Patterns of Breast Magnetic Resonance Imaging Use in Community Practice

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IMPORTANCE Breast magnetic resonance imaging (MRI) is increasingly used for breast cancer screening, diagnostic evaluation, and surveillance. However, we lack data on national patterns of breast MRI use in community practice.

OBJECTIVE To describe patterns of breast MRI use in US community practice during the period 2005 through 2009.

DESIGN, SETTING, AND PARTICIPANTS Observational cohort study using data collected from 2005 through 2009 on breast MRI and mammography from 5 national Breast Cancer Surveillance Consortium registries. Data included 8931 breast MRI examinations and 1,288,924 screening mammograms from women aged 18 to 79 years.

MAIN OUTCOMES AND MEASURES We calculated the rate of breast MRI examinations per 1000 women with breast imaging within the same year and described the clinical indications for the breast MRI examinations by year and age. We compared women screened with breast MRI to women screened with mammography alone for patient characteristics and lifetime breast cancer risk.

RESULTS The overall rate of breast MRI from 2005 through 2009 nearly tripled from 4.2 to 11.5 examinations per 1000 women, with the most rapid increase from 2005 to 2007 ($P = .02$). The most common clinical indication was diagnostic evaluation (40.3%), followed by screening (31.7%). Compared with women who received screening mammography alone, women who underwent screening breast MRI were more likely to be younger than 50 years, white non-Hispanic, and nulliparous and to have a personal history of breast cancer, a family history of breast cancer, and extremely dense breast tissue (all $P < .001$). The proportion of women screened using breast MRI at high lifetime risk for breast cancer (>20%) increased during the study period from 9% in 2005 to 29% in 2009.

CONCLUSIONS AND RELEVANCE Use of breast MRI for screening in high-risk women is increasing. However, our findings suggest that there is a need to improve appropriate use, including among women who may benefit from screening breast MRI.

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n 2012, women in the United States underwent nearly 39 million mammograms.1,2 However, breast magnetic resonance imaging (MRI) is increasingly used for breast cancer screening, diagnostic evaluation, and surveillance.3-4 Mammography remains the key imaging tool for population-based screening and for workup of women experiencing breast symptoms,5 but breast MRI is becoming more common in community settings.6-8 A benefit of breast MRI is its high sensitivity for identifying clinically occult malignant breast tumors.6 However, compared with mammography, breast MRI has a modest specificity that leads to higher false-positive rates9,10; it is also more expensive and requires the use of intravenous contrast medium.

National guidelines support the use of breast MRI for particular clinical indications. The most widely accepted guideline, from the American Cancer Society (ACS) in 2007, is to screen asymptomatic women at high risk for breast cancer, defined as (1) known BRCA gene mutation carriers; (2) first-degree relatives of a known BRCA gene mutation carrier who are themselves untested; or (3) women with more than 20% lifetime risk of breast cancer, according to risk assessment tools based on family history of breast cancer.11,12 The ACS lacked sufficient evidence to make recommendations for women in other risk subgroups. The National Comprehensive Cancer Network (NCCN)13 recommends considering the use of preoperative breast MRI for women with a new breast cancer diagnosis to determine the extent of disease before surgery in occult tumors, although there is not a broad consensus.6

Despite the rapid expansion of breast MRI in different settings and for multiple clinical applications, most published reports on its use are from single institutions3,7 and focus only on specific populations.7,8 We lack data on national patterns of breast MRI use in community practice.

Our purpose was to evaluate patterns of breast MRI use among community-based facilities across the United States. Using data from 2005 through 2009 from 5 registries in the Breast Cancer Surveillance Consortium (BCSC),14 we evaluated rates and distributions of clinical indications for breast MRI temporally and by age. We also compared characteristics of women screened with breast MRI with those of women who were screened with mammography alone.

Methods

**Study Registries**

The BCSC is a collaboration of breast imaging registries in community-based settings with linkages to tumor and/or pathology registries. The BCSC is supported by a Statistical Coordinating Center (SCC). The goals of the BCSC are to assess the delivery and quality of US breast cancer imaging and patient outcomes. This study used data from 5 registries: Carolina Mammography Registry, Group Health Cooperative (Washington state), New Hampshire Mammography Network, San Francisco Mammography Registry, and Vermont Breast Cancer Surveillance System.14 The data from these 5 registries reflect mammography practice as it is performed in the community and are located in counties that contain slightly more than 3.6% of the nation’s population. Each registry and the SCC received institutional review board approval for either active consent or passive permission or a waiver of consent to enroll participants, link study data, and perform analytic studies. All procedures are Health Insurance Portability and Accountability Act compliant. All registries and the SCC have received a Federal Certificate of Confidentiality and other protection for the identities of women, physicians, and facilities that are subjects of this research.

Data from the BCSC are collected as part of routine clinical care at the time of imaging from patients and radiologists. Mammography data include indication for the mammogram and American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) assessment and breast density.5 Each registry site sends their data to the SCC for pooling and statistical analysis. All data undergo rigorous quality control checks.

**Breast MRI Data**

We used data on breast MRI conducted during the period 2005 through 2009 for women aged 18 to 79 years. Data were obtained from registries retrospectively and prospectively using electronic radiology data systems (64%), chart abstraction of radiology reports (20%), completion of advanced imaging form at time of examination (16%), and billing codes (0.02%). For each examination, standardized information was recorded including the clinical indication for the breast MRI, BI-RADS assessment, and clinical recommendations (eg, routine mammographic follow-up, follow-up breast MRI in 6 months, or biopsy). To evaluate potential bias due to incomplete data capture from BCSC facilities, the registries surveyed BCSC facilities to estimate data capture for breast MRI examinations. Facilities estimated completeness of recording breast MRI data as none, less than 50%, 50% to 89%, or at least 90%.

Most examinations were coded with a single indication (89%). In the 11% of breast MRI examinations with more than 1 indication (up to 3 could be coded), we categorized clinical indication using the following hierarchy to isolate true screening breast MRI examinations in asymptomatic women: (1) evaluation of extent of disease in patients with a recent breast cancer diagnosis, (2) evaluation of response to neoadjuvant chemotherapy, (3) axillary adenopathy (malignant) of unknown primary tumor, (4) additional evaluation of recent mammogram or other non-MRI breast imaging, (5) evaluation of breast problem (ie, symptomatic), (6) recurrence vs scar, (7) short-interval follow-up of prior breast MRI examination, (8) screening (ie, asymptomatic), (9) evaluation of implants, and (10) other. For example, if an examination was coded as additional evaluation of a recent mammogram and screening, the indication was coded as additional evaluation of a recent mammogram. For all examinations, primary indications were combined into 4 broader groups: cancer staging and treatment (groups 1-3), diagnosis (groups 4-6), screening including surveillance (group 8), and other (groups 7, 9-10).

**Patient Characteristics**

At the time of mammography, women completed a questionnaire to ascertain age, race/ethnicity, first-degree family history, and other factors. To capture women with a new breast cancer diagnosis, we evaluated 1 indication (up to 3 could be coded), we categorized clinical indication using the following hierarchy to isolate true screening breast MRI examinations in asymptomatic women: (1) evaluation of extent of disease in patients with a recent breast cancer diagnosis, (2) evaluation of response to neoadjuvant chemotherapy, (3) axillary adenopathy (malignant) of unknown primary tumor, (4) additional evaluation of recent mammogram or other non-MRI breast imaging, (5) evaluation of breast problem (ie, symptomatic), (6) recurrence vs scar, (7) short-interval follow-up of prior breast MRI examination, (8) screening (ie, asymptomatic), (9) evaluation of implants, and (10) other. For example, if an examination was coded as additional evaluation of a recent mammogram and screening, the indication was coded as additional evaluation of a recent mammogram. For all examinations, primary indications were combined into 4 broader groups: cancer staging and treatment (groups 1-3), diagnosis (groups 4-6), screening including surveillance (group 8), and other (groups 7, 9-10).

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ory of breast cancer, history of breast procedures, and other risk factors. For breast MRI examinations, women typically did not complete an additional patient questionnaire. Therefore, we linked the breast MRI examination to the most recent patient questionnaire completed at a mammography visit within the prior 12 months (median time since questionnaire completion, 87 days).

History of mammography within the past 12 months was calculated on the basis of mammography receipt within BCSC data. A personal history of breast cancer was documented through either self-report or linkage with BCSC pathology and cancer registry data. The BI-RADS breast density was obtained from the most recent mammogram. If breast density measures were missing from the most recent mammogram, the next most recent mammogram within 18 months informed the missing breast density measure if there was no change in hormone therapy use and no incident breast cancer diagnosis. Finally, for each woman without a personal history of breast cancer, we calculated lifetime breast cancer risk on the basis of the National Cancer Institute Breast Cancer Risk Assessment Tool (BCRAT; http://www.cancer.gov/bcrisktool/). The BCRAT includes age, race, previous breast biopsy results, presence of atypia, age at menarche, age at first live birth, and history of breast cancer in first-degree relatives. Risk was categorized as less than 15%, 15% to 20%, and more than 20%, to correspond to cutoffs in the ACS guidelines for breast cancer screening with MRI.11

Statistical Analysis
We identified 9537 breast MRI examinations during the period 2005 through 2009. We excluded 606 examinations with missing data on clinical indication (6.4%). The final sample was 8931 breast MRI examinations from 6777 individual women (range, 1-13 examinations per woman). Approximately 92% of the breast MRI data are from facilities with more than 90% data capture. We calculated the total number of breast MRI examinations by year and the distribution by clinical indication, year of examination, and 10-year age groups. We calculated annual breast MRI rates as the number of breast MRI examinations per 1000 women with any breast imaging during the same year from facilities reporting more than 90% data capture of breast MRI examinations. Rates were calculated for overall breast MRI use and according to clinical indication. We used a linear regression model to test for trends in the rates of breast MRI use over time during the periods 2005 through 2007 and 2007 through 2009.

We compared patient characteristics, combinations of characteristics, and BCRAT lifetime risk scores among women screened with breast MRI (n = 2831 examinations) with those of women screened with mammography alone (n = 1 288 924 examinations). We present the distribution of patient characteristics by all women and restricted to women with no history of breast cancer. Differences in patient characteristics were calculated using a χ² test. In a sensitivity analysis, we restricted imaging data to facilities reporting more than 90% data capture of breast MRI examinations. Because the results were similar, we present the overall findings for all imaging examinations rather than the restricted sample. All analyses were performed using SAS software, version 9.2 (SAS Institute), and 2-sided P < .05 was considered statistically significant.

Results
Patterns of Breast MRI Use, 2005 Through 2009
From 2005 through 2009, the rate of breast MRI use increased from 4.2 to 11.5 examinations per 1000 women (Figure). The steepest rise in use occurred from 2005 to 2007, with an increase of 5.8 MRI examinations per 1000 women per year (P = .02), compared with only 1.5 additional examinations per 1000 women per year from 2007 to 2009 (P = .45). The rate of screening breast MRI increased more than 4-fold between 2005 and 2007 from 0.8 to 3.4 per 1000 women and then remained fairly stable at 4.3 breast MRI examinations per 1000 women in 2009.

The total number of breast MRI examinations per year increased from 863 in 2005 to 2264 in 2007. From 2007 to 2009, the number of examinations per year remained stable at approximately 2150 (Table 1). Across the 5-year study period, the most common indications were diagnostic workup of a non-MRI or clinical finding (40.3%), screening (31.7%), cancer staging and treatment (16.2%), and other (11.8%).

The proportion of examinations with an indication of diagnostic workup decreased from 53.2% in 2005 to 34.8% in 2009. The single most common indication contributing to the diagnostic workup classification was evaluation of a prior non-MRI finding. The proportion of examinations attributed to screening increased from 18.1% in 2005 to 34.5% in 2009. Evaluation for cancer staging and treatment, primarily among women with newly diagnosed breast cancer, remained fairly constant over the study period at 14.8% to 18.1% of all examinations.

Across all ages, use of breast MRI for diagnostic purposes was the most common indication, with the highest proportion in the oldest women in our study (70-79 years) (Table 2).
Screening accounted for 34.3% of MRI examinations in women younger than 40 years, compared with 17.8% in women aged 70 to 79 years. Proportions for other indications were similar across age groups.

Comparison of Patient Characteristics by Screening Breast MRI vs Mammography Alone
Compared with women screened for breast cancer by mammography alone, women screened using breast MRI were significantly more likely to be younger (age, <50 years), white non-Hispanic, or nulliparous; and they were more likely to have a first-degree relative with breast cancer, prior breast biopsy, or extremely dense breast tissue (Table 3). Women who received screening breast MRI were also more likely to have a personal history of breast cancer (44.9%), compared with women who received mammography alone (4.7%) (P < .001). When we restricted our evaluation to women without a personal history of breast cancer, the distribution of characteristics did not substantially change, with 2 exceptions. Among women without a personal history of breast cancer, screening breast MRI was used by significantly fewer women with a prior breast biopsy but significantly more women with a family history of breast cancer, compared with women who received mammography alone.

Women with combinations of prior breast biopsy, family history of breast cancer, and extremely dense breast tissue were more likely to be screened using breast MRI. Approximately one-third of all breast MRI for screening was in women with both a prior breast biopsy and family history of breast cancer (P < .001), regardless of personal history of breast cancer.

Among women who received screening breast MRI, 25% had a more than 20% lifetime risk of developing breast cancer according to the BCRAT model and 53% had less than 15% lifetime risk, compared with women who received mammography alone, among whom 2% had a more than 20% lifetime risk and 92% had less than 15% lifetime risk (Table 4). The proportion of women at high risk for breast cancer who received breast MRI for screening increased from 9% in 2005 to 29% in 2009 (test for trend, P < .001). No change by risk status over the study period was seen in women screened using mammography alone.
mammography alone. Over the 5-year study period, 25,237 women who were screened with mammography alone had a more than 20% lifetime breast cancer risk.

**Discussion**

Our study describes the patterns of breast MRI use in US community practice, the setting in which most women receive breast imaging. Our results confirm an increase in the use of breast MRI from 2005 to 2007. From 2007 to 2009, rates of use remained constant overall and across all clinical indications. Other reports demonstrated an increase in use of breast MRI without observing a plateau in use rates.

During our study period, the most common use of breast MRI was for diagnostic evaluation of a non-MRI finding. We could not determine whether these examinations were performed to avoid biopsy of a suspicious clinical finding or to plan...
for a subsequent biopsy. Breast MRI to avoid biopsy does not have a sufficiently high negative predictive value to warrant its use for this purpose, particularly given the relatively low pretest probability of malignancy (~2%) above which biopsy is performed as standard practice. Over the study period, the proportion of breast MRI examinations for diagnostic workup diminished. By 2009, the rate of breast MRI for diagnosis was similar to the rate for screening, which was the second most common indication overall.

We determined that several patient characteristics were associated with use of screening with breast MRI, which confirms findings by Miller et al suggesting increased use among women with a family history or personal history of breast cancer. We detected that younger, white women were more likely to receive breast MRI for screening, which differed from Miller et al, who found that older, black women were more likely to receive breast MRI. Differences in our results might be explained by our examination of screening breast MRI compared with the attention of Miller et al to breast MRI for any clinical indications. Also, women who had a prior breast biopsy and a family history of breast cancer were more likely to receive breast MRI than mammography alone, demonstrating 2 factors that influence patient care.

Of the women screened with breast MRI, 45% had a personal history of breast cancer. For the remaining 55%, we used the BCRAT model to determine whether breast MRI use was appropriate. We determined that several patient characteristics were associated with use of screening with breast MRI, which confirms findings by Miller et al suggesting increased use among women with a family history or personal history of breast cancer. We detected that younger, white women were more likely to receive breast MRI for screening, which differed from Miller et al, who found that older, black women were more likely to receive breast MRI. Differences in our results might be explained by our examination of screening breast MRI compared with the attention of Miller et al to breast MRI for any clinical indications. Also, women who had a prior breast biopsy and a family history of breast cancer were more likely to receive breast MRI than mammography alone, demonstrating 2 factors that influence patient care.

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affected the national recommendations that women at high lifetime risk of breast cancer receive screening breast MRI as an adjunct to mammography. We determined that only 25% of women screened with breast MRI were considered at high lifetime risk (>20%). The majority of women receiving screening breast MRI were at intermediate lifetime breast cancer risk (15%-20%), for which evidence for breast MRI screening is insufficient, or average risk (<15%), for which screening breast MRI is not recommended. No evidence suggested that the overall rate of screening breast MRI increased after the ACS recommendation in 2007, although the proportion of women at high risk for breast cancer who received breast MRI for screening increased over the 5-year study period. Overall, less than 5% of women with more than 20% lifetime risk received breast MRI for screening. Current patterns suggest that there was improvement in clinical alignment with breast cancer screening guidelines.

Several possibilities might explain why women with only an average lifetime breast cancer risk are screened using breast MRI. Some women with lifetime breast cancer risk scores of less than 20% might have indications for screening breast MRI that were not captured in our data (e.g., BRCA mutation, first-degree relative with BRCA mutation, prior chest radiation treatment). However, these are unlikely to account for a substantial portion of the women at lower risk but undergoing screening MRI, because they are relatively rare in the general population. Another possible reason is misperception about breast cancer risk. Both women and physicians tend to overestimate a woman’s lifetime risk of breast cancer,23,24 and in accurate perceptions about risk can arise in the absence of clear risk counseling. Both younger and older women estimate their lifetime risk of breast cancer as approximately 18% to 20% higher than their actual risk,23 and women who are at average risk are more likely to overestimate their risk than high-risk women.24 Physicians might base their estimate of high risk on report of family history alone without using a risk calculator.25 Also, women with dense breast tissue might also be receiving breast MRI because of low sensitivity of screening mammography in dense breast tissue.26 Our data suggest increased use of breast screening MRI by combinations of risk factors, which are easily assessed by providers.

Also clinically important were the women—approximately 25% in our study sample—who had a more than 20% lifetime risk of breast cancer but were screened with mammography alone. Guidelines from the ACS and NCCN recommend breast MRI screening with screening mammography for women at high risk for breast cancer. Brinton et al27 documented that women with a high lifetime breast cancer risk do not fully adopt screening with breast MRI and have a low overall rate of adherence to guidelines. Berg and colleagues28 evaluated reasons that high-risk women refuse breast MRI and found the most common to be claustrophobia, time constraints, financial concerns, a physician who did not provide referral or believe that MRI was warranted, and lack of patient interest. Additional issues could be availability of breast MRI outside urban and/or academic areas or providers who do not assess breast cancer risk. Our study did not address why women received a particular type of imaging.

A strength of our study is that it provides, to our knowledge, the only multifacility evaluation of breast MRI use patterns across US community practice. Although data were from 5 BCSC registries from a variety of community-based practice facilities across the United States, there remain some limitations. First, women from BCSC registries might have different patient characteristics than women outside the BCSC; however, when we restricted to facilities with sufficient data capture, there were no differences in the distribution of patient characteristics in our sensitivity analysis. Second, our data are reported in aggregate and we did not evaluate geographic variation. Therefore, we could not evaluate disparities in access to care, which contribute to determining who receives care involving the use of advanced technologies.28 The reporting of indication for breast MRI examinations could differ across contributing registries, which could lead to heterogeneity in examination indication. To address this, we reviewed the indications for examinations and created a hierarchy to identify true screening. Our study data included documented clinical indication, an improvement over studies using claims-based registries with no data on examination indication. Finally, we used the BCRAT model to estimate lifetime risk in our population. Although the ACS recommends classification with a familial-based model, this was not possible with our data. There are discrepancies in the reporting of lifetime risk of breast cancer as reported by Ozanne et al,29 who demonstrated inconsistency in familial-based risk models that put women in different categories with differential overlap.

Our rapidly changing health care environment demands that we frequently, accurately, and comprehensively evaluate the diffusion of new technology into community practice, including how often technology is being used and for what clinical indications. Our findings suggest that there have been improvements in appropriate use of breast MRI, with a smaller proportion of examinations performed for further evaluation of abnormal mammogram results and symptomatic patients, and more breast MRI performed for screening of women at high risk. We also identified a need for more appropriate risk-based use of breast MRI as a screening examination because we identified women at average risk receiving MRI screening and women at high risk not receiving MRI screening. Our findings suggest that there is a need for improvement in the use of diagnostic and screening breast MRI for women most likely to benefit from this imaging tool.
Patterns of Breast Magnetic Resonance Imaging Use


