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Multilevel factors associated with long-term adherence to screening mammography in older women in the U.S

Rebecca A. Hubbard, PhD[1], **Ellen S. O'Meara, PhD**[2], **Louise M. Henderson, PhD**[3], **Deirdre Hill, PhD**[4], **Dejana Braithwaite, PhD**[5], **Jennifer S. Haas, MD**[6], **Christoph I. Lee, MD**[7,8], **Brian L. Sprague, PhD**[9], **Jennifer Alford-Teaster, MPH**[10,11,12], **Anna N.A. Tosteson, ScD**[12,13], **Karen J. Wernli, PhD**[2,8], and **Tracy Onega, PhD**[10,11,12]

[1]Department of Biostatistics and Epidemiology, University of Pennsylvania, Philadelphia, PA

[2]Group Health Research Institute, Seattle, WA

[3]Department of Radiology, University of North Carolina at Chapel Hill, Chapel Hill, NC

[4]Department of Internal Medicine and Cancer Research and Treatment Center, University of New Mexico, Albuquerque, NM

[5]Department of Epidemiology and Biostatistics, University of California, San Francisco, CA

[6]Division of General Internal Medicine, Brigham and Women's Hospital, Boston, MA

[7]Department of Radiology, University of Washington, Seattle, WA

[8]Department of Health Services, University of Washington, Seattle, WA

[9]Department of Surgery, University of Vermont, Burlington, VT

[10]Department of Biomedical Science, Geisel School of Medicine at Dartmouth, Lebanon, NH

[11]Department of Epidemiology, Geisel School of Medicine at Dartmouth, Lebanon, NH

[12]Norris Cotton Cancer Center, Geisel School of Medicine at Dartmouth, Lebanon, NH

[13]Department of Medicine, The Dartmouth Institute for Health Policy and Clinical Practice, Dartmouth Medical School, Lebanon, NH

Abstract

In the U.S., guidelines recommend that women continue mammography screening until at least age 74, but recent evidence suggests declining screening rates in older women. We estimated adherence to screening mammography and multilevel factors associated with adherence in a longitudinal cohort of older women. Women aged 66–75 years receiving screening mammography

Corresponding author: Rebecca A. Hubbard, 604 Blockley Hall, 423 Guardian Dr, Philadelphia, PA 19104, phone: 215-898-3311, fax: 215-573-4865, rhubb@upenn.edu.

Conflict of Interest Statement

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within the Breast Cancer Surveillance Consortium were linked to Medicare claims (2005–2010). Claims data identified baseline adherence, defined as receiving subsequent mammography within approximately 2 years, and length of time adherent to guidelines. Characteristics associated with adherence were investigated using logistic and Cox proportional hazards regression models. Analyses were stratified by age to investigate variation in relationships between patient factors and adherence. Among 49,775 women, 89% were adherent at baseline. Among women 66–70 years, those with less than a high school education were more likely to be non-adherent at baseline (odds ratio [OR] 1.96; 95% confidence interval [CI] 1.65–2.33) and remain adherent for less time (hazard ratio [HR] 1.41; 95% CI 1.11–1.80) compared to women with a college degree. Women with ≥1 versus no Charlson co-morbidities were more likely to be non-adherent at baseline (OR 1.46; 95% CI 1.31–1.62) and remain adherent for less time (HR 1.44; 95% CI 1.24–1.66). Women aged 71–75 had lower adherence overall, but factors associated with non-adherence were similar. In summary, adherence to guidelines is high among Medicare-enrolled women in the U.S. receiving screening mammography. Efforts are needed to ensure that vulnerable populations attain these same high levels of adherence.

Introduction

Screening mammography is recommended by professional society guidelines and supported by organized screening programs in many developed countries. For instance, the European Union cancer screening policy recommends biennial screening from age 50–69 years (Council of the European Union, 2003). Similarly, in the U.K., the National Health Service Breast Screening Programme invites women to screen from age 50–70 years (Public Health England, 2016). In the U.S., screening mammography is recommended for older women until at least age 74 years (Siu, 2016) or for as long as a woman is in good health (Oeffinger et al., 2015). Because U.S. women often continue to screen well beyond age 70 (Ryerson et al., 2008), the U.S. provides a unique context in which to investigate factors related to screening mammography use in older women. This has the potential to inform proposed expansion of the screening age range in other countries as has been proposed for the UK (Moser et al., 2011).

In the U.S., screening mammography use increased sharply from the mid-1990s through 2005 (Breen et al., 2007; Rao et al., 2008). However, studies including data after 2005 have produced conflicting results with some indicating a continued increase in mammography use while others suggest a stabilization or possible decline (Breen et al., 2011; Breen et al., 2007; Pace et al., 2013; Sprague et al., 2014). Some evidence suggests that the 2009 U.S. Preventive Services Task Force (USPSTF) breast cancer screening recommendations calling for biennial screening may have contributed to a decline in mammography use among older women (Jiang et al., 2015b). Understanding multilevel characteristics associated with a possible decline is key to ensuring that the benefits of screening reach as many women as possible, particularly older women of screening age, given the increased risk of breast cancer in this group.

A variety of studies have investigated characteristics associated with participation in screening mammography. European national screening program registries have identified

demographic characteristics including lower socio-economic status and older age as factors associated with non-attendance (Aarts et al., 2011; Bulliard et al., 2004a; Lagerlund et al., 2002). In the U.S., characteristics including non-white race, increased burden of co-morbid disease, and lower socio-economic status have been associated with lower rates of screening (Blanchard et al., 2004; Koya et al., 2011). Older age is also associated with significantly lower rates of mammography utilization (Jiang et al., 2015a; Koya et al., 2011). Women receiving other preventive services are more likely to receive screening mammography (Koya et al., 2011). The majority of these findings were based on national surveys and cross-sectional studies using Medicare claims to identify characteristics associated with a single episode of screening mammography use. Relatively few studies have investigated characteristics associated with adherence to screening guidelines across multiple screening rounds (Blanchard et al., 2004).

We analyzed the association between participant characteristics and adherence to screening mammography guidelines across multiple rounds of screening in a U.S. cohort of Medicare-enrolled women aged 66–75 years. We followed individual women longitudinally to determine if and when they discontinued screening. Continued adherence, as compared to participation in only a single round, is necessary to ensure that the potential benefits of screening are realized. We hypothesized that women who had received prior screening would remain adherent across multiple rounds of screening at high rates. Based on reports that adherence rates vary by age, and that factors such as family history affect adherence differently by age, we hypothesized that, as women approach age limits recommended for cessation of screening, the factors influencing adherence to mammography recommendations might vary.

Methods

Data sources

Data were obtained from four Breast Cancer Surveillance Consortium (BCSC) mammography registries (http://breastscreening.cancer.gov) (Ballard-Barbash et al., 1997) that linked to Medicare claims data: New Hampshire Mammography Network, Carolina Mammography Registry, San Francisco Mammography Registry, and Vermont Breast Cancer Surveillance System. Registries collected data from community radiology facilities, including patient characteristics and clinical information at each mammogram. Breast cancer diagnoses were obtained by linking BCSC data to pathology services, regional Surveillance, Epidemiology, and End Results programs, and state tumor registries. Data were pooled at a central Statistical Coordinating Center (SCC). Registries and the SCC received Institutional Review Board approval for active or passive consenting processes or a waiver of consent to enroll participants, link data, and perform analysis. All research procedures were Health Insurance Portability and Accountability Act compliant, and registries and the Statistical Coordinating Center received a Federal Certificate of Confidentiality and other protections for the identities of women, physicians, and facilities.

For women who were enrolled in Medicare between 2005 and 2010 and who received mammograms at one of the four BCSC registries, information on health services use was obtained through linkage to the Centers for Medicare and Medicaid Services' (CMS)

Medicare Program Master Enrollment file using sex, name, birth date, death date, and social security number. Most U.S. adults over age 65 are enrolled in Medicare Part A, making the Medicare enrolled population broadly representative of older adults. The majority (86%) of BCSC women aged 65 and older were successfully linked to Medicare claims data. Failure to link to Medicare claims was most commonly due to lack of information on social security number, an identifier that was not available for some participating facilities. Medicare eligibility and enrollment information for this period as well as all claims data for Medicare-covered services were included in the database.

Study population

Women receiving a screening mammogram between January 1, 2005 and July 1, 2008 within one of the four participating BCSC registries were included if they met these criteria: age 66–75 years at the screening mammogram; continuously enrolled in Medicare Parts A and B and not enrolled in a Medicare managed care plan from 1 year before to 30 months after the screening mammogram; no history of breast cancer; and did not die or have a diagnosis of invasive carcinoma or ductal carcinoma in situ within 30 months after the screening mammogram. Each woman's first eligible screening mammogram during the study period was defined as the "index" mammogram. At the time of the index mammogram, we required the woman to be age 66 years or older with 1 prior year of continuous Medicare enrollment to facilitate computation of healthcare utilization and co-morbidity scores. We required 30 months of continuous Medicare enrollment after the index mammogram to ensure capture of subsequent mammography. We excluded women enrolled in a Medicare managed care plan because these plans are not required to submit itemized claims to CMS; capture of services for these women is expected to be incomplete. We excluded index mammograms in the BCSC database if a corresponding Medicare claim for a mammogram could not be found within 7 days before or after the recorded exam date.

Measures and definitions

At each BCSC mammogram, women completed a self-administered questionnaire that included age, race/ethnicity, educational attainment, family history of breast cancer in a first-degree relative, and previous mammography. Based on factors ascertained at the index mammogram, we computed the BCSC 5-year breast cancer risk score (Tice et al., 2008).

Women were linked to census-based community-level characteristics from the 2010 Environmental Systems Research Institute business analyst application by geocoding their residential address and joining the location to U.S. Census units (Environmental Systems Research Institute, 2014). Community characteristics included the proportion of individuals in the census tract who were linguistically isolated (residing in a household in which no one age 14 years old or over (a) speaks only English or (b) speaks a non-English language and speaks English "very well"), and, at the census block group level: diversity index (a measure of the racial and ethnic diversity of a geographic area ranging from 0 (no diversity) to 100 (complete diversity)), median disposable income, median household income, average annual health insurance expenditures, average annual public transportation expenditures, proportion with a college degree, proportion with access to the internet, proportion that read health magazines, and proportion that read a newspaper daily. These factors were selected because

they related to health literacy, potential barriers to use of health services due to transportation issues, or socioeconomic characteristics previously found to be associated with use of preventive services.

We identified mammograms using Medicare claims in the Inpatient, Outpatient, and Carrier files. Mammography claims were identified based on International Classification of Diseases, Ninth Revision procedure codes and Health Care Common Procedure Coding System codes (see Supplementary Table S1). Claims codes for both screening and diagnostic mammograms were included to allow for the possibility that a woman might forego a screening mammogram if she had recently received a diagnostic mammogram. Beginning at the time of a woman's index mammogram, we identified all subsequent mammograms.. We also used Medicare claims data from the year before the index mammogram to calculate the Klabunde modification to the Charlson co-morbidity score (Klabunde et al., 2000). We identified hospitalizations in the year before the index mammogram based on the presence of any inpatient claims. Similar to prior studies (Brawarsky et al., 2012; Earle et al., 2003; Kronman et al., 2008; Schootman et al., 2008), we identified primary care visits in the year before the index mammogram based on the presence of claims in the Carrier file with Healthcare Financing Administration codes: 01 (general practice), 11 (internal medicine), 08 (family practice), 16 (obstetrics/gynecology), 38 (geriatric medicine), and 70 (multispecialty group practices).

We defined two outcomes related to adherence to screening mammography. First, we defined *baseline adherence* as a binary indicator of whether the woman received subsequent mammography 9–30 months after the index mammogram. Because guidelines relating to screening mammography are inconsistent with respect to the recommended screening interval (Oeffinger et al., 2015; Siu, 2016), we conservatively allowed a 30-month window in which to receive subsequent mammography corresponding to the maximum recommended interval (24 months) and allowing an additional 6 months to accommodate deviation from recommendations due to scheduling or other logistical difficulties. We excluded the first 9 months following the screening mammogram to remove diagnostic mammograms received as follow-up for a positive index mammogram. Second, among women who were adherent at baseline (received a second mammogram within 30 months of the index mammogram), we ascertained a measure of *longitudinal adherence*, the length of time they remained adherent to screening recommendations. This measure is defined as the time from the index mammogram to the end of the first 30-month gap in mammography. By definition, women who were eligible for inclusion in the longitudinal analysis had a mammogram at least 9 months after their index mammogram. This post-index mammogram conferred an additional 30 months of adherence. Therefore, all women in the longitudinal analysis were adherent for at least 39 months after their index mammogram. Accordingly, longitudinal follow-up began 39 months after the index mammogram. Supplementary Figure S2 illustrates the definitions of our adherence measures. Our analysis focused on the length of time women remained adherent rather than the number of screening rounds they participated in because this directly informs the amount of person-time "covered" by screening in the population (Chubak and Hubbard, 2016).

Statistical analysis

We calculated counts and proportions for woman-level characteristics stratified by baseline adherence and estimated the proportion of women who were non-adherent in sub-groups defined by these characteristics stratified by age (66–70 and 71–75 years). We used multivariable logistic regression to analyze the association between characteristics and baseline non-adherence stratified by age group. Next, we analyzed longitudinal adherence using survival methods. Beginning 39 months after the index mammogram (the first date at which it was possible for a woman to become non-adherent), we constructed Kaplan-Meier curves for the time to the first period of non-adherence. Follow-up for screening mammography use continued until the earliest occurrence of death, disenrollment from Medicare parts A or B, enrollment in a Medicare managed care plan, breast cancer diagnosis, or the end of study follow-up, December 31, 2010. We used Cox proportional hazards models to analyze factors associated with increased hazard of non-adherence to screening mammography guidelines. We estimated adjusted hazard ratios for participant characteristics associated with non-adherence. Separate models were estimated for women 66–70 and 71–75 years old at the index mammogram. Models were adjusted for all participant characteristics, exam year, and BCSC registry and were estimated using complete case analysis.

Statistical significance was evaluated at the two-sided alpha = 0.05 level. Analyses were conducted using Stata (Stata Statistical Software: Release 12. College Station, TX: StataCorp LP).

Results

Our cohort included 49,775 women. Reasons for exclusion are summarized in Supplementary Figure S3. In our sample, 44,119 (88.6%) women were adherent at baseline (received a mammogram between 9 and 30 months after the index mammogram). Most (60.8%) were age 66–70 years at the index mammogram. Women who were adherent at baseline tended to be younger, have higher educational attainment, come from communities with higher average health insurance expenditures, and were more likely to have a family history of breast cancer, 5-year BCSC breast cancer risk score > 2.5%, Charlson co-morbidity score of 0, and a primary care visit in the prior year compared with women who were non-adherent (Table 1).

At baseline, non-adherence was 20% or less across all participant sub-groups investigated. The highest observed level of non-adherence (20%) was among women age 66–70 years with a 5-year breast cancer risk score less than 1% (Table 2, Supplementary Figure S4). Based on multivariable logistic regression models in both the older (71–75 years) and younger (66–70 years) age groups, women with less education were more likely to be non-adherent and those with higher breast cancer risk scores and residing in communities with a higher proportion of newspaper readership were less likely to be non-adherent. In the 66–70 year old age group, older age, Charlson co-morbidity scores greater than 0, and lack of a primary care visit in the prior year were associated with increased odds of non-adherence, while residing in communities with greater average public transportation expenditures was associated with decreased odds of non-adherence. In the 71–75 year old age group, women

living in communities with a higher diversity index and higher median household incomes were less likely to be non-adherent (Table 2, Supplementary Figure S5).

Women included in our longitudinal analysis were followed for a median of 60.1 months after the index mammogram (interquartile range: 50.7–65.6). Women 71–75 years old remained adherent to screening for slightly less time than did women 66–70 years old (Figure 1). After 30 months of longitudinal follow-up (69 months after the index exam), 89.1% (95% confidence interval [CI]: 88.4–89.7) of women 66–70 years old remained adherent compared with 85.4% (95% CI, 84.6–86.2%) of women 71–75 years old. Risk factors associated with shorter time to non-adherence were similar in the two age groups (Table 3, Supplementary Figures S6 and S7). For both age groups, the hazard ratio (HR) for non-adherence was higher among older women, those with less education, and those with a co-morbidity score greater than 0. In the younger age group, having a hospitalization in the prior year was also associated with an increased hazard of non-adherence. Residing in a community with median household income in the highest quartile was associated with a decreased hazard of non-adherence in the 66–70 year old age group. Among women 71–75, women from neighborhoods with greater diversity and in the highest quartile of expenditures on public transportation as well as women with 5-year breast cancer risk >2.5% had decreased hazards of non-adherence.

Discussion

Using longitudinal data from Medicare claims on mammography utilization, we identified patterns of adherence to screening mammography recommendations and factors associated with non-adherence in a cohort of older women in the U.S. In general, adherence was high in this cohort both at baseline and longitudinally. Almost 90% of women received a mammogram within 30 months of their index examination and, among these women, more than 85% remained adherent throughout the study follow-up period. Overall, this indicates that among U.S. women continuously enrolled in fee-for-service Medicare who have received a prior mammogram, levels of continued participation in screening mammography are very high.

We found that women aged 71–75 years had lower levels of adherence than women aged 66–70 years. While screening practices are unlikely to change abruptly or uniformly at age 70, we hypothesized that, as women approach the upper boundary of the recommended screening age range, factors associated with screening adherence might vary. Lower screening adherence levels among women over 70 years of age may represent appropriate cessation of screening as women experience greater co-morbid disease burden or approach 74 years of age, the upper limit specified by some screening recommendations. As remaining life expectancy decreases, the probability of harm due to overdiagnosis and unnecessary treatment increases (Braithwaite et al., 2013; Walter and Covinsky, 2001; Walter and Schonberg, 2014). Recommendations have therefore emphasized individualized decision making about continued screening in older women based on life expectancy (Smith et al., 2003; Walter and Covinsky, 2001). Our results indicating that screening adherence increases with increasing breast cancer risk and decreases in relation to increased co-morbid disease burden and prior hospitalization suggest that women are receiving screening

mammography concordant with their individual balance of screening benefits and harms. These results are similar to prior findings that screening mammography utilization declines with increasing age and decreasing life expectancy (Koya et al., 2011; Schonberg et al., 2013; Tan et al., 2012). Our findings relating to patterns of adherence in women over age 70 years may help inform outreach efforts in the U.S. as well as efforts to expand screening to this older age range in countries with organized screening programs.

We identified demographic and community characteristics associated with (1) baseline non-adherence and (2) shorter time to non-adherence. Women with lower educational attainment were more likely to be non-adherent at baseline and became non-adherent sooner when followed longitudinally. Among women 66–70, having a primary care visit in the year before the index mammogram was associated with baseline but not longitudinal adherence. The lack of observed association between primary care visits and longitudinal adherence may be due to changes in women's use of primary care over time, which were not captured by our study. Previous studies have also found that characteristics including higher educational attainment and use of other preventive health care services were associated with higher cross-sectional rates of screening mammography use (Schonberg et al., 2013) and screening re-attendance (Bulliard et al., 2004b). Community characteristics associated with better adherence at baseline included residing in a community with a higher proportion of daily newspaper readership and, among older women, higher diversity index and higher median household income. Our study confirms and expands on prior results by demonstrating that, in a population of older women receiving screening mammography, the probability of remaining adherent to screening guidelines is decreased in population sub-groups characterized by lower socioeconomic status.

Strengths of our study include its large size, inclusion of women from regional mammography registries throughout the U.S., and longitudinal follow-up. Additionally, the combination of detailed self-report and U.S. Census data on participant and community characteristics allowed us to investigate a broad range of factors that may influence mammography adherence. By linking these data to Medicare claims, we were able to identify all utilization of mammography after the index mammogram, as well as utilization of other healthcare services prior to baseline.

Our study also had several limitations. Because we have focused on a cohort of women continuously enrolled in fee-for-service Medicare, our results are not necessarily generalizable to women under 65 years, women enrolled in managed care plans, or those with intermittent Medicare enrollment. These women may differ in screening behavior or in characteristics associated with screening. For instance, women enrolled in managed care plans tend to be generally healthier than fee-for-service Medicare enrollees (Shimada et al., 2009). Despite these limitations, the fee-for-service Medicare population includes over 30 million U.S. women, making this a large and informative population to study. We have also defined "adherence" as receipt of any mammogram within 30 months, including both screening and diagnostic mammograms. While this provides an estimate of the proportion of women who are not in need of screening because they have received a recent mammogram, it overestimates the proportion of women who choose to participate in screening. We adopted this strategy in order to account for women foregoing screening due to a recent

diagnostic mammogram. Finally, we have identified characteristics associated with screening adherence, but there may be other factors not captured by our study that also influence screening. As such, our results describe screening mammography use patterns but should not be interpreted as causal relationships.

Conclusions

In conclusion, we found high levels of adherence to screening mammography recommendations among Medicare-enrolled U.S. women both at a single screening round and across multiple rounds of screening. Factors associated with adherence including younger age, lower Charlson co-morbidity score, and greater breast cancer risk suggest that women are making judicious choices about screening mammography, with continued use roughly corresponding to their likelihood of benefiting from screening. However, decreased screening among some socioeconomically vulnerable groups including women with lower educational attainment and women residing in communities with lower household incomes suggest that outreach is still needed to ensure that medically underserved populations receive guideline-concordant care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Highlights

- Medicare-enrolled women were highly adherent to screening mammography.
- Older age and increasing co-morbidity were associated with decreased adherence.
- Lower educational attainment and income were associated with decreased adherence.

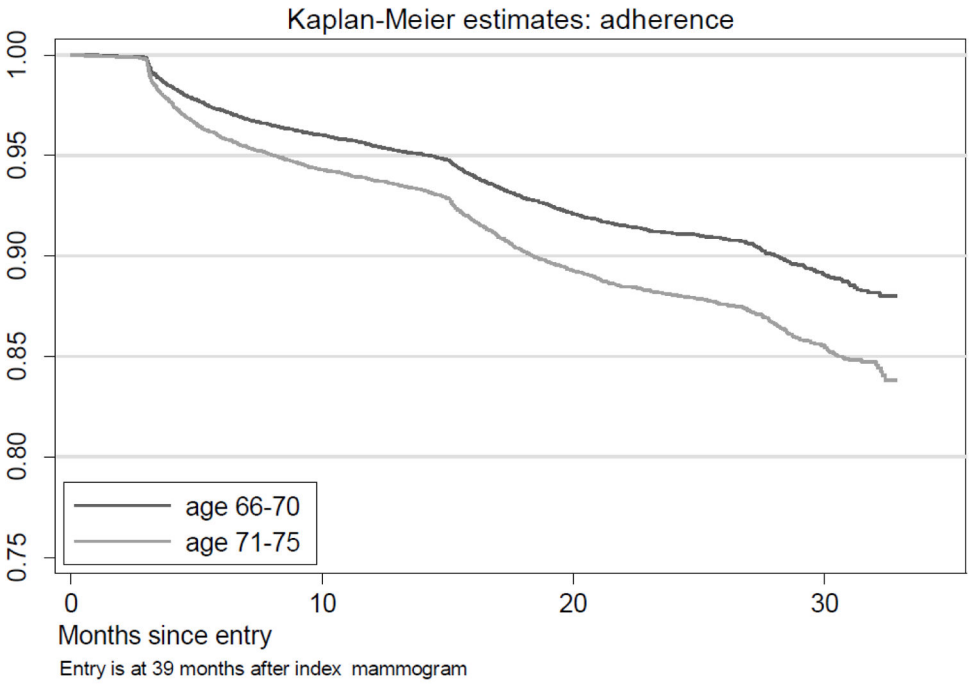

Figure 1.

Kaplan-Meier estimates of proportion of women adherent to screening mammography recommendations by age at index mammogram among women in the Breast Cancer Surveillance Consortium-Medicare cohort receiving an index screening mammogram between January 1, 2005 and July 1, 2008. Follow-up begins 39 months after index mammogram.

Table 1

Participant and community characteristics of women who were adherent (received a mammogram between 9 and 30 months after baseline) and non-adherent to screening mammography guidelines at baseline in the Breast Cancer Surveillance Consortium-Medicare cohort receiving an index screening mammogram between January 1, 2005 and July 1, 2008.

	Adherent (N = 44,119)		**Non-adherent (N = 5,656)**		**Total (N = 49,775)**	
	N	**%**	**N**	**%**	**N**	**%**
Demographic characteristics						
Age, years						
66	9,266	21.0	767	13.6	10,033	20.2
67	5,381	12.2	636	11.2	6,017	12.1
68	4,322	9.8	597	10.6	4,919	9.9
69	4,171	9.4	568	10.0	4,739	9.5
70	4,052	9.2	519	9.2	4,571	9.2
71	3,614	8.2	521	9.2	4,135	8.3
72	3,589	8.1	517	9.1	4,106	8.2
73	3,356	7.6	473	8.4	3,829	7.7
74	3,243	7.4	538	9.5	3,781	7.6
75	3,125	7.1	520	9.2	3,645	7.3
Race/ethnicity						
Non-Hispanic White	34,904	79.1	4,200	74.3	39,104	78.6
Non-Hispanic Black	1,767	4.0	338	6.0	2,105	4.2
Asian/Pacific Islander	1,240	2.8	253	4.5	1,493	3.0
Hispanic	625	1.4	117	2.1	742	1.5
Other/unknown	5,583	12.6	748	13.2	6,331	12.7
Education						
<High school graduate	3,299	8.8	656	14.5	3,955	9.4
High school graduate or GED	12,708	34.0	1,604	35.5	14,312	34.1
Some college or technical school	9,748	26.0	1,073	23.7	10,821	25.8
College graduate	11,675	31.2	1,191	26.3	12,866	30.7
Missing	*6,689*	*15.2*	*1,132*	*20.0*	*7,821*	*15.7*

	Adherent (N = 44,119)		Non-adherent (N = 5,656)		Total (N = 49,775)	
	N	**%**	**N**	**%**	**N**	**%**
Community characteristics						
Census tract diversity index						
<8.1	10,795	25.4	1,257	23.3	12,052	25.1
8.1–18.8	10,697	25.1	1,240	23.0	11,937	24.9
18.8–45.9	10,773	25.3	1,244	23.1	12,017	25.0
>45.9	10,317	24.2	1,650	30.6	11,967	24.9
Missing	*1,537*	*3.5*	*265*	*4.7*	*1,802*	*3.6*
Proportion linguistically isolated						
None	39,889	93.5	4,873	90.3	44,762	93.2
Any (>0)	2,766	6.5	525	9.7	3,291	6.8
Missing	*1,464*	*3.3*	*258*	*4.6*	*1,722*	*3.5*
Median household income						
<$43,827	10,446	24.5	1,562	29.0	12,008	25.0
$43,827–$55,386	10,798	25.4	1,288	23.9	12,086	25.2
$55,386–$75,553	10,821	25.4	1,230	22.8	12,051	25.1
>$75,553	10,517	24.7	1,311	24.3	11,828	24.7
Missing	*1,537*	*3.5*	*265*	*4.7*	*1,802*	*3.6*
Average health insurance expenditures						
<$658	10,435	24.5	1,583	29.3	12,018	25.1
$658–$788	10,607	24.9	1,402	26.0	12,009	25.0
$788–$1.047	10,914	25.6	1,193	22.1	12,107	25.2
>$1,047	10,699	25.1	1,220	22.6	11,919	24.8
Missing	*1,464*	*3.3*	*258*	*4.6*	*1,722*	*3.5*
Average public transportation expenditures						
<$20	10,610	24.9	1,495	27.7	12,105	25.2
$20–$28	10,770	25.2	1,310	24.3	12,080	25.2
$28–$44	10,905	25.6	1,209	22.4	12,114	25.3
>$44	10,370	24.3	1,384	25.6	11,754	24.5

	Adherent (N = 44,119)		Non-adherent (N = 5,656)		Total (N = 49,775)	
	N	**%**	**N**	**%**	**N**	**%**
Missing	*1,464*	*3.3*	*258*	*4.6*	*1,722*	*3.5*
Proportion with college degree						
<19%	10,966	25.8	1,553	28.8	12,519	26.1
19%–32%	10,178	23.9	1,305	24.2	11,483	23.9
32%–49%	10,772	25.3	1,213	22.5	11,985	25.0
>49%	10,666	25.0	1,320	24.5	11,986	25.0
Missing	*1,537*	*3.5*	*265*	*4.7*	*1,802*	*3.6*
Proportion with access to internet						
<81%	10,729	25.2	1,694	31.4	12,423	25.9
81%–84%	11,925	28.0	1,398	25.9	13,323	27.8
84%–93%	14,002	32.8	1,536	28.4	15,538	32.4
>93%	5,999	14.1	770	14.3	6,769	14.1
Missing	*1,464*	*3.3*	*258*	*4.6*	*1,722*	*3.5*
Proportion read health magazines						
<13%	11,959	28.0	1,725	32.0	13,684	28.5
13%–15%	15,298	35.9	1,832	33.9	17,130	35.7
15%–16%	9,232	21.6	1,039	19.2	10,271	21.4
>16%	6,166	14.5	802	14.9	6,968	14.5
Missing	*1,464*	*3.3*	*258*	*4.6*	*1,722*	*3.5*
Proportion read newspaper daily						
<41%	10,611	24.9	1,695	31.4	12,306	25.7
41%–46%	14,051	32.9	1,685	31.2	15,736	32.8
46%–51%	8,728	20.5	1,022	18.9	9,750	20.3
>51%	9,265	21.7	996	18.4	10,261	21.4
Missing	*1,464*	*3.3*	*258*	*4.6*	*1,722*	*3.5*
Breast cancer risk factors						
Family history of breast cancer						
Yes	7,423	17.0	733	13.2	8,156	16.5

	Adherent (N = 44,119)		Non-adherent (N = 5,656)		Total (N = 49,775)	
	N	%	N	%	N	%
No	36,370	83.0	4,808	86.8	41,178	83.5
Missing	*326*	*0.7*	*115*	*2.0*	*441*	*0.9*
BCSC 5-year breast cancer risk						
0 to <1%	454	1.2	107	2.4	561	1.3
1 to 1.66%	3,936	10.5	655	14.6	4,591	11.0
1.67 to 2.49%	19,359	51.8	2,495	55.5	21,854	52.1
>=2.5%	13,661	36.5	1,242	27.6	14,903	35.6
Missing	*6,709*	*15.2*	*1,157*	*20.5*	*7,866*	*15.8*
Co-morbidity and healthcare utilization						
Charlson co-morbidity score						
≥1	10,265	23.3	1,778	31.4	12,043	24.2
0	33,854	76.7	3,878	68.6	37,732	75.8
Primary care visit in prior year						
Yes	39,741	90.1	4,971	87.9	44,712	89.8
No	4,378	9.9	685	12.1	5,063	10.2
Hospitalization in prior year						
Yes	4,289	9.7	664	11.7	4,953	10.0
No	39,830	90.3	4,992	88.3	44,822	90.0

*“Missing” rows show percentage among all exams. Other percentages are among non-missings.

Table 2

Unadjusted non-adherence rates and multivariable adjusted odds ratios (ORs), 95% confidence intervals (CIs), and p-values for non-adherence to screening mammography guidelines (subsequent screening mammogram within 30 months) by participant and community characteristics in the Breast Cancer Surveillance Consortium-Medicare cohort receiving an index screening mammogram between January 1, 2005 and July 1, 2008. Models adjusted for all variables included in table, year of index exam, and BCSC registry.

	Age 66–70 at index					Age 71–75 at index				
			95% CI					95% CI		
Characteristic at the index mammogram	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**
Demographics										
Age, years										
66	8	1 (ref)			**<0.001**					
67	11	1.56	1.36	1.80						
68	12	1.98	1.71	2.30						
69	12	1.90	1.64	2.21						
70	11	1.73	1.48	2.02						
71						13	1 (ref)			0.12
72						13	1.01	0.85	1.20	
73						12	0.98	0.82	1.16	
74						14	1.20	1.01	1.42	
75						14	1.09	0.91	1.29	
Race/ethnicity										
White	10	1 (ref)			0.41	12	1 (ref)			0.58
Black	14	1.00	0.79	1.26		19	1.24	0.95	1.63	
Asian/Pacific Islander	16	0.90	0.62	1.30		19	0.99	0.63	1.57	
Hispanic	14	0.71	0.48	1.07		19	0.94	0.59	1.48	
Other/unknown	10	1.11	0.89	1.37		14	0.99	0.78	1.26	
Education										
<High school graduate	16	1.96	1.65	2.33	**<0.001**	17	1.63	1.35	1.97	**<0.001**
High school graduate or GED	10	1.28	1.12	1.45		13	1.20	1.03	1.40	
Some college or technical school	9	1.16	1.01	1.33		11	1.00	0.84	1.18	

	Age 66–70 at index					Age 71–75 at index				
			95% CI					95% CI		
Characteristic at the index mammogram	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**
College graduate	8	1 (ref)				11	1 (ref)			
Community characteristics										
Census tract diversity index										
<8.1	9	1 (ref)			0.28	12	1 (ref)			**0.002**
8.1–18.8	10	1.05	0.91	1.20		12	0.89	0.76	1.04	
18.8–45.9	9	0.90	0.76	1.07		12	0.69	0.57	0.85	
>45.9	12	0.91	0.74	1.11		16	0.87	0.69	1.10	
Proportion linguistically isolated										
None	10	1 (ref)			0.19	13	1 (ref)			0.40
Any (>0)	14	1.21	0.91	1.60		18	1.15	0.84	1.57	
Median household income										
<$43,827	12	1 (ref)			0.57	15	1 (ref)			**0.02**
$43,827–$55,386	10	0.97	0.84	1.12		12	0.78	0.66	0.92	
$55,386–$75,553	9	1.08	0.90	1.30		12	0.80	0.65	0.99	
>$75,553	10	1.12	0.88	1.41		13	0.76	0.58	0.99	
Average public transportation expenditures										
<$20	12	1 (ref)			**0.04**	14	1 (ref)			0.09
$20-$28	9	0.80	0.69	0.94		13	1.26	1.05	1.51	
$28-$44	9	0.83	0.68	1.00		12	1.17	0.94	1.46	
>$44	10	0.88	0.67	1.15		14	1.27	0.93	1.72	
Proportion with college degree										
<19%	11	1 (ref)			0.20	14	1 (ref)			0.55
19%–32%	10	1.09	0.95	1.26		13	0.90	0.77	1.06	
32%–49%	9	1.16	0.96	1.41		11	0.96	0.78	1.18	
>49%	10	1.00	0.78	1.29		13	1.02	0.78	1.35	
Proportion with access to internet										

	Age 66–70 at index					Age 71–75 at index				
			95% CI					95% CI		
Characteristic at the index mammogram	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**
<81%	13	1 (ref)			0.64	15	1 (ref)			0.43
81%–84%	9	0.87	0.70	1.08		13	0.84	0.66	1.07	
84%–93%	9	0.95	0.76	1.17		11	1.00	0.78	1.28	
>93%	10	0.92	0.70	1.21		14	1.02	0.75	1.40	
Proportion read health magazines										
<13%	11	1 (ref)			0.63	14	1 (ref)			0.44
13%–15%	9	0.98	0.84	1.15		13	1.12	0.93	1.34	
15%–16%	9	1.04	0.88	1.22		12	1.16	0.96	1.41	
>16%	10	1.11	0.90	1.36		13	1.16	0.91	1.47	
Proportion read newspaper daily										
<41%	13	1 (ref)			**0.003**	16	1 (ref)			**0.02**
41%–46%	10	0.97	0.80	1.17		13	1.12	0.90	1.39	
46%–51%	9	0.74	0.61	0.90		13	0.94	0.75	1.17	
>51%	9	0.70	0.56	0.88		11	0.73	0.57	0.95	
Breast cancer risk factors										
Family history of breast cancer										
Yes	8	0.91	0.77	1.06	0.23	11	0.94	0.79	1.13	0.53
No	11	1 (ref)				13	1 (ref)			
BCSC 5-year breast cancer risk										
0 to <1%	20	1.54	1.04	2.29	**<0.001**	18	0.97	0.60	1.57	**<0.001**
1 to 1.66%	13	1.14	0.98	1.33		17	1.08	0.90	1.29	
1.67 to 2.49%	10	1 (ref)				13	1 (ref)			
>=2.5%	7	0.74	0.65	0.83		10	0.73	0.63	0.84	
Co-morbidity and healthcare utilization										
Charlson co-morbidity score										
≥1	14	1.46	1.31	1.62	**<0.001**	16	1.36	1.20	1.54	**<0.001**

	Age 66–70 at index					Age 71–75 at index				
			95% CI					95% CI		
Characteristic at the index mammogram	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**	**Non-adherent, row %**	**OR of non-adherence**	**lower bound**	**upper bound**	**p**
0	9	1 (ref)				12	1 (ref)			
Primary care visit in prior year										
Yes	10	1 (ref)			**<0.001**	13	1 (ref)			0.33
No	13	1.46	1.27	1.68		15	1.09	0.92	1.31	
Hospitalization in prior year										
Yes	13	1.14	0.97	1.33	0.11	14	0.85	0.71	1.02	0.07
No	10	1 (ref)				13	1 (ref)			

Boldface indicates statistical significance (p<0.05)

Table 3

Hazard ratios (HRs), 95% confidence intervals (CIs), and p-values for time to non-adherence to screening mammography guidelines from multivariable Cox proportional hazards model, by participant and community characteristics, estimated in the Breast Cancer Surveillance Consortium-Medicare cohort receiving an index screening mammogram between January 1, 2005 and July 1, 2008.

	Age 66–70 at index				Age 71–75 at index			
		95% CI				95% CI		
Characteristic at the index mammogram	**HR of non-adherence**	**lower bound**	**upper bound**	**p**	**HR of non-adherence**	**lower bound**	**upper bound**	**p**
Demographics								
Age, years								
66	1 (ref)			**0.03**				
67	1.18	0.97	1.43					
68	1.26	1.04	1.53					
69	1.27	1.04	1.54					
70	1.33	1.10	1.61					
71					1 (ref)			**0.05**
72					1.04	0.86	1.27	
73					1.04	0.86	1.27	
74					1.14	0.94	1.39	
75					1.31	1.08	1.59	
Race/ethnicity								
White	1 (ref)			0.76	1 (ref)			0.57
Black	1.02	0.73	1.44		1.01	0.70	1.45	
Asian/Pacific Islander	1.44	0.85	2.45		0.81	0.42	1.56	
Hispanic	0.98	0.55	1.74		0.77	0.41	1.44	
Other/unknown	1.03	0.79	1.35		0.83	0.63	1.09	
Education								
<HS graduate	1.41	1.11	1.80	**0.03**	1.55	1.24	1.93	**0.001**
HS graduate or GED	1.17	0.99	1.38		1.21	1.02	1.43	
Some college or technical school	1.19	1.01	1.42		1.06	0.88	1.27	
College graduate	1 (ref)				1 (ref)			

	Age 66–70 at index				Age 71–75 at index			
		95% CI				95% CI		
Characteristic at the index mammogram	**HR of non-adherence**	**lower bound**	**upper bound**	**p**	**HR of non-adherence**	**lower bound**	**upper bound**	**p**
Community characteristics								
Census tract diversity index								
<8.1	1 (ref)			0.24	1 (ref)			**0.02**
8.1–18.8	0.87	0.73	1.03		0.77	0.65	0.92	
18.8–45.9	0.82	0.66	1.01		0.78	0.63	0.96	
>45.9	0.81	0.62	1.05		0.81	0.63	1.06	
Proportion linguistically isolated								
None	1 (ref)			0.78	1 (ref)			0.86
Any (>0)	0.94	0.59	1.48		1.04	0.66	1.64	
Median household income								
<$43,827	1 (ref)			**0.02**	1 (ref)			0.16
$43,827-$55,386	1.09	0.90	1.30		1.07	0.90	1.28	
$55,386-$75,553	1.07	0.84	1.37		0.94	0.73	1.20	
>$75,553	0.73	0.53	1.01		1.21	0.88	1.67	
Average public transportation expenditures								
<$20	1 (ref)			0.09	1 (ref)			**0.05**
$20-$28	0.83	0.67	1.02		0.99	0.81	1.21	
$28-$44	0.92	0.72	1.19		1.04	0.82	1.34	
>$44	1.12	0.79	1.58		0.71	0.50	1.02	
Proportion with college degree								
<19%	1 (ref)			0.33	1 (ref)			0.35
19%–32%	0.97	0.81	1.17		0.93	0.77	1.11	
32%–49%	1.17	0.92	1.48		0.82	0.65	1.05	
>49%	1.05	0.77	1.43		0.95	0.70	1.29	
Proportion with access to internet								
<81%	1 (ref)			0.18	1 (ref)			0.78
81%–84%	0.96	0.73	1.27		1.03	0.78	1.36	

	Age 66–70 at index				Age 71–75 at index			
		95% CI				95% CI		
Characteristic at the index mammogram	**HR of non-adherence**	**lower bound**	**upper bound**	**p**	**HR of non-adherence**	**lower bound**	**upper bound**	**p**
84%–93%	0.79	0.59	1.06		0.89	0.66	1.18	
>93%	1.06	0.74	1.52		0.92	0.64	1.32	
Proportion read health magazines								
<13%	1 (ref)			0.61	1 (ref)			0.15
13%–15%	0.90	0.74	1.11		0.79	0.64	0.97	
15%–16%	0.89	0.71	1.10		0.87	0.70	1.09	
>16%	0.97	0.74	1.28		0.77	0.58	1.03	
Proportion read newspaper daily								
<41%	1 (ref)			0.11	1 (ref)			0.82
41%–46%	0.94	0.73	1.21		1.05	0.81	1.35	
46%–51%	1.10	0.84	1.44		1.14	0.87	1.50	
>51%	0.82	0.61	1.09		1.10	0.82	1.47	
Breast cancer risk factors								
Family history of breast cancer								
Yes	1.04	0.86	1.26	0.71	0.88	0.72	1.07	0.21
No	1 (ref)				1 (ref)			
BCSC 5-year breast cancer risk								
0 to <1%	1.23	0.64	2.35	0.12	0.76	0.34	1.70	**0.007**
1 to 1.66%	1.22	0.99	1.50		1.17	0.95	1.44	
1.67 to 2.49%	1 (ref)				1 (ref)			
>=2.5%	0.91	0.78	1.06		0.81	0.70	0.95	
Co-morbidity and healthcare utilization								
Charlson co-morbidity score								
≥1	1.44	1.24	1.66	**<0.001**	1.32	1.15	1.52	**<0.001**
0	1 (ref)				1 (ref)			
Primary care visit in prior year								
Yes	1 (ref)			0.14	1 (ref)			0.95

	Age 66–70 at index				Age 71–75 at index			
		95% CI				95% CI		
Characteristic at the index mammogram	**HR of non-adherence**	**lower bound**	**upper bound**	**p**	**HR of non-adherence**	**lower bound**	**upper bound**	**p**
No	1.16	0.96	1.41		0.99	0.81	1.22	
Hospitalization in prior year								
Yes	1.31	1.08	1.59	**0.008**	1.04	0.86	1.26	0.69
No	1 (ref)				1 (ref)			

Boldface indicates statistical significance (p<0.05)