

Mythreyi Bhargavan, PhD
Jonathan H. Sunshine, PhD

Published online before print
10.1148/radiol.2343031536
Radiology 2005; 234:824–832

Abbreviations:

CPT = Current Procedural Terminology
HMO = health maintenance organization
MEPS = Medical Expenditure Panel Survey

¹ From the Research Department, American College of Radiology, 1891 Preston White Dr, Reston, VA 20191 (M.B., J.H.S.); and Department of Diagnostic Radiology, Yale University, New Haven, Conn (J.H.S.). Received September 26, 2003; revision requested December 8; final revision received March 17, 2004; accepted May 12. **Address correspondence** to M.B. (e-mail: mythreyib@acr.org).

Authors stated no financial relationship to disclose.

Author contributions:

Guarantors of integrity of entire study, M.B., J.H.S.; study concepts and design, M.B., J.H.S.; literature research, M.B., J.H.S.; data acquisition and analysis/interpretation, M.B., J.H.S.; statistical analysis, M.B.; manuscript preparation, definition of intellectual content, editing, revision/review, and final version approval, M.B., J.H.S.

© RSNA, 2005

Utilization of Radiology Services in the United States: Levels and Trends in Modalities, Regions, and Populations¹

PURPOSE: To assess the most recent available data for levels and trends in utilization of radiology procedures across populations, modalities, and geographic areas.

MATERIALS AND METHODS: Aggregated claims data from Medicare enrollees for all radiology procedures and from the Medical Expenditure Panel Survey (MEPS), a nationally representative survey of almost 25 000 Americans, for some radiology procedures, were used to calculate population-based utilization for the relevant age groups. Limited private insurer data also were obtained. All radiology utilization was measured and reported, irrespective of provider specialty. Average levels and percentiles of utilization were measured according to modality, and average annual rates of increase in utilization were compared across modalities, data sources, and regions. Rates of increase in utilization according to modality and state were compared for correlation with state characteristics and initial utilization levels.

RESULTS: In 2001, 4176 diagnostic and 274 therapeutic radiology procedures were performed per 1000 Medicare non-managed care enrollees. Nearly one-half of diagnostic procedures ($n = 2057$) involved radiography. The other half involved computed tomography (CT) ($n = 391$), magnetic resonance (MR) imaging ($n = 114$), ultrasonography (US) ($n = 921$), interventional radiology ($n = 215$), mammography ($n = 221$), and nuclear medicine ($n = 249$). On average, between 1998 and 2001, utilization per Medicare enrollee increased 16% per year for MR imaging and 7%–15% per year for CT, US, interventional radiology, and nuclear medicine, while that for radiography increased 1% per year. The proportion of diagnostic radiology procedures performed in ambulatory settings increased from 62% in 1992 to 68% in 2001. There was wide variation across states in utilization by Medicare enrollees. State totals for diagnostic radiology were 3038 in the 10th percentile and 4573 in the 90th percentile. In 1999, MEPS reported average utilization in ambulatory settings as follows: 64 MR imaging, 102 US, 73 mammographic, 326 radiographic, and 43 radiation therapy procedures per 1000 persons (all ages) in the U.S. population.

CONCLUSION: Utilization of high-technology modalities increased rapidly, while that of radiography was relatively stagnant. Variation in utilization among states and census regions was substantial.

© RSNA, 2005

Information about utilization of radiology services is useful to practices, payers, and policy makers for planning growth, helping to ensure that necessary services are available for patients, making financial decisions, and negotiating contracts. Data about utilization are available from the early 1990s (1). Since then, managed care has evolved substantially, with the focus shifting away from tightly managed health maintenance organizations

(HMOs) to loosely organized preferred provider organizations. During the same period, there have been several advances in high-technology radiology and its adoption. Thus, the purpose of our study was to assess the most recent available data for levels and trends in utilization of radiology procedures across populations, modalities, and geographic areas.

MATERIALS AND METHODS

Medicare Information

For patients enrolled in Medicare, we used the Medicare Physician/Supplier Procedure Summary Files for 1995, 1998, and 2001, which contain information about claims for all patients who have Medicare Supplemental Medical Insurance (or coverage under Part B) but are not in managed care plans. The Physician/Supplier Procedure Summary File data are publicly available for purchase from the Centers for Medicare and Medicaid Services. The files contain summarized counts of procedures and associated costs (Medicare-allowed dollars) and do not contain any information that is identifiable at the patient level or claim level.

The Medicare files contain data about 100–130 million diagnostic radiology procedures that pertain to approximately 30 million enrollees for each year reported. Utilization levels were measured for each Current Procedural Terminology (CPT) code (2), state, and place of service (eg, inpatient hospital, emergency room). We (M.B., J.H.S.) applied a list used by the American College of Radiology to group CPT codes into modalities. The analysis includes the 70000 series of CPT codes, as well as the 90000 series for echocardiographic procedures, and includes procedures performed by all providers. With regard to interventional procedures for which a combination of surgery codes and radiology supervision and intervention codes was used, we (M.B., J.H.S.) counted claims only for supervision and intervention codes that were in the 70000s and did not count each surgery code independently, to avoid counting each procedure more than once.

The data were grouped according to modality, place of service, and state. (The District of Columbia and the counties of Maryland and Virginia that are included in the Washington metropolitan area all share the same geographic identifier; hence, numbers of claims for the District of Columbia, Maryland, and Virginia do not strictly correspond to the state geographic borders.) We (M.B., J.H.S.) in-

cluded data only for the 50 states and the District of Columbia; data about procedures performed in Puerto Rico and the Virgin Islands were excluded. Our numbers for ambulatory radiology services include all nonhospital procedures, emergency room procedures, and hospital outpatient procedures. The overall total includes ambulatory care plus hospital inpatient care.

The number of enrollees eligible for services included in the Physician/Supplier Procedure Summary File for each year was obtained from the Centers for Medicare and Medicaid Services (formerly the Health Care Financing Administration) Web site (3) and was calculated as the number of Supplemental Medical Insurance enrollees minus the number of Medicare managed care enrollees as measured in July of each year (4). These are publicly available data that include total counts of Medicare beneficiaries enrolled in Part A, Part B, and managed care by county only; there are no patient identifiers.

For comparison of trends between 1992 and 2001, we (M.B., J.H.S.) used the data stratified according to modality that are reported in Burkhardt and Sunshine (1) for procedures performed in an ambulatory setting and for total procedures.

Medical Expenditure Panel Survey Data

The Medical Expenditure Panel Survey (MEPS), a nationally representative survey conducted by the federal government's Agency for Healthcare Research and Quality, was used as a source of data about selected radiology procedures (magnetic resonance [MR] imaging, ultrasonography [US], mammography, radiography, and radiation therapy) performed in 1996 and 1999. The MEPS data are public-use data available for download from the Internet, and beneficiaries are not identifiable. (For more information, readers may visit the MEPS Web site at www.meeps.ahrq.gov.)

The MEPS is a complex sample survey that contains responses from 22 601 persons in 1996 and 24 618 persons in 1999, including both elderly and nonelderly respondents, and with responses weighted to make results representative of the national population. The number of events (ie, visits to a physician's office, emergency room, or outpatient hospital department) that involved radiology was relatively small for some types of events. (In 1996 and 1999, the numbers of radiation therapy events were approximately 600 and 1000, those of MR imaging

events were approximately 800 and 1500, and those of radiography events were approximately 6700 and 7700.) The weights in the sample allowed us (M.B., J.H.S.) to calculate nationally representative average utilization per person.

Data from the MEPS are based on responses from persons living in the 50 states and the District of Columbia, and data about medical events are for ambulatory care only, including that provided in physicians' offices, hospital outpatient departments, and emergency rooms. Respondents are told to maintain event logs, and attempts are made to verify these logs with the reported medical providers.

MEPS data include demographic information about the respondents, information about the medical event, statistical weights for each person and each survey design-specific sampling cluster, and stratum identifiers to enable calculation of nationally representative statistics. To protect confidentiality, information about the respondent's state of residence is not available; MEPS data do, however, indicate the census region (Northeast, Midwest, South, or West) in which the respondent resides.

Private Insurers

We (M.B., J.H.S.) also obtained limited information about utilization by commercially insured patients, primarily nonelderly, from two sources. A medical imaging management company (MedSolutions, Franklin, Tenn) provided data from a number of private insurers across the country for utilization of computed tomography (CT), MR imaging, and nuclear medicine for 2000 and for trends since 1996. These outpatient data came from several managed care firms and represent a total of 127 million member-months over a 5-year period (1996–2000) (Poenitske A, personal communication, September 4, 2001). While these data are not nationally representative, they provide a useful indication of the managed care experience of some private payers.

The other source of information about utilization by commercially insured patients was an HMO in the northeastern United States. We (M.B., J.H.S.) obtained data about utilization of CT, MR imaging, and US per 1000 enrollees in this HMO for 1993–1998 (Moskowitz H, personal communication, 2001), during which time enrollment in the HMO ranged from approximately 100 000 to more than 160 000 (5).

The information cited for each private

payer was given to us in aggregate (as procedure counts per beneficiary, for each modality, for each region). There were no patient identifiers. All the data that we received are presented in this article in the same form in which we received them; therefore, the data we obtained are available to everyone who has access to this publication.

Statistical Analyses

All statistical calculations and analyses were performed by the two authors. We used the Medicare data for 2001 to calculate national average utilization per 1000 non-managed care enrollees according to modality. To demonstrate the level of variability across states, several percentile measures of state-level utilization were calculated for each modality.

We calculated mean utilization per 1000 persons from the MEPS while taking into account the sample design, including clustering and stratification, and applying appropriate weights to calculate average utilization and standard errors.

Mammography is performed almost entirely in women, and the appropriate measure for utilization of mammography therefore is the number of procedures per 1000 women; however, state-level counts of Medicare enrollees according to sex at birth are not available. (The only counts available include enrollees of both birth sexes.) Therefore, we reported utilization of mammography as we did that of all other modalities, as number of procedures per 1000 persons among MEPS respondents and Medicare enrollees, with men and women combined. Approximately 60% of all Medicare enrollees (6) and 50% of persons younger than 65 years (7,8) are women.

The private payer data were simply tabulated in the form in which we received them, with no further statistical analysis. We measured the compound average annual rate of increase in Medicare-reported utilization per 1000 enrollees for 1992–1995, 1995–1998, 1998–2001, and 1992–2001. Rates were calculated by using numbers reported in Burkhardt and Sunshine (1) for 1992 and numbers that we calculated for 1995, 1998, and 2001. We calculated compound annual rates of increase in utilization per 1000 persons for MEPS between 1996 and 1999, and we tabulated rates based on the managed care data across years for which annual rates of increase were available. With regard to the single HMO, we used the utilization level for each year for which we had these data to calculate compound

average annual rates of increase in utilization.

We also measured procedures performed in an ambulatory setting as a proportion of all diagnostic radiology procedures reported in Medicare data for 1992 and 2001. We compared levels and trends in utilization between Medicare data and MEPS data for persons aged 65 years or older.

Data from the MEPS and data from MedSolutions with regard to privately insured persons were separable according to region, and Medicare data were grouped according to state within the four U.S. census regions. (The regions in the MEPS data are consistent with the census regions. The regions in MedSolutions data, however, do not strictly correspond to the census regions: Texas and Oklahoma are included in the West in the census data.) We compared utilization by MEPS respondents younger than 65 years to that by MedSolutions customers, and that by MEPS respondents aged 65 years or older to that by Medicare patients according to census region. In some instances, data for these comparisons were not available for identical years, and we compared data with a displacement of 1 year.

To analyze variations in utilization across states, we sorted states into quartiles of utilization per 1000 persons and mapped these state quartiles. In addition, we calculated correlation coefficients for comparisons between, on one hand, the number of procedures per 1000 Medicare enrollees in each state in 2001 and, on the other hand, the numbers of Medicare providers in that state, radiologists in that state, Medicare providers per person in the state population, radiologists per person in the state population, and persons in the state population. We also performed linear regression analyses by using state-level utilization per 1000 Medicare enrollees as the dependent variable and by using combinations of the other state-level variables as independent variables. We then performed a stepwise regression analysis to determine which of the state-level statistics were most predictive of the variation across states in radiology utilization per 1000 Medicare enrollees. The state population data for 2001 were obtained from the Web site of the U.S. Census Bureau (www.census.gov), data about Medicare providers (counts according to state in September 2002) came from the Web site of the Centers for Medicare and Medicaid Services (www.cms.hhs.gov), and the numbers of radiol-

ogists in each state were obtained from the American Medical Association (9).

With regard to Medicare utilization levels and rates of increase across modalities and states, we calculated correlation coefficients for the 1995 level with the 1995–1998 rates of increase and coefficients for the 1998 level with the 1998–2001 rates of increase.

Finally, we calculated coefficients of variation for utilization per 1000 Medicare enrollees in 1995, 1998, and 2001 across states and for each modality.

RESULTS

Utilization Levels

In 2001 (the most recent year for which data were available), non-managed care Medicare enrollees used, on average, 2859 diagnostic and 266 therapeutic radiology procedures per 1000 persons in ambulatory settings (ie, excluding hospital inpatient services) and 4176 diagnostic and 274 therapeutic radiology procedures per 1000 persons across all service settings (Table 1). Close to one-half of all diagnostic procedures involved general radiography, which was by far the most frequently used modality. US was the second most frequently used modality. We also calculated the 10th, 25th, 50th (median), 75th, and 90th percentiles of state-level utilization for each modality. For most modalities, utilization in the states in the 25th and 75th percentiles was within 15%–20% of the median, and that in the states in the 10th and 90th percentiles was within 25%–30% of the median (Table 1). Differences across percentiles were smaller for all diagnostic radiology combined than for individual modalities.

When states were sorted according to utilization of diagnostic radiology per 1000 Medicare enrollees, nine of the 10 states with the largest populations were in the upper two quartiles (Figure). Most of the states with utilization in the lowest quartile were geographic neighbors located in one of two census regions—Washington, Oregon, Idaho, Montana, Wyoming, Utah, Colorado, and New Mexico, in the West; and Maine, New Hampshire, and Vermont, in the Northeast.

The correlation between the number of procedures per 1000 Medicare enrollees in 2001 and the total number of Medicare providers in the state (Pearson correlation coefficient = 0.47, adjusted R^2 = 0.20) was positive and statistically significant. In addition, correlations between

TABLE 1
Utilization of Radiology Procedures per 1000 Medicare Enrollees in 2001

Modality	No. of Procedures per 1000 Enrollees					
	National Average	10th Percentile State	25th Percentile State	50th Percentile State	75th Percentile State	90th Percentile State
Ambulatory Settings*						
CT	247	207	212	239	264	284
MR imaging	94	69	78	93	102	113
US	622	418	468	541	630	696
Interventional	117	86	94	105	127	143
Angiography	31	20	23	28	35	39
Other imaging	52	32	40	48	59	69
Repair	34	26	29	33	36	40
Mammography	220	194	201	225	245	256
Nuclear medicine	193	116	139	174	215	247
Radiography	1359	1118	1203	1323	1418	1562
Other diagnostic	7	3	4	6	8	10
All diagnostic	2859	2274	2518	2743	2898	3180
Therapeutic	266	160	191	234	275	342
All Service Settings						
CT	391	297	315	365	412	450
MR imaging	114	84	98	113	122	136
US	921	586	691	811	936	1040
Interventional	215	153	170	196	230	260
Angiography	57	38	42	51	61	76
Other imaging	99	62	78	90	113	125
Repair	59	40	48	57	60	71
Mammography	221	195	201	227	246	257
Nuclear medicine	249	142	182	224	279	323
Radiography	2057	1551	1750	2000	2151	2317
Other diagnostic	9	3	6	8	10	12
All diagnostic	4176	3038	3482	4064	4362	4573
Therapeutic	274	166	195	234	282	353

* Includes hospital outpatient, emergency room, and nonhospital care (excludes inpatient care).

the number of procedures per 1000 Medicare enrollees in 2001 and the total number of radiologists in the state (Pearson correlation coefficient = 0.42, adjusted $R^2 = 0.16$) and between the number of procedures per 1000 Medicare enrollees in 2001 and the total state population (Pearson correlation coefficient = 0.41, adjusted $R^2 = 0.15$) were positive and statistically significant. Correlations of radiology utilization per 1000 Medicare enrollees with the number of radiologists per person in the state population and the number of Medicare providers per person in the state population were weaker and generally not significant. Regression analyses performed by using the number of procedures per 1000 Medicare enrollees in 2001 as the dependent variable and combinations of the other state-specific variables as independent variables resulted in values for the adjusted coefficient of determination (R^2) that were approximately 0.20 or lower. The two variables that proved most predictive of variations in state-level Medicare radiology utilization per 1000 enrollees were the total number of Medicare providers

in the state and the number of radiologists per state population, and only the correlation with the number of Medicare providers was statistically significant ($P < .01$).

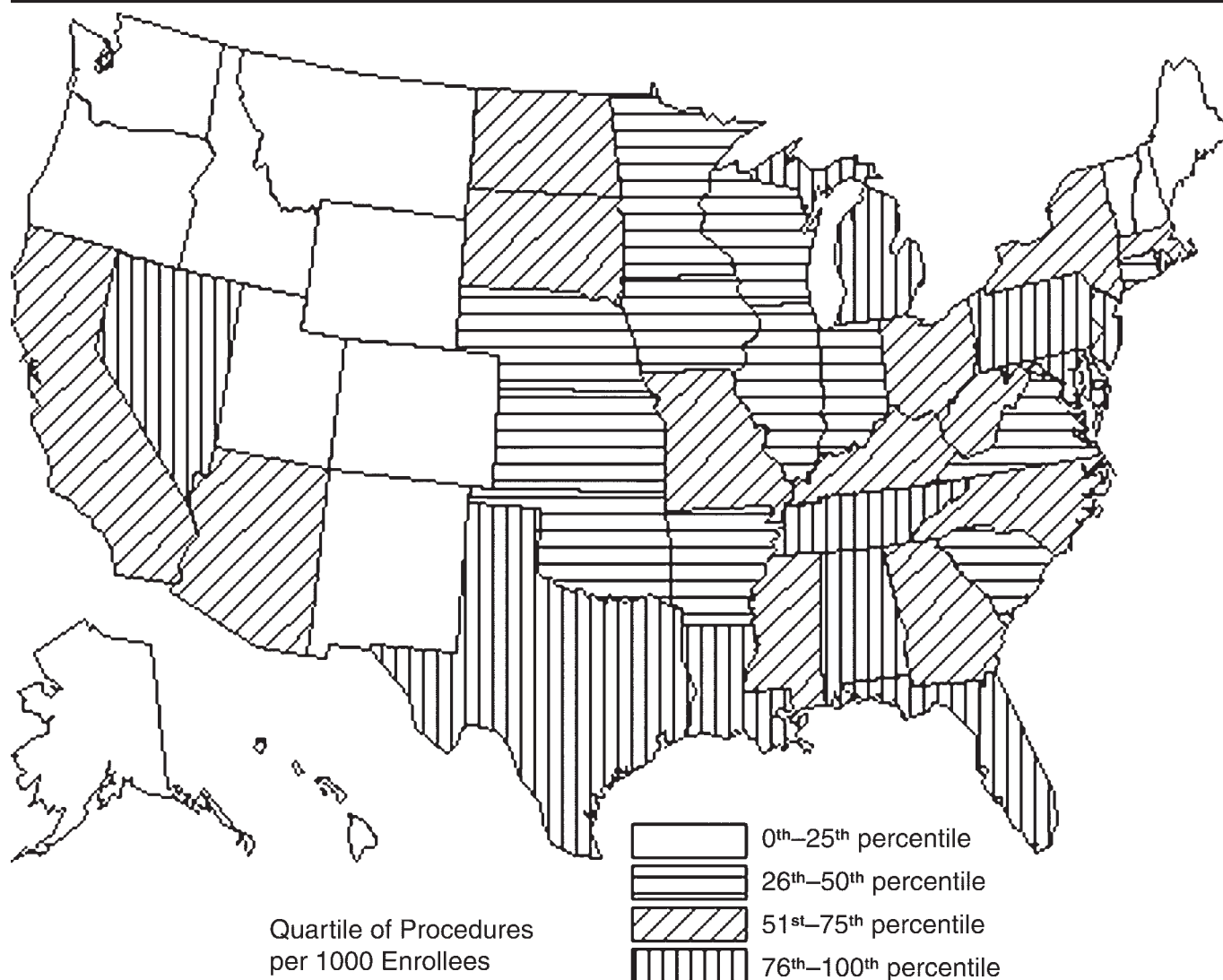
According to data from the 1999 MEPS, utilization of MR imaging and mammography per 1000 persons 65 years or older was, on average, about three times that per 1000 persons younger than 65 years (Table 2). Among those aged 65 years or older, utilization of radiography (in MEPS data, counted as "x-rays") was two and a half times, and utilization of US was nearly one and a half times, the level among those younger than 65 years. As the standard errors in Table 2 show, the uncertainty of utilization reported in MEPS among those aged 65 years and older is large because MEPS is a sample survey in which each respondent, on average, represents more than 11 000 persons. For radiation therapy, standard errors were particularly large because fewer than 1% of respondents underwent radiation therapy.

Utilization data obtained from private insurers about commercially insured

managed care populations demonstrate that individual health plans may experience utilization rates that differ substantially from national averages in nationally representative data (Table 3).

Trends

We calculated the average compound annual rate of increase in utilization of procedures per 1000 Medicare enrollees between 1992 and 1995, 1995 and 1998, and 1998 and 2001 (Table 4). The 1992 data are from Burkhardt and Sunshine (1). In ambulatory settings, utilization of high-technology modalities such as MR imaging, interventional radiology, and nuclear medicine increased by more than 10% per year on average, and that of CT and US increased by approximately 8% annually, between 1992 and 2001 (Table 4). In contrast, utilization of radiography, which accounts for the largest percentage of procedures overall, increased by only 1% annually. Utilization of screening mammography (which is not separated from diagnostic mammography in Table 4) increased relatively rap-



Map shows states according to radiology utilization quartiles based on number of procedures per 1000 Medicare enrollees.

idly in both ambulatory and nonambulatory settings, at about 16.5% annually between 1995 and 2001.

The number of procedures per 1000 enrollees that were performed in ambulatory settings increased at least marginally in all modalities. Overall, the proportion of all diagnostic radiology procedures that were performed in ambulatory settings increased from 62% in 1992 to 68% in 2001.

In the state-level analysis, we found that a high utilization per 1000 Medicare enrollees in any year was strongly correlated with a low compound average annual rate of increase in utilization per 1000 enrollees in the ensuing years. There was a statistically significant and strongly negative correlation between the number of procedures per 1000 enrollees in 1998 and the average

annual rate of increase in utilization of procedures per 1000 enrollees in the ensuing 3-year period from 1998 to 2001 (Pearson correlation coefficient = -0.951) and between the number of procedures per 1000 enrollees in 1995 and the annual rate of increase in utilization of procedures per 1000 enrollees in the ensuing 6-year period from 1995 to 2001 (Pearson correlation coefficient = -0.947). In almost all modalities, the variability in utilization across states decreased during 1998–2001 and 1995–1998.

The average rate of increase in radiography and MR imaging utilization for those aged 65 years and older among MEPS respondents in 1996–1999 is similar to the corresponding average annual rate of increase among Medicare enrollees for the overlapping period of 1995–

1998 (Table 5). We found a decrease in reported utilization of US in MEPS data, in contrast to a fairly rapid increase in utilization reported in Medicare data. While the average rate of increase in mammography utilization appears to differ between the two sources, the 95% confidence intervals for the MEPS averages are so large that the differences are not statistically significant. Similarly, although the average rates of increase in utilization differ between MEPS respondents who are 65 years old or older and those who are younger than 65 years, the differences are not statistically significant because of the large standard errors in the MEPS estimates.

Rates of increase in managed care utilization reported by the two private payer sources were much higher than those found for the national popula-

tion younger than 65 years in the MEPS (Table 6).

Regional Utilization

Regional variations were found across modalities and data sources (Table 7). The Northeast has the highest utilization of diagnostic radiology among Medicare enrollees. With regard to individual modalities, the region leads in utilization of CT, MR imaging, US, and mammography. It has the lowest utilization of non-angiographic interventional radiology procedures.

Among MedSolutions enrollees, utilization was highest in the Northeast for all modalities for which we had data. MEPS utilization levels did not differ significantly between regions ($P > .05$).

DISCUSSION

Implications of Study Findings

Utilization of screening mammography in the Medicare-insured population increased relatively rapidly between 1998 and 2001, probably because of increased awareness and newly instituted Medicare reimbursement, but also possibly in part reflecting an earlier misclassification of screening mammography as diagnostic mammography.

The Medicare data indicate that the total number of radiology procedures per 1000 enrollees increased at a compound annual average rate of almost 5% between 1998 and 2001. Population aging is responsible for an approximately 0.5% increase annually (10), but, on the other hand, relative value units per procedure are increasing approximately 1.5% annually (11), which means that utilization in relative value units per age-standardized Medicare enrollee is increasing by approximately 6% annually. This is a rapid increase, and it implies almost a doubling of per capita utilization every decade. This increase in utilization, which is sometimes attributed to technologic progress, is a measure of the increasing power of radiology to help patients.

While the benefits to patients seem clear, increased utilization entails a major problem for radiologists. If we add to the approximately 6% annual increase in utilization per age-standardized person an approximately 0.5% increase to account for overall population aging and an approximately 1% annual increase to accommodate the increasing numbers in the U.S. population, we must conclude that the total radiology workload is increasing by approximately 8% annually.

TABLE 2
Ambulatory Utilization of Imaging and Radiation Oncology Procedures according to MEPS 1999 Data

Modality Used and Patient Age (y)	Procedures per 1000 Persons		
	National Average	Standard Error	95% Confidence Interval
MR Imaging			
All ages	64	4.3	56, 73
<65	52	4.3	44, 61
≥65	151	18.7	115, 188
US			
All ages	102	6.1	90, 114
<65	98	6.7	85, 111
≥65	137	15.8	107, 168
Mammography			
All ages	73	2.7	67, 78
<65	59	2.7	53, 64
≥65	182	10.8	161, 203
Radiography			
All ages	326	10.9	304, 347
<65	272	9.5	254, 291
≥65	711	49.4	614, 808
Radiation therapy			
All ages	43	8.2	27, 59
<65	24	6.1	12, 36
≥65	175	47.7	82, 269

In contrast, the number of radiologists in practice is estimated to increase by approximately 1.5% annually (12). It seems that radiologists must either continue to manage a rapidly increasing work load (11)—possibly through adoption of technologic advances such as three-dimensional “fly-through” viewing of cross-sectional images and computer-aided detection—or see a greater portion of the radiology work load devolve to other specialties, as is already happening with nuclear cardiology (13). Indeed, it is most likely that both trends will continue to develop quite rapidly.

States with a large total population and large numbers of radiologists and Medicare providers have higher radiology utilization per 1000 Medicare enrollees. Strangely, there generally are no similar correlations between utilization per 1000 Medicare enrollees and resources per capita (for example, physicians per 100 000 persons in the state population or per 1000 Medicare enrollees), although such correlations would be more expected. We do not know the reason for this odd pattern, but geographic differences in utilization have been widely noted (14). Also, while we have found some correlations, the results of regression analysis show that these variables, even in combination, do not explain more than 20% of the geographic variation in utilization. The correlations do not explain the underlying mechanism that drives utilization.

With regard to utilization according to modality, there are negative correlations between the rate of increase for a modality and the age of that modality (ie, how long the technology has been available). Increase in the utilization of radiography, by far the longest-available modality, has essentially stopped, a fact that suggests that utilization of modalities eventually plateaus. At the other extreme, MR imaging is the newest modality and the one for which utilization is increasing most rapidly, which indicates that modalities grow (as a percentage of radiology utilization) especially rapidly in their early stages. For most modalities, we found that the variability in Medicare utilization across states has decreased over time, which is consistent with the notion of a plateau in utilization. We noticed a similar plateau for all modalities combined, as well: States with high utilization in the early 1990s experienced low rates of increase in utilization for the rest of the decade. We do not have enough information to identify the mechanisms that cause these correlations. Presumably, states and modalities with high utilization in 1992 were those in which equipment penetration and, possibly, provider influx occurred earlier than elsewhere, and once these were in place, there was not as much room for rapid increase in utilization. Conversely, states with low initial utilization experienced a more rapid increase in utilization through the 1990s, since it was relatively

TABLE 3
Ambulatory Utilization of Imaging Procedures according to Managed Care Data

A: MedSolutions Data*

Modality	Procedures per 1000 Enrollees in Year 2000
CT	56
MR imaging	41
Nuclear medicine	39
All diagnostic	769

B: Data from HMO in Northeastern United States

Modality	Procedures per 1000 Enrollees in Year				
	1993	1994	1995	1997	1998
CT	39	40	43	81	113
MR imaging	19	17	22	46	62
US, excluding echocardiography	101	95	100	140	175

* Data were compiled from several major HMOs across the country.

TABLE 4
Radiology Utilization Trends among Medicare Enrollees in 1992–2001

Modality	Procedures per 1000 Enrollees							
	1992*	1995	1992–1995 Compound Annual Rate of Increase (%) [†]	1998	1995–1998 Compound Annual Rate of Increase (%) [†]	2001	1998–2001 Compound Annual Rate of Increase (%) [‡]	1992–2001 Compound Annual Rate of Increase (%) [‡]
	Ambulatory Settings [‡]							
CT	121	133	3.3	178	10.1	247	11.7	8.3
MR imaging	35	40	4.7	59	13.9	94	16.6	11.6
US	323	395	6.9	490	7.5	622	8.3	7.6
Interventional	34	54	16.7	74	11.1	117	16.4	14.7
Angiography	0	16	0	22	11.5	31	12.7	0
Other imaging	0	20	0	27	9.9	52	24.6	0
Repair	0	18	0	26	12.1	34	10.1	0
Mammography	140	142	0.6	198	11.5	220	3.7	5.1
Nuclear medicine	80	76	-1.5	118	15.4	193	17.9	10.3
Radiography	1239	1215	-0.6	1277	1.7	1359	2.1	1.0
Other diagnostic	ND	3	ND	3	8.1	7	27.1	ND
All diagnostic	1972	2059	1.5	2397	5.2	2859	6.1	4.2
Therapeutic	256	247	-1.2	235	-1.6	266	4.2	0.4
	All Service Settings							
CT	218	231	1.9	294	8.4	391	10.0	6.7
MR imaging	44	50	4.4	73	13.5	114	16.1	11.2
US	494	616	7.6	748	6.7	921	7.2	7.2
Interventional	118	127	2.5	155	6.8	215	11.6	6.9
Angiography	0	35	0	43	7.0	57	9.7	0
Other imaging	0	62	0	69	3.6	99	12.7	0
Repair	0	30	0	42	12.6	59	11.6	0
Mammography	143	144	0.2	199	11.4	221	3.6	4.9
Nuclear medicine	131	119	-3.1	165	11.4	249	14.7	7.4
Radiography	2037	1942	-1.6	1990	0.8	2057	1.1	0.1
Other diagnostic	ND	3	ND	4	6.5	9	27.4	ND
All diagnostic	3185	3232	0.5	3628	3.9	4176	4.8	3.1
Therapeutic	269	257	-1.5	243	-1.8	274	4.0	0.2

Note.—ND = no data.

* From reference 1.

[†] The numbers for utilization are rounded. The rates of increase were calculated by using actual (unrounded) values. Therefore, calculations of rates of increase based on table values will not exactly match reported rates of increase.

[‡] Includes hospital outpatient, emergency room, and nonhospital care (excludes inpatient procedures).

easy to expand equipment use and physician employment.

The share of ambulatory settings

among Medicare-reported diagnostic radiology procedures increased from 62% in 1992 to 68% in 2001, in keeping with

the general health care trend away from the hospital inpatient setting. In part, this trend is due to new techniques, such

as laparoscopic surgery, that permit speedier patient discharge or movement of procedures to outpatient settings. In addition, pressures from the payment system—for example, the incentive incorporated in Medicare reimbursement according to diagnosis-related groups to discharge patients as rapidly as feasible—are almost certainly also partly responsible.

Comparing Medicare results in this study to earlier results from 1992 that were reported in Burkhardt and Sunshine (1), we found that the average annual rate of increase was lower between 1992 and 1995 for all modalities except interventional radiology than it was through the rest of the 1990s. It is interesting that although all the Medicare enrollees in the study were in the fee-for-service category, the trends in utilization parallel the intensification and easing of managed care constraints: The period of 1992–1995 was one of increasingly restrictive managed care, and the years after 1995 saw an easing of managed care restrictions (15).

The Medicare data for utilization of mammography indicate a rate of increase of 7.4% per year between 1995 and 2001, but use of screening mammography increased much faster, at about 16.5% per year in 1995–2001 (the most recent years for which we have data about screening mammography as a category distinct from diagnostic mammography). Breen et al (16) analyzed the National Health Interview Survey data for screening mammography, and their numbers translate into an average annual rate of increase of about 5.6% for women aged 65 years or older between 1992 and 1998, which is closer to the 5.9% increase in utilization per year in 1992–1998 for all mammography (screening and diagnostic) reported in Medicare data. Since utilization of Medicare-reported screening mammography increased significantly faster than did that of diagnostic mammography, the rates reported by Breen et al are substantially different from the ones we found for women aged 65 years and older. It is possible that self-reported definitions are not always accurate and may understate rates of increase, but it is also possible that with Medicare having instituted coverage for screening mammography, providers have changed practice styles to substitute screening mammography for what earlier would have been classified as diagnostic mammography.

It was reported in an issue brief from the Center for Studying Health System Change (15) that with managed care losing its hold in the past few years, and

TABLE 5
MEPS Ambulatory Radiology Utilization Trends, 1996–1999

Modality Used and Patient Age (y)	Procedures per 1000 Persons in U.S. Population		Compound Annual Rate of Increase (%)
	1996	1999	
MR imaging			
All ages	43	64	14.1
<65	37	52	12.5
≥65	90	151	19.0
US			
All ages	109	102	-2.0
<65	102	98	-1.4
≥65	158	137	-4.5
Mammography			
All ages	64	73	4.5
<65	54	59	2.7
≥65	137	182	9.8
Radiography			
All ages	346	326	-2.0
<65	294	272	-2.5
≥65	720	711	-0.4
Radiation therapy			
All ages	36	43	6.9
<65	12	24	26.4
≥65	178	175	-0.5

Note.—Ambulatory radiology services include office, hospital outpatient, and emergency room services.

TABLE 6
Private Managed Care Ambulatory Radiology Utilization Trends

A: MedSolutions Data				
Modality	Compound Average Annual Rate of Increase (%)			
	1996–1997	1997–1998	1998–1999	1999–2000
CT	18.9	19.4	20.5	27.4
MR imaging	17.2	14.3	13.2	22.7
Nuclear medicine	19.2	17.0	17.2	28.2
All diagnostic	10.0	8.0	7.1	10.4

B: Data from HMO in Northeastern United States				
Modality	Compound Average Annual Rate of Increase (%)			
	1993–1994	1994–1995	1995–1997	1997–1998
CT	1.0	8.8	37.3	38.5
MR imaging	-8.1	27.6	45.9	33.3
US, excluding echocardiography	-6.0	6.0	18.2	24.9

Note.—Data are calculations based on number of procedures per 1000 enrollees.

with loosening of restrictions by employers and insurers, health care utilization and costs have increased rapidly overall. In this study, not only did we find an increase in the utilization of radiology by Medicare enrollees, but our limited managed care data also indicate a much more rapid increase in utilization than that indicated by the Medicare data. The findings by the Center for Studying Health System Change suggest that our managed care data, despite limitations, may reflect some of this upsurge.

Limitations of the Data

The individual information resources we used differ substantially from each other. It is understandable that data from an individual payer such as the single HMO might differ from national averages. Moreover, it is likely that the managed care organizations that contacted us with their data did so because they experienced unusually high rates of increase in utilization. Therefore, these data might well not be nationally representative.

TABLE 7
Ambulatory Radiology Utilization per 1000 Persons according to Region

A: MedSolutions Data for Year 2000*

Modality	Northeast	Midwest	Southeast	West
CT	61	59	50	37
MR imaging	46	39	37	37
Nuclear medicine	44	43	31	20
All diagnostic	808	790	684	704

B: MEPS Data for Year 1999†

Modality and Patient Age (y)	Northeast	Midwest	Southeast	West
MR imaging				
<65	46	53	55	53
≥65	150	138	147	175
US				
<65	100	85	98	110
≥65	141	106	173	104
Mammography				
<65	61	70	54	52
≥65	181	214	173	160
Radiography				
<65	227	285	299	256
≥65	685	628	849	579

C: Medicare Data for Year 2001‡

Modality	Northeast	Midwest	Southeast	West
CT	243	207	217	187
MR imaging	82	64	79	78
US	637	476	534	543
Interventional	84	89	107	81
Angiography	23	23	29	19
Other imaging	32	38	48	35
Repair	30	28	30	27
Mammography	224	218	207	202
Nuclear medicine	169	152	170	113
Radiography	1287	1209	1310	1144
Other diagnostic	5	3	5	7
All diagnostic	2732	2418	2629	2355

* Geographic delineation of regions in MedSolutions data does not correspond exactly to that in U.S. census data: Texas and Oklahoma are included in the West in MedSolutions data and in the South in U.S. census data.

† Delineation of regions is that used in U.S. census data.

‡ Delineation of regions is that used in U.S. census data. Enrollees are predominantly 65 years old or older.

formative but should not be taken as rigid norms for a practice or for a locality.

References

- Burkhardt JH, Sunshine JH. Utilization of radiologic services in different payment systems and patient populations. *Radiology* 1996; 200:201-207.
- Anderson CA, Beebe M, Dalton JA, et al. Current procedural terminology: CPT 2002. Chicago, Ill: American Medical Association, 2001.
- Centers for Medicare and Medicaid Services. CMS statistics: Medicare enrollment. Available at: www.cms.hhs.gov/statistics/enrollment. Accessed December 2003.
- Centers for Medicare and Medicaid Services. Managed care and Medicare Advantage reports, files, and data. Available at: www.cms.hhs.gov/healthplans/reportfilesdata. Accessed September 2003.
- Moskowitz H, Sunshine J, Grossman D, Adams L, Gelin L. The effect of imaging guidelines on the number and quality of outpatient radiographic examinations. *AJR Am J Roentgenol* 2000; 175:9-15.
- Pastor PN, Makuc DM, Reuben C, Xia H. *Chartbook on trends in the health of Americans: health, United States, 2002*. Hyattsville, Md: National Center for Health Statistics, 2002.
- U.S. Census Bureau, Population Division. Intercensal estimates of the United States resident population by age groups and sex, 1990-2000: selected months. Release date: September 13, 2002. Available at: www.census.gov/popest/archives/EST90INTERCENSAL/US-EST90INT-04.html. Accessed December 15, 2004.
- U.S. Census Bureau, Population Division. Annual resident population estimates of the United States by age and sex: April 1, 2000 to July 1, 2002. Release date: June 18, 2003. Available at: www.census.gov/popest/archives/2000s/vintage_2002/NA-EST2002-ASRO-01.html. Accessed December 15, 2004.
- Pasko T, Seidman B. Physician characteristics and distribution in the U.S., 2002-2003 edition. Chicago, Ill: American Medical Association, 2002.
- Smith S, Heffler SK, Calfo S, et al. National health projections through 2008. *Health Care Financ Rev* 1999; 21:211-237.
- Bhargavan M, Sunshine JH. Workload of radiologists in the United States in 1998-1999 and trends since 1995-1996. *AJR Am J Roentgenol* 2002; 179:1123-1128.
- Bhargavan M, Sunshine JH, Schepps B. Too few radiologists? *AJR Am J Roentgenol* 2002; 178:1075-1082.
- Levin DC, Parker L, Intenzo CM, Sunshine JH. Recent rapid increase in utilization of myocardial perfusion imaging and related procedures: 1996-1998 practice patterns. *Radiology* 2002; 222:144-148.
- Medicare Payment Advisory Commission. Report to the Congress: variation and innovation in Medicare. Washington, DC: Medicare Payment Advisory Commission, June 2003; 3-15.
- Lesser CS, Ginsburg PB. Health care cost and access problems intensify: initial findings from HSC's recent site visits. *Issue Brief Cent Stud Health Syst Change* 2003; 63:1-6.
- Breen N, Wagener DK, Brown ML, Davis WW, Ballard-Barbash R. Progress in cancer screening over a decade: cancer screening from the 1987, 1992, and 1998 National Health Interview Surveys. *J Natl Cancer Inst* 2001; 93:1704-1713.

Even data from relatively large nationally representative surveys such as the MEPS are not particularly congruent with corresponding data for the same population from administrative databases such as that of the Medicare administration. The differences in reported levels of utilization between MEPS and Medicare could simply be definitional. In the Medicare data, we identified procedures by their CPT codes, and we used an American College of Radiology list to identify the modalities to which each CPT code pertains. In surveys such as the MEPS, the modalities are self-defined and may cover more or fewer services than those we identified in the Medicare data. As we had expected, because national uti-

lization did not match across sources, we did not find agreement in absolute levels of regional utilization reported across sources.

Conclusion

Overall, the data show that utilization of high-technology modalities such as MR imaging and interventional radiology increased rapidly through the 1990s, while utilization of radiography stayed at about the same level. As noted, however, there are substantial differences in utilization among census regions and states. Presumably, smaller geographic areas may show even larger differences. Thus, national, regional, and state data are in-