

# Radiology Performed by Nonradiologists in the United States: Who Does What?

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**OBJECTIVE.** When nonradiologists perform radiologic procedures, rather than referring their patients to radiologists, utilization—and therefore costs—are high, and quality appears often to be poor. In light of these public policy concerns, the American College of Radiology developed a detailed descriptive analysis of radiology performed by nonradiologists.

**MATERIALS AND METHODS.** Medicare data from 1989, which make up a uniform record of one third of the nation's health care, were the source of the information. These data are reasonably, although not exactly, representative of patients of all ages. We measured radiologic work, and nonradiologists' share of it, in professional component relative value units, using the Medicare radiology relative value scale.

**RESULTS.** Nonradiologists performed 25% of all radiologic work in the United States; their share was 46% in offices and freestanding centers, 27% for hospital inpatients, and 8% for outpatients. Counting procedures (rather than work measured in relative value units), nonradiologists' share was 64% in offices and freestanding centers and 8% for inpatients. Nonradiologists performed two thirds of all work in sonography, half of interventional radiology/angiography, 15–17% of general radiology and nuclear medicine, and a few percent of CT/MR and radiation oncology. Cardiologists performed 10% of all radiologic work in the United States; internists 5%; and orthopedists, ophthalmologists, and family and general practitioners, 2% each. Almost half of radiologic work performed by nonradiologists consisted of coronary angiography and cardiac sonography, done principally by cardiologists. Radiologists do less than 5% of this work. Office and freestanding center general radiology, performed mostly by orthopedists and primary care physicians, accounted for one fourth of the radiologic work done by nonradiologists.

**CONCLUSION.** The general radiology performed by nonradiologists is of a magnitude that easily could be transferred to radiologists, particularly because many unnecessary imaging studies would most likely be eliminated as a result. Such a transfer would reduce costs and probably improve quality but might sometimes decrease patient convenience. However, because many radiologists do not perform coronary angiography and cardiac sonography, a transfer of these responsibilities to radiologists would be problematic and likely to require extensive additional training of radiologists.

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The performance of radiology by nonradiologists—here called “self-referral” for short—gives rise to two important public policy problems. First, self-referral generates much higher use and, consequently, higher health care costs than does the referral of patients to radiologists [1, 2]. Self-referring physicians are up to seven times more likely to perform imaging studies than are radiologist-referring physicians seeing patients with the same clinical condition. Second, there appear to be serious quality problems with some of the radiology performed by nonradiologists, although studies on quality in self-referral are just beginning to appear, and the evidence on this point is, so far, quite limited [3].

Because of these problems, the extent to which radiologic procedures are performed by nonradiologists is a matter of concern. Available information on this topic, compiled by Levin and Matteucci [4, 5] and the American Association of Academic Chief Residents in Radiology [6, 7], is useful. These data have two

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important limitations, however. First, as Levin and Matteucci note, they cover only hospitals, while self-referral is probably more extensive in nonhospital settings; and second, they offer no way of aggregating the findings for individual procedures or groups of procedures into a total for an imaging technique (such as sonography) or for radiology as a whole.

In order to extend the available data and transcend their limitations, staff of the American College of Radiology turned to a different data source. This article presents the findings of the resulting study.

## Materials and Methods

Our data source is the 1989 Part B Medicare Annual Data (BMAD) procedure file. This file is a complete tabulation of all physician services rendered to Medicare beneficiaries in 1989 (data for Rhode Island are missing, however). The BMAD procedure file identifies services separately by procedure code as defined in *Current Procedural Terminology* (CPT) [8], by the specialty of the physician billing for the service, by the place of service, and by geographic locality.

In our analysis, we assume that the specialty of the physician performing a service is the same as the specialty of the physician billing the service. We counted as radiologists all physicians classified as radiologists, radiation oncologists, and nuclear medicine specialists by the carriers (private insurers) who operate the Medicare program in each state. We counted as radiologic procedures all procedures in the 70,000 series of CPT codes (i.e., procedures with CPT codes ranging from 70,000 to 79,999—these are the codes generally thought of as constituting radiology), plus the coronary and vascular sonography procedures listed in the 90,000 series of CPT (some of these exactly duplicate 70,000 series procedures) and coronary angiography (also found in the 90,000 series of CPT).

We measured radiologic work on the basis of the professional component relative value units (RVUs) associated with each service. For this purpose, we used the radiology relative value scale developed by the American College of Radiology and used by Medicare beginning in 1989 [9]. (For radiologic procedures outside the 70,000 series, the American College of Radiology had developed and recommended relative values, and we used these, even though Medicare put into effect only the recommendations for 70,000 series codes.) On this relative value scale, the professional relative value of a one-view chest radiograph is set equal to 1.00. As an example of our volume measurement and aggregation method, consider a category consisting of (1) a procedure that has the professional relative value 2.00, performed 10,000 times, and (2) another procedure, with professional relative value equal to 5.00 that was performed 6000 times. The total RVUs associated with this category would be  $2 \times 10,000 + 5 \times 6000 = 50,000$  RVUs. At some points, however, which are noted, we use a simple count of procedures rather than a sum of RVUs.

We estimated the percentage of radiologic work in any category that was performed by nonradiologists as (nonradiologists' total RVUs in the category  $\times 100$ ) / (radiologists' + nonradiologists' total RVUs in the category).

Approximately 5% of radiologic work is performed by multispecialty groups (Medicare calls these groups clinics). Currently available Medicare data do not indicate the specialty of the individual physician within such a group who performed procedures billed by the group. Hence, the work of these groups is omitted in the percentage calculations. Omitting the work of these groups from percentage calculations is equivalent to assuming that their radiologic work divides between radiologists and nonradiologists in the same proportion as do the same procedures performed outside these groups. For example, if cardiologists perform 95% of the cardiac sonography done outside multispecialty groups, our methodology assumes cardiologists perform 95% of

the cardiac sonography done in multispecialty groups. This seemed the most reasonable assumption to make. Note that the workload of multispecialty groups is included in our estimates of workload.

To convert our Medicare data into workload estimates for the entire population of the United States, we multiplied data dealing with all types of radiology by three, which we have previously shown is the correct scaling factor [10, 11]. However, because cancer, the disease treated by radiation oncologists, is very much an illness of the elderly (the population covered by Medicare), we multiplied Medicare radiation oncology data by two to obtain estimates for all radiation oncology in the United States. (The scaling factor of two is based on simple analyses of data from a few states.)

## Results

We first report the extent of radiologic activities performed by nonradiologists and which nonradiologic specialties are principally involved, doing this at three levels of aggregation: (1) all radiology combined, (2) separately for the six major radiologic techniques: general radiology, CT/MR, nuclear medicine, sonography, interventional radiology, and radiation oncology, and (3) separately for selected groups of procedures. At each level of aggregation, data are presented for three sites of service—hospital inpatient care, hospital outpatient care, and office/freestanding center care—as well as for all sites of service combined. We next report data for each state of the United States. Then, for each of the six leading self-referring specialties, we present an analysis of the specialty's principal radiologic activities. Finally, we identify the individual radiologic procedures most dominated by nonradiologists.

### All Radiology

We estimate that nonradiologists performed 25% of the total radiologic work in the United States in 1989 (Table 1). (Recall that our metric is work, as measured by professional component RVUs, not a count of procedures.) With the total professional radiologic work in the United States amounting to approximately 660 million RVUs, this meant nonradiologist physicians billed for 165 million RVUs of professional radiologic work. (One RVU is the professional work involved in a one-view chest radiograph.) Forty-six percent of radiology done in offices and freestanding centers was performed by nonradiologists; nonradiologists performed 27% of all radiology in the inpatient setting but only 8% of all radiology in the hospital outpatient setting. The 165 million radiologic professional RVUs performed by nonradiologists were distributed about equally between the office/freestanding center setting and the hospital inpatient setting. Only a small amount (approximately one eighth of the total) took place in the hospital outpatient setting.

Cardiologists were most prominent among nonradiologist providers, performing 10% of all radiologic work in the United States. Next in importance were internists (5%), orthopedic surgeons (2%), ophthalmologists (2%), and family and general practitioners (2%). Cardiology was the most important specialty at the hospital, while in the office/freestanding center setting, internists were most important, doing 10% of all office/freestanding center radiology, followed by family and general practitioners (7%).

**TABLE 1: Radiology Performed by Nonradiologists**

	Office/ Center	Inpatient	Outpatient	All Places <sup>a</sup>
<b>All Radiology</b>				
Approx. total professional RVUs performed by all specialties (radiology included) (millions of RVUs) <sup>b</sup>	170	270	220	660
Percent of radiologic work performed by nonradiologists	46	27	8	25
Specialties principally involved:				
Internal medicine	10	4	2	5
Orthopedic surgery	6	— <sup>c</sup>	—	2
Cardiology	6	18	3	10
Ophthalmology	6	—	—	2
Family practice	4	—	—	1
General practice	3	—	—	1
Urology	3	—	—	1
General surgery	2	1	1	1
Podiatry	2	—	—	—
Neurology	1	—	—	1
Thoracic surgery	1	1	—	1
Anesthesiology	—	2	—	1
All others	3	2	2	2
Approx. total professional RVUs performed by all nonradiologists (millions of RVUs)	75	75	20	165
Percent of procedures performed by nonradiologists	64	8	5	23
<b>General Radiology</b>				
Approx. total professional RVUs performed by all specialties (radiology included) (millions of RVUs) <sup>b</sup>	73	94	78	245
Percent of imaging work performed by nonradiologists	57	1	1	17
Specialties principally involved:				
Orthopedic surgery	16	—	—	5
Internal medicine	16	—	—	5
Family practice	8	—	—	2
General practice	5	—	—	2
Podiatry	3	—	—	1
Cardiology	2	—	—	1
Urology	1	—	—	—
General surgery	1	—	—	—
Pulmonary medicine	1	—	—	—
Gastroenterology	1	—	—	—
ENT	1	—	—	—
Ob-gyn	1	—	—	—
All others	1	—	—	2
Approx. total professional RVUs performed by all nonradiologists (millions of RVUs)	41	1	1	42
Percent of procedures performed by nonradiologists	66	1	2	20
<b>Sonography<sup>d</sup></b>				
Approx. total professional RVUs performed by all specialties (radiology included) (millions of RVUs) <sup>b</sup>	41	42	22	106
Percent of imaging work performed by nonradiologists	84	58	38	64
Specialties principally involved:				
Ophthalmology	27	—	1	11
Cardiology	18	36	18	25
Internal medicine	12	12	7	11
General surgery	7	4	7	6
Urology	4	—	—	2
Thoracic surgery	4	2	2	3

TABLE 1: Continued

	Office/ Center	Inpatient	Outpatient	All Places <sup>a</sup>
Sonography <sup>d</sup> (Cont.)				
General practice	3	—	—	1
Family practice	2	—	—	1
Podiatry	2	—	—	1
Neurology	2	2	1	2
All others	3	2	2	2
Approx. total professional RVUs performed by all nonradiologists (millions of RVUs)	34	24	8	68
Percent of procedures performed by nonradiologists	85	58	39	66
Interventional Radiology and Angiography				
Approx. total professional RVUs performed by all specialties (radiology included) (millions of RVUs) <sup>b</sup>	4	61	15	80
Percent of imaging work performed by nonradiologists	67	47	25	44
Specialties principally involved:				
Urology	47	—	2	3
Cardiology	11	37	18	32
Internal medicine	3	6	3	6
General surgery	1	1	1	1
Thoracic surgery	1	1	1	1
General practice	1	—	—	—
All others	4	1	1	1
Approx. total professional RVUs performed by all nonradiologists (millions of RVUs)	3	29	4	35
Percent of procedures performed by nonradiologists	65	37	18	34
Nuclear Medicine				
Approx. total professional RVUs performed by all specialties (radiology included) (millions of RVUs) <sup>b</sup>	5	21	17	44
Percent of imaging work performed by nonradiologists	49	10	10	15
Specialties principally involved:				
Cardiology	31	4	4	7
Internal medicine	11	3	4	4
General practice	1	—	—	—
Pathology	1	2	2	2
Nephrology	1	—	—	—
Urology	1	—	—	—
Family practice	1	—	—	—
All others	2	1	1	1
Approx. total professional RVUs performed by all nonradiologists (millions of RVUs)	3	2	2	7
Percent of procedures performed by nonradiologists	45	9	9	14

Note.—Because of rounding, details may not add to totals. Source: Computed from 1989 HCFA/BMAD Procedure File.

<sup>a</sup>Includes small amounts in other places such as surgicenters.

<sup>b</sup>One RVU = work involved in one single-view chest radiograph.

<sup>c</sup>Dashes indicate less than 0.5.

<sup>d</sup>Because data are from Medicare, which involves very little obstetrics, obstetrical sonography is greatly under-represented.

Although nonradiologists performed 46% of office/freestanding center radiologic work (measured by professional RVUs), they performed 64% of radiologic procedures in this setting, meaning their activity was concentrated in simpler procedures. In contrast, they performed 27% of inpatient work, while performing only 8% of inpatient procedures, indicating their activity typically involved more complex procedures than the inpatient work of radiologists.

#### Individual Radiologic Techniques

Nonradiologists performed 17% of work in general radiology, principally plain film studies (Table 1). The figure was 57% in the office/freestanding center setting but only 1% in hospitals. The most prominent specialists among the nonradiologists performing the 57% of office/freestanding center general radiology were orthopedists (16% of all office/free-

standing center general radiology), internists (16%), and family and general practitioners (13%).

Nonradiologists performed approximately two thirds of sonographic work (Table 1). Their share was five sixths in the office/freestanding center setting, more than half for inpatients, and in excess of one third for outpatients. Cardiologists were by far the most prominent providers among nonradiologists, doing 25% of all sonography in the United States, followed by ophthalmologists (11%), internists (11%), and general surgeons (6%). The ophthalmologists' role was largely limited to the office/freestanding center setting, where theirs was the most important single nonradiologic specialty. Cardiologists dominated the self-referral list in the hospital and were second in the office/freestanding center setting.

Almost half of interventional radiology and angiography work was performed by nonradiologists (Table 1). Cardiologists dominated the roles of nonradiologists, performing about three fourths of the total of interventional and angiographic work done by nonradiologists. An exception was found in the small amount of interventional/angiographic work done in the office/freestanding center setting. This was dominated by urologists, who were almost entirely doing sonography-guided needle biopsies of the prostate.

Nonradiologists performed approximately 15% of nuclear medicine (Table 1). (Recall that we have classified nuclear medicine specialists as radiologists. This includes nuclear medicine specialists certified by the American Board of Nuclear Medicine and not trained in radiology programs. However, the role in nuclear medicine of all physicians classified as nuclear medicine specialists is small relative to that of those classified as radiologists per se.) About half of the 15% of nuclear medicine done by nonradiologists was done by cardiologists and one fourth of it was done by internists. Nonradiologists' share of nuclear medicine was 10% in the hospital but approximately 50% for the much smaller amount of nuclear medicine done in offices and freestanding centers.

Nonradiologists' share in both radiation oncology and CT/MR was only a few percent. In CT/MR, neurology was the most important single specialty, accounting for half of the 2% of all CT/MR done by nonradiologists. Nonradiologists had a much larger share (8%) in the approximately 15% of all CT/MR that was done in the office/freestanding center setting than in the 85% of CT/MR that was done in hospitals, where nonradiologists' share was only 1%.

The most extensive single type and setting of radiologic activity of nonradiologists was office/freestanding center general radiology, which accounted for approximately 25% of their 165 million RVUs of radiologic work. Next most important were office/freestanding center sonographic work (approximately 20% of nonradiologists' radiologic activity), inpatient interventional and angiographic work (18%), and inpatient sonographic activity (15%). All other techniques and settings combined totaled only a little more than one fifth of nonradiologists' radiologic activity.

#### *Specific Procedures and Groups of Procedures*

Table 2 shows the extent of self-referral and the specialties principally involved for 17 specific procedures or groups of procedures. The table also indicates (in RVUs) the total workload associated with each procedure or group of procedures.

The two-view chest radiograph is the most common radiologic procedure in the United States. Overall, one fifth of two-view chest radiographs were obtained by nonradiologists in 1989, but the pattern differed greatly between the office/freestanding center setting, where two thirds of two-view chest radiographs were obtained by nonradiologists, and the hospital setting, where only 1% of such radiographs were obtained by nonradiologists. Internists obtained about half of the two-view chest radiographs obtained by nonradiologists, with family practitioners and general practitioners obtaining most of the rest. Overall, the work involved in two-view chest radiographs (both those obtained by radiologists and those obtained by nonradiologists) totaled approximately 60 million professional RVUs, some 9% of all radiologic work in the United States.

The picture for cardiac studies is quite different. Nonradiologists performed one third of the workload of thallium studies, with their share at approximately 22% in hospitals but 70% in offices and freestanding centers. Cardiologists predominated among the nonradiologists doing these studies, with internists responsible for most of the rest. (The internists involved in these and other cardiac studies may well be those who take a special interest in cardiology, even though they are not designated as cardiologists.) The picture for the totality of cardiac nuclear medicine is similar. About two thirds of this work consists of thallium studies.

Nonradiologists performed more than 95% of coronary angiography and cardiac sonography, with cardiologists dominating and internists next in importance. Together, these two types of procedures involved almost 80 million professional RVUs—about 12% of all radiologic work—and accounted for about half of all radiology done by nonradiologists.

Nonradiologists performed approximately three fourths of vascular sonography, with general surgeons most prominent among them, but cardiologists, internists, and thoracic surgeons were also important.

Nonradiologists performed only about 3% of CT of the head and 5% of MR of the head, but their share was larger (13% and 7%, respectively) for studies done in the office/freestanding center setting. Neurologists were responsible for most of the work done by nonradiologists in both these procedures.

Both CT and MR of the extremities had a pattern similar to that seen in CT and MR of the head. The nonradiologists' share was 3% overall but higher (10% for CT and 5% for MR imaging) in the office/freestanding center setting.

For a variety of bone and joint plain film studies, the nonradiologists' share was approximately 30–50%. Orthopedists usually dominated the list of nonradiologists involved, but primary care physicians played an important role in lumbosacral spine studies, and podiatrists played a major role in peripheral extremity imaging studies. For all these studies, it is important to distinguish between the office/freestanding center setting, where nonradiologist did two thirds or more of the work, and the hospital setting, where their share was only 1–2%.

Nonradiologists did 5% of upper gastrointestinal and barium enema work, with, again, a larger share (17%) in the office and only a 1% share in the hospital. The situation for diagnostic mammography was similar, with nonradiologists doing 9% of the work overall but twice that amount in the

TABLE 2: Nonradiologists' Share of Selected Procedures

	Office	Inpatient	Outpatient	All Places		Office	Inpatient	Outpatient	All Places
<b>2-View Chest Radiographs</b>					<b>CT Head</b>				
Total professional RVUs <sup>a</sup> (millions)	18.0	22.5	17.1	57.9	Total professional RVUs <sup>a</sup> (millions)	3.3	21.0	11.7	35.7
Percent of RVUs by all nonradiologists	67	1	1	21	Percent of RVUs by all nonradiologist	13	2	2	3
Internal medicine	32	0	0	10	Neurology	7	1	1	2
Family practice	13	0	0	4	Internal Medicine	2	0	0	0
General practice	8	0	0	3	Neurosurgery	2	0	0	0
Cardiology	6	0	0	2	General practice	0	0	0	0
Pulmonary medicine	3	0	0	1	All others	2	1	1	1
General surgery	1	0	0	1	<b>MR Head</b>				
Gastroenterology	1	0	0	0	Total professional RVUs <sup>a</sup> (millions)	3.3	2.1	2.1	7.8
All others	2	0	0	1	Percent of RVUs by all nonradiologists	7	3	2	5
<b>Thallium Studies</b>					Neurology	5	2	1	3
Total professional RVUs <sup>a</sup> (millions)	1.8	2.4	4.5	8.7	General practice	1	0	0	1
Percent of RVUs by all nonradiologists	70	24	21	32	All others	1	1	1	1
Cardiology	51	14	10	20	<b>CT Extremity and Joints</b>				
Internal medicine	11	6	6	7	Total professional RVUs <sup>a</sup> (millions)	0.09	0.18	0.21	0.51
Pathology	0	2	2	2	Percent of RVUs by all nonradiologists	10	1	1	3
General practice	1	0	0	0	Internal medicine	2	0	0	1
All others	1	0	1	1	Orthopedic surgery	2	0	0	1
<b>Coronary Angiography</b>					Family practice	1	0	0	0
Total professional RVUs <sup>a</sup> (millions)	0.06	39.9	3.9	44.4	General practice	1	0	0	0
Percent of RVUs by all nonradiologists	91	97	92	96	General surgery	1	0	0	0
Cardiology	63	62	70	63	Neurology	1	0	0	0
Internal medicine	15	13	12	13	All others	2	0	0	1
Anesthesiology	3	12	1	11	<b>MR Extremity and Joints</b>				
Thoracic surgery	2	1	2	1	Total professional RVUs <sup>a</sup> (millions)	0.21	0.00	0.09	0.33
Pulmonary medicine	1	2	0	1	Percent of RVUs by all nonradiologists	5	2	1	3
General surgery	1	1	0	1	Neurology	2	1	0	1
All others	3	0	0	0	General practice	1	0	0	1
<b>Cardiac Ultrasound</b>					Orthopedic surgery	1	0	0	1
Total professional RVUs <sup>a</sup> (millions)	9.0	19.2	4.8	33.0	All others	1	1	0	1
Percent of RVUs by all nonradiologists	96	97	95	96	<b>Lumbosacral Spine Plain Film</b>				
Cardiology	60	66	61	63	Total professional RVUs <sup>a</sup> (millions)	3.9	1.5	3.0	8.1
Internal medicine	24	20	21	21	Percent of RVUs by all nonradiologists	65	1	1	30
General practice	2	0	1	1	Orthopedic surgery	31	0	0	14
Family practice	2	0	0	1	Internal medicine	12	0	0	6
All others	2	2	2	2	Family practice	8	0	0	4
<b>Vascular Ultrasound</b>					General practice	6	0	0	3
Total professional RVUs <sup>a</sup> (millions)	11.7	8.1	6.3	26.1	General surgery	1	0	0	0
Percent of RVUs by all nonradiologists	89	60	58	73	All others	3	0	0	1
General Surgery	21	19	22	20	<b>Hip and Knees Plain Film</b>				
Cardiology	11	11	10	11	Total professional RVUs <sup>a</sup> (millions)	6.9	3.3	3.3	13.5
Internal medicine	14	6	6	10	Percent of RVUs by all nonradiologists	81	1	2	41
Thoracic Surgery	11	8	8	9	Orthopedic surgery	60	1	0	30
Neurology	6	8	5	6	Internal medicine	7	0	0	4
General practice	6	0	0	3	Family practice	5	0	0	2
Podiatry	6	0	0	3	General practice	3	0	0	2
Family practice	4	0	0	2	General surgery	1	0	0	0
All others	4	2	2	3	All others	1	0	0	1

TABLE 2: Continued

	Office	Inpatient	Outpatient	All Places
<b>Long Bones Plain Film</b>				
Total professional RVUs <sup>a</sup> (millions)	1.2	0.9	1.2	3.6
Percent of RVUs by all nonradiologists	79	1	2	29
Orthopedic surgery	55	1	0	20
Family practice	6	0	0	3
Internal medicine	6	0	0	2
General practice	4	0	1	2
General surgery	1	0	0	0
All others	1	0	0	1
<b>Fingers, Wrist, Toes, Foot, and Ankle Plain Film</b>				
Total Professional RVUs <sup>a</sup> (millions)	6.6	1.2	3.0	10.8
Percent of RVUs by all nonradiologists	88	2	2	54
Orthopedic surgery	34	1	0	21
Podiatry	32	1	0	20
Internal Medicine	6	0	0	4
Family practice	5	0	0	3
General practice	4	0	1	2
General surgery	1	0	0	1
All others	1	0	0	1
<b>Upper GI and Barium Enema</b>				
Total professional RVUs <sup>a</sup> (millions)	8.4	10.5	14.7	33.6
Percent of RVUs by all nonradiologists	17	1	1	5
Internal medicine	8	0	0	2
Family practice	2	0	0	1
Gastroenterology	2	0	0	1
General practice	1	0	0	0
General surgery	1	0	0	0
All others	1	0	0	1
<b>Diagnostic Mammography</b>				
Total professional RVUs <sup>a</sup> (millions)	18.0	0.6	8.4	18.0
Percent of RVUs by all nonradiologists	18	2	1	9
Internal medicine	7	1	0	4
Ob-gyn	4	0	0	2
Family practice	3	0	0	2
General practice	2	0	0	1
General surgery	1	0	0	1
All others	1	0	0	1
<b>Coronary Angioplasty<sup>b</sup></b>				
Total Professional RVUs <sup>a</sup> (millions)	0.09	13.2	0.18	13.5
Percent of RVUs by all nonradiologists	99	99	89	99
Cardiology	58	78	65	77
Internal medicine	15	12	9	12
Anesthesiology	3	2	4	2
Thoracic surgery	14	2	7	2
General surgery	2	0	0	0
General practice	1	0	0	0
All others	2	0	0	0
<b>Noncoronary Percutaneous Transluminal Angioplasty<sup>b</sup></b>				
Total professional RVUs <sup>a</sup> (millions)	0.06	2.4	0.06	2.7
Percent of RVUs by all nonradiologists	36	32	11	29
Cardiology	16	15	3	13
Thoracic surgery	11	7	2	6
General surgery	4	5	2	5
Internal medicine	2	2	1	2
Anesthesiology	1	1	0	0
All others	1	1	2	1

Note.—Because of rounding, details may not add to totals. Source: 1989 HCFA/BMAD Procedure File.

<sup>a</sup>Includes all specialties, radiologists and others, and patients of all ages.

<sup>b</sup>Not radiology, but of interest to this study.

office/freestanding center setting and only 1% in the hospital. (In 1989, Medicare did not cover screening mammography.)

Finally, Table 2 includes coronary angioplasty and noncoronary percutaneous transluminal angioplasty, two nonradiologic interventional procedures (not counted in any radiology totals in this study) of interest to radiologists. Nonradiologists did 99% of the coronary angioplasty, with cardiologists predominating, but only about 30% of the noncoronary percutaneous transluminal angioplasty.

#### Data for Individual States

Most states show a pattern of activity by nonradiologists similar to that for the United States as a whole (Table 3). For example, in approximately three fourths of the states, the share of nonradiologists in all radiology was 20–30%, similar to the national average of 25%. Also, in almost every state, the figures follow the national pattern that nonradiologists'

share was largest in the office/freestanding center setting, substantially smaller for inpatients, and smallest for outpatients. In most states, the nonradiologists' share was greatest for sonography and second greatest for angiography/interventional radiology, as in the nation as a whole. The states with the largest nonradiologists' share of all radiology were North Dakota (where 43% of all radiologic work was done by nonradiologists), Michigan (41%), Idaho (34%), Florida (32%), and South Carolina (32%). The smallest nonradiologists' shares were found in Maryland (14%), Maine (16%), Vermont (17%), New Hampshire (18%), and Alaska (18%).

#### Radiologic Activities of Major Self-Referring Specialties

Cardiology, as noted, is the nonradiology specialty in which the greatest amount of radiology is performed. This radiologic work (which amounts to approximately 10% of all radiologic work done in the United States) is divided about

TABLE 3: Nonradiologists' Share of Radiology by State and Region (% of Professional RVUs)

	All Radiology	By Place of Service					By Type of Radiology				
		Office	Inpatient	Outpatient	Interventional/ Angiography	CT/ MR	General Radiology	Nuclear Medicine	Radiation Oncology	Ultrasound	
All United States	25	46	27	8	44	2	17	15	5	64	
Midwest	26	56	28	9	46	2	15	18	2	67	
Northeast	22	43	21	7	38	1	13	14	4	62	
South	27	50	28	8	45	3	20	15	7	65	
West	25	35	32	6	46	2	20	11	2	60	
Alabama	27	59	30	6	49	1	22	17	1	65	
Alaska	18	29	23	2	34	0	22	0	0	35	
Arizona	26	38	30	4	43	3	24	12	3	60	
Arkansas	29	52	26	6	43	1	26	3	2	65	
California	24	31	34	5	51	1	17	11	2	62	
Colorado	23	58	24	4	37	3	20	7	2	51	
Connecticut	20	39	22	4	34	1	15	11	0	40	
Delaware	20	36	22	9	46	2	12	17	0	61	
District of Columbia	22	31	22	5	50	1	18	26	0	63	
Florida	32	46	34	11	47	4	25	23	13	69	
Georgia	25	48	25	7	41	6	17	17	5	63	
Hawaii	20	23	29	7	32	0	7	1	0	53	
Idaho	34	42	50	20	54	18	39	32	1	75	
Illinois	22	48	26	7	41	1	9	11	2	66	
Indiana	26	58	32	7	46	1	11	28	0	72	
Iowa	19	58	20	3	44	1	14	8	1	46	
Kansas	22	73	19	3	27	1	22	20	3	51	
Kentucky	26	52	26	10	42	4	17	15	11	67	
Louisiana	30	48	31	9	54	2	17	18	3	69	
Maine	16	78	19	2	28	0	8	8	0	41	
Maryland	14	26	15	3	19	1	9	4	0	57	
Massachusetts	19	66	18	5	16	0	9	29	0	60	
Michigan	41	69	44	23	66	4	23	46	4	77	
Minnesota	24	43	26	6	35	1	20	7	3	58	
Mississippi	21	67	16	4	34	0	17	5	1	54	
Missouri	24	42	30	6	42	2	16	13	0	69	
Montana	27	48	35	6	48	2	23	24	0	60	
Nebraska	24	70	21	6	39	1	26	0	6	45	
Nevada	24	30	28	4	34	4	19	16	1	59	
New Hampshire	18	74	24	5	38	1	7	28	0	51	
New Jersey	20	37	19	7	34	1	13	9	7	62	
New Mexico	24	50	31	4	39	1	15	18	1	63	
New York	27	44	23	7	53	2	18	13	6	64	
North Carolina	25	51	26	5	37	4	17	6	1	65	
North Dakota	43	84	44	9	56	1	47	30	27	71	
Ohio	21	45	24	7	45	1	11	8	1	59	
Oklahoma	31	65	31	8	50	1	23	13	8	71	
Oregon	25	44	29	7	40	0	26	12	2	51	
Pennsylvania	21	41	22	8	36	1	9	14	2	64	
Puerto Rico and Virgin Islands	30	36	32	8	36	0	6	10	2	71	
South Carolina	32	73	32	15	49	1	21	22	27	66	
South Dakota	28	54	26	7	26	0	24	22	1	60	
Tennessee	21	58	21	3	42	1	18	6	1	57	
Texas	29	57	30	8	50	2	20	12	5	65	
Utah	27	56	31	8	43	6	22	8	7	53	
Vermont	17	86	15	4	40	0	8	5	0	49	
Virginia	23	61	21	9	45	3	16	8	2	66	
Washington	26	36	29	9	29	3	24	12	2	57	
West Virginia	21	49	23	6	42	3	11	7	1	60	
Wisconsin	20	55	22	6	49	0	15	11	4	49	
Wyoming	25	21	28	25	31	7	21	16	45	44	

Note.—Source: 1989 HCFA/BMAD Procedure File.

half and half between interventional/angiographic procedures and sonography. Their interventional/angiographic work is largely performed on inpatients. In contrast, while most of their sonographic work is done on inpatients, more than a fourth of it is done in the office/freestanding center setting, and about 15% of it is done on outpatients.

Internists, who are next in importance overall in self-referral (performing approximately 5% of all radiology in the United States), engage in a somewhat more varied set of radiologic activities. About one third of their radiologic work is general radiology, almost all of it done in offices and centers. Another third is sonography, done about half in the office/freestanding center setting and half on inpatients. About one seventh of their activity is interventional radiology/angiography, almost all done on inpatients, and they do small amounts of other types of radiology.

General and family practitioners together performed approximately 2% of all radiology. Three fourths of their radiologic work was general radiology, almost all at offices/freestanding centers. Office-based sonography constituted most of the rest of their radiologic activity.

Orthopedists, who performed 2% of radiologic work, were involved almost exclusively in general radiology in the office/freestanding center setting. Ophthalmologists (also responsible for approximately 2% of all radiologic work) were involved almost exclusively in sonography in the office/freestanding center setting.

Other surgeons (responsible for approximately 3% of all radiologic work) were involved in a more varied pattern of radiologic activities, possibly reflecting the diverse specialties concerned. Almost two thirds of their radiologic work was sonography, about half of it in the office/freestanding center setting and the rest about evenly divided between inpatients and outpatients. Two ninths of the radiologic work of these other surgeons was general radiology, essentially all of it done in the office, and one ninth was interventional/angiographic work, which took place predominantly in the inpatient setting.

#### *Procedures Most Dominated by Nonradiologists*

We examined which individual radiologic procedures were performed by nonradiologists more than 80% of the time, considering only procedures performed at least 1000 times annually in the Medicare data, which would imply a minimum of 3000 instances of each procedure annually in the entire population of the United States. The list is dominated by ophthalmologic sonography, coronary angiography, and echocardiography. It also includes some noncardiac vascular sonographic procedures (see the Discussion), one plain film study of the foot (predominantly performed by podiatrists), and one plain film study of the teeth (predominantly performed by oral surgeons).

## **Discussion**

### *Data Strengths and Limitations*

Like any data source, the Medicare data used in this study have both strengths and limitations. Their principal strength

is that they constitute complete data for one third of all patients in the entire United States (except for Rhode Island), collected in a reasonably uniform fashion. Thus, they are free of problems of possible response bias resulting from a limited response to a survey and from problems of geographic selectivity or of a small patient base.

Four weaknesses, however, should be noted. First, as in almost any available data base, specialty designations are somewhat arbitrary. In particular, we have noted that some of the radiologic work of internists parallels that of cardiologists. Most likely this is because some of the physicians labeled internists partially concentrate their practice on cardiology. Note, however, that in any classification scheme for specialties, drawing distinctions among physicians who are partly specialized in their work would present problems. There may also be a problem of a small amount of "noise" introduced into the data through nonstandard use of Medicare's specialty codes by the carriers (individual, private insurance companies) that administer the Medicare program in each state. However, we have not noticed any anomalies of this type in our work with the data.

Second, the Medicare data base requires us to assume that the specialty of the physician who performed a service is the same as the specialty of the physician who billed for the services. We know from other studies and other data sources that it is not always true that the billing physician does the work. For example, the American College of Radiology's mammography accreditation program has shown that a substantial number of screening mammograms are read by radiologists but billed by other specialists. Although the effect of the required assumption is to exaggerate the role of nonradiologists, we believe it does not lead to major errors. As described below, in other situations in which our data are affected by limitations, we were able to compare our figures with independent information sources not affected by limitations, and the differences were quite modest.

Third, while Medicare services are generally representative of all radiologic services in the United States, Medicare's representativeness is not perfect. Most obviously, obstetric sonography (and other obstetric services) are greatly underrepresented. As a result, our data probably badly underreport the role of obstetrician-gynecologists in self-referral and we may underestimate the role of nonradiologists in sonography. Conversely, ophthalmologic sonography is probably much overrepresented in the Medicare data, tending to exaggerate the role of nonradiologists in sonography.

Fourth, peculiarities of the CPT coding system and its use lead to some distortion. For example, the codes used for vascular sonographic studies are predominantly generic codes for noninvasive vascular studies, not specific to sonography. Hence, they (inappropriately for our purposes) include nonsonographic work, such as pressure measurement, presumably performed mainly by nonradiologists. The result is to exaggerate the role of nonradiologists in sonography, just the opposite of the effect of omitting most obstetric work. Another peculiarity of the CPT system (as it stood and was used in 1989) probably led to a modest underestimate of the role of nonradiologists in angiographic/interventional procedures. Specifically, in some states, Medicare's carriers required radiologists to bill the complete procedure, whereas

nonradiologists were permitted to "split bill." Split billing puts the catheterization and injection portion of an interventional procedure outside the 70,000 series of CPT and thus outside the activities counted in our analyses.

Overall, the limitations tend somewhat to offset one another, and we believe that they produce only modest or small errors in most of our statistics, although there may be larger errors in some details (most obviously in the role of obstetrician-gynecologists). We would judge, for example, that the true proportion of radiology performed by nonradiologists lies within 2–3 percentage points (or closer) to the 25% figure we obtained. Certainly, our basic findings are reliable—for example, that nonradiologists' share is much higher in the office than elsewhere or that cardiologists are the most prominent specialists among nonradiologists in terms of the amount of radiology they do.

Another reason to think our results are accurate is the generally excellent agreement (when comparison is possible) between our findings and those of Levin and Matteucci [4, 5] and the American Association of Academic Chief Residents in Radiology [6, 7]. This agreement demonstrates the general soundness of our methods, including, for example, the use of Medicare radiologic data, properly weighted, as representative of data on radiologic services received by the entire population. Among the points of agreement are that bone radiography in the hospital setting (inpatient or outpatient) is almost exclusively performed by radiologists, as are CT and MR of the head. Also, echocardiography is done in the hospital almost entirely by nonradiologists.

Possibly even more important in validating the data are agreements in findings for activity that is shared. Thus, we, Levin and Matteucci [4, 5], and the chief residents' survey [7] find that nonradiologists perform approximately half of vascular sonography in hospitals. Our figure, as noted previously, is inflated by the overly broad CPT codes used for vascular sonography, and it is therefore encouraging to find quite good agreement, with the small disagreements in the direction expected: We find nonradiologists' share in vascular sonography is approximately 60%, whereas the chief residents find it to be approximately 50%, and Levin and Matteucci appear to find it about 40%. In short, one of the known problems in our data does not produce a major distortion, even for the procedures to which it directly applies. This suggests that the effect of other data problems is also relatively limited.

Our data also agree quite closely with those of Levin and Matteucci in finding that nonradiologists have a minority share, albeit a significant one, in peripheral angioplasty at the hospital. We find a share of approximately 30%; the Levin and Matteucci data suggest a share more like 20%.

The most prominent disparity between our study and others lies in the results concerning coronary angiography and angioplasty. We find a negligible role (only a few percent) for radiologists. Levin and Matteucci [4, 5] report that in 15–20% of hospitals, radiologists interpret these studies although nonradiologists perform them, and the chief residents' survey [6] similarly reports a "partnership" arrangement in 14% of teaching hospitals. Given that our data are based on billing, perhaps the explanation is that in hospitals where radiologists

interpret these studies the norm is for the nonradiologist who performed the study to bill for the entire procedure.

### *Significance of Findings*

The similarity of findings from state to state is noteworthy. It indicates that the performance of radiology by nonradiologists is basically a uniform nationwide phenomenon. States with a particularly high share of all radiology performed by nonradiologists are often sparsely populated, with access to most specialists (including radiologists) relatively difficult (North Dakota and Idaho, for example). Others, most notably Florida, seem to be areas where physicians' pursuit of their financial self-interest is especially aggressive [12, 13]. States with a particularly low share for nonradiologists are concentrated in the Northeast, particularly New England. This may reflect a relative conservatism in financial entrepreneurship by physicians in this part of the country.

Taken together, our findings provide a profile of radiology performed by nonradiologists in the United States in 1989. In brief, the principal features of that profile are as follows. Nonradiologists perform 25% of all radiologic work, or some 165 million professional RVUs. Of the 165 million RVUs of radiologic work done by nonradiologists, almost half consist of coronary angiography or cardiac sonography, performed principally by cardiologists. Radiologists have little role in these procedures. Another 6% (approximately) of all radiologic work done by nonradiologists consists of ophthalmologic sonography performed by ophthalmologists, almost all of it in offices. Again, radiologists have almost no role in these procedures. Approximately 12% of nonradiologists' radiologic activity consists of general radiology done by primary care physicians (internists, general practitioners, and family practitioners); almost all of it takes place in the office. The remaining significant radiologic activity of primary care physicians is noncardiac sonography; this activity made up about 4% of all radiologic activity by nonradiologists. The radiologic activity of orthopedists constitutes approximately 6% of all radiology done by nonradiologists. Orthopedists' radiologic activity consists almost entirely of bone and joint radiographs obtained in the office setting. Noncardiac sonography by other surgeons was approximately 7% of all radiology done by nonradiologists. Two thirds of this was vascular sonography; it took place in varied settings. Our data essentially exclude obstetrician-gynecologists. Plausibly, their radiologic activity (principally in obstetric sonography) is as extensive as that of orthopedists.

This profile contrasts significantly with the conventional image of the radiology performed by nonradiologists, which centers on primary care physicians or orthopedists doing general radiology, such as obtaining chest radiographs or lumbosacral spine studies. For such studies, it is fairly clear that radiologists could take on the workload now performed by nonradiologists and that, in so doing, they would achieve the public policy goals of containing costs and (at least for procedures now done by primary care physicians) improving quality [4]. Patient convenience would increase when unnecessary studies were eliminated but might decrease when the patient had to go to another office for an imaging study.

The profile we have developed, in contrast, shows that general radiology in fact constitutes only about one fourth of all radiologic work done by nonradiologists. Coronary angiography and cardiac sonography are the largest single portion of the radiologic work done by nonradiologists—almost half the total—and radiologists currently have little role in these procedures. For radiologists to take on these procedures in pursuit of public policy goals would probably require considerable effort devoted to training enough proficient radiologists. Such training would be difficult to develop because the relevant patients and procedures currently are largely the domain of cardiology departments. Indeed, in the latest survey by the American Association of Academic Chief Residents in Radiology, 39% of chief residents rated their training in cardiac radiology as inadequate (by far the highest “inadequate” percentage of any radiology field), and an additional 28% rated their training as adequate but would have preferred more training [7]. Only a third were satisfied with their training in cardiac radiology.

In this article, self-referral has been used to mean radiologic procedures performed by nonradiologists. The latter phrase is more precise, but we frequently use the former because it is more concise. Some of the radiologic work done by nonradiologists is not, strictly speaking, self-referral—for example, coronary angiography done by interventional cardiologists on referral from noninterventional cardiologists or workups done by cardiologists on specific request from general internists. Such work is included in this article's analysis of radiology performed by nonradiologists.

In considering the significance of our findings, it is important to recognize that radiology performed by nonradiologists is only one form of self-referral. Other types of self-referral that are important include joint ventures and the use of nonradiologic procedures in preference to radiologic procedures when the latter seem preferable on grounds of efficacy or cost—for example, colonoscopies rather than barium enemas. There is evidence that these additional forms of self-referral are growing and have important negative consequences of their own

[12–14] (Levin D et al., presented at the Radiological Society of North America meeting, December 1991).

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#### REFERENCES

- Hillman B, Joseph C, Mabry M, Sunshine J, Kennedy S, Noether M. Frequency and costs of diagnostic imaging in office practice: a comparison of self-referring and radiologist-referring physicians. *N Engl J Med* 1990; 323:1604–1608
- Hillman B, Olson G, Griffith M, et al. Physicians' utilization and charges for outpatient diagnostic imaging in a medicare population. *JAMA* 1992; 268:2050–2054
- Hopper K, Rosetti G, Edminston R, et al. Diagnostic radiology peer review: a method inclusive of all interpreters of radiographic examinations regardless of specialty. *Radiology* 1991;180:557–561
- Levin D, Matteucci T. Do radiologists control imaging studies? Survey results from 198 academic institutions. *Radiology* 1989;170:879–881
- Levin D, Matteucci T. “Turf battles” over imaging and interventional procedures in community hospitals: survey results. *Radiology* 1990;176:321–324
- Getz T, Evens R. Residencies in diagnostic radiology and perception of residents: 1987 A<sup>3</sup>CR<sup>2</sup> survey. *Invest Radiol* 1988;23:308–311
- Bower B, Engels J, Evens R. Results of the 1989 Survey of the American Association of Academic Chief Residents in Radiology. *Invest Radiol* 1991;26:99–102
- Current procedural terminology (CPT)*, 4th ed. Chicago: American Medical Association, 1992
- Medicare program: fee schedules for radiologist services. *Federal Register* 1989;54:8894–9023
- Sunshine J, Mabry M, Bansal S. The volume and cost of radiologic services in the United States in 1990. *AJR* 1991;157:609–613
- Sunshine J, Swartzman J. Medicare's share in United States physicians' revenues. Washington, DC: Physician Payment Review Commission (PPRC background paper 89.4) 1989:1–5
- Mitchell J, Scott E. New evidence of the prevalence and scope of physician joint ventures. *JAMA* 1992;268:80–84
- Mitchell J, Sunshine J. Consequences of physicians' ownership of health care facilities: joint ventures in radiation therapy. *N Engl J Med* 1992; 327:1497–1501
- Crane T. The problem of physician self-referral under the medicare and medicaid antikickback statute. *JAMA* 1992;268:85–91

The reader's attention is directed to the commentary on this article, which appears on pages 430–431.