

# The Effect of Imaging Guidelines on the Number and Quality of Outpatient Radiographic Examinations

Harold Moskowitz<sup>1,2</sup>  
Jonathan Sunshine<sup>3</sup>  
Donald Grossman<sup>4</sup>  
Leslie Adams<sup>1,2</sup>  
Lynn Gelinis<sup>4</sup>

**OBJECTIVE.** A significant percentage of outpatient diagnostic radiology is performed by nonradiologists. Studies have shown nonradiologists have higher utilization and cost, as well as quality problems. We sought to determine if, in a managed care environment, a set of guidelines limiting imaging privileges of nonradiologist physicians could decrease imaging costs while ensuring that equipment and personnel providing imaging were of the highest quality.

**MATERIALS AND METHODS.** We determined the number and type of radiographic imaging studies performed the year after these guidelines were set in place (1997) and compared these findings with those of the year before the guidelines were established (1995) and with preguideline trends. We established quality criteria and, based thereon, inspected imaging offices.

**RESULTS.** The number of radiographic examinations per 1000 enrollees decreased 20–25% from the previous trend. Nonradiologists' share of the total fell from 39% to 15%. No deficiencies were found in the inspection of five radiologists' offices, whereas significant deficiencies of equipment, equipment maintenance, or documentation of the examinations performed were found in 78% of nonradiologists' offices. None of the quality indicators monitored by the health plan showed significant change.

**CONCLUSION.** Specific guidelines can effect change in the location and number of radiologic examinations performed, with an improvement in the quality of the studies and a decrease in radiation dose and cost. No decline in quality of care appears to result, despite claims by opponents to such changes that widespread serious quality impairment would occur.

**T**he portion of society's resources devoted to health care has been the subject of significant debate in the United States for decades. In 1965, the United States devoted 5.9% of its gross national product to health expenditures. By 1995, this figure had risen to approximately 14%, and this increase had a significant impact on employers and the government. If current projections hold, it is estimated that expenditures will double to \$2.3 trillion (United State dollars) or approximately 17% of the gross national product by 2007 [1]. Methods of curbing this significant increase have been sought, and the results have changed the face of American medicine. The rapid emergence of managed care as a majority health insurer for Americans has been heralded as the reason for some of the recent slowdown in the rise of health care costs. Managed care claims credit for eliminating

many of the excesses of the system. However, with the increasing age of our population and their health care needs as well as the continued development of new technology, health care costs now seem to be once again increasing at a rate higher than current inflation. Although managed care has helped the system curtail costs, there have been negative effects related to physician choice, accessibility, and the accountability of health plans. Various techniques to decrease health care costs have been developed. One is to decrease the benefits to which a patient is entitled; another, to decrease the payment for each unit of service. Yet another technique is to institute a utilization management program, with the expectation of eliminating unnecessary services.

Diagnostic radiology services constitute a significant portion of both inpatient and outpatient costs. It has been estimated that radiology services use approximately 8% of the health

Received September 27, 1999; accepted after revision December 8, 1999.

<sup>1</sup>Magellan Specialty Health, Windsor, CT 06095.

<sup>2</sup>University of Connecticut School of Medicine, Farmington, CT. Address correspondence to H. Moskowitz, 14 Arlen Way, West Hartford, CT 06117.

<sup>3</sup>Research Department, American College of Radiology, Reston, VA 20191.

<sup>4</sup>CIGNA HealthCare of Connecticut, Bloomfield, CT 06002.

*AJR* 2000;175:9–15

0361–803X/00/1751–9

© American Roentgen Ray Society

care dollar paid to physicians. Many studies have shown that approximately 50% of non-hospital radiology services are performed in a nonradiologist's offices [2-4] and that nonradiologic physicians who have an X-ray machine in their office perform as many as four to five times as many examinations per patient as physicians in the same specialties seeing patients with the same problems but who refer their patients to radiologists for imaging. [5-7]. Other studies have suggested that many radiologic examinations performed in nonradiologists' offices are of poor diagnostic quality and are interpreted incorrectly [8-11].

**Materials and Methods**

A large health maintenance organization in the northeastern United States decided to establish an effective radiology utilization program based on several objectives. The organization's goals were to reduce utilization of imaging tests that were noncontributory to patient treatment and that thus were inappropriate and, at the same time, to deliver the most cost-effective, high-quality imaging product. The health maintenance organization wanted to address the problems of volume, cost, and quality and to ensure that the equipment and personnel producing and interpreting a radiographic or imaging study were of the highest quality.

The health plan established a radiology advisory committee that consisted of physicians drawn from various academic and community practices throughout the state. The advisory committee is a multispecialty committee consisting of radiologists, a surgeon, an internist, a primary care physician, an orthopedic surgeon, an obstetrician or a gynecologist, and the medical director of the health plan. These physicians were chosen on the basis of board certification in their field, volume of practice, volume of radiographic examinations performed, and, in some cases, individual physician experience. This committee eventually established the guidelines regarding who could perform imaging studies in their office practice. Imaging studies that could be performed by nonradiologists were carefully delineated on the basis of each physician's specialty and demonstrated expertise.

These expertise- and relevance-based guidelines limited the amount of imaging permitted to be performed by nonradiologists. The guidelines removed all imaging privileges from gastroenterologists, general surgeons, nephrologists, neurosurgeons, oncologists, pediatric surgeons, and physiatrists. Cardiologists were limited to performing chest radiography, echocardiography, and nuclear cardiology, and pulmonologists could perform only chest radiography. The only imaging an obstetrician-gynecologist could perform was obstetric and gynecologic sonography; breast sonography was specifically excluded. If an obstetrician's office obtained United States Food and Drug Administration (FDA) approval for mammography, only the technical component of a screening mammogram would be paid by the health maintenance organization. The images had to be

sent to a radiologist for interpretation. Orthopedic surgeons were permitted to perform conventional orthopedic radiography but were excluded from performing and interpreting all CT and MR procedures. Otolaryngologists were permitted to obtain conventional radiographs of the sinuses and nasal bones, but soft-tissue radiographs of the neck and cervical spine were excluded. Podiatrists could perform and bill only for radiography of the foot, and rheumatologists could perform only extremity radiography; they were excluded from performing spine radiography.

Primary care physicians, including family practitioners, internists, and pediatricians, were permitted to obtain only chest, rib, and extremity radiographs and were paid only for the technical component. It was required that these images be interpreted by a radiologist who would then bill for the professional component.

The second aspect of the program was to evaluate and ensure the technical quality of the imaging performed. A technology assessment questionnaire (Fig. 1) was sent to all providers who requested imaging privileges. This questionnaire required details of many aspects of the imaging being practiced, including a description of the imaging equipment present in the office, its year of manufacture, its service records, and a physicist's evaluation of the radi-

ology equipment including its output and radiation dose to a patient. The questionnaire inquired about the availability of quality assurance programs (e.g., whether demographic labeling of a radiograph was performed routinely and whether there was a written radiology report for each imaging examination performed). Another requirement was that only licensed technologists could perform radiography. Patient safety programs—for example, whether a patient was questioned regarding pregnancy status—had to be in place. The health plan required that practices performing mammography have FDA approval. Physicians who wished to perform sonographic examinations had to be accredited by the American Institute of Ultrasound in Medicine, the American College of Radiology, or, in the case of vascular sonography, by the Intersocietal Commission for Accreditation of Vascular Laboratories.

Four hundred fifty-two questionnaires were distributed and 411 completed questionnaires were returned to our office for a return rate of 91%. We then inspected a representative group of radiology offices, and we attempted to inspect approximately 25% (100) of the nonradiology offices at which imaging studies were performed. Because of various scheduling problems we could inspect only 92 of

**PROVIDER INFORMATION**

Please complete this form for each practice location that provides diagnostic imaging services and one Assessment Checklist for each equipment location.

**Please type or print information.**

Legal Practice Name: \_\_\_\_\_  
 Group Practice Tax ID Number: \_\_\_\_\_

**\*\*Please fill out a separate Application/Checklist for each Imaging Site Location\*\***

**Imaging Site**

Site Name / D.B.A.: \_\_\_\_\_  
 Address: \_\_\_\_\_ Suite: \_\_\_\_\_  
 City, State, Zip code: \_\_\_\_\_  
 Phone: \_\_\_\_\_ Fax: \_\_\_\_\_

\_\_\_\_\_ Equipment Only      \_\_\_\_\_ Billing and Equipment

---

**Billing Site**

Site Name / D.B.A.: \_\_\_\_\_  
 Address: \_\_\_\_\_ Suite: \_\_\_\_\_  
 City, State, Zip code: \_\_\_\_\_  
 Phone: \_\_\_\_\_ Fax: \_\_\_\_\_

\_\_\_\_\_ Billing Only      \_\_\_\_\_ Billing and Equipment      \_\_\_\_\_ Billing Service

---

**Imaging Site Demographics**

What is your patient volume for diagnostic imaging per month? \_\_\_\_\_  
 What is your maximum patient volume for diagnostic imaging per month? \_\_\_\_\_  
 Office Manager: \_\_\_\_\_  
 Chief Technologist: \_\_\_\_\_  
 Document Prepared by: \_\_\_\_\_

**Fig. 1.**—Form shows second page of technology assessment questionnaire. This questionnaire requires provider to respond to questions regarding imaging equipment, personnel, and quality assurance programs in each office. D.B.A. = doing business as.

## Imaging Guidelines for Outpatient Radiographic Examinations

these 100 offices. The 100 offices selected for inspection were those at which the highest number of imaging studies were performed per month. They were inspected by registered radiology technologists who used a checklist to evaluate each specific facet of the inspection and were required to complete a questionnaire about each office. Evaluation of parameters such as quality of the imaging study, storage and handling of films, patient demographic information on the film (patient name, age, date of examination), and the presence of a report on each imaging study was part of the inspection performed by the technologist (Fig. 2).

Only outpatient radiologic examinations were studied in our research. This article addresses only radiography, essentially the only technique aside from sonography that nonradiologists perform in large volume. CT, MR imaging, sonography, and nuclear medicine studies were specifically excluded. We recognize the importance of these studies on radiology expenditures and their place in the changing patterns of imaging examinations used to work up specific disease entities; they are presently being studied and will be the subject of a separate analysis. Outpatient examinations were included in our study regardless of whether they were performed in a private office, imaging center, multispecialty clinic, or hospital. Data were gathered from billing statistics. Each procedure is identified by a specific *Current Procedural Terminology* code [12] and there had to be an appropriate *International Classification of Diseases indication* [13] for the study. Also, the name of the referring physician as well as that of the physician performing the study and both physicians' specialty were noted. Data were obtained from the HCFA-1500 (Health Care Financing Administration) claim form that was sent to our office for payment of the imaging study.

Our analysis was based on the number of examinations per 1000 enrollees. Because the health plan was growing and the number of enrollees rose during our study years, comparisons of simple counts would not be valid.

The health plan's data for the calendar year before we assumed responsibility for managing radiologic studies (1995) were compared with data for the calendar year after our program had been put into effect (1997). (We assumed responsibility for the health plan in 1996.) This gave us detailed data before our initiation of this program and a complete year's data following, thus avoiding start-up problems. Comparison of the enrollees on the basis of age and sex was undertaken. There was no significant change in the age or sex distribution of the patient population between study years. This was important to study because the number of enrollees rose from 125,000 to 162,000. A change in age or sex distribution of the population could affect radiology utilization. For 1993 and 1994, we had limited access to data that included only the total number of examinations performed and the number of examinations per 1000 enrollees. We used these 1993 and 1994 data to estimate the utilization trends that would have been expected to continue if our program had not been instituted.

<b>RADIOLOGY INSPECTION CHECK LIST</b>				
PHYSICIAN NAME: _____		GROUP NAME: _____		
ADDRESS: _____		COUNTY: _____		
DATE: _____		SURVEYOR: _____		
		YES	NO	N/A
1.	<b>Radiology equipment inspected within the past twelve (12) months?</b>			
	<b>A. X-RAY EQUIPMENT:</b>			
	a) Date: _____			
	By: _____			
	_____ Physicist			
	_____ Service Engineer			
	_____ Other (please specify)			
	b) Deficiencies corrected within the past twelve (12) months?			
	<b>B. ULTRASOUND EQUIPMENT</b>			
	a) Date: _____			
	By: _____			
	_____ Physicist			
	_____ Service Engineer			
	_____ Other (please specify)			
	b) Deficiencies corrected within the past twelve (12) months?			
	<b>C. NUCLEAR IMAGING EQUIPMENT (Dose Calibrator)</b>			
	a) Date: _____			
	By: _____			
	_____ Physicist			
	_____ Service Engineer			
	_____ Other (please specify)			
	b) Deficiencies corrected within the past twelve (12) months?			
2.	<b>Program for exposure of women of child-bearing age</b>			
	A. Program/protocol in place to prevent x-ray exposure for women of child-bearing age?			
3.	<b>Patient / Employee Safety</b>			
	A. Office has current OSHA manual?			

**Fig. 2.**—Form shows page one of three-page inspection document. This document details inspectors' findings regarding equipment service records, patient safety, image quality, and reporting methods. N/A = not applicable, OSHA = Occupational Safety and Health Administration.

### Results

Initially, there was considerable unhappiness created by the restriction of physician privileges. Many physician groups insisted that the guidelines would negatively impact their ability to care for patients. After the first several months, it became apparent that these guidelines had not caused significant hardship, and most complaints subsided. All quality-of-care measures charted by the health plan, including those mandated by accreditation from the National Committee for Quality Assurance and those required by the Health Care Financing Administration, were unchanged by the institution of our guidelines. Specifically, there was no significant change in the per enrollee number of hospital days, in emergency department visits, or in quality-of-care complaints by members. In areas such as maternity care management, diabetic care,

asthma care management, and all other specific clinical care practices monitored by the health plan, no significant changes occurred.

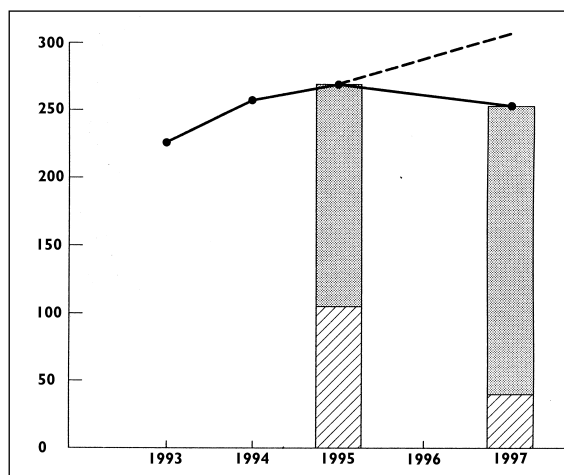
In 1993, 22,350 radiographic examinations were performed, which is a rate of 226 examinations per 1000 enrollees. In 1994, 30,071 examinations were performed, which is a rate of 257 per 1000. In 1995, of 34,436 radiographic examinations were performed, for a rate of 269 per 1000. In that year, 20,906 examinations, or 163 per 1000, were performed by radiologists and 13,530 (39% of the total), or 105 per 1000, were performed by nonradiologists. In 1997, 38,912 radiographic examinations were performed, for a rate of 253 per 1000. Of the examinations in 1997, 32,970 or 214 per 1000 were performed by radiologists and only 5942 (15%) or 39 per 1000 were performed by nonradiologists. If we directly compare the

1995 data with the 1997 data, a 6% decrease in the number of radiologic examinations per 1000 examinations performed is revealed; a 31% increase in the number of examinations per 1000 enrollees performed by radiologists and a 63% decrease in those performed by nonradiologists are also revealed.

Another comparison reveals that in the years preceding the institution of this plan, radiology services per 1000 enrollees increased approximately 5–10% per year. In 1997, the number of radiographs per 1000 decreased by approximately 20–25% from the number expected if the trend had continued (Fig. 3).

For each anatomic area, a marked increase in the percentage of imaging examinations performed by radiologists and a marked decrease in that of imaging examinations performed by nonradiologists were also revealed. For example, 96 per 1000 chest radiographs were obtained in 1995, 29% of which were obtained by nonradiologists. In 1997, 104 per 1000 chest radiographs were obtained, with 15% obtained by nonradiologists. These findings indicate a 29% increase in chest radiographs per 1000 obtained by radiologists and a 43% decrease in those obtained by nonradiologists. Even larger changes occurred in examinations of the lumbar spine. In 1995, 10.4 per 1000 examinations were performed, 35% of which were performed by nonradiologists. In 1997, 9.6 per 1000 examinations of the lumbar spine were performed with only 5% performed by nonradiologists. Overall, a decrease in spine examinations of 7% per 1000 was seen; a 35% increase in spine examinations performed by radiologists and an 86% decrease in those performed by nonradiologists occurred. Similarly, of extremity examinations, 11.1 per 1000 wrist examinations were performed in 1995. Of these, 46% were performed by nonradiologists. In 1997, 7.9 per 1000 were performed, only 9% of which were performed by nonradiologists. Overall, a 29% decrease in the number of wrist examinations performed per 1000, with a 20% increase in those performed by a radiologist and an 87% decrease in those performed by nonradiologists (Table 1).

Our technical assessment questionnaire and the follow-up inspection also revealed important findings. Although we examined only five radiology offices, no significant deficiencies were encountered in any of these offices. We then made the assumption that continuing to inspect radiology offices would not be benefi-



**Fig. 3.**—Graph shows radiographs per 1000 enrollees. Once plan was instituted, total (solid line) decreased 20–25% below previous trend (dashed line) and 6% in absolute terms below preplan year. Area with diagonal lines = radiographs obtained by nonradiologists, gray area = radiographs obtained by radiologists.

cial because they routinely had their equipment inspected, issued a report on each imaging study, and had appropriate patient demographic information on each radiography report and on each image. They also routinely used technologists to perform the radiographic examinations, and all offices had a quality assurance program in place.

Of the 92 nonradiologist offices inspected, 10% had not had their equipment inspected within the previous 12 months. Nine percent of the offices that had deficiencies identified by either a physicist or service personnel had not corrected the deficiencies at the time of the survey. Sixteen percent of the offices did not have the images identified using right-sided or left-sided markers. Sixty-two percent of the offices inspected did not issue a formal radiology report of the imaging procedure performed; a note was made in the chart cryptically stating that a radiograph was either positive or negative, but no formal report was available. This seriously limited audit and quality assurance initiatives.

After tabulation of the deficiencies identified on our inspection, a certified letter was sent to each office requiring that the deficiencies be corrected within 90 days. We required that quality assurance programs be instituted if they were not in place and that all imaging studies have a formal report, either legibly handwritten or typed, and placed in the patient's chart. Of the 92 nonradiologist offices inspected, 72 offices, or 78%, had a significant deficiency identified. If the absence of a report is excluded as a criterion, 32% of the offices had serious deficiencies.

## Discussion

There is an extensive literature showing that nonradiologist physicians who have a fi-

nancial interest in the diagnostic imaging of their patients order more imaging than colleagues in the same specialty who do not have this type of financial interest [3, 5–7, 14–16]. This finding holds regardless of whether the nonradiologist has a financial interest in an outside imaging facility to which he or she refers patients or the financial interest consists of imaging that the nonradiologist performs in his or her own office. The finding also holds regardless of whether data are compared on the basis of the patient's presenting complaint or the data are an aggregate for all patients seen by a physician. Similar findings also hold for other ancillary services, such as physical therapy [17].

Given the ubiquity of this finding and the large differences in imaging frequency typically observed, the usual conclusion has been that financial self-interest is an important cause of the higher imaging utilization of self-referrers. However, because almost all studies are comparisons of two different sets of physicians, rather than comparisons of one set of physicians under two different financial incentives, other explanations are possible. For example, it is possible that physicians whose practice style includes much more imaging (perhaps because they are less inclined to rely on history and physical examination than colleagues) acquire imaging equipment because they naturally use it.

Our study is one of few that directly tests the role of financial incentives. Our plan halted reimbursement to nonradiologists for some forms of imaging but left them entirely free to refer their patients to radiologists if they believed the imaging they had been conducting on their patients was needed.

## Imaging Guidelines for Outpatient Radiographic Examinations

Current Procedural Terminology Codes		Detailed Analysis of Radiographic Procedures: 1995 Compared with 1997										Comparison of 1995 and 1997 Values (% per 1000)				
		1995					1997					Total Units	Performed by Radiologists	Performed by All Others		
Description		Total Units	Per 1000	Performed by Radiologists	Per 1000	Performed by All Others	Per 1000	Total Units	Per 1000	Performed by Radiologists	Per 1000	Performed by All Others	Per 1000	Total Units	Performed by Radiologists	Performed by All Others
71010	Chest (one view)	3561	27.8	3209	25.1	352	2.7	4882	31.6	4800	31.2	62	0.4	14	24	-85
71020	Chest (two views)	12,327	96.2	8721	68.1	3606	28.2	16,027	104.1	13,543	88.0	2484	16.1	8	29	-43
73620	Foot (two views)	1712	13.4	74	0.6	1638	12.8	1760	11.4	292	1.9	1468	9.5	-14	228	-25
73630	Foot (complete)	2320	18.1	1128	8.8	1192	9.3	2781	18.1	1924	12.5	857	5.6	0	42	-40
73130	Hand (complete)	1369	10.7	994	7.8	375	2.9	1421	9.2	1285	8.3	136	0.9	-14	8	-70
73610	Ankle (complete)	1877	14.7	1118	8.7	759	5.9	1740	11.3	1641	10.7	99	0.6	-23	22	-89
73600	Ankle (two views)	278	2.2	40	0.3	238	1.9	184	1.2	150	1.0	31	0.2	-45	212	-89
72110	Spine (lumbarsacral)	1326	10.4	867	6.8	459	3.6	1485	9.6	1409	9.2	80	0.5	-7	35	-86
72050	Spine (cervical)	926	7.2	650	5.1	276	2.2	1166	7.6	1087	7.1	79	0.5	5	39	-76
73030	Shoulder	1417	11.1	617	4.8	800	6.2	1145	7.4	1024	6.7	121	0.8	-33	38	-87
73080	Elbow (complete)	471	3.7	294	2.3	177	1.4	571	3.7	538	3.5	33	0.2	1	52	-84
73090	Forearm (two views)	421	3.3	233	1.8	188	1.5	398	2.6	384	2.5	14	0.1	-21	37	-94
73100	Wrist (two views)	591	4.6	87	0.7	504	3.9	206	1.3	179	1.2	27	0.2	-71	71	-96
73110	Wrist (complete)	1417	11.1	767	6.0	650	5.1	1210	7.9	1107	7.2	103	0.7	-29	20	-87
73060	Humerus	188	1.5	104	0.8	84	0.7	203	1.3	198	1.3	5	0.0	-10	58	-95
73510	Hip (complete)	804	6.3	439	3.4	365	2.8	848	5.5	778	5.1	70	0.5	-12	47	-84
72170	Pelvis (anteroposterior only)	665	5.2	396	3.1	269	2.1	850	5.5	804	5.2	46	0.3	6	69	-86
73550	Femur	197	1.5	139	1.1	58	0.5	220	1.4	216	1.4	4	0.0	-7	29	-94
73560	Knee (two views)	1183	9.2	353	2.8	830	6.5	635	4.1	530	3.4	105	0.7	-55	25	-89
73562	Knee (three views)	821	6.4	397	3.1	424	3.3	650	4.2	559	3.6	91	0.6	-34	17	-82
73590	Tibia and fibula	565	4.4	279	2.2	286	2.2	550	3.6	522	3.4	27	0.2	-19	56	-92
Total		34,436	268.9	20,906	163.2	13,530	105.6	36,912	252.7	32,970	214.1	5942	38.6	-6	31	-63

Note.—Codes are from [12].

We found this change produced a decline in imaging of 20–25% from what would have been expected given the previous trend of imaging growth, and an absolute decline of 6%.

Before the institution of our plan, nonradiologists had been performing 39% of outpatient radiographs. The 20–25% decline from the trend that we observed was roughly half this 39% initial share. Thus, our research shows that approximately half the imaging performed by self-referrers disappeared when they lost their financial self-interest in it.

This estimate—that eliminating financial incentives decreases half the imaging self-referrers order—coincides remarkably well with the most relevant data comparing two different groups of physicians. An analysis of Medicare claims data from all nonradiologist physicians in Florida by the United States General Accounting Office reveals that nonradiologists who obtained radiographs of their own patients performed twice as many radiographic examinations per 1000 patient office visits as did physicians who referred their patients to outside offices for radiography [6].

However, results were generally different in the three published studies that, like our research, investigated how physician orders for radiologic studies changed when financial incentives changed. Hemenway et al. [18] reported that when the compensation of primary care physicians at a chain of for-profit ambulatory care clinics was changed from a flat hourly wage to include a bonus related to revenues generated, the number of radiographs per patient visit increased 16% and the number of laboratory tests per visit increased 23%. The authors note that these findings seem like relatively small changes and speculate that the relatively small response may reflect the structure of the bonus system, which provided only a relatively weak financial incentive. Hillman et al. [19] reported that a program somewhat like ours, which generally terminated payment to nonradiologists for the professional component of imaging services but left nonradiologists free to collect payment for the technical component, resulted in a 41% increase in the number of imaging claims payable and a 12% increase in imaging costs in localities in which the insurer instituting the program had a relatively large market share. In contrast, in areas in which the insurer had a small market share, no dramatic changes were seen. It seems possible that if payments from the insurer were a major source of revenues for physicians, physicians noted the new policy and were manipulating the system to maintain their incomes.

Kangaroo [20] reported on the effect of a program somewhat like ours that was introduced into the employee health benefit coverage of a large Florida firm that had been experiencing 25% annual increases in total costs for diagnostic imaging. In the first year of the program, the number of radiographs per 1000 covered persons was 419, a 9% decline from the previous year's level. This seems roughly similar to our finding of a 20–25% decrease from the health plan's previous trend, given that there had been a rapid increase in total imaging costs. However, because Kangaroo did not quantify the previous trend in the number of radiographs, only a rough comparison is possible. Obviously, more data than those of the three previous studies plus our study are required to make generalized conclusions about nonradiologists' responses to changes in financial incentives for imaging.

The widely reported finding that self-referrers do more imaging than radiologist referrers casts doubt on the necessity and appropriateness of the large number of radiographs self-referrers obtain. Our finding that many of these radiographs are not obtained, rather than shift to radiologists, when financial incentives change is further evidence of their questionable necessity. To be fair, however, we should note that advocates of in-office self-referral argue that the inconvenience of sending patients outside the office for imaging and then waiting for results causes physicians to omit imaging examinations that would be useful for patient treatment.

However, we could not find any quality-of-care parameters required by accrediting agencies or monitored by the health plan that were altered by our program. There seems to be no measured adverse health effect when self-referral is terminated. The quality parameters monitored may not be particularly sensitive to minor changes in population health, but opponents to programs like ours tend to predict that these programs will produce widespread and severe deterioration in the quality of care. Even somewhat insensitive indicators should detect such changes.

The most dramatic effect of our program was the decline in the number of radiographs obtained by nonradiologists: it fell from 39% of the total before the program was instituted to 15% after it began.

The resulting shift of examinations to a radiologist's office means that more examinations are now performed using modern equipment with low-dose screens, resulting in a reduction in dose per examination and

an overall decrease in radiation exposure for the patient. Quality, too, was enhanced; as noted, we found many quality deficiencies in nonradiologists' offices. Although some deficiencies, such as formal reports for each examination, may not have a direct impact on patient care, deficiencies such as failure to have equipment inspected, increased dose per examination, or failure to correct a deficiency that had been identified by a physicist are clinically serious. The lack of adequate labeling of a radiograph could also have serious and tragic consequences.

In addition, we believe our inspection program resulted in improvement in the performance of the imaging that still occurred in a nonradiologist's facility. The program set standards for equipment located in a clinician's office and also ensured that a technologist obtained the radiograph. Quality assurance programs were initiated and deficiencies were corrected. Many offices, faced with increased surveillance and costs, decided to abandon performing radiology examinations. We know that 132 offices have stopped billing the plan for imaging procedures; whether they continue to obtain radiographs and bill other carriers or have ceased imaging is something we do not know.

Like all research, our study has limitations. Data on 1993–1997 trends in the utilization of imaging among health plans not affected by our program would have been useful to show that the trends that were seen in 1993–1995 continued, as we have assumed. The long-term effects of our program can be shown only by data from 1998 and subsequent years, which are not yet available. Quite possibly, utilization may start rising again; historically, the use of health services has grown over time. However, if utilization does start rising, it will start from a level 20–25% below that had we not intervened. Also, effects of our program on other imaging techniques, such as sonography (for which we required accreditation), are presumably important, and there may be spillover effects between radiography and other imaging techniques. As far as we could determine, there was no significant out-of-network utilization of radiology services during the study. Because the health plan is a restrictive health maintenance organization, with a specific panel of providers, there is a small possibility that an occasional patient may have been referred to imaging facilities not associated with the health plan. These studies would not have been paid for by the health maintenance organization, a significant disincentive for this to occur.

## Imaging Guidelines for Outpatient Radiographic Examinations

In conclusion, our study shows that a program that limits imaging studies to appropriate physicians can decrease cost and improve quality. We reduced the number of radiographic examinations performed by 20–25% from the preceding trend without significantly interfering with the health care of subscribers. Before our study, approximately 40% of radiographs were obtained by nonradiologists; this decreased to 15%, representing a dramatic reduction. One can infer that many of the procedures previously performed in nonradiologists' offices were not necessary. Issues of radiography equipment maintenance, patient safety, and reporting were addressed by inspecting offices that performed imaging. Seventy-eight percent of the nonradiologists' offices had significant deficiencies that we required to be subsequently corrected. Our program decreased cost and radiation burden.

### References

1. Moynihan DP. On the commodification of medicine. *Acad Med* **1995**;73:453–459
2. Sunshine JH, Bansal S, Evens RG. Radiology performed by nonradiologists in the United States: who does what? *AJR* **1993**;161:419–429
3. Levin DC. The practice of radiology by nonradiologists: cost, quality and utilization issues. *AJR* **1994**;162:513–518
4. Spettell CM, Levin DC, Rao VM, Sunshine JH, Bansal S. Practice patterns of radiologists and nonradiologists: nationwide Medicare data on the performance of chest and skeletal radiography and abdominal and pelvic sonography. *AJR* **1998**; 171:3–5
5. Hillman B, Joseph C, Mabry M, Sunshine JH, Kennedy S, Noether M. Frequency and costs of diagnostic imaging in office practices: a comparison of self-referring and radiologist referring physicians. *N Engl J Med* **1990**;323:1604–1608
6. 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
7. Aranovitz LG. Medicare diagnostic imaging rates. In: Unites States General Accounting Office. *Letter to Subcommittee on Health, Committee on Ways and Means, U.S. House of Representatives*. Washington, DC; April 5, **1994**. Publications GAO/HEHS-and means and GAO/HEHS-94-129R
8. Hooper 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**;180:553–561
9. Scott WW, Bluemke DA, Mysko WK, et al. Interpretation of emergency department radiographs by radiologists and emergency medicine physicians: teleradiology workstation versus radiograph readings. *Radiology* **1995**;195:223–229
10. Verrilli DK, Bloch SM, Rousseau J, Crozier ME, Yecies SB. Design of a privileging program for diagnostic imaging: costs and implications for a large insurer in Massachusetts. *Radiology* **1998**; 208:385–392
11. Edmiston RB, Levin DC. Film quality assessment varies among specialties. *Diagn Imaging* **1992**; 14:37–39
12. American Medical Association. *Physicians current procedural terminology*, 4th ed. Chicago: American Medical Association, **1997**
13. American Medical Association. *International classification of diseases 9-CM*. Dover (DE): American Medical Association, **1997**
14. Childs AW, Hunter ED. Non-medical factors influencing use of diagnostic x-ray by physicians. *Med Care* **1972**;10:323–335
15. Rao VM, Levin DC, Spettell CM, Sunshine JH, Bansal S. Who performs neuroimaging? Results from the 1993 national Medicare database. *Radiology* **1997**;204:443–445
16. Shikles JL. Physicians who invest in imaging centers refer more patients for more costly services. In: United States General Accounting Office. *Testimony before the Subcommittee on Health, Committee on Ways and Means, U.S. House of Representatives*, Washington, DC; April 20, **1993**. Publication GAO/T-HRD-93-14
17. Mitchell JM, Scott E. Physician ownership of physical therapy services: effects on charges, utilization, profits and service characteristics. *JAMA* **1992**;268:2055–2059
18. Hemenway D, Killen A, Cashman SB, Parks CL, Bicknell WJ. Physicians' responses to financial incentives: evidence from a for-profit ambulatory care center. *N Engl J Med* **1990**;332:1059–1063
19. Hillman BJ, Olson GT, Colbert RW, Bernhardt LB. Responses to a payment policy denying professional charges for diagnostic imaging by nonradiologist physicians. *JAMA* **1995**;274:885–887
20. Kangaroo H. Effect of a conversion from a fee-for-service plan to a capitation reimbursement system on a circumscribed outpatient radiology practice of 20,000 persons. *Radiology* **1996**;201:79–84