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Clinical outcomes of mammography in the National Breast and Cervical Cancer Early Detection Program, 2009–2012

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Abstract

Purpose—The National Breast and Cervical Cancer Early Detection Program (NBCCEDP) enrolls asymptomatic women for cancer screening and symptomatic women for diagnostic services. Tiris study describes the results of mammograms provided by the NBCCEDP, by examination indication (screening or diagnostic), and by age group.

Methods—For the first NBCCEDP-funded mammogram received during 2009–2012, we calculated age-specific percentages of abnormal findings, rates of follow-up testing, and invasive and in situ breast cancer diagnoses per 1,000 mammograms. Logistic regression was used to estimate the odds for each of these outcomes by examination indication.

Results—The NBCCEDP provided 941,649 screening, 175,310 diagnostic, and 30,434 unknown indication mammograms to 1,147,393 women. The percentage with abnormal mammograms was higher for diagnostic mammograms (40.1 %) than for screening mammograms (15.5 %). Compared with women aged 40–49 years, fewer women aged 50–64 years had abnormal results for screening (13.7 vs. 19.7 %) and diagnostic mammograms (37.7 vs. 42.7 %). Follow-up rates per 1,000 mammograms were lower among women aged 50–64 compared to those aged 40–49 (screening: 143.9 vs. 207.5; diagnostic: 645.3 vs. 760.9); biopsy rates exhibited a similar pattern (screening: 24.1 vs. 32.9; diagnostic: 167.7 vs. 169.7). For screening mammograms, older women had more cancers detected than younger women (invasive: 3.6 vs. 2.2; in situ: 2.3 vs. 2.0). Similarly, for diagnostic mammograms, cancer detection was higher for older women (invasive: 67.8 vs. 36.6; in situ: 17.4 vs. 11.1).

Conclusions—Abnormal mammograms and diagnostic follow-up procedures were less frequent in women aged 50–64 years compared to women aged 40–49 years, while breast cancer detection was higher, regardless of indication for the mammogram. Some of these differences between age

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Ethical standard This study was approved by the Centers for Disease Control and Prevention Human Subjects Committee.

groups were greater for screening mammograms than for diagnostic mammograms. Cancer detection rates were higher for diagnostic mammograms compared with screening mammograms. These findings support the NBCCEDP's priority of serving women aged 50–64 years and providing both screening and diagnostic mammograms.

Keywords

Breast cancer; Mammography; Screening

Introduction

To improve access to cancer screening among low-income, uninsured women, the US Congress passed the Breast and Cervical Cancer Mortality Prevention Act of 1990 (Public Law 101-354), which created the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) [1]. This nationwide, comprehensive public health program is administered through the Centers for Disease Control and Prevention (CDC) and provides uninsured, underinsured, and underserved women with access to screening services for the early detection of breast and cervical cancer [1]. Eligibility is limited to women with incomes less than or equal to 250 % of the federal poverty level and who are uninsured or underinsured. Underinsured includes women who have insurance that does not cover breast cancer screening and women who cannot afford their insurance deductibles or copays. Because resources are limited, programs have been directed to focus on screening women aged 50–64 years. The NBCCEDP requires that at least 75 % of all program-paid mammograms be provided to this priority population [1]. States often use other funds to provide services to women aged 40–49 years.

The NBCCEDP priority age population is consistent with recommendations from the US Preventive Services Task Force (USPSTF) [2]. For many years, the USPSTF recommended screening mammography, with or without a clinical breast examination for women aged 40 years and older. However, the 2009 update to the USPSTF changed the recommendation from annual to biennial screening mammography for all women aged 50–74 years. Routine screening before the age of 50 years was not recommended, yet should be supported if a woman chooses to be screened [2]. These changes in the recommendation were supported by evidence from randomized controlled trials, which have shown that the absolute benefit of screening is greater in women aged 50–74 years than in women aged 40–49 [2].

Previous studies of the NBCCEDP have demonstrated that women aged 40–49 years had the highest rates of abnormal mammograms and of diagnostic follow-up but lower rates of cancer detection [3, 4]. However, these studies did not account for whether indication for receiving the mammogram was screening or diagnostic. It is possible that younger women (aged 40–49 years) are more likely than older women (aged 50–64 years) to receive a mammogram for diagnostic purposes. It is unclear whether differences exist in screening outcomes between these age groups when accounting for whether the indication for the mammogram was screening versus diagnostic. Therefore, we examined whether mammography findings, diagnostic follow-up, and cancer detection in the NBCCEDP's

priority population of older women (aged 50–64 years) differed from younger women (aged 40–49 years) by mammography indication during 2009 through 2012.

Materials and methods

Data sources

The NBCCEDP has been implemented in all 50 states, the District of Columbia, some US territories, and American Indian/Alaska Native tribes and tribal organizations [1]. NBCCEDP data were obtained for breast cancer screening, referral, and follow-up provided by these programs. Grantees regularly report a set of standardized surveillance and evaluation data, known as minimum data elements (MDEs), to CDC. These datasets include variables that are minimally necessary to monitor client demographics, track clinical outcomes, establish policies and practices, assess screening outcomes, and respond to the informational needs of CDC stakeholders and partners [1].

The NBCCEDP collects variables related to demographics, clinical breast examination (CBE) results, indication for initial mammogram, mammogram results, diagnostic procedures, and final diagnosis. Self-reported demographics including race, ethnicity, and age are also available. Women who identified as Hispanic were classified as such, regardless of race. Race was categorized for non-Hispanic groups as follows: white, black, American Indian/Alaska Native, Asian/Pacific Islander, and multiracial or unknown. Age was categorized to allow comparison between the priority population (aged 50–64 years and non-Medicare enrolled) and younger women (aged 40–49 years). Residence was based on each woman's county of residence linked with the corresponding US Department of Agriculture urban–rural continuum code and classified as metropolitan, urban, rural area, or unknown [5]. Also, region of residence was categorized by Census region [6]. Tribes and territories were classified in the same region as the states where they are located. Providers reported dates and results of CBEs, mammograms, diagnostic procedures, and outcomes. Results for CBEs, classified as normal, abnormal, or unknown, are not reported in this paper.

For MDE reporting and this analysis, the initial mammogram begins a breast screening record and is used to report screening results, and the indication for the initial mammogram is used to distinguish routine screening from problem-focused screening. The results of additional diagnostic follow-up procedures are used to report the diagnostic outcomes of the screening process. Indication for the initial mammogram was categorized as screening or diagnostic. Screening indication was assigned to initial mammograms performed as part of a routine screening schedule and in the absence of symptoms or a recent positive CBE; diagnostic indication included initial mammograms performed to evaluate symptoms, an abnormal CBE, or recent abnormal mammogram result. Mammograms for women referred into the NBCCEDP for diagnostic evaluation because of previous initial abnormal breast cancer screening results were also classified as diagnostic indication, and the referral date was used when the mammography examination date was missing. Mammograms of unknown indication only represented 2.7 % and were excluded from the analyses.

Mammogram results were reported using the American College of Radiology's Breast Imaging Reporting and Data System (BI-RADS) categories: assessment incomplete (category 0), normal (category 1), benign (category 2), probably benign (category 3), suspicious abnormality (category 4), and highly suggestive of malignancy (category 5) [7]. Abnormal mammograms were defined by the following BI-RAD categories: suspicious abnormality (category 4), highly suggestive of malignancy (category 5), or assessment incomplete (category 0). The percentage of abnormal mammograms was calculated. Diagnostic follow-up consists of any surgical or imaging procedures other than the screening mammogram or CBE, including additional mammographic views, ultrasound, a repeat CBE or surgical consultation, a fine-needle or cyst aspiration, and biopsy [1]. The NBCCEDP requires all women with abnormal results for CBEs or abnormal mammograms to undergo diagnostic follow-up [1]. The rate of diagnostic follow-up was calculated per 1,000 mammograms for the study period and defined by the number of mammogram records where at least one subsequent diagnostic procedure was performed regardless of mammogram result. The biopsy rate was based on the number of incisional, excisional, or core biopsies per 1,000 mammograms during this time period. The cancer detection rate was estimated per 1,000 mammograms and defined by the number of invasive cancers and in situ cancers diagnosed.

Study population

The study population consisted of women aged 40–64 years who had an initial NBCCEDP mammogram during 1 January 2009 through 31 December 2012. Only the women's first NBCCEDP mammogram in the selected time period was included in the analysis regardless of whether they reported a previous mammogram elsewhere. Many women only receive one mammogram through the NBCCEDP. Results from subsequent mammograms were not included. After all exclusions, our final study population consisted of 1,147,393 unique women with a mammogram during this time period.

Data analysis

Demographic and clinical characteristics of women receiving an initial mammogram from 2009 to 2012 were summarized using percentages by age group. Further, all percentages and rates were calculated by age group (40–49, 50–59, 60–64, 50–64, or total). Few differences were noted between women aged 50–59 years and 60–64 years, so these categories were collapsed. Using logistic regression, adjusted odds ratios (aORs), and corresponding 95 % confidence intervals (CIs) were estimated for women with a screening indication mammogram and women with a diagnostic indication mammogram for the odds of an abnormal mammogram, diagnostic follow-up, final diagnosis of in situ breast cancer, and final diagnosis of invasive breast cancer. All models were adjusted for age, race, rural or urban residence, and region. All analyses were performed using SAS software version 9.2 (SAS Institute, Cary, North Carolina).

Results

Characteristics

From 2009 to 2012, 1,147,393 women received a mammogram through the NBCCEDP (Table 1). Of these women, most (67.1 %) were aged 50–64 years. Almost half (46.7 %) of the women were white, non-Hispanic followed by Hispanic (24.4 %) and black non-Hispanic (18.1 %) women. Many women resided in metropolitan areas (74.0 %) and in the South (34.1 %). Most (82.1 %) women received a mammogram for screening, while 15.3 % received a diagnostic mammogram. Mammography indication was unknown for 2.7 % of women, and therefore, these mammograms were excluded from subsequent analyses. Compared to 40- to 49-year-old women, a higher percentage of women aged 50–64 years were black, non-Hispanic (19.2 % vs. 15.8 %) or Asian/Pacific Islander (6.5 % vs. 3.9 %), resided in the South (36.5 % vs. 29.1 %) or West (25.4 % vs. 19.3 %), and received a mammogram for screening purposes (85.4 % vs. 75.4 %). The percentage of women who received a mammogram and were diagnosed with invasive cancer was similar for women aged 40–49 years (1.0 %; $n = 3,752$) and 50–59 years (1.1 %; $n = 6,083$) and slightly higher (1.4 %; $n = 2,752$) for women aged 60–64 years.

Table 2 shows findings for mammograms by age group and indication for mammogram. Overall, 15.5 % of all screening mammograms were abnormal compared with 40.1 % of all diagnostic mammograms. For screening mammograms, fewer 50- to 64-year-old women had abnormal results (13.7 %) than 40- to 49-year-olds (19.7 %). Similarly, for diagnostic mammograms, 37.7 % of 50- to 64-year-old women had abnormal results compared to 42.7 % of 40- to 49-year-old women.

There were also differences in diagnostic follow-up and cancer detection by mammogram indication (Table 3). Overall, compared with screening mammograms, diagnostic mammograms were followed by significantly more diagnostic procedures (699.7 vs. 163.1) and biopsies (168.7 vs. 26.8) per 1,000 mammograms. Cancer detection rates for diagnostic mammograms were higher than screening mammograms for invasive (53.1 vs. 3.2) and in situ (14.5 vs. 2.2) cancers. For screening mammograms, 50- to 64-year-olds had fewer diagnostic procedures (143.9 vs. 207.5) and biopsies (24.1 vs. 32.9) per 1,000 mammograms compared with 40- to 49-year-olds. In spite of this, 50- to 64-year-olds had more invasive cancers (3.6 vs. 2.2) or in situ cancers (2.3 vs. 2.0) detected per 1,000 mammograms than 40- to 49-year-olds. Similarly, for diagnostic mammograms, 50- to 64-year-old women had fewer diagnostic procedures (645.3 vs. 760.9) and biopsies (167.7 vs. 169.7), yet greater cancer detection (invasive: 67.8 vs. 36.6; in situ: 17.4 vs. 11.1) than 40- to 49-year-old women.

Table 4 shows the adjusted odds for having an abnormal result by mammogram indication. Among women with a screening mammogram, the odds of having an abnormal result were lower for 50- to 64-year-olds (aOR = 0.65; 95 % CI 0.64–0.66) compared with 40- to 49-year-olds after adjusting for race, residence, and region. Among those with a diagnostic mammogram, the pattern was similar but the difference between age groups was less (50- to 64-year-olds: aOR = 0.82; 95 % CI 0.80–0.83). Finally, although there were statistically significant differences for screening mammograms by race/ethnicity, for abnormal

diagnostic mammograms, only American Indian/Alaska Natives (aOR 1.13; 95 % CI 1.05–1.22) and Hispanics (aOR 0.86; 95 % CI 0.84–0.88) differed from whites (Table 4).

In Table 5, the odds of having any diagnostic follow-up are presented by mammogram indication. The odds of having diagnostic follow-up were lower for 50- to 64-year-old women (aOR = 0.64; 95 % CI 0.63–0.65) than for 40- to 49-year-old women among those with a screening indication; among those with a diagnostic indication, the pattern was similar but the difference between the age groups was greater (aOR = 0.57; 95 % CI 0.55–0.58).

Table 6 presents the odds of having a final diagnosis of carcinoma in situ by mammogram indication. In situ cancer detection was greater for 50- to 64-year-old women than for 40- to 49-year-old women for screening indication (aOR = 1.15; 95 % CI 1.05–1.27). For diagnostic indication, the difference was even greater for 50- to 64-year-old women compared with younger women (aOR = 1.51; 95 % CI 1.39–1.64).

Table 7 displays the odds of having a final diagnosis of invasive cancer by mammogram indication. Women aged 50–64 years had higher invasive cancer detection rates than 40- to 49-year-olds, regardless of indication (screening indication: aOR = 1.60; 95 % CI 1.47–1.75; diagnostic indication: aOR = 1.85; 95 % CI 1.77–1.94); however, the difference was greater for those with a diagnostic indication. Among women with diagnostic mammograms, only Hispanics (aOR 0.47, 95 % CI 0.44–0.50) and American Indians/Alaska natives (aOR 0.83, 95 % CI 0.69–0.99) differed from whites, with lower odds of having a final diagnosis of invasive cancer (Table 7).

Discussion

In this study, significant differences in breast cancer screening clinical outcomes were noted between the NBCCEDP's priority population (aged 50–64 years) and younger women (aged 40–49 years) who received services through the NBCCEDP, with some variation by mammography indication. First, 50- to 64-year-old women had fewer abnormal mammograms regardless of screening or diagnostic indication, although the difference between the age groups was greater for screening indication. Furthermore, the priority population had less diagnostic follow-up than younger women; these differences were greater among women with diagnostic mammograms. Cancer detection was higher for the priority population than for younger women. Overall, cancer detection was higher for diagnostic mammograms than for screening mammograms.

Previous studies have examined breast cancer screening clinical outcomes in the NBCCEDP [3, 4]. The higher rates of abnormal mammograms and diagnostic follow-up for women aged 40–49 years compared with women aged 50–64 years, regardless of the type of service received, are partially explained by greater breast density in younger women [8]. Higher breast density decreases the sensitivity of mammography for detecting breast cancer and increases false-positive results, leading to higher recall rates [8]. The value of screening mammography for younger women remains an active area of discussion and debate.

This study is the first to examine screening outcomes by mammography indication in the NBCCEDP. Although the NBCCEDP does not make a distinction between the need for screening or diagnostic services when enrolling women, there is a focus on women at high risk of cancer. NBCCEDP-eligible women with symptoms or abnormal clinical breast examinations are at increased risk of having breast cancer and therefore have greater need for available services. Furthermore, many women served through the NBCCEDP do not receive routine preventive health care; the NBCCEDP is their only source for breast cancer detection and treatment services [1]. These data showed that overall breast cancer detection was much higher for diagnostic mammograms than for screening mammograms. This finding further supports the NBCCEDP's focus on providing both screening and diagnostic mammograms to medically underserved women at high risk of breast cancer. The NBCCEDP's focus on high-risk women is evident when comparing findings with the Breast Cancer Surveillance Consortium (BCSC), a collaborative network of seven mammography registries across the nation with linkages to tumor and/or pathology registries that include women of all incomes and insurance status. These data allow examination of the delivery and quality of breast cancer screening and outcomes. In the NBCCEDP, the overall cancer detection rates for screening mammograms are higher for both screening (5.4 vs. 4.1 per 1,000) and diagnostic mammograms (67.7 vs. 29.3 per 1,000). Although the overall rates include different age groups (NBCCEDP aged 40–64 years; BCSC aged 18–80+ years), cancer detection in the NBCCEDP is higher for women aged 40–49 years and 50–64 years.

Similar patterns in outcomes for screening and diagnostic mammograms were observed between the priority population and younger women. However, the difference in follow-up and cancer detection between women aged 50–64 years and women aged 40–49 years was greater for diagnostic mammograms (115.6 per 1,000; 37.5 per 1,000, respectively) than for screening mammograms (63.6 per 1,000; 1.7 per 1,000). This finding was expected because some programs only see young women if they are symptomatic. Racial differences in abnormal mammograms and cancer detection varied by indication for mammography. Among those with diagnostic mammography indication, there were no differences in abnormal mammograms and invasive cancer detection observed for black, Asian/Pacific Islander or multiracial/unknown women compared with white women. The odds of having abnormal mammograms or invasive cancers detected were lower for these groups compared with whites for screening indication. It is unclear why racial differences exist for screening indication but not for diagnostic indication.

The NBCCEDP breast cancer screening results are subject to limitations. First, this study focused on breast cancer screening and follow-up in organized state-based screening programs and may have limited generalizability to uninsured and low-income women in other settings. Second, we classified women who were referred into the NBCCEDP as receiving diagnostic services. It is unclear the extent to which these women might have been referred for “true” screening. Finally, despite standardized data collection documents, there may be variation across programs in the methods used for data collection, especially in regard to self-reported variables.

In conclusion, the findings show that compared with women aged 40–49 years, the NBCCEDP's priority population (aged 50–64 years) had fewer abnormal mammograms,

less diagnostic follow-up, and higher breast cancer detection, regardless of indication for the mammogram. Furthermore, cancer detection rates for all ages were much higher for diagnostic mammograms than for screening mammograms. These outcomes not only support the NBCCEDP's policy of focusing priority on screening women aged 50–64 years but also highlight the need to continue to offer services to women aged 40–49 years who may be at high risk of developing breast cancer. By providing both screening and diagnostic mammograms, the NBCCEDP offers much-needed services to this high-risk population. However, the NBCCEDP only reaches about 11 % of all eligible women [9]. More targeted public health efforts are needed to improve access to screening, timely follow-up, and treatment for breast cancer for all women in the USA.

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Table 1

Characteristics of women receiving a mammogram^a through the National Breast and Cervical Cancer Early Detection Program by age group ($n = 1,147,393$), 2009–2012

	<u>Total (40–64 years)</u>		<u>40–49 years</u>		<u>50–64 years</u>	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Total	1,147,393	100.0	377,001	100.0	770,392	100.0
Race/ethnicity						
White, non-Hispanic	536,206	46.7	175,547	46.6	360,659	46.8
Black, non-Hispanic	207,135	18.1	59,518	15.8	147,617	19.2
Asian/Pacific Islander	64,688	5.6	14,520	3.9	50,168	6.5
American Indian/Alaska Native	35,189	3.1	12,147	3.2	23,042	3.0
Hispanic	279,934	24.4	107,464	28.5	172,470	22.4
Multiracial/unknown	24,241	2.1	7,805	2.1	16,436	2.1
Residence						
Urban/rural continuum						
Metro	849,168	74.0	273,818	72.6	575,350	74.7
Urban	251,507	21.9	87,069	23.1	164,438	21.3
Rural	43,779	3.8	15,188	4.0	28,591	3.7
Unknown	2,939	0.3	926	0.2	2,013	0.3
Region where services were provided						
Northeast	183,645	16.0	70,891	18.8	112,754	14.6
Midwest	304,540	26.5	123,342	32.7	181,198	23.5
South	390,946	34.1	109,831	29.1	281,115	36.5
West	268,262	23.4	72,937	19.3	195,325	25.4
Type of service women received/indication for initial mammogram						
Unknown	30,434	2.7	10,494	2.8	19,940	2.6
Screening	941,649	82.1	284,110	75.4	657,539	85.4
Diagnostic	175,310	15.3	82,397	21.9	92,913	12.1
Cancer diagnoses						
<i>Invasive cancer</i>						
Yes	12,587	1.1	3,752	1.0	8,835	1.1
No	1,134,806	98.9	373,249	99.0	761,557	98.9
<i>Carcinoma in situ</i>						
Yes	4,702	0.4	1,510	0.4	3,192	0.4
No	1,142,691	99.6	375,491	99.6	767,200	99.6

^aBased on women's initial mammogram during 2009–2012

Table 2

Breast cancer screening test results by age group and mammogram indication, National Breast and Cervical Cancer Early Detection Program, 2009–2012

	<u>Total (40–64 years)</u>		<u>40–49 years</u>		<u>50–64 years</u>	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
<i>Indication of screening</i>						
Total screening mammograms	941,649	100.0	284,110	100.0	657,539	100.0
Normal						
Total normal	795,825	84.5	228,243	80.3	567,582	86.3
Negative	452,497	48.1	140,226	49.4	312,271	47.5
Benign	329,550	35.0	83,112	29.3	246,438	37.5
Probably benign	13,506	1.4	4,791	1.7	8,715	1.3
Unsatisfactory	272	<0.1	114	<0.1	158	<0.1
Abnormal						
Total abnormal	145,824	15.5	55,867	19.7	89,957	13.7
Suspicious abnormality	3,856	0.4	1,450	0.5	2,406	0.4
Highly suggestive of malignancy	732	0.1	187	0.1	545	0.1
Assessment incomplete	136,357	14.5	52,812	18.6	83,545	12.7
Non-program	7	<0.1	1	<0.1	6	<0.1
Film comparison required	4,872	0.5	1,417	0.5	3,455	0.5
<i>Indication of diagnostic</i>						
Total diagnostic mammograms	175,310	100.0	82,397	100.0	92,913	100.0
Normal						
Total normal	105,093	59.9	47,203	57.3	57,890	62.3
Negative	38,320	21.9	17,572	21.3	20,748	22.3
Benign	53,423	30.5	23,073	28.0	30,350	32.7
Probably benign	13,303	7.6	6,533	7.9	6,770	7.3
Unsatisfactory	47	<0.1	25	<0.1	22	<0.1
Abnormal						
Total abnormal	70,217	40.1	35,194	42.7	35,023	37.7
Suspicious abnormality	12,071	6.9	6,042	7.3	6,029	6.5
Highly suggestive of malignancy	4,860	2.8	1,494	1.8	3,366	3.6
Assessment incomplete	51,145	29.2	26,676	32.4	24,469	26.3
Non-program	916	0.5	478	0.6	438	0.5
Film comparison required	1,225	0.7	504	0.6	721	0.8

Table 3

Diagnostic follow-up of abnormal mammograms^a and cancer detection rates^b among women by age group and mammogram indication, National Breast and Cervical Cancer Early Detection Program, 2009–2012

	<u>Total (40–64 years)</u>		<u>40–49 years</u>		<u>50–64 years</u>	
	<i>n</i>	Per 1,000	<i>n</i>	Per 1,000	<i>n</i>	Per 1,000
<i>Indication of screening</i>						
Total	941,649	1,000.0	284,110	1,000.0	657,539	1,000.0
Any diagnostic procedure						
Yes	153,591	163.1	58,960	207.5	94,631	143.9
No	788,058	836.8	225,150	792.4	562,908	856.0
Breast biopsy						
Yes	25,267	26.8	9,355	32.9	15,912	24.1
No	916,382	973.1	274,755	967.0	641,627	975.8
Invasive cancer or CIS						
Yes	5,120	5.4	1,221	4.2	3,899	5.9
No	936,529	994.5	282,889	995.7	653,640	994.0
Invasive cancer						
Yes	3,036	3.2	651	2.2	2,385	3.6
No	938,613	996.7	283,459	997.7	655,154	996.3
Carcinoma in situ						
Yes	2,084	2.2	570	2.0	1,514	2.3
No	939,565	997.7	283,540	997.9	656,025	997.6
<i>Indication of diagnostic</i>						
Total	175,310	1,000.0	82,397	1,000.0	92,913	1,000.0
Any diagnostic procedure						
Yes	122,668	699.7	62,704	760.9	59,964	645.3
No	52,642	300.2	19,693	239.0	32,949	354.6
Breast biopsy						
Yes	29,576	168.7	13,986	169.7	15,590	167.7
No	145,734	831.2	68,411	830.2	77,323	832.2
Invasive or CIS ^c						
Yes	11,871	67.7	3,943	47.8	7,928	85.3
No	163,439	932.2	78,454	952.1	84,985	914.6
Invasive cancer						
Yes	9,326	53.1	3,023	36.6	6,303	67.8
No	165,984	946.8	79,374	963.3	86,610	932.1
Carcinoma in situ						
Yes	2,545	14.5	920	11.1	1,625	17.4
No	172,765	985.4	81,477	988.8	91,288	982.5

^a Abnormal mammograms include suspicious abnormality, highly suggestive of malignancy, or assessment incomplete

^b Rates are calculated per 1,000 mammograms

^cCarcinoma in situ

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Table 4

Logistic regression (aOR and 95 % CI) for having an abnormal result by mammogram indication

	<u>Screening indication</u>				<u>Diagnostic indication</u>			
	Odds ratio	Lower 95 % CI	Upper 95 % CI	p value	Odds ratio	Lower 95 % CI	Upper 95 % CI	p value
Age group (years)								
40–49	1.0	REF			1.0	REF		
50–64	0.65	0.64	0.66	<0.0001	0.82	0.80	0.83	<0.0001
Race/ethnicity								
White, non-Hispanic	1.0	REF			1.0	REF		
Black, non-Hispanic	0.97	0.96	0.99	0.0005	1.01	0.98	1.04	0.5054
Asian/Pacific Islander	0.83	0.81	0.85	<0.0001	1.02	0.97	1.08	0.4643
American Indian/Alaska Native	0.80	0.77	0.83	<0.0001	1.13	1.05	1.22	0.0019
Hispanic	0.90	0.89	0.91	<0.0001	0.86	0.84	0.88	<0.0001
Multiracial/unknown	0.96	0.92	0.9997	0.0483	0.94	0.88	1.01	0.0827
Metro								
Urban	0.85	0.84	0.86	<0.0001	0.87	0.85	0.89	<0.0001
Rural	0.79	0.76	0.81	<0.0001	0.86	0.81	0.91	<0.0001
Unknown	1.54	1.39	1.70	<0.0001	1.07	0.84	1.35	0.6052
Region								
West	1.0	REF			1.0	REF		
Northeast	1.36	1.33	1.38	<0.0001	1.19	1.15	1.23	<0.0001
Midwest	1.04	1.02	1.06	<0.0001	1.06	1.03	1.09	<0.0001
South	1.15	1.13	1.17	<0.0001	0.85	0.83	0.87	<0.0001

Table 5

Logistic regression results (aOR and 95 % CI) for having any diagnostic follow-up by mammogram indication

	<u>Screening indication</u>				<u>Diagnostic indication</u>			
	Odds ratio	Lower 95 % CI	Upper 95 % CI	<i>p</i> value	Odds ratio	Lower 95 % CI	Upper 95 % CI	<i>p</i> value
Age group (years)								
40–49	1.0	REF			1.0	REF		
50–64	0.64	0.63	0.65	<0.0001	0.57	0.55	0.58	<0.0001
Race/ethnicity								
White, non-Hispanic	1.0	REF			1.0	REF		
Black, non-Hispanic	0.93	0.91	0.94	<0.0001	0.86	0.83	0.88	<0.0001
Asian/Pacific Islander	0.86	0.84	0.89	<0.0001	0.88	0.83	0.93	<0.0001
American Indian/Alaska Native	0.77	0.75	0.80	<0.0001	1.08	0.99	1.18	0.0725
Hispanic	0.88	0.87	0.90	<0.0001	0.86	0.84	0.89	<0.0001
Multiracial/unknown	0.94	0.90	0.98	0.0020	0.91	0.85	0.98	0.0122
Residence								
Metro	1.0	REF			1.0	REF		
Urban	0.86	0.84	0.87	<0.0001	0.77	0.75	0.79	<0.0001
Rural	0.78	0.76	0.81	<0.0001	0.74	0.70	0.78	<0.0001
Unknown	1.42	1.29	1.57	<0.0001	1.02	0.79	1.33	0.8878
Region								
West	1.0	REF			1.0	REF		
Northeast	1.29	1.27	1.32	<0.0001	1.26	1.21	1.31	<0.0001
Midwest	1.03	1.01	1.05	0.0012	1.20	1.17	1.24	<0.0001
South	1.14	1.12	1.16	<0.0001	1.25	1.21	1.28	<0.0001

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Table 6

Logistic regression results (aOR and 95 % CI) for having a final diagnosis of carcinoma in situ by mammogram indication

	Screening indication				Diagnostic indication			
	Odds ratio	Lower 95 % CI	Upper 95 % CI	<i>p</i> value	Odds ratio	Lower 95 % CI	Upper 95 % CI	<i>p</i> value
Age group (years)								
40–49	1.0	REF			1.0	REF		
50–64	1.15	1.05	1.27	0.0039	1.51	1.39	1.64	<0.0001
Race/ethnicity								
White, non-Hispanic	1.0	REF			1.0	REF		
Black, non-Hispanic	0.96	0.85	1.07	0.4466	0.97	0.87	1.08	0.5863
Asian/Pacific Islander	0.76	0.61	0.92	0.0057	1.35	1.11	1.64	0.0033
American Indian/Alaska Native	1.05	0.81	1.33	0.7195	0.84	0.58	1.17	0.3227
Hispanic	0.61	0.53	0.69	<0.0001	0.58	0.51	0.65	<0.0001
Multiracial/unknown	0.66	0.45	0.92	0.0134	0.77	0.56	1.03	0.0800
Residence								
Metro	1.0	REF			1.0	REF		
Urban	0.83	0.74	0.93	0.0009	0.98	0.89	1.09	0.7577
Rural	0.91	0.72	1.13	0.3931	0.98	0.78	1.20	0.8167
Unknown	1.08	0.38	2.38	0.8616	0.88	0.27	2.10	0.8003
Region								
West	1.0	REF			1.0	REF		
Northeast	1.29	1.12	1.50	0.0006	1.23	1.06	1.43	0.0070
Midwest	1.28	1.12	1.46	0.0004	1.15	1.01	1.30	0.0299
South	1.12	0.98	1.29	0.0885	1.38	1.23	1.55	<0.0001

Table 7

Logistic regression results (aOR and 95 % CI) for having a final diagnosis of invasive cancer by mammogram indication

	Screening indication				Diagnostic indication			
	Odds ratio	Lower 95 % CI	Upper 95 % CI	<i>p</i> value	Odds ratio	Lower 95 % CI	Upper 95 % CI	<i>p</i> value
Age group (years)								
40–49	1.0	REF			1.0	REF		
50–64	1.60	1.47	1.75	<0.0001	1.85	1.77	1.94	<0.0001
Race/ethnicity								
White, non-Hispanic	1.0	REF			1.0	REF		
Black, non-Hispanic	0.74	0.67	0.81	<0.0001	1.01	0.95	1.07	0.8370
Asian/Pacific Islander	0.57	0.48	0.68	<0.0001	0.95	0.85	1.07	0.3973
American Indian/Alaska Native	0.62	0.49	0.79	<0.0001	0.83	0.69	0.99	0.0374
Hispanic	0.43	0.39	0.48	<0.0001	0.47	0.44	0.50	<0.0001
Multiracial/unknown	0.67	0.50	0.87	0.0024	1.0	0.86	1.15	0.9720
Residence								
Metro	1.0	REF			1.0	REF		
Urban	0.87	0.80	0.96	0.0029	0.90	0.85	0.95	<0.0001
Rural	0.73	0.59	0.88	0.0008	0.97	0.86	1.08	0.5481
Unknown	2.31	1.31	3.78	0.0054	0.91	0.50	1.51	0.7237
Region								
West	1.0	REF			1.0	REF		
Northeast	0.93	0.82	1.06	0.2602	0.95	0.88	1.03	0.2431
Midwest	1.38	1.24	1.54	<0.0001	1.11	1.05	1.18	0.0007
South	0.90	0.81	1.01	0.0667	1.00	0.95	1.06	0.9354