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Rising Use Of Diagnostic Medical Imaging In A Large Integrated Health System:

The use of imaging has skyrocketed in the past decade, but no one patient population or medical condition is responsible

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Abstract

Little has been published characterizing specific patterns of the dramatic rise in diagnostic imaging during the past decade. In a large health plan, 377,048 patients underwent 4.9 million diagnostic tests from 1997 through 2006. Cross-sectional imaging nearly doubled over those years, rising from 260 to 478 examinations per thousand enrollees per year. Imaging with computed tomography (CT) doubled, and imaging with magnetic resonance imaging (MRI) tripled. Cross-sectional studies added to existing studies instead of replacing them, and the annual per enrollee cost of radiology imaging more than doubled. The dramatic rise in imaging raises both costs and radiation exposure.

The use of diagnostic imaging has increased dramatically over the past decade, contributing to medical costs and to medical exposure to ionizing radiation.¹ The recent overview from the Medicare Payment Advisory Commission (MedPAC) to the Centers for Medicare and Medicaid Services (CMS) reported that the rise in volume of imaging services per Medicare beneficiary outstripped the growth of all other services physicians provide.² Several factors have contributed to this increase, including wider availability of technology, increased demand by patients and physicians, favorable reimbursement, and improvements in the technology resulting in a lower threshold for using it.

Several studies have documented the increase in imaging over time, but relatively little has been published characterizing patterns of imaging in detail—specifically, how imaging patterns vary by patient factors, imaging modality, or the anatomic area being imaged.³ This type of analysis would allow those interested in cost containment to understand where most imaging—and most expense—occurs. Further, it is largely unknown whether newer and more expensive imaging tests are replacing or being used in addition to older tests, such as x-rays.

To achieve the important goal of overall cost containment, newer imaging tests should replace older and potentially less accurate exams, not supplement them.

This study aimed to determine temporal patterns of diagnostic medical imaging and how these patterns vary by patients' age and sex, imaging modality, and anatomic area. Further, we wanted to determine whether the rise in use of imaging was due to an increase in the proportion of patients being imaged or a greater number of imaging tests being performed per person per condition.

Study Data And Methods

We evaluated trends in diagnostic imaging among members of Group Health Cooperative, a large, mixed-model, nonprofit health care system providing integrated care and coverage to approximately 10 percent of Washington State residents. Group Health provides care through its own facilities, including twenty-eight primary care or family medical centers, five specialty medical centers, and two hospitals; it has affiliations with forty-five other major institutions for selected specialty services unavailable at Group Health. Group Health has complete and comprehensive automated information systems that capture enrollees' receipt of diagnostic imaging studies, allowing the use of imaging to be assessed per patient over time. We assessed patterns of imaging in each year from 1997 to 2006.

■ Characterizing patterns of imaging

All imaging examinations were coded in Group Health automated systems using standardized *International Classification of Diseases*, Ninth Revision (ICD-9), and *Current Procedural Terminology*, Fourth Edition (CPT-4), codes. All imaging examinations were grouped into nonoverlapping anatomic areas (abdomen, breast, cardiac, central nervous system [CNS], chest, endocrine, extremity, obstetrical, spine, vascular, and other) and imaging modality categories as computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, nuclear medicine (NM), radiography (x-ray films), and arteriography. CT, MRI, and ultrasound were combined into a single cross-sectional imaging category. For subanalyses, x-ray exams of the abdomen were subdivided into those with and without contrast (that is, using oral or intravenous agents). Imaging examinations were included irrespective of the specialty that conducted or interpreted the examination.

■ Defining "utilization."

For each Group Health member, for each year of the study, we assessed the use of imaging tests during each day of the study period, by modality and anatomic area, and within defined age strata. If multiple examinations within the same modality and anatomic area were recorded on the same day, they were collapsed into a single examination to avoid overcounting examinations that might have occurred only once.

■ Analysis

We calculated the number of imaging tests per thousand enrollees per year, stratified by anatomic area, modality, and year. These rates were calculated overall and stratified within age groups. These rates were also calculated among elderly enrollees, defined as those age sixty-five and older. We calculated the proportion of patients who underwent any imaging and any cross-sectional imaging within each year, by defined age strata. Among patients who underwent cross-sectional abdominal imaging and CNS imaging, we calculated the annual mean number of abdominal and CNS tests, respectively, per patient to estimate the amount of repeat imaging. We focused on the most frequent anatomic area (CNS) and the one for which we suspected that repeat imaging would be common (abdomen). All rates were standardized to the age distribution in 2000 using direct standardization. To simplify the exhibits, we did

not show results in the figures for imaging tests that accounted for a small proportion of the total.

■ Costs

To estimate the costs associated with the increase in imaging over time, we calculated radiology costs per enrollee for each year of the study, basing costs on the Medicare fee reimbursement schedule in 2006.⁴ By choosing to estimate costs using a single-year fee schedule, we are focusing on the increase in real costs associated with the increased volume of examinations per enrollee. To estimate the cost of each examination, we included a global cost covering both the technical and professional components. We calculated the change in cost over time using compound annual growth.

■ Study population

Our study population consisted of 377,048 patients enrolled in Group Health between 1997 and 2006 who underwent approximately 4.9 million imaging examinations over the ten years of the study. Slightly more than half of the enrollees (54 percent) were female, and the age of the enrollees increased over time.⁵ Overall, 13 percent of enrollees were minorities, including African Americans (3 percent), Asian and Pacific Islanders (3 percent), Hispanic (2 percent), and mixed race (5 percent).

Study Results

Between 1997 and 2006, imaging increased for nearly every imaging modality studied (Exhibit 1). Cross-sectional imaging approximately doubled, increasing from 260 to 478 examinations per thousand enrollees (average 9 percent annual increase). Ultrasound increased 5 percent per year, from 157 to 225 examinations per thousand patients per year; CT increased 14 percent per year, from 81 to 181 examinations; and MRI increased 26 percent per year, from 22 to 72 examinations. Over the ten-year period studied, ultrasound increased by nearly 40 percent, CT doubled, and MRI nearly tripled. Utilization of NM examinations remained stable, varying between thirty-two and thirty-five imaging tests per thousand patients per year, with no temporal trend. Overall rates of imaging were approximately twice as high among elderly enrollees, but trends were similar.⁶ Total use of x-ray exams was much higher than for other imaging tests and accounted for the greatest number of imaging studies during each year studied. However, because of its dramatic rise, cross-sectional imaging accounted for a larger proportion of examinations over time, increasing from approximately one in four imaging examinations (24 percent) in 1997 to one in three (35 percent) by 2006. In terms of cost, cross-sectional imaging accounted for 54.0 percent of total imaging costs in 1997, whereas it accounted for 70.2 percent of total imaging costs in 2006.

The total number of imaging tests increased markedly with age, and the types of tests used varied with age (Exhibit 2). Cross-sectional imaging accounted for around 15 percent of examinations among children and 30-40 percent among adults.

To try to ascertain whether a change in the distribution of diseases might explain the increase in imaging over time, we evaluated the use of all imaging examinations by anatomic area.⁷ No large changes were seen in the distribution of which anatomic sites were being imaged. The extremities and chest were the most common areas imaged during each year studied, and imaging increased modestly over time across all anatomic areas.

For each imaging modality we evaluated the trends in imaging stratified by anatomic area to determine if the increases in the use of specific imaging modalities were limited to selected anatomic areas. Imaging with CT and MRI increased consistently across all anatomic areas.

Rates of imaging with CT and MRI were two- to threefold higher, and the increase in imaging was faster among elderly enrollees compared with younger patients (Exhibit 3). For ultrasound, imaging patterns were less consistent across different anatomic areas, with the only dramatic increase occurring for cardiac imaging (echocardiography), which increased approximately 10 percent annually.⁸ This resulted in a tripling of the number of echocardiography examinations over the years studied. Breast imaging (mammography, which uses x-rays) demonstrated a consistent 5 percent annual increase. Imaging with x-rays remained relatively stable over time, with one significant change.⁹ Concomitant with the dramatic rise in abdominal CT, we found a substantial decline in abdominal x-ray examinations involving use of oral or intravenous contrast.¹⁰ This was the only decrease in imaging we could document across all imaging modalities and all anatomic areas studied.

Because of the overall increase in imaging, concomitant with greater use of more expensive technologies, the annual per enrollee cost of radiology imaging more than doubled over the decade of the study. Mean annual cost increased from \$229 per enrollee in 1997 to \$463 per enrollee in 2006 (Exhibit 4). The costs associated with imaging of different anatomic areas varied, with particularly high growth in spending for the CNS and spine (annual increases of 12 percent, Exhibit 5). Cardiac and chest were the next most costly and showed the second highest annual increase (9 percent). The increase in costs associated with these anatomic areas resulted from the greater use of advanced and expensive imaging tests.

The observed increase in cross-sectional imaging was due to increases in both the proportion of patients imaged and the number of imaging studies per patient. For example, the proportion of patients who underwent at least one cross-sectional imaging test in a year increased from 13.5 percent in 1997 to 21.0 percent in 2006. Among patients age sixty-five and older, the proportion who underwent at least one cross-sectional imaging test was even higher and increased from 26.9 percent in 1997 to 40.6 percent in 2006. The frequency of repeat imaging also increased over time. For example, among patients who underwent cross-sectional imaging of the abdomen, the median number of cross-sectional imaging tests increased 30 percent from 2.2 in 1997 to 2.9 in 2006 (Exhibit 6). Approximately 5 percent of patients underwent more than five cross-sectional imaging tests annually. Among patients who underwent CT, approximately 1 percent had more than ten CT scans annually.

Discussion

Based on MedPAC's reports to Congress, Medicare spending for imaging services has been growing rapidly over the past decade.¹¹ For example, between 2000 and 2005, spending for imaging services more than doubled from \$6.6 billion to \$13.7 billion, an average annual growth rate twice the overall rate of growth in physician fee schedule services. In 2005 imaging services represented an estimated 14 percent of 2005 spending included in the sustainable growth rate (SGR) calculation, but represented 27 percent of the total increase in such spending between 2004 and 2005. The majority of the growth occurred for advanced imaging, including CT and MRI.

Our results build on these findings in several important ways. First, MedPAC reported the doubling in imaging-related spending only among the elderly and within four relatively broad categories. We have expanded on these results by completing detailed analysis across the entire age spectrum and broken down by anatomic area and modality. This level of detail is important, because imaging rates tend to be higher among the elderly, and trends in imaging may differ by age group and anatomic area (crudely reflecting different disease groups). Although absolute imaging rates differed by sex, age group, anatomic area, and modality, we found substantial and similar trends of increasing use across all groups, especially for MRI and CT. We demonstrated a decline in use for remarkably few tests. The

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broad patterns of increasing imaging among every group studied makes it clear that no single group—defined by age, sex, or disease—can be the single target of efforts to reduce the use of imaging. Our results also provide evidence that newer and more expensive technologies are being used widely as additions to the older tests, with relatively little substitution of the newer tests for the older ones. This pattern is often seen with the development of new technology.¹²

Second, previous studies on imaging trends have focused on the Medicare fee- for-service (FFS) population or patients with generous private insurance.¹³ In these cases, clear financial incentives encourage increasing imaging. This is the first study to document the pattern of imaging over time in a managed care setting where no such financial incentives exist. We found rising use of imaging services among health maintenance organization (HMO) members, closely paralleling the trends found in FFS Medicare or privately insured populations. This suggests that incentives in a managed care model will not necessarily suffice to change the forces leading to increased use of advanced imaging techniques. Practice patterns occurring within the general FFS environment almost certainly extend to the managed care setting through clinical practice patterns, standards of care, and patients’ expectations.

Third, and closely related, MedPAC, the American College of Radiology, and others have raised concern that self-referral could be contributing to the increase in imaging.¹⁴ Although the Stark amendments prohibit physicians from making referrals to institutions with which they have a financial relationship, data from California suggest that physicians exploit broad exceptions to this law to self-refer patients for imaging, contributing to rising imaging rates.¹⁵ It has been suggested that the increasing trend toward nonradiologist-ownership of imaging equipment may further exacerbate utilization resulting from self-referral. Yet we found a dramatic rise in the use of advanced imaging procedures in an environment with no opportunity to profit from self-referral. Thus, legislative efforts that focus entirely on self-referral are likely not sufficient to limit the drivers of imaging.

■ Rising disease prevalence

A rise in the prevalence of certain conditions and illnesses has been hypothesized to have contributed to the increase in imaging. Our detailed analyses by anatomic area do not support this hypothesis: we found no consistent shift in where in the body imaging occurred. However, we found dramatic differences in the cost of imaging associated with different anatomic areas, with the most dramatic increases for imaging of the CNS, spine, chest, and cardiac system; this primarily reflects greater relative use of CT and MRI as well as ultrasound for cardiac imaging. This suggests that certain physicians are embracing the new technology more rapidly, perhaps with greater discretionary spending in these areas.

■ Why the increase in CT and MRI?

Why have imaging rates increased so dramatically for CT and MRI, despite their high costs? One obvious explanation is that the techniques have improved so much over time that physicians may be using them for concerns that might not have prompted imaging in the past. For example, CT’s speed and resolution for detecting pulmonary embolism have improved so dramatically over the past decade that CT is now the primary method used to evaluate this condition, and this has undoubtedly contributed to the dramatic rise in costs associated with imaging of the chest. However, for other areas, such as spine imaging, it is hard to document clear evidence of improved accuracy or outcomes that would have prompted such a dramatic increase in imaging based on the improvements in the technology. Patient-generated demand, physicians’ fear of medical malpractice law-suits, and repeated surveillance among certain groups of patients (for example, those with cancer) almost certainly have also contributed to

the increase, although it was not possible for us to quantify the importance of each. Improvements in resolution might have also led to identifying more lesions suspicious for cancer, which could have resulted in additional imaging tests for surveillance.

The supply of CT and MRI scanners has also increased dramatically, which might have contributed to further use of and spending on these services. Within Group Health, the availability of CT and MRI increased over time; thus, the dramatic rise may in part reflect pent-up demand. Rapid growth in the volume of these tests may also signal that Medicare's payments for these services are too high relative to the effort needed to provide them, and the difference in their profitability may therefore in part drive the use of these technologies. Within the radiology community, the profit margin is considered greatest for MRI (where we saw the steepest rise in imaging), followed by CT (where we saw the next-largest increase). Although such financial incentives might not have contributed directly to imaging in our managed care setting, widespread financial incentives in the FFS environment could affect clinical practice standards that extend into the managed care setting. The reimbursement schemes used by the CMS should not provide inappropriate incentives for growth in volume and intensity.

■ Connection with improved outcomes?

Our study cannot address the appropriateness of the documented increase in imaging use or whether this increase was associated with improvements in patient outcomes. Some have argued that the increase in imaging reflects improved patient care, while others have argued that the costs associated with imaging are rising out of proportion to any possible benefit. The truth likely lies somewhere between these two extremes. However, even if imaging is beneficial, the dramatic increases in costs cannot be sustained; thus, studies of patient outcomes are essential to help determine when imaging use is most likely to lead to improved outcomes at a cost we can afford, and conversely where value is limited or not existent. Whatever the financial structure where the imaging is provided (HMO, FFS, self-pay, or no pay), someone is bearing the substantial costs of the increase in imaging.

“The increased dose per CT exam, with the increased number of exams, has pushed radiation exposure into the range of concern.”

■ Increased radiation exposure

One potential harm of increased CT use bears special mention, because it is an extremely important measure of health care quality. Although CT is considered by many one of the most important technological advances in medicine, it is associated with substantial radiation exposure.¹⁶ Radiation is of concern because extensive epidemiologic evidence has linked exposure to ionizing radiation to the subsequent development of cancer. Further, irrespective of the number of CT examinations performed, the dose per examination has also increased dramatically over the past decade, coincident with technical advances. Thus, the increased dose per exam, compounded with the increased number of examinations, has likely pushed radiation exposure into the range where carcinogenesis is of concern. David Brenner suggests that about one-third of all CT scans are unnecessary and that overusing these tests may raise the total public risk of cancer deaths due to radiation exposure in the coming decades.¹⁷ Fred Mettler estimates that the amount of radiation from clinical imaging examinations experienced by the U.S. public has increased more than 600 percent in the past two decades.¹⁸ Thus, diagnostic testing may expose some patients to needless risk, in addition to generating unwarranted costs. The dramatic rise in CT usage across all age groups and anatomic areas should prompt researchers to assess and quantify the risks and benefits of using it.

■ Strengths and limitations

Our study's several strengths include using data from a large integrated health care system with near-complete capture of imaging examinations, allowing us to examine detailed patterns of use by patient characteristics and across different modalities. Our study's limitations include that we likely missed imaging examinations that were not included as benefits provided by Group Health, such as coronary calcification scoring. No physician group recommends these screening studies, and Group Health does not perform them; thus, we have no way to assess how many of them might have been performed. Second, we included only a single imaging examination of the same type and anatomic area on each day of the study period. This may result in the occasional undercounting of studies. Third, use of imaging at Group Health might not be representative of imaging in other locations or within other medical fee structures. In particular, imaging rates tend to be lower in managed care settings than in FFS settings; thus, imaging rates might be even higher in other settings. However, we found that the trends in imaging among elderly Group Health enrollees resembled those documented by others among Medicare beneficiaries.

Lastly, there are numerous ways to calculate the costs associated with medical imaging, and each will reflect a different perspective (patient, provider, third-party payer, society) and emphasize a different aspect of costs (fixed equipment costs, variable costs such as payment for contrast, or professional costs related to the interpretation of the images). Changes in imaging patterns (greater reliance on outpatient imaging), differences in the reimbursement trends based on these patterns, and differences in the relative value units (RVUs) associated with specific tests can all make the interpretation of costs difficult. To simplify interpretation of the cost data, we used a single reimbursement scheme across all years of the study. This reflects an overview of the resource use associated with imaging. The costs cannot be seen as reflecting actual costs, but they can provide insight into the relative costs of imaging. Using this methodology, we found that the cost of imaging more than doubled over the decade of the study. Different methodologies of calculating costs might yield different results but should not affect trends, and the conclusion that the costs of imaging increased dramatically over the past ten years is unlikely to change.

Health care payers have used numerous strategies to try to slow down the soaring use of imaging, which is contributing to the rise in health care costs. The ideal way to curtail medical imaging would decrease costly yet inappropriate or ineffective imaging, while maintaining and increasing the use of imaging associated with improved health outcomes. Unfortunately, it is difficult to identify which imaging tests are most beneficial, and strategies that rely on financial disincentives tend to decrease imaging across the board, instead of selectively reducing unnecessary imaging. Cost-effectiveness and patient outcome studies are essential to decide how best to use imaging technology. Several recent studies have begun to tackle when and how best to use imaging for particular clinical questions, such as mild head trauma.¹⁹ Given the unrelenting rise in health care spending, continued increases in imaging seem unsustainable; thus, these studies are necessary to help direct how and when to use imaging. In the absence of such studies, we should consider the development of multidisciplinary consensus processes aimed at identifying excess imaging, and perhaps use wide spread variation in testing as targets for focused efforts. At a minimum, we must consider how to limit the strong financial incentives contributing to the dramatic rise in CT and MRI.

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NOTES

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EXHIBIT 1. Cross-Sectional Imaging Tests Per Thousand Enrollees Per Year, 1997-2006

SOURCE: Group Health Cooperative data.

NOTES: Results are stratified by imaging modality and adjusted to a standard age distribution across all years of the study. CT is computed tomography. MRI is magnetic resonance imaging.

EXHIBIT 2. Number Of Imaging Tests Per Thousand Enrollees Per Year, By Modality And Age, 2000-2006

SOURCE: Group Health Cooperative data.

NOTES: Results are stratified by patient age, averaged across 2000-2006. MRI is magnetic resonance imaging. CT is computed tomography.

EXHIBIT 3. Computed Tomography (CT) And Magnetic Resonance Imaging (MRI) Among Plan Enrollees Age Sixty-Five And Older, By Anatomic Area, 1997-2006

SOURCE: Group Health Cooperative data.

NOTES: Data are adjusted to a standard age distribution across all years of study. CT is computed tomography. CNS is central nervous system. MRI is magnetic resonance imaging.

EXHIBIT 4. Annual Imaging Costs Per Health Plan Enrollee, 1997-2006

SOURCE: Group Health Cooperative data.

NOTE: Data are adjusted to a standard age distribution across all years of study.

EXHIBIT 5. Annual Imaging Costs Per Health Plan Enrollee, By Anatomic Area, 1997-2006

SOURCE: Group Health Cooperative data.

NOTES: Data are adjusted to a standard age distribution across all years of study. CNS is central nervous system. CAG is compound annual growth.

EXHIBIT 6. Number Of Repeat Imaging Tests Within One Year Among Enrollees Who Underwent Abdominal Or Central Nervous System (CNS) Imaging, 1997-2006
SOURCE: Group Health Cooperative data.