Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

Cancer Epidemiology, Biomarkers & Prevention

Research Article

A Prospective Assessment of Racial/Ethnic Differences in Future Mammography Behavior among Women Who had Early Mammography

Julie M. Kapp[1], Rod Walker[2], Sebastien Haneuse[2], and Bonnie C. Yankaskas[3]

Abstract

Background: Twenty-nine percent of women, aged 30 to 39, report having had a mammogram, though sensitivity and specificity are low. We investigate racial/ethnic differences in future mammography behavior among women who had a baseline screening mammogram prior to age 40.

Methods: Using 1994–2008 data from the Breast Cancer Surveillance Consortium (BCSC), we identified 29,390 women aged 35 to 39 with a baseline screening mammogram. We followed this cohort for 2 outcomes: (i) future BCSC mammography between ages 40 and 45; and (2) among those, delay in screening mammography until ages 43 to 45 compared with ages 40 to 42. Using adjusted log-linear models, we estimated the relative risk (RR) of these outcomes by race/ethnicity, while also considering the impact of false-positive/true-negative (FP/TN) baseline mammography results on these outcomes.

Results: Relative to non-Hispanic white women, Hispanic women had an increased risk of no future BCSC mammography (RR: 1.21, 95% CI: 1.13–1.30); Asian women had a decreased risk (RR: 0.67, 95% CI: 0.61–0.74). Women with a FP result, compared with a TN result, had a decreased risk of no future BCSC mammography (RR: 0.89, 95% CI: 0.85–0.95). Among those with future BCSC screening mammography, African American women were more likely to delay the timing (RR: 1.26, 95% CI: 1.09–1.45). The interaction between race/ethnicity and FP/TN baseline results was not significant.

Conclusions: Race/ethnicity is differentially associated with future BCSC mammography and the timing of screening mammography after age 40.

Impact: These findings introduce the need for research that examines disparities in lifetime mammography use patterns from the initiation of mammography screening. *Cancer Epidemiol Biomarkers Prev; 20(4); 600–8. ©2011 AACR.*

Introduction

Guidelines for the age at which to begin breast cancer screening have evolved over the last few decades and have at times conflicted across major organizations. In 1989, the U.S. Preventive Services Task Force (USPSTF) recommended mammography for women beginning at age 50 (1). They discouraged "baseline" mammograms before age 50; however, they suggested that it might be prudent to begin regular mammography earlier (e.g., age 35) for women at high risk because of family history (1). In 1996, the USPSTF suggested insufficient evidence for, or against, mammography screening for women younger than 50 (2). In 2002, their guidelines recommended mammography screening every 1 to 2 years beginning at age 40 (3). Most recently, (4) the USPSTF suggested that beginning regular, biennial screening mammography before age 50 is an individual decision. In contrast, the American Cancer Society (ACS) guidelines have recommended a baseline mammogram for women between ages 35 and 39 (5) and, since 1992, have recommended regular screening begin at age 40 (5, 6).

Yet, in 2005, when the age at which to begin routine screening was generally recommended as 40, a population-based study estimated 29% of the U.S. women aged 30 to 39 reported having had a mammogram; this percentage was even higher among non-Hispanic African American (AA) women (34%; ref. 7). Among women younger than 40 (which we refer to here as "younger women") who had a mammogram, 74% were reported to be for screening purposes; of those, only 13% reported a family history (8). Among AA women, 40% reported the age at their first mammogram as less than 40 years (9) and were more likely than white women to report multiple mammograms before age 40 (7).

Authors' Affiliations: [1]Department of Family and Community Medicine, University of Missouri, Columbia, Missouri; [2]Group Health Research Institute, Seattle, Washington; and [3]Department of Radiology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina

Corresponding Author: Julie M. Kapp, Department of Family and Community Medicine, University of Missouri, MA306 Medical Sciences Bldg, 1 Hospital Drive, Columbia, MO 65212. Phone: 573-884-2119; Fax: 573-884-6172. E-mail: kappj@health.missouri.edu

doi: 10.1158/1055-9965.EPI-10-1070

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

In contrast, after age 40, AA and Asian women are less likely to receive adequate mammography screening (10). Racial/ethnic variation in mammography use patterns before and after age 40 may reflect different subgroups of women. Alternatively, it is as yet unknown whether racial/ethnic variation exists in longitudinal mammography use patterns when following a cohort of women between early and later mammography use.

One important consideration in addressing screening mammography for younger women is the implications of poor mammography performance. A recent study estimated that a population of 10,000 women aged 35 to 39 undergoing a first screening mammogram would produce 1,266 further work-ups, detect 16 cancers, and produce 1,250 false-positive (FP) results (11). A related study of women with first mammograms before 40 reported 1 FP result for every 8 screening mammograms and that AA women were more likely than white women to be recommended for additional work-up (8). In a sample of women of all ages who underwent mammography, only 80% of AA and 71% of Hispanic women reported being likely or very likely to continue screening mammography after receiving FP results compared to 93% of white women (12); however, responses in the latter study were based on hypothetical questions and not on actual screening behaviors. Reports of the impact of FP mammograms suggest an increase in patients' anxiety or psychological difficulty but not a decreased adherence to further screening (13–18). However, a common limitation among these studies is that they did not examine the impact by race/ethnicity.

The data available to longitudinally examine the association between race/ethnicity and later (after age 40) mammography, among women with early (before age 40) mammography, while incorporating mammography type (screening vs. diagnostic) and outcomes (e.g., FP results) is extremely limited. The National Cancer Institute's Breast Cancer Surveillance Consortium (BCSC; ref. 19) data are rich in their racial/ethnic diversity and ability to prospectively follow women over time. Using a defined cohort of women who had a first screening mammogram between ages 35 and 39 (referred to here as a "baseline mammogram"), our objective was to examine the relationship between race/ethnicity and mammography use after age 40. Our primary hypothesis is that race/ethnicity will be differentially associated with future mammography use among women who had a baseline screening mammogram before age 40. Our secondary hypothesis is that these results will be modified by FP baseline mammography results.

Methods

Data sources

Data were pooled from the National Cancer Institute's BCSC, a collaborative network of community-based mammography registries created for the purpose of assessing the delivery and quality of breast cancer mammography utilization and outcomes in the United States. The 7 registries are located across the United States in North Carolina, Washington, New Hampshire, New Mexico, California, Colorado, and Vermont. A Statistical Coordinating Center (SCC) oversees the coordination, pooling, and cleaning of data from the 7 sites. Each registry and the SCC have received Institutional Review Board (IRB) approval for either active or passive consenting processes or a waiver of consent to enroll participants, link data, and perform analytic studies. All procedures are HIPAA (Health Insurance Portability and Accountability Act) compliant and 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. The University of Missouri's Health Sciences IRB approved this study as exempt.

The BCSC data are collected prospectively at the time of each screening visit from the patient, technologists, and radiologists. Participating radiology practices gather information from women at each breast imaging visit via a patient history form, including age, race, ethnicity, education, history of breast procedures, and personal and first-degree family history of breast cancer. The radiologists and/or technologists record information on the imaging studies, including mammography indication (screening or diagnostic). Each registry annually links to a state tumor registry or regional SEER (Surveillance, Epidemiology, and End Results) program that collects population-based cancer data; some registries also link to pathology databases. The BCSC registries are described in greater detail elsewhere (19).

Study sample

As noted earlier, in 2002, both the USPSTF and ACS recommended mammography screening beginning at age 40. Therefore, we identified 32,670 women aged 35 to 39 with early mammography whose first mammogram was for screening and was captured in the BCSC data between the years 1994 and 2002 (see Fig. 1). As our study required sufficient follow-up time to have the ability to observe these women, between ages 40 and 45, returning to a BCSC facility for future mammography, we chose years 1994–2002 to only include women who would have had the potential to turn age 45 before the end of our observation time in the BCSC data. The end of our observation time was based on mammography completeness dates for each of the BCSC registries, which was through 2008. Additional eligibility criteria for our analysis included no personal history of breast cancer, breast mastectomy, or breast augmentation.

Self-reported information was used to create mutually exclusive categories of race/ethnicity: non-Hispanic African American, non-Hispanic white, Asian, and Hispanic. For brevity, we refer to these as AA, white, Asian, and Hispanic. We excluded 3,205 (9.8%) women who were either missing self-reported race/ethnicity or reported a race/ethnicity not in these 4 categories due to the difficulty in deriving a meaningful interpretation from this

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

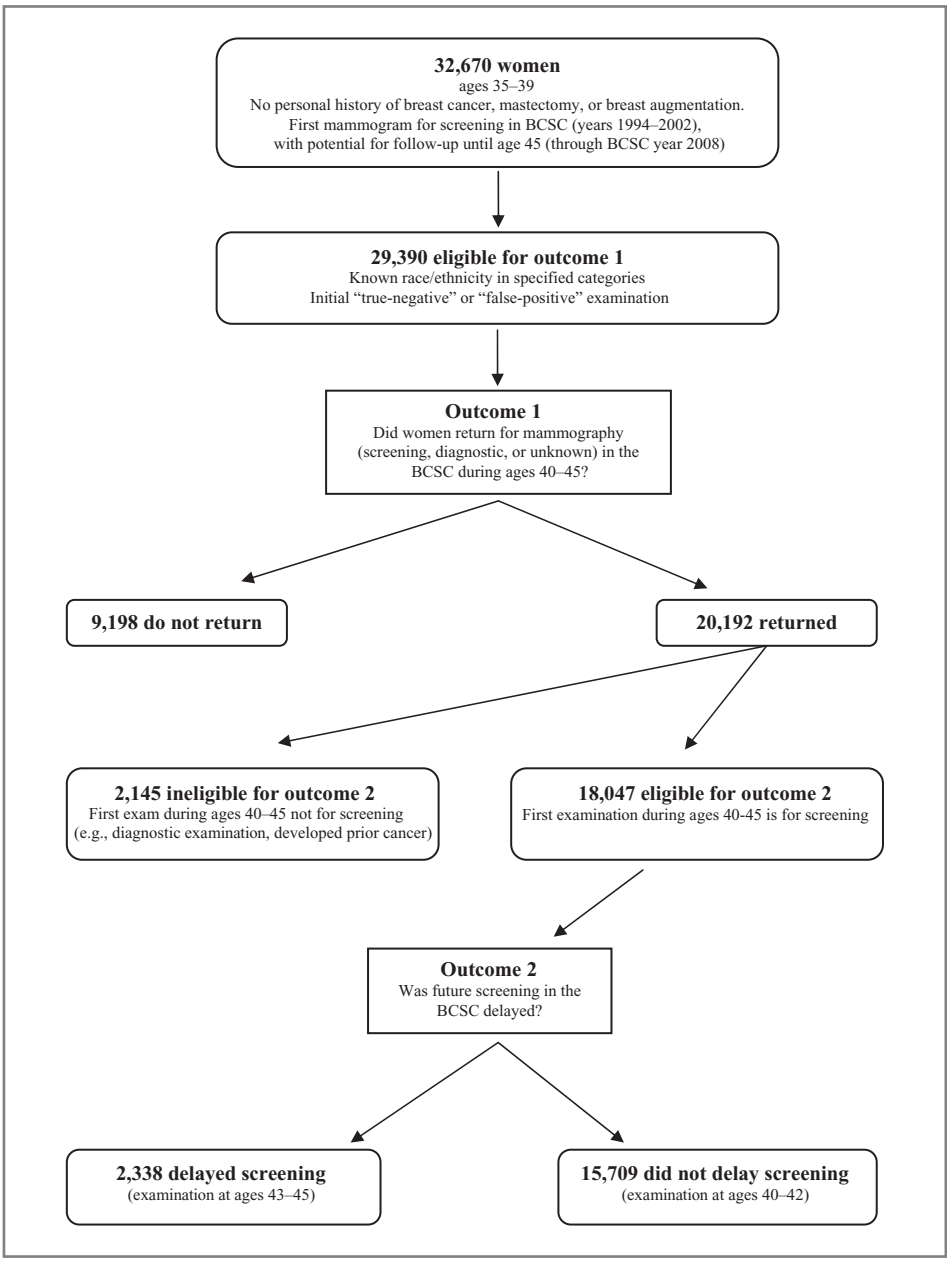

Figure 1. Flow chart of study population, BCSC data.

heterogeneous group. We additionally excluded 75 women who received a cancer diagnosis within the year following their baseline screening examination. The final study sample consisted of 29,390 women.

Measurements and definitions

The BCSC has previously addressed complex issues of variable definitions, (20, 21), which we adopt here together with standard definitions based on the Breast Imaging Reporting and Data System (BI-RADS; ref. 22). We defined a screening mammogram as a mammography examination, with bilateral routine views taken with no other radiologic breast imaging within the prior 9 months and where the radiologist or technologist indicated the mammogram was for screening purposes. Radiologists interpreted the screening mammograms according to the ACR BI-RADS coding system, assigning a 0 or 1–6 to each breast, and provided a recommendation for follow-up action. On the basis of the most severe assessment and the follow-up recommendations, we defined a positive assessment as BI-RADS category 4, 5, 0, or 3, with a recommendation for immediate follow-up. We defined a negative assessment as BI-RADS category 1, 2, or 3, with no recommendation for immediate follow-up. A woman was considered to have breast cancer if she was diagnosed with invasive carcinoma

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

or ductal carcinoma *in situ* within the 12 months following the screening mammogram and before her next screening examination. For women who did not receive a breast cancer diagnosis, a screening mammogram was considered a true-negative (TN) result if the radiologist provided a negative assessment and a FP result if the radiologist provided a positive assessment (21).

For this study, we defined a "baseline" screening mammogram as a woman's first screening mammogram between ages 35 and 39. To qualify as a baseline mammogram, the BCSC database could have no record of prior mammography, no indication of comparison films, and no self-report of prior mammography from the woman. We considered baseline mammography outcomes for our secondary hypothesis because health behaviors and perspectives would not be contaminated by previous mammography outcomes at that time.

Rural or urban status was based on a classification scheme using a woman's reported ZIP code at the time of her baseline mammogram, the standard Bureau of Census Urbanized Area and Urban Clusters definitions, and the 2000 Census work commuting information (23).

We examined 2 outcomes by race/ethnicity. First, among the 29,390 women in our study sample, we examined whether or not a woman returned to one of the BCSC facilities for any type of mammogram (screening, diagnostic, or unknown) between ages 40 and 45 (defined as "future BCSC mammography"; Fig. 1). Second, among the 20,192 women who had future BCSC mammography, we assessed delay in the timing of the first "future screening mammogram" between ages 40 and 45. This was not necessarily her next screening mammogram after baseline; she might have had additional mammography between baseline and age 40 (see the Statistical analyses section). We defined a delay as having a routine screening mammogram between ages 43 and 45 compared with ages 40 to 42, given the recommended interval of 1 to 2 years. Women whose first mammogram between ages 40 and 45 was for diagnostic or unknown purposes were excluded from this second outcome, as were 78 women who developed breast cancer between baseline and their first age 40 to 45 mammogram, leaving a total of 18,047 women for the second analysis.

Statistical analyses

We characterize our sample at the time of the baseline mammogram, using frequencies and percentages, overall and by whether the women had future BCSC mammography between ages 40 and 45. We further describe the sample of women with future BCSC mammography by race/ethnicity and FP/TN baseline results.

We fit a series of log-linear models to estimate the relative risk (RR) of each of our 2 outcomes with race/ethnicity and the baseline mammogram result (FP or TN). Next, we added, in sequence, each of the following covariables as potential mediators to observe any changes in our RRs of interest: mammography registry, age at baseline screening mammogram, rural/urban residential status at the time of baseline screening, and additional screening mammography before age 40.

We examined education and first-degree family history (yes vs. other) as potential mediating factors; however, given the large percentage of missing data for those covariables, we considered this a sensitivity analysis (and reported it as such) and thus did not include those terms in the final presented model.

We considered effect modification between race/ethnicity and outcome of the baseline mammogram (FP or TN) by including interaction terms into each of the log-linear models. All analyses were run using SAS V9.2 (SAS Institute Inc.).

Results

Overall, 22.1% of the 29,390 women in our study sample were nonwhite (Table 1). The largest proportion (44.6%) of our study sample was college educated, most (70.1%) resided in an urban area, and 45.2% had a baseline screening mammogram between ages 35 and 37 (mean age at baseline = 37.5). Only 9.9% reported a first-degree family history of breast cancer. At this baseline screen, 11.4% had a FP result; 21.2% had more than 1 mammogram before age 40 [subjects with additional screening beyond baseline (n = 3,712) or diagnostic beyond baseline (n = 3,079) but before age 40].

Overall, 31.3% did not have future BCSC mammography between ages 40 and 45. Women who did not have future BCSC mammography were more likely at their baseline mammogram to be younger, AA, live in an urban area, and have a TN baseline result than women who did. Women who did not have future BCSC mammography were more likely to have only had 1 mammogram (their baseline mammogram) at a BCSC facility before age 40. Conversely, a greater percentage of women with future BCSC mammography between ages 40 and 45 tended to be Asian and college educated.

Characteristics of the women with future BCSC mammography between ages 40 and 45 are presented in Table 2. Overall, there was a mean of 40.6 months between the baseline and follow-up mammograms, with 13.1% of the women having had their first post-40 follow-up screening mammogram delayed (i.e., ages 43 to 45); this was higher among AA (15.1%) and Hispanic (17.2%) women than among white (12.6%) and Asian (13.3%) women. AA and Hispanic women in this sample were much less likely to be college graduates. Hispanic women were more likely to be older at baseline (ages 38–39) and less likely to have additional screens before age 40. AA women were more likely to have a breast cancer family history. Asian women were much more likely to reside in urban areas, be older at baseline, and were much less likely to have additional screens before age 40. When considering baseline mammography results, the proportion of women having had their first post-40 follow-up screening mammogram delayed was lower among those with

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

Table 1. Characteristics of study participants at their baseline screening mammogram at ages 35 to 39, overall and by whether they returned to a BCSC facility for future mammography between ages 40 and 45[a]

	Overall		Had future mammography at ages 40–45 as captured in the BCSC		Did not have future mammography at ages 40–45 as captured in the BCSC	
	n	%[b]	*n*	%	*n*	%
Total	29,390		20,192		9,198	
Age at baseline mammogram						
35	3,294	11.2	2,095	10.4	1,199	13.0
36	4,291	14.6	2,701	13.4	1,590	17.3
37	5,712	19.4	3,835	19.0	1,877	20.4
38	6,737	22.9	4,751	23.5	1,986	21.6
39	9,356	31.8	6,810	33.7	2,546	27.7
Race/ethnicity						
White	22,888	77.9	15,794	78.2	7,094	77.1
AA	2,609	8.9	1,585	7.8	1,024	11.1
Asian	2,002	6.8	1,581	7.8	421	4.6
Hispanic	1,891	6.4	1,232	6.1	659	7.2
Education level						
Less than high school graduate	1,057	4.5	681	4.1	376	5.7
High school graduate/GED	5,307	22.8	3,759	22.5	1,548	23.5
Some college/technical school	6,526	28.0	4,559	27.3	1,967	29.9
College graduate	10,388	44.6	7,700	46.1	2,688	40.9
Unknown	6,112		3,493		2,619	
Rural/urban status						
Urban focused	20,461	70.1	13,296	66.3	7,165	78.7
Large rural	4,178	14.3	3,232	16.1	946	10.4
Small/isolated rural	4,536	15.6	3,538	17.7	998	11.0
Unknown	215		126		89	
First-degree family history of breast cancer						
No	18,294	90.1	13,200	90.2	5,094	89.8
Yes	2,009	9.9	1,430	9.8	579	10.2
Unknown	9,087		5,562		3,525	
Baseline mammography outcome						
False positive	3,357	11.4	2,445	12.1	912	9.9
True negative	26,033	88.6	17,747	87.9	8,286	90.1
Additional screening before age 40						
No	25,678	87.4	17,062	84.5	8,616	93.7
Yes	3,712	12.6	3,130	15.5	582	6.3
Number of mammograms (any type) before age 40						
Baseline mammogram only	23,146	78.8	15,124	74.9	8,022	87.2
2	4,411	15.0	3,522	17.4	889	9.7
3+	1,833	6.2	1,546	7.7	287	3.1

[a]Data years: 1994–2008.

[b]Column percentages are calculated among the nonmissing values.

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

Table 2. Characteristics of 20,192 women in our study sample[a] with follow-up, by race/ethnicity and FP or TN baseline mammography results

	Total ($N = 20,192$)		White ($N = 15,794$)		AA ($N = 1,585$)		Asian ($N = 1,581$)		Hispanic ($N = 1,232$)	
	n	%[b]	*n*	%	*n*	%	*n*	%	*n*	%
FP	2,445	12.1	1,955	12.4	201	12.7	128	8.1	161	13.1
TN	17,747	87.9	13,839	87.6	1,384	87.3	1,453	91.9	1,071	86.9
Mean (SD) months between baseline and future mammogram	40.6 (20.5)		40.8 (20.6)		41.8 (21.1)		37.9 (18.9)		40.2 (20.9)	
Age at first (baseline) mammogram										
35	2,095	10.4	1,750	11.1	171	10.8	96	6.1	78	6.3
36	2,701	13.4	2,168	13.7	213	13.4	181	11.4	139	11.3
37	3,835	19.0	3,027	19.2	302	19.1	273	17.3	233	18.9
38	4,751	23.5	3,686	23.3	379	23.9	379	24.0	307	24.9
39	6,810	33.7	5,163	32.7	520	32.8	652	41.2	475	38.6
Education level										
Less than high school graduate	681	4.1	334	2.5	105	8.5	156	11.4	86	13.5
High school graduate/GED	3,759	22.5	2,958	22.0	374	30.1	272	19.9	155	24.4
Some college/ technical school	4,559	27.3	3,693	27.4	382	30.8	294	21.5	190	29.9
College graduate	7,700	46.1	6,470	48.1	381	30.7	644	47.1	205	32.2
Unknown	3,493		2,339		343		215		596	
First-degree family history of breast cancer										
No	13,200	90.2	10,516	90.0	337	87.8	1,309	93.0	1,038	90.2
Yes	1,430	9.8	1,171	10.0	47	12.2	99	7.0	113	9.8
Unknown	5,562		4,107		1,201		173		81	
Rural/urban status										
Urban focused	13,296	66.3	9,592	61.1	1,131	71.7	1,528	97.8	1,045	85.7
Large rural	3,232	16.1	2,900	18.5	212	13.4	19	1.2	101	8.3
Small/isolated rural	3,538	17.7	3,216	20.5	234	14.8	15	1.0	73	6.0
Unknown	126		86		8		19		13	
Additional screening prior to age 40										
No	17,062	84.5	13,252	83.9	1,336	84.3	1,395	88.2	1,079	87.6
Yes	3,130	15.5	2,542	16.1	249	15.7	186	11.8	153	12.4
Number of mammograms (any type) prior to age 40										
Baseline	15,124	74.9	11,706	74.1	1,160	73.2	1,297	82.0	961	78.0
2	3,522	17.4	2,826	17.9	298	18.8	204	12.9	194	15.7
3+	1,546	7.7	1,262	8.0	127	8.0	80	5.1	77	6.3

[a]Study sample defined as women who had a baseline screening mammogram ages 35 to 39 in the BCSC data in years 1994–2002 and followed to ages 40 to 45 at the time of their first post-40 mammogram.
[b]Percentages are calculated among the nonmissing values.

an FP result (10.6%) than among those with a TN result (13.4%). Women with an FP result were more likely to have a breast cancer family history and were more likely to have undergone additional screening between baseline and age 40. Overall, 25.1% of the sample had 2 or more mammograms (of any type) before age 40; this was significantly higher for women with a baseline FP result (68.1%) as would be expected.

In our log-linear models for both not having future BCSC mammography between ages 40 and 45 and delayed age among those who did, the interactions between race/ethnicity and baseline mammography outcome were not significant ($P > 0.1$ for all models). Therefore, we report the main effects models in Table 3, adjusting for mammography registry, age at baseline screening mammogram, rural/urban residential status

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

Table 3. Log-linear model to estimate the association of not returning for future mammography and age of future screening mammogram between 40 and 45

	Not returning for future mammography RR (95% CI)[a,b]	Delayed age of future mammography RR (95% CI)[a,c]
Race/ethnicity		
NH AA	1.04 (0.98–1.09)	1.26 (1.09–1.45)
Asian	0.67 (0.61–0.74)	0.92 (0.78–1.09)
Hispanic	1.21 (1.13–1.30)	1.17 (1.00–1.36)
NH white	Referent	Referent
Outcome of baseline mammogram		
FP	0.89 (0.85–0.95)	0.97 (0.85–1.10)
TN	Referent	Referent
Model *n*	29,175	17,935

Abbreviation: NH: non-Hispanic.

[a]Adjusted for mammography registry site, age at baseline screening mammogram ages 35 to 39, rural/urban status at baseline, and whether additional screening occurred before age 40.

[b]Defined as not having a mammogram, compared with having 1, captured in the BCSC data between ages 40 and 45, including screening, diagnostic, or unknown mammograms.

[c]Defined as the first future screening mammogram between ages 40 and 45 among women who returned to a BCSC facility for mammography; ages 43 to 45 compared with 40 to 42.

at the time of baseline screening, and additional screening mammography before age 40.

After adjusting for the aforementioned covariables, Hispanic women, compared with white women, were at increased risk (RR = 1.21; 95% CI: 1.13–1.30) of not having future BCSC mammography. The risk was significantly decreased for Asian women (RR = 0.67; 95% CI: 0.61–0.74), and there was no significant difference for AA compared with white women (RR = 1.04; 95% CI: 0.98–1.09). The risk of not having future BCSC mammography was significantly decreased for having a baseline mammography result of FP compared with TN (RR = 0.89; 95% CI: 0.85–0.95). The point estimates in our models did not vary substantially with the addition of each potentially mediating covariable; with the exception of the model with education. Adding education to our main model moderately attenuated the RRs comparing Asian and Hispanics to white women (RR: 0.79, 95% CI: 0.70–0.89 for Asian women; RR: 1.17, 95% CI: 1.06–1.28 for Hispanic women).

Among those having future BCSC mammography specifically for screening mammography between ages 40 and 45, we modeled the risk of delay in the timing of the first future screening mammogram between ages 40 and 45. After adjusting for covariates, the risk of having delayed future screening was not significantly different for Asian or Hispanic women compared with white women. AA compared with white women had a significantly increased risk of delay (ages 43–45 vs. 40–42) in the age of their future screening mammogram (RR = 1.26; 95% CI: 1.09–1.45). There was no significant difference found for an FP result compared with TN baseline result (RR: 0.97, 95% CI: 0.85–1.10). The point estimates in our model of delay in the timing of future screening did not vary substantially with the addition of each covariable, with the exception of the model with education (RR: 0.79, 95% CI: 0.66–0.96 for Asian women; RR: 1.03, 95% CI: 0.83–1.26 for Hispanic women).

Discussion

Our study has important findings related to racial/ethnic disparities among women who begin mammography screening before age 40. About a third of our sample did not return to a BCSC facility for mammography between ages 40 and 45. Risk of not having future BCSC mammography was greater among Hispanic women, whereas Asian women were more likely to return to a BCSC facility.

Others have reported that nonwhite group members are less likely than non-Hispanic whites to have a regular site of care (24) and certain Latino subgroups are less likely to have a usual source of care than non-Latino whites (25). Women with both a usual place of care and usual provider have almost 5 times the odds of having had a mammogram in the past year compared with women who had no usual place (26); not having a physician recommendation is one of the strongest reasons women do not undergo testing (27). Therefore, it is possible that the Hispanic women in our sample were less likely to have a usual provider, although we cannot determine that directly from these data. As our data include only women who have had a mammogram, this suggests some means of access to health care. Further investigation of access, such as examination of insurance information, is unfortunately limited and inconsistent in these data. A *post hoc* examination of our data revealed that of the 9,198 women who did not have future BCSC mammography, 4,692 (51.0%) of these women had their baseline mammogram at a facility that stopped participating in data collection efforts prior to the woman turning age 45. This did not seem to vary differentially by race/ethnicity (Hispanic, 52.5%; white, 51.9%; AA, 53.7%) except for Asian women (27.1%). We note, too, that women within BCSC registries can attend multiple facilities, so the closing of one facility does not necessarily mean the woman is lost to future observation within a BCSC registry. We examined this issue by assigning mammography facil-

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

ities to "clusters", that is, groups of facilities that seem to cover similar catchment areas. To do this, we first identified women in the broader BCSC data who visit multiple different facilities for screening mammography over a relatively short window of time (5 years). We then assumed that multiple facilities being attended by a single woman likely cover overlapping areas and thus might reasonably be able to serve common sets of women. Considering "clusters" of facilities that a woman may reasonably attend within each of the given BCSC registries, only approximately 2% of the aforementioned 4,692 women had their cluster of facilities end participation before their turning age 45.

AA race/ethnicity was associated with an increased risk of delayed age at first routine screening mammography between ages 40 and 45. That we did not find an interaction in our model suggests there is no significant racial/ethnic variability in the effect of the baseline result on the timing of future mammography among women who return to a BCSC facility for future screening between ages 40 and 45. We cannot know from these data why AA women were at greater risk for a delay in the age of their future mammogram. However, it is important to note the presence of such disparities so early in the screening lifetime. In women 40 years and older, the proportion and rates of advanced stage cancer are similar across racial and ethnic groups after accounting for variations in mammography screening (10). Improved adherence to recommended screening intervals might reduce the prevalence of advanced stage disease and resulting mortality rates (10). Therefore, these findings generate important avenues for future disparities work, including examination of lifelong mammography use patterns, whether delays in mammography timing increase between screening intervals, and the implications of an individualized, tailored approach to decision making at mammography initiation in consistency of care.

Although ours is the first known study to examine the impact of racial/ethnic and baseline result differences on subsequent mammography use, these findings should be considered in the context of limitations. First, of the 31% who did not have future BCSC mammography between ages 40 and 45, we do not know whether these women had a mammogram outside our data capture area or whether they simply did not have future mammography. Earlier in the discussion, we noted that approximately half of those who did not have future BCSC mammography had their baseline mammogram at a facility that stopped participating in data collection efforts before the woman turning age 45. Even though those women had opportunity to attend other facilities within their registries, this does not preclude the possibility that the association seen for our first outcome of interest might be explained by differences across racial/ethnic groups in women's interest or ability in attending different BCSC mammography facilities. We recognize this as an important limitation of our study. To provide some estimate of migration, if we examine the 20,192 women in our sample who did have future BCSC mammography, 74.9% were seen for a mammogram after age 40 at the same facility as their baseline mammogram; this percentage varied minimally across racial/ethnic groups and FP/TN results (72.2%–75.8%), with the exception of Hispanic women (64.9%). Further research is needed to understand whether Hispanic women tend to have different patient behaviors, live in more isolated areas and therefore depend on certain clinics, or are more transient. Second, although we did not find a significant interaction between race/ethnicity and baseline mammography results in either of our models, the possibility of inadequate statistical power to detect these interactions should be considered. Although these data are among the best available for this purpose, by nature of the research question, the cell sizes become rather modest when examining these interactions, particularly among the nonwhite FP groups. Related to this point, women who had a baseline mammogram at age 39 and who had a diagnostic mammogram after age 40 would not have been included in our second analysis of delay in timing of future screening and so may be underrepresented. We encourage additional work to confirm a nonsignificant interaction between race/ethnicity and baseline results on future mammography behaviors. Third, because of the percentage of missing data for education, we had limited ability to interpret its potential role as a mediator on our main associations, that is, wherein, with the addition of education in the model, Asian women were at significantly decreased risk of delaying the age of their future screening mammogram. Fourth, to adequately address the research question of the impact of baseline mammography outcomes on long-term mammography use would require a defined cohort followed for decades and include multifaceted, detailed information on physician recommendations, women's screening preferences, migration, and risk. In the absence of this, these data are perhaps the closest proxy, being rich in their ability to describe mammography use by race/ethnicity, distinguish screening from diagnostic mammography, use clinical records as opposed to strictly self-report, and then follow women longitudinally.

Conclusions

Using the 1994–2008 BCSC data, we found that race/ethnicity is differentially associated with having future BCSC mammography and the timing of future mammography screening after age 40. Risk of not returning to one of our facilities for mammography was greater among Hispanic women than among non-Hispanic whites. Among those who returned, AA race was associated with an increased risk of delayed age at first screening mammography between ages

Published OnlineFirst January 17, 2011; DOI: 10.1158/1055-9965.EPI-10-1070

40 and 45 compared with non-Hispanic whites. Neither of these results was modified by the baseline mammography result of FP/TN. These findings introduce the need for research that examines disparities in lifetime mammography use patterns from the initiation of mammography screening and what factors impact long-term mammography use.

Disclosure of Potential Conflicts of Interest

The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Cancer Institute or the NIH.

Acknowledgments

The authors thank the participating women, mammography facilities, and radiologists for the data they have provided for this study. A list of the BCSC investigators and procedures for requesting BCSC data for research purposes are provided at http://breastscreening.cancer.gov/.

Grant Support

This work was supported by the National Cancer Institute [grant number R03CA134196 to J.M. Kapp] and the National Cancer Institute–funded Breast Cancer Surveillance Consortium cooperative agreement (U01CA63740, U01CA86076, U01CA86082, U01CA63736, U01CA70013, U01CA69976, U01CA63731, and U01CA70040). The collection of cancer data used in this study was supported in part by several state public health departments and cancer registries throughout the United States. For a full description of these sources, see: http://www.breastscreening.cancer.gov/work/acknowledgement.html.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received October 12, 2010; revised December 22, 2011; accepted January 3, 2011; published online March 31, 2011.

References

1. Woolf SH. United States Preventive Services Task Force recommendations on breast cancer screening. Cancer 1992;69:1913–8.
2. Frame PS, Berg AO, Woolf S. U.S. Preventive Services Task Force: highlights of the 1996 report. Am Fam Physician 1997;55:567–2.
3. U.S. Preventive Services Task Force. Screening for breast cancer: recommendations and rationale. Ann Intern Med 2002;137:344–6.
4. U.S. Preventive Services Task Force. Screening for breast cancer: U. S. Preventive Services Task Force recommendation statement. Ann Intern Med 2009;151:716–26.
5. Dodd GD. American Cancer Society guidelines on screening for breast cancer. an overview. Cancer 1992;69:1885–7.
6. Smith RA, Cokkinides V, Brooks D, Saslow D, Brawley OW. Cancer screening in the United States, 2010: a review of current American Cancer Society guidelines and issues in cancer screening. CA Cancer J Clin 2010;60:99–119.
7. Kapp JM, Ryerson AB, Coughlin SS, Thompson TD. Racial and ethnic differences in mammography use among U.S. women younger than age 40. Breast Cancer Res Treat 2009;113:327–37.
8. Kapp JM, Walker R, Haneuse S, Buist DS, Yankaskas BC. Are there racial/ethnic disparities among women younger than 40 undergoing mammography?Breast Cancer Res Treat 2010. [Epub ahead of print]. doi:10.1007/s10549-010-0812-4.
9. Bowie JV, Wells AM, Juon HS, Sydnor KD, Rodriguez EM. How old are African American women when they receive their first mammogram? Results from a church-based study. J Community Health 2008;33:183–91.
10. Smith-Bindman R, Miglioretti DL, Lurie N, Abraham L, Barbash RB, Strzelczyk J, et al. Does utilization of screening mammography explain racial and ethnic differences in breast cancer?Ann Intern Med 2006;144:541–53.
11. Yankaskas BC, Haneuse S, Kapp JM, Kerlikowske K, Geller B, Buist DS. Performance of first mammography examination in women younger than 40 years. J Natl Cancer Inst 2010;102:692–701.
12. Jafri NF, Ayyala RS, Ozonoff A, Jordan-Gray J, Slanetz PJ. Screening mammography: does ethnicity influence patient preferences for higher recall rates given the potential for earlier detection of breast cancer?Radiology 2008;249:785–91.
13. Pisano ED, Earp J, Schell M, Vokaty K, Denham A. Screening behavior of women after a false-positive mammogram. Radiology 1998;208:245–9.
14. Fletcher SW, Elmore JG. Clinical practice. Mammographic screening for breast cancer. N Engl J Med 2003;348:1672–80.
15. Lerman C, Trock B, Rimer BK, Boyce A, Jepson C, Engstrom PF. Psychological and behavioral implications of abnormal mammograms. Ann Intern Med 1991;114:657–61.
16. Brewer NT, Salz T, Lillie SE. Systematic review: the long-term effects of false-positive mammograms. Ann Intern Med 2007;146:502–10.
17. Burman ML, Taplin SH, Herta DF, Elmore JG. Effect of false-positive mammograms on interval breast cancer screening in a health maintenance organization. Ann Intern Med 1999;131:1–6.
18. Gierisch JM, O'Neill SC, Rimer BK, DeFrank JT, Bowling JM, Skinner CS. Factors associated with annual-interval mammography for women in their 40s. Cancer Epidemiol 2009;33:72–8.
19. National Cancer Institute. Breast Cancer Surveillance Consortium. Bethesda, MD: National Cancer Institute, Division of Cancer Control and Population Sciences, Applied Research Program; 2008. [cited 2009 July 9]. Available from:http://www.breastscreening.cancer.gov/.
20. Ballard-Barbash R, Taplin SH, Yankaskas BC, Ernster VL, Rosenberg RD, Carney PA, et al. Breast Cancer Surveillance Consortium: a national mammography screening and outcomes database. AJR Am J Roentgenol 1997;169:1001–8.
21. BCSC Glossary of Terms. Bethesda, MD: Breast Cancer Surveillance Consortium, National Cancer Institute; 2008. [cited 2009 Mar 16]. Available from:http://breastscreening.cancer.gov/data/bcsc_data_definitions.pdf.
22. American College of Radiology. Breast Imaging and Reporting Data System (BI-RADS) Mammography. 4th ed. Reston, VA: American College of Radiology; 2003.
23. Morrill R, Cromartie J, Hart G. Rural-Urban Commuting Area Codes (RUCAs). Seattle, WA: WWAMI Rural Health Research Center; 2010. [cited 2010 Apr 7]. Available from:http://depts.washington.edu/uwruca/index.php.
24. Doescher MP, Saver BG, Fiscella K, Franks P. Racial/ethnic inequities in continuity and site of care: location, location, location. Health Serv Res 2001;36:78–89.
25. Vargas Bustamante A, Chen J, Rodriguez HP, Rizzo JA, Ortega AN. Use of preventive care services among Latino subgroups. Am J Prev Med 2010;38:610–19.
26. Blewett LA, Johnson PJ, Lee B, Scal PB. When a usual source of care and usual provider matter: adult prevention and screening services. J Gen Intern Med 2008;23:1354–60.
27. Schueler KM, Chu PW, Smith-Bindman R. Factors associated with mammography utilization: a systematic quantitative review of the literature. J Womens Health 2008;17:1477–98.

Cancer Epidemiology, Biomarkers & Prevention

AACR American Association for Cancer Research

A Prospective Assessment of Racial/Ethnic Differences in Future Mammography Behavior among Women Who had Early Mammography

Julie M. Kapp, Rod Walker, Sebastien Haneuse, et al.

Cancer Epidemiol Biomarkers Prev 2011;20:600-608. Published OnlineFirst January 17, 2011.