Results

The demographic characteristics of this study population are described in Table 1. Over the 6-year period 2007–2012, the demographic characteristics of the North Carolina Medicaid population were essentially unchanged. Table 1 shows the proportion of enrollees in each demographic group who underwent at least 1 CT scan during those 6 years and the proportion of enrollees who underwent 10 or more CT scans during at least 1 of those 6 years.

Table 2 shows the number of North Carolina Medicaid enrollees who underwent at least 1 CT scan during a given year, the total number of CT scans performed each year, and the number of scans performed per 1,000 enrollees. The annual Medicaid enrollment increased every year during the 6-year period. The number of Medicaid patients undergoing CT scans during a given year and the total number of CT scans performed during that year increased by a statistically significant (P<.01) amount every year from 2007 through 2009. Increases in the number of CT scans performed per year in the North Carolina Medicaid population began to plateau in 2009; after that, there was a small increase in the number of scans performed, but the percentage of Medicaid enrollees undergoing CT scans decreased (Table 2).

The demographic characteristics of the high-exposure patients are similar to those of the patients undergoing at least 1 CT scan, with the majority of patients in both groups being 19–64 years of age. The high-exposure group is further defined in Table 3, where it is subdivided into 2 groups—those with a diagnosis of cancer and those without a diagnosis of cancer. The data demonstrate statistically significant (P<.01) increases in the number and percentage of cancer and noncancer patients who were exposed to 10 or more CT scans per year. High-exposure cancer patients underwent an average of 13.0 CT scans per year, and high-exposure noncancer patients underwent an average of 13.4 CT scans per year. Approximately 78.2% (14,818 of 18,953) of high-exposure patients did not have cancer diagnoses in their claims histories during the 2 years prior to the time frame analyzed. Although the annual number of CT scans performed stabilized in 2009, the total number of high-exposure patients has continued to increase (P<.01).

Among the subgroup of high-exposure patients who did not have a preexisting cancer diagnosis, subdividing ICD-9-CM codes by common chief complaints revealed that 2.6% of CT scans (5,172 of 197,258) were ordered for headache; 4.6% (9,167 of 197,258) were ordered for respiratory complaints, such as shortness of breath or chest pain; 15.3% (30,260 of 197,258) were ordered for abdominal pain; 0.9% (1,821 of 197,258) were ordered for back pain; and 14.5% (28,620 of 197,258) were ordered for injury or trauma.

TABLE 1.
Demographic Characteristics of North Carolina Medicaid Population and Subgroups That Utilized Computed Tomography (CT), 2007–2012

	Percentage of all Medicaid enrollees[a]	Percentage of patients undergoing at least 1 CT scan[b]	Percentage of patients undergoing 10 or more CT scans per year[c]
Age			
0–18 years	64.0%	1.4%	0.008%
19–44 years	19.7%	8.0%	0.26%
45–64 years	9.1%	15.7%	0.62%
65 years or older	7.2%	16.7%	0.42%
Sex			
Male	42%	7.1%	0.16%
Female	58%	9.9%	0.18%
Ethnicity			
Non-Hispanic	82.6%	9.1%	2.0%
Hispanic	17.4%	5.5%	1.8%
Race			
White	45.4%	10.3%	0.22%
African American	37.4%	8.3%	0.16%
Asian	1.4%	4.4%	0.07%
Native American	1.7%	10.6%	0.27%
Pacific Islander	0.1%	4.4%	0.03%
Other	14.0%	5.1%	0.07%

[a]The total number of all Medicaid patients (N = 10,880,973) represents the sum of member years over the 6-year time period; the mean age for this group is 22 years.
[b]A total of 953,571 Medicaid patients underwent at least 1 CT scan; the mean age for this group is 45 years.
[c]A total of 18,953 Medicaid patients underwent 10 or more CT scans per year; the mean age for this group is 49 years.

TABLE 2.
Annual Utilization of Computed Tomography (CT) in the North Carolina Medicaid Population, 2007–2012

Year	Number of enrollees in North Carolina Medicaid	Enrollees undergoing at least 1 CT scan No. (%)	Total number of CT scans performed	Number of CT scans performed per 1,000 enrollees
2007	1,577,585	126,082 (8.0)	294,747	241.9
2008	1,663,809	138,782 (8.3)	326,280	249.7
2009	1,754,226	168,849 (9.6)	400,477	291.7
2010	1,847,908	169,081 (9.1)	417,705	289.1
2011	1,994,752	173,325 (8.7)	439,726	294.9
2012	2,042,693	177,452 (8.7)	453,381	289.8

Note. The annual number of enrollees is the sum of each month's enrollment for that year (taken from the DMA Web site [27]) divided by 12.

Figure 1 shows the number of CT scans performed over the 6-year period in each type of clinical setting: inpatient, nonoffice/hospital outpatient (mostly EDs), and physician offices. The number of scans performed on inpatients and the number of scans performed on patients seen in physician offices did not substantially increase over this period; however, the number of scans performed in nonoffice outpatient settings rose dramatically.

Figure 2 shows the annual totals for CT scans performed on high-exposure patients in each type of clinical setting. Over the 6-year period, there was a modest increase in the number of inpatient CT scans performed annually on high-exposure patients; the number of scans performed on hospital outpatients (most of whom were seen in EDs and urgent care facilities) increased dramatically; and the number of office-based CT scans remained relatively stable. Over the 6-year time period, approximately 59.8% (150,241 of 251,052) of CT examinations of high-exposure patients were performed in a nonoffice outpatient setting.

Discussion

Over the past decade, CT scans have become vital in the evaluation and diagnosis of various medical conditions, and the number of scans performed annually has grown impressively [5-7, 16, 17, 28, 29]. Our intent was to document trends in CT imaging in the North Carolina Medicaid population, to calculate the number of high-exposure patients, and to further describe the population at greatest risk for radiation-induced injury.

CT utilization in the North Carolina Medicaid population is similar to the national trend, with utilization increasing steadily through 2009 and then plateauing [18]. There are several possible reasons for this trend: growing national recognition of the harms of excess imaging; a decrease in reimbursement for non–hospital-affiliated imaging centers; an increase in the use of other modes of imaging; a leveling off in the number of CT scanners in the state; an increase in prior-authorization programs in the state in general, or in the Medicaid program in particular; recent media coverage; and the proactive efforts of professional organizations [16, 21-24].

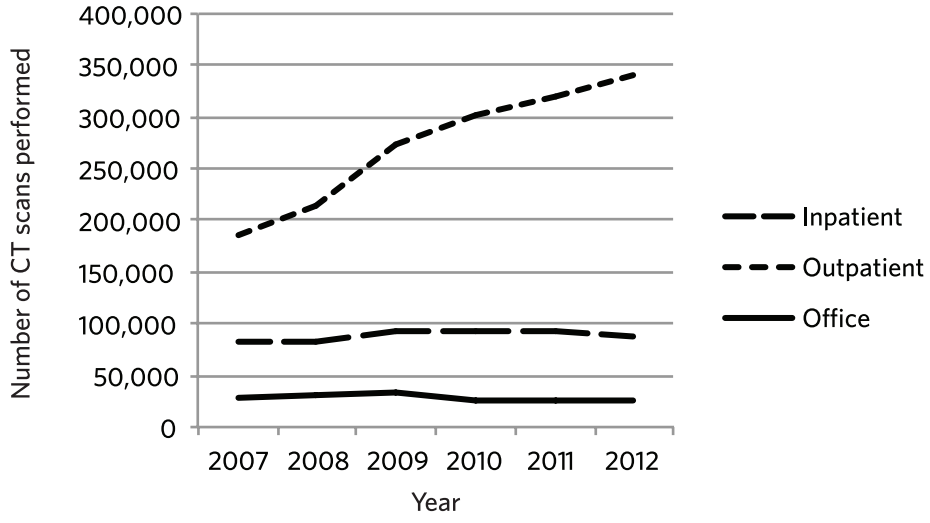
North Carolina Medicaid partnered with an RBM firm in December 2009. The program's contract with the firm prohibited any prior-authorization requirement for imaging of inpatients or patients seen in EDs, because such a requirement would be clinically inappropriate in those settings.

TABLE 3.
Annual Utilization of Computed Tomography (CT) by High-Exposure Patients With and Without a Diagnosis of Cancer in the North Carolina Medicaid Population, 2007–2012

		Cancer patients[b]			Noncancer patients[c]		
Year	Number of high-exposure patients[a]	Number of Medicaid enrollees with a cancer diagnosis	Number of high-exposure cancer patients[d] No. (%)	Number of CT scans per high-exposure cancer patient	Number of Medicaid enrollees without a cancer diagnosis	Number of high-exposure noncancer patients[d] No. (%)	Number of CT scans per high-exposure noncancer patient
2007	2,171	30,237	422 (1.4)	13.1	1,547,348	1,749 (0.11)	13.4
2008	2,496	33,343	500 (1.5)	13.0	1,630,466	1,996 (0.12)	13.3
2009	3,059	34,619	729 (2.1)	13.2	1,719,607	2,330 (0.14)	13.4
2010	3,434	35,592	788 (2.2)	12.8	1,812,316	2,646 (0.15)	13.3
2011	3,776	36,705	804 (2.2)	13.0	1,958,047	2,972 (0.15)	13.4
2012	4,017	35,861	892 (2.5)	12.8	2,006,832	3,125 (0.16)	13.3

[a]High-exposure patients are those who underwent 10 or more CT scans during the year.
[b]Cancer patients are those with a current procedural terminology (CPT) code of 140.0–208.9 on any claim within that calendar year or the preceding calendar year.
[c]Noncancer patients are those without a diagnosis of cancer on any claim within that calendar year or the preceding calendar year.
[d]The percentages reported represent the proportion of all cancer or noncancer patients who were in the high-exposure group.

FIGURE 1.
Total Number of Computed Tomography (CT) Scans Performed in All North Carolina Medicaid Patients, 2007–2012, by Clinical Setting of Service



Note. Outpatient scans include those that were performed in emergency departments or urgent care facilities, or in a hospital outpatient scanner following an office visit.

Thus the contract only addresses the relatively small percentage of imaging that is ordered by community physicians in offices and other outpatient settings, making it unlikely that this RBM contract would have had much of an effect on the observed change in CT utilization. It is important to note that similar trends for the same timeline have been noted in other populations nationally: the Medicare population, which never had an RBM program or a prior-authorization requirement [16]; a large group of insured employees [16] and the patients at 6 large integrated health systems [17], all of whom had a prior-authorization requirement for the entire period; and the national population, which contains a mixture of patients with and without prior-authorization requirements [3].

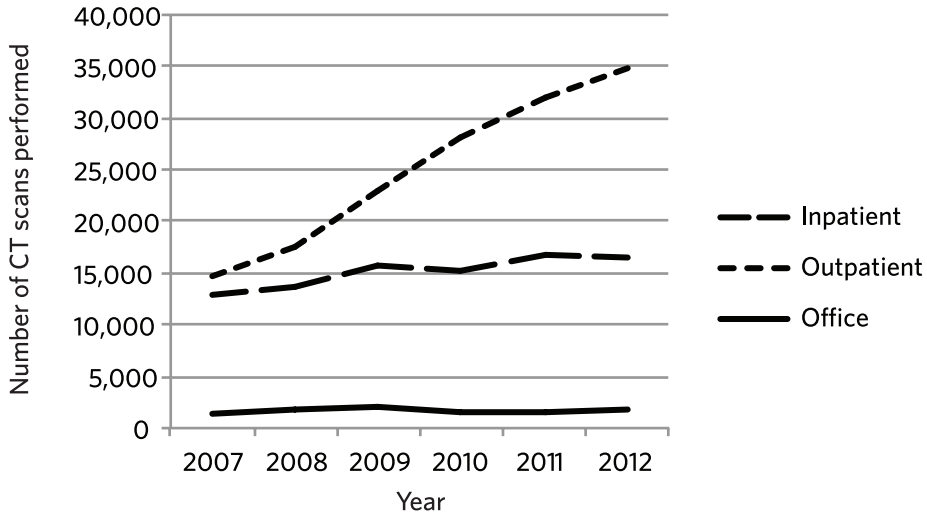
Our results are similar to those of other studies over the past decade, which have found that the percentage of CT scans performed in outpatient hospital settings and EDs has increased from 66% to 82% [3, 30]. This trend holds true for the entire North Carolina Medicaid population as well as for the high-exposure group, likely reflecting the clinical benefit of having a fast, highly informative diagnostic tool such as CT for the evaluation of patients who are acutely ill. However, with the majority of the increase in CT volume occurring in the outpatient setting [31, 32], we should consider ways of avoiding unnecessary exposure to ionizing radiation in this setting. We are currently working in partnership with DMA and others on a project to address this issue. [Editor's note: For more information on this project, please refer to the article by Biola and colleagues on pages 102-109 of this issue.]

Although prior-authorization programs are neither clinically appropriate nor feasible in an ED setting, computer-assisted clinical decision support programs have proven successful in this setting when used to reduce the number of chest CT angiograms for pulmonary embolism [33]. Recent studies have also demonstrated that integrating clinical decision support tools with computerized physician order entry is clinically feasible [34] and is associated with an overall decrease in the rate of growth of outpatient CT scans [35]. However, these systems are expensive and may require more physician time [36]. There is also hesitancy to use automated systems to direct physicians with regard to the best management of their patients.

The North Carolina Medicaid population represents approximately 19% of the state's population and is quite similar to the average US Medicaid population with regard to income limits and population characteristics. The most recent data for North Carolina (for fiscal year 2009) showed that 10% of Medicaid enrollees were 65 years of age or older, 17% were eligible for Medicaid due to a disability, 20% were adults, and 53% were children [37]. In the United States as a whole, data for fiscal year 2010 showed that 9% of Medicaid enrollees were 65 years of age or older, 15% were eligible for Medicaid due to a disability, 27% were adults, and 49% were children [37]. Therefore, we believe that our data could be extrapolated to the national Medicaid population. However, we suspect that, as is the case for other medical services, regional variations would exist, depending in part on the availability of CT scanners and on local norms or standards of care in EDs with regards to imaging [38]. We also recognize that the Medicaid population consists solely of low-income individuals.

One limitation of our study is the possibility that data are missing. CT scans performed during any gap in Medicaid

FIGURE 2.
Total Number of Computed Tomography (CT) Scans Performed in High-Exposure[a] North Carolina Medicaid Patients, 2007–2012, by Clinical Setting of Service



Note. Outpatient scans include those that were performed in emergency departments or urgent care facilities, or in a hospital outpatient scanner following an office visit.
[a]High-exposure patients are those who underwent 10 or more CT scans during the year.

coverage were not available for inclusion in this analysis, and the DMA requires some categories of Medicaid enrollees to reapply every 12 months. Also, North Carolina is similar to other states in that its Medicaid population tends to fluctuate at a rate of about 5% per month. Furthermore, it should be noted that our data do not represent the totality of ionizing radiation from medical procedures to which this population was exposed during the study period. We focused solely on CT procedures and did not include data concerning fluoroscopic procedures, positron emission tomography scans, plain radiographs, or nuclear medicine procedures, which together could result in considerable additional radiation exposure.

Another possible limitation is that accurate counts of CT scans were difficult to ensure. We attempted to achieve accurate data counts through multiple iterations of queries to our database. Medical records for more than 2,200 CT readings for 30–40 patients at 3 different hospitals were reviewed to assure that all claims were appropriately counted. We found 5 enrollees for whom the radiation exposure was underestimated because they had had CT scans performed during gaps in their Medicaid coverage. In addition, we had difficulty identifying claims for scans that were performed during an inpatient stay (and therefore subjected to bundled reimbursement claims), which may have resulted in our undercounting CT scans. Inpatient claims to Medicaid do not always document CT scans in the same data fields, and these claims are often paid under a global fee instead of as a line item; it was therefore challenging to acquire data from those claims when searching the entire North Carolina Medicaid population. However, the quality control measures discussed above revealed only 1 inpatient claim that had not been included in our counts. Similarly, there were some instances in which CT studies were overcounted. We found that this happened when a CT scan was obtained during an ED visit that occurred around midnight and the hospital charged the technical fee before midnight but charged for the reading of the scan after midnight, thus splitting the claim across 2 dates of service; when this occurred, it appeared as 2 scans in our counts. This double-counting was observed in 4 cases discovered during our data quality checks. We accounted for these 4 cases in our data, but there may have been similar cases that were not accounted for.

The results of our study show that CT utilization in the North Carolina Medicaid population is similar to the national trend, having increasing steadily until reaching a plateau in about 2009. However, there has been a progressive rise in the number of high-exposure patients undergoing 10 or more CT scans per year. The greatest increase in CT utilization among these high-exposure patients occurred in EDs and urgent care settings. It appears that further efforts are necessary to address the safety of the high-exposure population. NCMJ

Lauren M. B. Burke, MD assistant professor of radiology, Department of Radiology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.
Holly Biola MD, MPH physician consultant, Community Care of North Carolina, Raleigh, North Carolina; and family physician and quality improvement physician champion, Lincoln Community Health Center, Durham, North Carolina.
Linda Grey account manager, OptumInsight, Raleigh, North Carolina.
Rita M. Lahlou, MD, MPH graduate, School of Medicine, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.
Randall M. Best, MD, JD chief medical officer, Division of Medical

Assistance, North Carolina Department of Health and Human Services, Raleigh, North Carolina; and assistant professor, Division of Emergency Medicine, Department of Surgery, Duke University Medical Center, Durham, North Carolina.

Richard C. Semelka, MD professor of radiology, Department of Radiology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

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Potential conflicts of interest. H.B. consults with the North Carolina Division of Medical Assistance, Community Care of North Carolina, Pfizer, and Johnson & Johnson regarding Alzheimer care. Although she does not believe that these relationships represent a conflict of interest with respect to this study, this information is provided in the spirit of full disclosure. All other authors have no relevant conflicts of interest.

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