Use of Diagnostic Imaging Studies and Associated Radiation Exposure for Patients Enrolled in Large Integrated Healthcare Systems, 1996–2010

Asma Abu Baker Jandan, Maha Trad Alanazi, Nouf Abdullah Alnumani, Ahlam Nazeh Alenezi
Corresponding author: Asma Abu Baker Jandan
Address:
[1,3]Radiology Technologist [2]Ultrasound Sonographer [4]Nuclear Medicine Technologist
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Abstract

Diagnostic imaging use increased significantly within fee-for-service models of care. Little is known about patterns of imaging among members of integrated health care systems. Objective:To estimate trends in imaging utilization and associated radiation exposure among members of integrated healthcare systems. Design, Setting, and Participants: Retrospective analysis of electronic records of members of six large integrated health systems from diverse regions of the country. Review of medical records allowed direct estimation of radiation exposure from selected tests. Between 1–2 million member- patients were included each year from 1996 to 2010. Main Outcome Measure: Advanced diagnostic imaging rates, and cumulative annual radiation exposure from medical imaging. Within integrated health care systems there was a large increase in the rate of advanced diagnostic imaging and associated radiation exposure between 1996 and 2010.

Key Words: Diagnostic Imaging, Radiation, Healthcare Systems

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Introduction

The use of diagnostic imaging in the Medicare population has increased significantly over the last two decades, particularly using expensive new technologies such as computed tomography (CT), magnetic resonance imaging (MRI), and nuclear medicine positron emission technology (PET). (Iglehart, 2009). The development and improvement in these advanced diagnostic imaging technologies is widely credited with leading to earlier and more accurate diagnoses of disease using non-invasive techniques. However, utilization and costs of advanced diagnostic imaging in the United States are high and rapidly growing, and payments to physicians for diagnostic imaging have had the highest rate of growth among all physician services over the last decade (Winter, 2008). CT and nuclear medicine examinations deliver much higher doses of ionizing radiation than conventional radiographs, and extensive epidemiological evidence has linked exposure to radiation levels in this range with the development of radiation-induced cancers. it is estimated that 2% of future cancers will result from current imaging use, if imaging continues at current rates(Preston, 2007).

We conducted a population-based study of diagnostic imaging trends between 1996 and 2010 among members of six geographically diverse integrated health care delivery systems that have both care delivery and insurance relationships with their member-patients. The availability of administrative and electronic medical record data on all health care received— including diagnostic imaging— allowed us to assess patterns of imaging over time as they varied by health system and patient demographics (Brennerm 2007).

Data Sources And Study Population

The study population includes members enrolled in one of six health care systems, each of which participates in the HMO Research Network, (Levin ,2010). including Group Health Cooperative in Washington State; Kaiser Permanente in Colorado, Georgia, Hawaii, and Oregon/Washington; and Marshfield Clinic/Security Health Plan in Wisconsin. We included all members enrolled in group- and staff-model plans, and in addition to commercial plans, the health system members include enrollees with prepaid Medicaid contracts, state- subsidized prepaid plans and Medicare Advantage plans. We excluded data for health plan members who purchased fee- for-service (network) plans and patients treated at health plan facilities without being enrolled in the HMO plans because of the high likelihood of incomplete capture of imaging for these patients. Enrollees were included in the study for each year in which they were continuously enrolled. A data resource utility called the Virtual Data Warehouse (VDW) that includes comprehensive diagnostic imaging data was used to capture standardized data from the electronic medical and administrative records. A waiver of informed consent was received for each participating health care system (Fazel ,2009).

Imaging Utilization

All diagnostic imaging tests were included regardless of where they were ordered, performed, or interpreted. Imaging procedures done in conjunction with radiation treatment for cancer were not included. Individual health systems contributed data for at least 11 and up to 15 years, depending on participation in their local VDW. Imaging procedures were coded using standardized ICD-9-CM, CPT-4, and HCPCS codes. There were 1467 unique imaging codes across all years, and each was mapped to an anatomic area (ie, abdomen/pelvis [abdomen], brain [central nervous system, abbreviated as CNS], breast, cardiovascular, chest, extremity, obstetric, spine, and other/unknown) and where they could not differentiated, extremity and spine were combined as musculoskeletal. Exams were also characterized by modality (ie, angiography/fluoroscopy; CT; MRI; nuclear medicine [PET, a subset of nuclear medicine categorized separately because of its high cost]; Radiography; ultrasound; and other/unknown. Multiple examinations with the same procedure code performed on the same patient on the same day were counted only once to reduce the likelihood of over- counting (Graham, 2005).

Radiation Dose

The dosage data provided detailed information on the variability in effective radiation dose within procedure type. We used this information to create a dose estimate that accounts for the variability of dose. A truncated lognormal distribution was a good fit to dose data, with the truncation occurring at three standard deviations on the log scale. For each exam each patient underwent during the study period, we randomly imputed a dose value from the log- normal distribution. This technique allowed each person to be assigned a dose value that reflected the true underlying distribution in dose, rather than assuming each person received the mean dose associated with a particular exam type (Brenner, 2007).

We used the data describing the number of imaging tests and associated radiation dose per test to calculate the total dose of radiation each member received each year of the study, and to calculate the collective effective dose to the entire population. To estimate cumulative annual radiation exposure for each patient, we summed the doses for each examination within each year. If patients underwent more than one examination using the same modality on the same anatomic area on the same day, we only included the examination with the highest radiation exposure to calculate dose so as not to overestimate doses received (Hackbarth , 2008).

Utilization Over Time:

Radiography and angiography/fluoroscopy rates were relatively stable over time: radiography increased 1.2% per year, and angiography/fluoroscopy decreased 1.3% per year. In contrast, the utilization of advanced diagnostic imaging changed markedly

Radiation Exposure and Changes Over Time

The increase in the utilization of CT resulted in an increase in enrollee exposure to radiation, with the mean per capita effective dose rising from 1.2 mSv in 1996 to 2.3 mSv in 2010. The percent of enrollees who received high (>20–50 mSv) or very high (>50 mSv) radiation exposure during a given year also approximately doubled across study years (Smith, 2008).

Challenges and opportunities

We found that imaging rose steeply with age, particularly for CT and nuclear medicine examinations, resulting in high radiation exposures received by the oldest enrollees. Among enrollees age 45 and above who underwent imaging, nearly 20% received high or very high radiation exposure annually. Although cancer risks from radiation are often considered to decline with age, recent models suggest that cancer risks decline with age until middle age, when cancer risks may then increase in a U-shaped distribution. (Lieu, 2011) Thus radiation related cancer risks after exposure in middle and older ages may be higher than previously believed (Fazel, 2009). Since the utilization of imaging is higher in older adults, and since the potential harm from these tests may also be higher in these patients, it is particularly important to quantify the benefits of imaging in these patients.

There is growing concern about the geographic variation in health care utilization, noted to be particularly high for diagnostic imaging,30,38 raising concerns that use in some areas may be inappropriate. We found even greater variation in imaging rates among these health systems than reported for Medicare fee-for-service enrollees.30

Recommendations:

We conducted a population-based study of diagnostic imaging trends between 1996 and 2010 among members of six geographically diverse integrated health care delivery systems that have both care delivery and insurance relationships with their member- patients. The availability of administrative and electronic medical record data on all health care received—including diagnostic imaging—allowed us to assess patterns of imaging over time as they varied by health system and patient demographics.

Conclusion:

Within integrated health care systems there was a large increase in the rate of advanced diagnostic imaging and associated radiation exposure between 1996 and 2010. Increased use of CT resulted in increased radiation exposure for enrollees, with a doubling in the mean per capita effective dose and in the proportion of enrollees who received high (>20–50 mSv) or very high (>50mSv) annual radiation exposure. By 2010, nearly 7% of enrollees who underwent imaging received a high annual radiation exposure (>20–50 mSv) and 4% received a very high annual exposure (>50 mSv).

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