Change in Breast Cancer Screening Intervals Since the 2009 USPSTF Guideline

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Abstract

Background: In 2009, the U.S. Preventive Services Task Force (USPSTF) recommended biennial mammography for women aged 50–74 years and shared decision-making for women aged 40–49 years for breast cancer screening. We evaluated changes in mammography screening interval after the 2009 recommendations.

Materials and Methods: We conducted a prospective cohort study of women aged 40–74 years who received 821,052 screening mammograms between 2006 and 2012 using data from the Breast Cancer Surveillance Consortium. We compared changes in screening intervals and stratified intervals based on whether the mammogram at the end of the interval occurred before or after the 2009 recommendation. Differences in mean interval length by woman-level characteristics were compared using linear regression.

Results: The mean interval (in months) minimally decreased after the 2009 USPSTF recommendations. Among women aged 40–49 years, the mean interval decreased from 17.2 months to 17.1 months (difference -0.16% , 95% confidence interval [CI] -0.30 to -0.01). Similar small reductions were seen for most age groups. The largest change in interval length in the post-USPSTF period was declines among women with a first-degree family history of breast cancer (difference -0.68% , 95% CI -0.82 to -0.54) or a 5-year breast cancer risk $\geq 2.5\%$ (difference -0.58% , 95% CI -0.73 to -0.44).

Conclusions: The 2009 USPSTF recommendation did not lengthen the average mammography interval among women routinely participating in mammography screening. Future studies should evaluate whether breast cancer screening intervals lengthen toward biennial intervals following new national 2016 breast cancer screening recommendations, particularly among women less than 50 years of age.

Keywords: breast neoplasms, early detection of cancer, mammography, standards

Background

IN 2009, THE U.S. Preventive Services Task Force (USPSTF) altered their prior breast cancer screening recommendations to biennial screening for women aged 50–74

years and shared decision-making for women aged 40–49 years based on personal risk factors.^{1,2} These changes were affirmed in their 2016 guidelines.² Previously, the USPSTF had recommended screening mammography every 1–2 years for women beginning at age 40 years. A potential impact of

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recommending biennial mammography rather than annual mammography for most U.S. women is the possible delay beyond 24 months in returning to screening, negatively impacting early detection and potential breast cancer mortality reduction associated with breast cancer screening.

Changes in screening rates among U.S. women have been well studied in the 7 years since the Task Force revision.^{3–12} Early national surveys of self-reported breast cancer screening (*i.e.*, Medical Expenditure Panel Surveys, Behavioral Risk Factor Surveillance System, and National Health Interview Survey) suggested no noticeable differences in self-reported prevalence of annual screening by age group before and after the 2009 recommendations, even among women 40–49 years.^{3–5} However, more recent research based on longer follow-up through 2012,^{6,12} using claims data^{7,8,10} or medical records,¹¹ suggest a decline in cancer screening rates. However, only one study has evaluated changes in mammography screening rates within an integrated care delivery system in the northwestern United States.⁹ Nelson et al. detected reductions in the screening rate for women <50 years and >74 years, but no changes in rates in women aged 50–74 years. While prior studies have looked at changes in screening prevalence after 2009, there is limited evidence about changes in interval length, which would be the more direct and anticipated result of the guideline update in longitudinal data.¹⁰

Our objective was to describe changes in the mammography screening interval length before and after the 2009 USPSTF recommendations by patient characteristics, using data from a national sample of women in the Breast Cancer Surveillance Consortium (BCSC).¹³ We hypothesized that the screening interval would lengthen given changes in recommendations among women overall and by age group.

Materials and Methods

Study setting

The BCSC is a collaborative network of breast imaging registries in community-based settings with linkages to tumor and/or pathology registries. The BCSC is supported by a central Statistical Coordinating Center (SCC). The primary goals of the BCSC are to assess the delivery and quality of U.S. breast cancer imaging and related patient outcomes. This study used data from five registries as follows: Carolina Mammography Registry, Group Health Cooperative (Washington State), New Hampshire Mammography Network, San Francisco Mammography Registry, and Vermont Breast Cancer Surveillance System.¹⁴ Registries partner with radiology practices to capture breast imaging data from each practice. Each registry and the SCC received institutional review board approval for either active or passive consent or a waiver of consent to enroll participants, link study data, and perform analytic studies. All procedures are Health Insurance Portability and Accountability Act (HIPAA) compliant.

BCSC data are collected as part of routine clinical care at the time of imaging from patients and radiologists. Mammography data include clinical indication for the mammogram, the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) assessment, and BI-RADS breast density categories.¹⁵ Each registry site shares data with the SCC for pooling and statistical analysis. All data undergo rigorous quality control checks.

Study population

We included women aged 40–74 years who underwent a screening mammogram between October 1, 2006 and December 31, 2012. We excluded examinations if women had not received a prior mammogram within 50 months (3.4% of eligible examinations). A mammogram was defined as a screening examination if the radiologist or technologist reported that the examination was for screening purposes, the woman had not received a mammogram in the prior 9 months, and the woman did not have a personal history of breast cancer or breast implants. A personal history of breast cancer was documented through either self-report or linkage with BCSC pathology and tumor registry data. At the time of mammography, women completed a questionnaire and provided information on age, race/ethnicity, first-degree family history of breast cancer, history of breast biopsy procedure, and other breast cancer risk factors. If BI-RADS breast density was not available for a given mammogram, density information was imputed from the next mammogram within 18 months (3.8% of all examinations imputed) as long as there were no changes in hormone therapy use and no incident breast cancer diagnosis.

Definitions of time intervals

At the time of each examination, we defined screening interval as the time to the most recent prior mammogram. We divided the study period into pre- and post-USPSTF periods. Pre-USPSTF was defined as the period between October 1, 2006 and November 30, 2009; and the post-USPSTF period was defined from December 1, 2009 to December 31, 2012. The two time periods were balanced periods of 37 months around the November 2009 guideline release and were chosen to prevent sampling bias, which would result if the pre- and postperiods were of unequal length. The date of the examination ending the interval was used to determine whether the interval was categorized into the pre- or post-USPSTF period. For example, two successive mammograms with the second examination performed on December 31, 2009 would have been categorized into the post-USPSTF period.

Statistical analysis

For each woman, we included all screening mammograms captured during the study period. Analysis was performed at the level of the screening interval calculated at the time of the screening examination that ended each interval. We modeled the screening interval (in months) as a continuous response variable. We used generalized estimating equations with independence working correlation structure to account for correlation among repeated screening examinations from the same woman.¹⁶ Our model included the following woman and breast health characteristics: age, race/ethnicity, education, median household income based on the census block group of the woman's home address, urban/rural residence based on current Rural/Urban Commuting Area Codes,¹⁷ travel time from the woman's home address to the nearest mammography facility, examination year, BI-RADS breast density, current hormone therapy use, first-degree family history of breast cancer, history of breast biopsy, 5-year breast cancer risk based on the BCSC risk model,¹⁸ and BCSC registry. Screening examinations with missing/unknown data

were excluded from our analyses. We also included an interaction term between USPSTF period (pre-2009 vs. post-2009) and all covariates to investigate whether associations between screening interval and period differed for subgroups defined by woman or examination characteristics. On the basis of these interaction models, we report mean intervals and 95% confidence intervals (CIs) in the pre- and post-USPSTF periods for each level of all woman and examination characteristics adjusted by standardizing the mean interval in the pre- and postperiods with respect to the distribution of all other covariates included in the model. We also report adjusted differences in mean interval and 95% CI comparing the pre- and post-USPSTF periods for each subgroup.

All analyses were performed using SAS software version 9.3 (SAS institute), and a 2-sided $p < 0.05$ was considered statistically significant. Figures were produced using Stata version 12 (StataCorp., College Station, TX).

Results

Our sample included 821,052 screening mammograms from 320,972 women. Of these, 458,325 occurred in the pre-USPSTF period and 362,727 examinations occurred in the post-USPSTF period (Table 1). A greater proportion of women included in the post-USPSTF period were Asian/Pacific Islander compared with the pre-USPSTF period. Women were also more likely to have a college degree, to have a median household income in the highest quartile, and were more likely to live in an urban location in the post-USPSTF period compared to the pre-USPSTF period. There were few differences in breast health characteristics between the pre- and post-USPSTF periods.

Distributions of screening interval in the pre- and post-USPSTF 2009 periods demonstrate minimal differences in the mean and median months since last screening mammogram (Fig. 1a, b). The median interval was the same in both time periods at 14.0 months, and the adjusted mean interval was 16.7 months in the pre-2009 period and 16.5 months in the post-2009 period. The mode for interval in both periods occurred at the 1 year mark.

Comparing the mean screening interval by woman and examination characteristics in the pre- and post-USPSTF periods, the mean interval decreased in the post-USPSTF period for almost all subgroups (Table 2). For women aged 40–49 years, the adjusted mean screening interval was <0.2 months shorter (decreasing from 17.2 to 17.1 months, 95% CI –0.30 to –0.01 months, in the pre-USPSTF period compared to the post-USPSTF period). Similar differences were observed within strata defined by most other woman and breast health characteristics investigated. Declines of more than a half-month were observed among women with a first-degree family history of breast cancer (difference –0.68 months, 95% CI –0.82 to –0.54), prior breast biopsy (difference –0.58 months, 95% CI –0.73 to –0.43), and $\geq 2.5\%$ 5-year breast cancer risk (difference –0.58 months, 95% CI –0.73 to –0.44).

Discussion

Among women participating in repeat mammography screening, the average screening interval did not increase following the release of the 2009 USPSTF guidelines, regardless of age or other patient characteristics. Statistically

significant decreases in screening interval were observed, although these were generally small in magnitude (2 weeks or less) and clinically insignificant.

Patient characteristics associated with the greatest declines in mammography interval were a family history of breast cancer, prior breast biopsy, and high 5-year risk of breast cancer. These breast cancer risk factors have also been associated with screening mammography participation.^{19–21} In particular, family history of breast cancer has been strongly associated with receipt of screening mammography over decades. However, it is not entirely clear how patient risk factors might change after the release of the 2009 USPSTF recommendation.

Prior studies indicated that the prevalence of annual mammography screening might have reduced or remained similar after the updated recommendations.^{9,11} However, our results indicate that there were no clinically relevant changes in screening interval during the same time period; while women maintain more frequent screening interval, they are consequently at risk for harms of overscreening, such as overdiagnosis.

To some extent, the lack of change in mammography screening intervals could potentially be driven by patient choice. Few studies have evaluated women's perceptions of the guideline changes.^{22,23} In national telephone surveys of women regarding the USPSTF guideline changes, most women were not aware of the guideline change; patient factors associated with awareness of the change were higher education, higher income, and aged 40–49 years.²³ Furthermore, a qualitative study of women aged 40–50 years old in the Boston areas also suggested that most women were not aware of the change from the USPSTF and, regardless of the guideline, women intended to continue screening.²²

Likely a bigger driver of the lack of change in screening intervals is the physician's recommendation to a woman. Guideline announcement alone, even by the USPSTF, is likely insufficient to change physician practice. In fact, the majority of physicians report not changing their clinical practice due to the 2009 revised recommendation and continue to order annual mammography for women beginning at age 40, including practitioners in internal medicine (77%), family medicine (74%), and obstetricians/gynecologists (98%).²⁴ Barriers to adoption of current recommendations reported by women's healthcare providers include patient concerns, provider disagreement with recommendations, health system assessment of provider's screening practices that use conflicting measurement criteria, concern about malpractice risk, and lack of time to discuss benefits and harms with patients.²⁵

Compared to internal medicine or family practice physicians, obstetrician/gynecologists are more likely to recommend screening mammography to women in their 40s because they believe mammography to be very effective in reducing breast cancer mortality.²⁶ In web surveys, they report similar belief in efficacy for women aged 70–89 years. Furthermore, obstetrician/gynecologists rate the USPSTF recommendations as less influential to their practice than the American Cancer Society (ACS) and The American Congress of Obstetricians and Gynecologists (ACOG) societal recommendations.^{26,27} ACOG²⁸ and American College of Radiology²⁹ currently recommend annual mammography beginning at age 40 years. Routine radiology practice sends annual reminder letters to women based on the ACR and ACS

TABLE 1. PATIENT CHARACTERISTICS FOR MAMMOGRAPHY EXAMINATIONS FROM THE BCSC,
BY TOTAL AND STRATIFIED BY USPSTF PERIOD

<i>Patient characteristics</i>	<i>Pre-USPSTF 2009, N (%)</i>	<i>Post-USPSTF 2009, N (%)</i>	<i>Total, N (%)</i>
<i>Total</i>	458,325 (55.8)	362,727 (44.2)	821,052 (100.0)
Age, Years			
40–49	121,912 (26.6)	88,233 (24.3)	210,145 (25.6)
50–59	170,075 (37.1)	131,421 (36.2)	301,496 (36.7)
60–69	126,225 (27.5)	112,271 (31.0)	238,496 (29.0)
70–74	40,113 (8.8)	30,802 (8.5)	70,915 (8.6)
Race			
White, non-Hispanic	370,063 (80.7)	278,442 (76.8)	648,505 (79.0)
Black, non-Hispanic	20,933 (4.6)	13,993 (3.9)	34,926 (4.3)
Asian/Pacific Islander	40,230 (8.8)	45,614 (12.6)	85,844 (10.5)
American Indian	1,042 (0.2)	770 (0.2)	1,812 (0.2)
Hispanic	16,664 (3.6)	15,820 (4.4)	32,484 (4.0)
Mixed, other	9,393 (2.0)	8,088 (2.2)	17,481 (2.1)
Education			
<High school graduate	25,873 (5.6)	18,283 (5.0)	44,156 (5.4)
High school graduate	95,527 (20.8)	63,858 (17.6)	159,385 (19.4)
Some college	119,208 (26.0)	90,298 (24.9)	209,506 (25.5)
College degree	217,717 (47.5)	190,288 (52.5)	408,005 (49.7)
Census block median annual income, in quartiles ^a			
≤\$60,702	123,289 (26.9)	76,717 (21.2)	200,006 (24.4)
\$60,703–75,632	114,215 (24.9)	89,259 (24.6)	203,474 (24.8)
\$75,633–95,681	115,443 (25.2)	94,877 (26.2)	210,320 (25.6)
≥\$95,682	105,378 (23.0)	101,874 (28.1)	207,252 (25.2)
Residence			
Urban	281,249 (61.4)	251,909 (69.4)	533,158 (64.9)
Travel time to nearest facility, minutes			
≤10	205,773 (44.9)	172,491 (47.6)	378,264 (46.1)
11–20	121,742 (26.6)	95,267 (26.3)	217,009 (26.4)
21–30	67,408 (14.7)	50,492 (13.9)	117,900 (14.4)
≥31	63,402 (13.8)	44,477 (12.3)	107,879 (13.1)
Breast health			
Year of mammogram			
2006	33,020 (7.2)	N/A	33,020 (4.0)
2007	143,059 (31.2)	N/A	143,059 (17.4)
2008	148,165 (32.3)	N/A	148,165 (18.0)
2009	134,081 (29.3)	12,129 (3.3)	146,210 (17.8)
2010	N/A	128,288 (35.4)	128,288 (15.6)
2011	N/A	113,650 (31.3)	113,650 (13.8)
2012	N/A	108,660 (30.0)	108,660 (13.2)
BI-RADS breast density			
Almost entirely fatty	49,512 (10.8)	47,316 (13.0)	96,828 (11.8)
Scattered fibroglandular	191,721 (41.8)	149,569 (41.2)	341,290 (41.6)
Heterogeneously dense	175,941 (38.4)	132,830 (36.6)	308,771 (37.6)
Extremely dense	41,151 (9.0)	33,012 (9.1)	74,163 (9.0)
Current use of hormone therapy			
Yes	42,291 (9.2)	27,620 (7.6)	69,911 (8.5)
First-degree relative with breast cancer			
Yes	78,006 (17.0)	67,521 (18.6)	145,527 (17.7)
Prior biopsy procedure			
None	356,799 (77.8)	280,800 (77.4)	637,599 (77.7)
Biopsy only	66,076 (14.4)	50,945 (14.0)	117,021 (14.3)
Aspiration only	8,574 (1.9)	6,563 (1.8)	15,137 (1.8)
Biopsy and aspiration	26,876 (5.9)	24,419 (6.7)	51,295 (6.2)
BCSC 5-year breast cancer risk, (%)			
<1.00	139,855 (30.5)	112,683 (31.1)	252,538 (30.8)
1.00–1.66	133,339 (29.1)	104,747 (28.9)	238,086 (29.0)
1.67–2.49	114,113 (24.9)	87,410 (24.1)	201,523 (24.5)
≥2.50	71,018 (15.5)	57,887 (16.0)	128,905 (15.7)

^aCensus block level.

BI-RADS, Breast Imaging Reporting and Data System; BCSC, Breast Cancer Surveillance Consortium; USPSTF, U.S. Preventive Services Task Force.

FIG. 1. (a) Distribution of screening mammography interval in the pre-2009 USPSTF guideline period; (b) Distribution of screening mammography interval in the post-2009 USPSTF guideline period.

guidelines. Both the USPSTF and the ACS³⁰ have updated their recommendations in 2015, and the guidelines by age group are more aligned than in previous years, although not entirely overlapping.

Our study has several strengths. Our longitudinal sample of more than 300,000 U.S. women allows us to evaluate patterns of screening among women screened in community practice over time and does not rely on cross-sectional surveys. We also can distinguish screening from diagnostic mammograms. In calculating adjusted mean intervals, we were able to adjust for multiple confounders, including women's risk of breast cancer, which can contribute to screening interval length. However, our study is not without limitations. First, our analysis does not allow for a lag period

to allow practice patterns to change, but rather evaluates changes in the interval just after the release of the recommendation statement. Additional studies of mammography screening might be able to further address changing interval length with additional data. To conduct this analysis, we examined defined periods on either side of the USPSTF guideline release. We do not have any detail regarding actual physician practice within the local community or the specialty of the physician making the mammography recommendation. Further understanding which physician is recommending mammography would help clarify the role of clinical recommendations in determining screening mammography patterns. Finally, while the BCSC is a national consortium, the registries represent five geographic regions

TABLE 2. ADJUSTED MEAN SCREENING INTERVAL BY PATIENT CHARACTERISTICS, STRATIFIED BY USPSTF INTERVAL AND DIFFERENCE IN INTERVAL LENGTH

<i>Patient characteristics</i>	<i>Pre-USPSTF 2009 Mean interval,^a months, (95% CI)</i>	<i>Post-USPSTF 2009 Mean interval,^a months, (95% CI)</i>	<i>Differences in months, (95% CI)^b</i>
Overall	16.7 (16.6–16.8)	16.5 (16.4–16.6)	–0.2 (–0.07 to –0.33)
Demographics			
Age, years			
40–49	17.2 (17.1–17.4)	17.1 (16.9–17.2)	–0.16 (–0.30 to –0.01)
50–59	17.0 (16.9–17.1)	16.7 (16.6–16.8)	–0.25 (–0.39 to –0.11)
60–69	16.4 (16.2–16.5)	16.1 (16.0–16.2)	–0.26 (–0.40 to –0.12)
70–74	16.0 (15.9–16.1)	16.2 (16.0–16.3)	0.14 (–0.02 to 0.30)
Race			
White, non-Hispanic	17.2 (16.7–17.7)	16.7 (16.0–17.4)	–0.50 (–1.3 to 0.32)
Black, non-Hispanic	16.0 (15.9–16.1)	16.0 (15.8–16.1)	–0.01 (–0.16 to 0.15)
Asian/Pacific Islander	16.9 (16.7–17.0)	16.5 (16.4–16.7)	–0.32 (–0.52 to –0.11)
American Indian	16.4 (16.3–16.6)	16.4 (16.2–16.5)	–0.03 (–0.23 to 0.17)
Latina	17.3 (17.1–17.5)	16.7 (16.5–16.9)	–0.56 (–0.82 to –0.30)
Mixed, other	16.5 (16.4–16.6)	16.3 (16.2–16.4)	–0.21 (–0.34 to –0.08)
Education			
<High school graduate	17.1 (17.0–17.3)	17.3 (17.1–17.5)	0.18 (–0.01 to 0.37)
High school graduate	16.3 (16.2–16.4)	16.1 (16.0–16.3)	–0.17 (–0.30 to –0.04)
Some college	16.6 (16.4–16.7)	16.3 (16.2–16.4)	–0.24 (–0.38 to –0.09)
College degree	16.6 (16.5–16.7)	16.3 (16.2–16.4)	–0.29 (–0.43 to –0.15)
Median annual income			
≤\$60,702	17.0 (16.9–17.1)	16.7 (16.5–16.8)	–0.33 (–0.47 to –0.19)
\$60,703–75,632	16.4 (16.3–16.6)	16.3 (16.2–16.4)	–0.15 (–0.29 to –0.01)
\$75,633–95,681	17.0 (16.9–17.1)	16.8 (16.6–16.9)	–0.25 (–0.39 to –0.11)
≥\$95,682	16.2 (16.1–16.3)	16.1 (16.0–16.3)	–0.07 (–0.21 to 0.06)
Residence			
Rural	16.9 (16.7–17.0)	16.6 (16.5–16.7)	–0.27 (–0.40 to –0.13)
Urban	16.5 (16.4–16.6)	16.3 (16.2–16.5)	–0.16 (–0.29 to –0.02)
Travel time to nearest facility, minutes			
≤10	16.7 (16.6–16.8)	16.5 (16.3–16.6)	–0.23 (–0.37 to –0.09)
11–20	16.8 (16.7–16.9)	16.4 (16.3–16.5)	–0.39 (–0.54 to –0.24)
21–30	16.7 (16.5–16.8)	16.5 (16.4–16.7)	–0.11 (–0.24 to 0.03)
≥31	16.6 (16.5–16.7)	16.4 (16.3–16.5)	–0.22 (–0.37 to –0.07)
Breast health			
Year of mammogram			
2006	16.9 (16.8–17.0)	N/A	N/A
2007	16.7 (16.6–16.8)	N/A	N/A
2008	16.6 (16.5–16.7)	N/A	N/A
2009	16.4 (16.3–16.5)	16.3 (16.1–16.4)	–0.20 (–0.33 to –0.07)
2010	N/A	16.2 (16.1–16.3)	N/A
2011	N/A	16.5 (16.4–16.6)	N/A
2012	N/A	16.8 (16.7–16.9)	N/A
BI-RADS breast density			
Almost entirely fatty	16.6 (16.5–16.8)	16.5 (16.4–16.7)	–0.11 (–0.26 to 0.05)
Scattered fibroglandular	16.7 (16.6–16.9)	16.5 (16.3–16.6)	–0.29 (–0.45 to –0.12)
Heterogeneously dense	16.6 (16.5–16.8)	16.4 (16.3–16.6)	–0.21 (–0.34 to –0.07)
Extremely dense	16.6 (16.5–16.8)	16.4 (16.3–16.6)	–0.19 (–0.33 to –0.06)
Current use of hormone therapy			
No	17.0 (16.9–17.1)	16.8 (16.7–16.9)	–0.21 (–0.33 to –0.08)
Yes	16.3 (16.2–16.4)	16.2 (16.1–16.3)	–0.10 (–0.26 to 0.05)
First-degree relative with breast cancer			
No	17.2 (17.1–17.3)	17.1 (16.9–17.2)	–0.09 (–0.22 to 0.04)
Yes	16.4 (16.2–16.5)	15.7 (15.5–15.8)	–0.68 (–0.82 to –0.54)
Prior biopsy procedure			
Aspiration only	16.8 (16.6–16.9)	16.6 (16.4–16.8)	–0.13 (–0.36 to 0.10)
Biopsy only	16.7 (16.5–16.8)	16.1 (16.0–16.2)	–0.58 (–0.73 to –0.43)
Biopsy and aspiration	16.2 (16.1–16.3)	15.8 (15.7–16.0)	–0.37 (–0.53 to –0.21)
None	17.2 (17.1–17.4)	17.1 (17.0–17.2)	–0.12 (–0.25 to 0.02)
BCSC 5-year breast cancer risk, (%)			
<1	16.8 (16.7–16.9)	16.7 (16.5–16.8)	–0.13 (–0.27 to 0.01)
1–1.66	16.5 (16.4–16.6)	16.3 (16.1–16.4)	–0.21 (–0.35 to –0.07)
1.67–2.49	17.1 (17.0–17.3)	17.1 (16.9–17.2)	–0.06 (–0.19 to 0.08)
≥2.5	16.4 (16.2–16.5)	15.8 (15.6–15.9)	–0.58 (–0.73 to –0.44)

^aAdjusted for all patient characteristics presented in the table.

^bBoldface indicates statistical significance ($p < 0.05$).

CI, confidence interval.

within the United States, which may not reflect clinical practice in regions not covered by the registries. However, the population of study is statistically representative of the US population.¹⁴

Conclusions

There was no increase in the length of the screening interval among women undergoing regular screening mammography following the release of the 2009 USPSTF breast cancer screening guidelines. With new national guidelines released in 2016, it will be important to investigate changes in physician practice across specialties to evaluate the alignment of practice with evidence-based care.

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Author Disclosure Statement

No competing financial interests exist.

References

1. U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med* 2009;151:716–726, W-236.
2. Siu AL, U. S. Preventive Services Task Force. Screening for Breast Cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med* 2016;164:279–296.
3. Pace LE, He Y, Keating NL. Trends in mammography screening rates after publication of the 2009 US Preventive Services Task Force recommendations. *Cancer* 2013;119:2518–2523.
4. Howard DH, Adams EK. Mammography rates after the 2009 US Preventive Services Task Force breast cancer screening recommendation. *Prev Med* 2012;55:485–487.
5. Block LD, Jarlenski MP, Wu AW, Bennett WL. Mammography use among women ages 40–49 after the 2009 U.S. Preventive Services Task Force recommendation. *J Gen Intern Med* 2013;28:1447–1453.
6. Dehkordy SF, Hall KS, Roach AL, Rothman ED, Dalton VK, Carlos RC. Trends in breast cancer screening: Impact of U.S. Preventive Services Task Force recommendations. *Am J Prev Med* 2015;49:419–422.
7. Sharpe RE, Jr., Levin DC, Parker L, Rao VM. The effect of the controversial US Preventive Services Task Force recommendations on the use of screening mammography. *J Am Coll Radiol* 2013;10:21–24.
8. Wharam JF, Landon BE, Xu X, Zhang F, Ross-Degnan D. National trends and disparities in mammography among commercially insured women, 2001–2010. *J Public Health Manag Pract* 2015;21:426–432.
9. Nelson HD, Weerasinghe R, Wang L, Grunkemeier G. Mammography screening in a large health system following the U.S. Preventive Services Task Force recommendations and the affordable care Act. *PLoS One* 2015;10:e0131903.
10. Jiang M, Hughes DR, Appleton CM, McGinty G, Duszak R, Jr. Recent trends in adherence to continuous screening for breast cancer among Medicare beneficiaries. *Prev Med* 2015;73:47–52.
11. Sprague BL, Bolton KC, Mace JL, et al. Registry-based study of trends in breast cancer screening mammography before and after the 2009 U.S. Preventive Services Task Force recommendations. *Radiology* 2014;270:354–361.
12. Gray N, Picone G. The Effect of the 2009 U.S. Preventive Services Task Force breast cancer screening recommendations on mammography rates. *Health Serv Res* 2016; [Epub ahead of print], Doi: 10.1111/1475-6773.12445.
13. National Cancer Institute. Breast Cancer Surveillance Consortium home page. 2015 [cited December 1, 2015]; Available at: <http://breastscreening.cancer.gov> Accessed July 6, 2015.
14. Ballard-Barbash R, Taplin SH, Yankaskas BC, et al. Breast cancer surveillance consortium: A national mammography screening and outcomes database. *AJR Am J Roentgenol* 1997;169:1001–1008.
15. Sickles EA, D'Orsi CJ, Bassett LW, et al. ACR BI-RADS® Mammography. In: ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System. Reston, VA, American College of Radiology 2013.
16. Zeger SL, Liang KY, Albert PS. Models for longitudinal data: A generalized estimating equation approach. *Biometrics* 1988;44:1049–1060.
17. WWAMI RUCA Rural Health Research Center. RUCA Data Version 2.0. [cited 2015 December 1]; Available at: <http://depts.washington.edu/uwruca/ruca-data.php> Accessed February 2, 2017.
18. Tice JA, Cummings SR, Smith-Bindman R, Ichikawa L, Barlow WE, Kerlikowske K. Using clinical factors and mammographic breast density to estimate breast cancer risk: Development and validation of a new predictive model. *Ann Intern Med* 2008;148:337–347.
19. Borrayo EA, Hines L, Byers T, et al. Characteristics associated with mammography screening among both Hispanic and non-Hispanic white women. *J Womens Health (Larchmt)* 2009;18:1585–1894.
20. Beckmann KR, Roder DM, Hiller JE, Farshid G, Lynch JW. Do breast cancer risk factors differ among those who do and do not undertake mammography screening? *J Med Screen* 2013;20:208–219.
21. Taplin S, Anderman C, Grothaus L. Breast cancer risk and participation in mammographic screening. *Am J Public Health* 1989;79:1494–1498.
22. Allen JD, Bluethmann SM, Sheets M, et al. Women's responses to changes in U.S. Preventive Task Force's mammography screening guidelines: Results of focus groups with ethnically diverse women. *BMC Public Health* 2013;13:1169.

23. Kiviniemi MT, Hay JL. Awareness of the 2009 US Preventive Services Task Force recommended changes in mammography screening guidelines, accuracy of awareness, sources of knowledge about recommendations, and attitudes about updated screening guidelines in women ages 40–49 and 50+. *BMC Public Health* 2012;12:899.
24. Corbelli J, Borrero S, Bonnema R, et al. Physician adherence to U.S. Preventive Services Task Force mammography guidelines. *Womens Health Issues* 2014;24:e313–e319.
25. Haas JS, Sprague BL, Klabunde CN, et al. Provider attitudes and screening practices following changes in breast and cervical cancer screening guidelines. *J Gen Intern Med* 2016;31:52–59.
26. Yasmeen S, Romano PS, Tancredi DJ, Saito NH, Rainwater J, Kravitz RL. Screening mammography beliefs and recommendations: A web-based survey of primary care physicians. *BMC Health Serv Res* 2012;12:32.
27. Anderson BL, Pearlman M, Griffin J, Schulkin J. Conflicting and changing breast cancer screening recommendations: Survey study of a national sample of ob-gyns after the release of the 2009 USPSTF guidelines. *J Healthc Qual* 2013;35(4):25–35.
28. American College of Obstetricians-Gynecologists. Practice bulletin no. 122: Breast cancer screening. *Obstet Gynecol* 2011;118:372–382.
29. Lee CH, Dershaw DD, Kopans D, et al. Breast cancer screening with imaging: Recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. *J Am Coll Radiol* 2010;7:18–27.
30. American Cancer Society. American Cancer Society recommendations for early breast cancer detection in women without breast symptoms. 2015 [cited December 1, 2015]; Available at: www.cancer.org/cancer/breastcancer/moreinformation/breastcancerearlydetection/breast-cancer-early-detection-ac-recs Accessed October 20, 2015.

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