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Breast cancer screening initiation after turning 40 years of age within the PROSPR consortium

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ETHICAL APPROVAL

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Abstract

Purpose—Although United States clinical guidelines differ, the earliest recommended age for average risk breast cancer screening is age 40. Little is known about factors influencing screening initiation.

Methods—We conducted a cohort study within the National Cancer Institute-funded PROSPR (Population-based Research Optimizing Screening through Personalized Regimens) consortium. We identified 3,413 women on their 40th birthday in primary care networks at Geisel School of Medicine at Dartmouth (DH) and Brigham and Women's Hospital (BWH) during 2011–2013 with no prior breast imaging or breast cancer. Cumulative incidence curves and Cox modeling were used to determine time from the 40th birthday to first breast cancer screening, cohort exit, or 42nd birthday. We calculated hazards ratios (HR) and 95% confidence intervals (CI) from multivariable Cox proportional hazards models.

Results—Breast cancer screening cumulative incidence by the 42nd birthday was 62.9% (BWH) and 39.8% (DH). Factors associated with screening initiation were: a primary care visit within a year (HR=4.99, 95% CI=4.23–5.89), an increasing number of primary care visits within a year (p for trend <0.0001), ZIP code of residence annual median household income \$52,000 (HR=0.79, 95% CI=0.68–0.92), and health insurance (Medicaid HR=0.72, 95% CI=0.58–0.88; Medicare HR=0.55, 95% CI=0.39–0.77; uninsured HR=0.37, 95% CI=0.25–0.57).

Conclusions—Breast cancer screening uptake after the 40th birthday varies by health system, primary care visits, median household income, and health insurance type, suggesting the need for further exploration. Future research should evaluate screening performance metrics after initiation and consider cumulative benefits and risks associated with breast cancer screening over time.

Keywords

breast neoplasms; mass screening; prevention & control; primary health care; early detection of cancer; mammography

INTRODUCTION

Forty years is the earliest recommended age for average risk breast cancer screening in the United States (US) and it is when private insurance plans must begin covering breast cancer screening under the Affordable Care Act (ACA) [1]. However, there is variation in when women begin to screen. This is likely due at least in part to the fact that breast cancer screening recommendations vary across organizations, professional societies, and expert groups. Whereas the American College of Radiology and the American College of Obstetrics and Gynecology recommend annual screening beginning at 40 years of age, the American Cancer Society recommends annual screening among women 45 to 54 years of age and biannual screening among women 55 and older [2–4]. The United States Preventive Services Task Force (USPSTF) recommends that asymptomatic average risk women ages 50–74 receive biennial breast cancer screening with mammography, and that the decision to screen before 50 years of age should be an individual one incorporating patient values and

context [5,6]. Contradictory guidelines have led to variation in practices by primary care providers with respect to the age at recommending screening and counseling patients about benefits and risks to inform screening decisions [7,8].

Although much is known about outcomes after screening begins [9,10], there is a paucity of information about when women in the US begin breast cancer screening after turning 40 years of age and the factors associated with screening initiation. Therefore, we evaluated factors influencing when women begin screening after turning 40 years of age within a network of primary care practices.

MATERIALS AND METHODS

Study Population, Data Definitions, and Outcomes

This cohort study was conducted as part of the National Cancer Institute (NCI)-funded consortium Population-Based Research Optimizing Screening through Personalized Regimens (PROSPR) [11]. The overall aim of PROSPR is to conduct multi-site, coordinated, transdisciplinary research to evaluate and improve cancer screening processes. The ten PROSPR Research Centers reflect the diversity of US delivery system organizations. Three of the ten PROSPR centers are breast cancer research centers. Our analyses only included the primary care practice networks located at Dartmouth-Hitchcock Health System in New Hampshire (DH) and Brigham and Women's Hospital (BWH) in Massachusetts—the two clinical sites comprising the Dartmouth-BWH research center—because these sites' cohorts included women with and without breast cancer screening. To enter PROSPR cohorts, women 30 years of age or older were required to have a primary care visit during January 1, 2011 to September 30, 2013 within the Dartmouth-Hitchcock Regional Primary Care Collaborative or the Brigham and Women's Primary Care Practice-Based Research Network. Our analyses were restricted to women in Dartmouth-BWH's cohort on the cusp of their 40th birthday with no prior breast cancer, or documented or self-reported breast imaging in the prior 2 years. Using radiology reports and billing data, we identified the first breast imaging exam with an indication of screening received after a woman's 40th birthday up to her 42nd birthday, the maximum amount of follow-up time available in our data.

We assessed the following factors available from a combination of electronic health records and patient self-report during the calendar year of the woman's 40th birthday using the categories described in Table 1: PROSPR primary care network, race/ethnicity, body mass index (BMI), health insurance type, annual median household income of the ZIP code of residence derived from the American Community Survey [12], number of primary care visits, primary care provider type and specialty, and the Charlson comorbidity index [13,14]. If a Charlson index was unavailable during the year of the woman's 40th birthday, then we used a Charlson index from the previous year. We were unable to assess breast cancer screening initiation separately among American Indians, Alaska Natives, multiple races, and other races due to small populations, or similarly, among primary care providers with a specialty of obstetrics and gynecology or other. All activities were approved by the institutional review boards at the PROSPR Statistical Coordinating Center and the research centers. Research activities complied with the Health Insurance Portability and Accountability Act.

Statistical Analyses

We described characteristics of eligible women turning 40 years of age and their primary care providers and calculated the Kaplan-Meier estimated cumulative incidence of receiving screening at 2 years. We used Cox proportional hazards regression to evaluate associations between the characteristics and time to breast cancer screening initiation after a woman's 40th birthday. We estimated unadjusted and adjusted hazard ratios (HRs) and 95% confidence intervals (CIs). A two-sided P-value <0.05 was considered statistically significant. Person-time began on a woman's 40th birthday and women were censored at the time of diagnostic imaging, cohort exit, or on the 42nd birthday, whichever occurred earlier. We first evaluated the association between PROSPR primary care network and breast cancer screening initiation due to known system-level differences between DH and BWH, such as using EHR decision support. We used Cox proportional hazards models stratified by PROSPR primary care network to evaluate the association between screening initiation and characteristics of women and primary care providers. We calculated a test for interaction of PROSPR primary care network and each characteristic of women and primary care providers in a stratified Cox proportional hazards model. We adjusted for all characteristics that were statistically significantly associated with screening initiation individually in multivariable-adjusted HRs stratified by PROSPR primary care network. Unknown covariate values were not included in the Cox proportional hazard models. We constructed unadjusted cumulative incidence curves depicting the age at screening initiation after a woman's 40th birthday up to her 42nd birthday for all characteristics that were statistically significantly associated with screening initiation. Analyses were completed using SAS Version 9.4 (SAS Institute, Inc.) and Stata Version 14.0 (StataCorp LP).

RESULTS

There were 3,413 women eligible for breast cancer screening initiation by their 40th birthday and 1,098 of them received screening during the follow-up period (Table 1). Characteristics of women varied at DH and BWH (Online Resource). The total person-time at risk among all women was 2,791.2 years. A small number of women were censored due to receiving diagnostic imaging (DH: $n=27$; BWH: $n=40$). DH included 158 primary care providers and 22 primary care clinics. BWH included 197 primary care providers and 15 clinics. The Kaplan-Meier estimated cumulative incidence of breast cancer screening by the 42nd birthday was 62.9% and 39.8% at BWH and DH, respectively (Table 1 and Fig. 1a).

Breast cancer screening uptake after a woman's 40th birthday occurred more rapidly at BWH compared to DH (HR=1.92, 95% CI=1.70–2.16, Table 2). All subsequent analyses used stratified Cox proportional hazards regression models allowing for separate baseline hazards for each primary care network. Race/ethnicity, BMI, Charlson comorbidity index, and primary care provider type and specialty were not statistically significantly associated with breast cancer screening initiation (Table 2). In contrast, health insurance type, ZIP code level median household income, having a recent primary care visit, and number of primary care visits were all statistically significantly associated with screening uptake, and therefore adjusted for in multivariable models. We tested for an interaction between PROSPR primary care network and each factor of interest and none were statistically significant. Health

insurance coverage by Medicaid (adjusted HR=0.72, 95% CI=0.58–0.88), Medicare (adjusted HR=0.55, 95% CI=0.39–0.77), or being uninsured (adjusted HR=0.37, 95% CI=0.25–0.57) during the calendar year of the 40th birthday was associated with a decreased uptake in breast cancer screening after multivariable adjustment relative to coverage by commercial/private or other health insurance. Similarly, a ZIP code level median annual household income of \$52,000 was associated with decreased screening uptake compared to an annual income greater than \$52,000 (adjusted HR=0.79, 95% CI=0.68–0.92). Having a primary care visit in the year of the 40th birthday was associated with a 5-fold increased uptake in screening (adjusted HR=4.99, 95% CI=4.23–5.89). Furthermore, an increased number of primary care visits during the year was statistically significantly associated with increased screening uptake (p for trend <0.0001). Unadjusted Kaplan-Meier estimated cumulative incidence curves visually depicted the time from a woman's 40th birthday until receipt of screening for all statistically significant factors (Fig. 1a–1d).

DISCUSSION

To our knowledge, ours is the first study to evaluate factors associated with screening initiation in the US using radiology reports and billing data and to include never-screened women in the denominator. Our results suggest that there is considerable screening uptake after turning 40 years of age, and that uptake varies by health system and is associated with recent primary care provider contact, health insurance status, and ZIP code level median household income.

Our results are difficult to compare to prior studies due to the challenge of defining and following a population in the US eligible for breast cancer screening. Behavioral Risk Factor Surveillance System (BRFSS) survey data [15] from 2012 reported that 46.5% of women 41 years of age received a mammogram in the prior 12 months [16]. However, BRFSS data are cross-sectional, do not distinguish between screening and diagnostic mammograms, and rely on self-reported data that overestimate cancer screening prevalence [17,18]. A study using screening utilization data from the Massachusetts General Hospital Avon Comprehensive Breast Center from 2000–2002 found that 60% of women initiated screening by their 41st birthday and 75% by their 45th birthday [19]. Screening uptake in our study by the 42nd birthday was less rapid, perhaps because our population included women who were not screened, our follow-up began on the 40th birthday, and we evaluated a time period after the 2009 USPSTF breast cancer screening recommendations.

We observed a notable difference by health system in breast cancer screening uptake with more rapid uptake at BWH than DH (63% initiated screening by the 42nd birthday at BWH vs. 40% at DH). This difference may be attributable, at least in part, to an EHR prompt within BWH primary care clinics, active during the study period, alerting providers to consider screening mammography when a patient turns 40 years of age versus no such prompt in the DH system. Beyond EHR decision support, there were no consistent policies or systems to differentially promote screening initiation at BWH and DH that we could identify. DH was an early adopter of shared decision-making as a clinical service [20] and Dartmouth investigators have been prominent in defining the risks of overdiagnosis [21]. This organizational culture may have influenced provider behaviors and possibly screening

initiation age at DH. Additionally, there may be regional differences in screening initiation preferences between women in the Greater Boston area and southern New Hampshire that we could not assess. Other system-level factors associated with breast cancer screening uptake in prior studies that we could not directly evaluate include flexible appointment timing, care coordination, and greater organizational commitment to quality [22].

In our data, the factor most strongly associated with increased screening uptake was having a primary care visit during the year of the 40th birthday. All women in our study had previous contact with primary care, yet we still observed a decreased time to initial screening as the number of primary care visits during the year increased. Although this association suggests that more interactions with primary care increase the likelihood of screening initiation, the potential mechanism remains unclear. Screening may be initiated through provider-patient discussions of breast cancer screening risks, benefits, and patient preferences, providers might order or not order screening based on personal beliefs absent discussion with the patient, or mammograms may be automatically ordered by the provider or health system. Residual confounding is also possible; primary care visits may be markers of other unmeasured differences between women who do and do not initiate screening after turning 40, such as health seeking behaviors, lifestyle factors, breast cancer risk factors, or breast cancer knowledge. Prior research supports our findings and indicates that receipt of a preventive health examination [23,24], visiting a physician within the past year [25], having a primary care provider [19,25], and having physician-recommended mammography [22,25] are associated with completion of mammography [23,22,24,25] or initiating screening at an earlier age [19].

We found that having Medicaid or Medicare health insurance, being uninsured, and having a lower ZIP code level median household income were associated with longer intervals to first screening examination after multivariable adjustment. Similar to our findings, other studies concluded that lacking insurance [25], having public insurance [19,25], and having a low income or money concerns [25] were negatively associated with mammography receipt [25] or screening initiation at an earlier age [19], whereas health status and provider specialty were not statistically significantly associated with mammography receipt [25]. We did not observe an association between obesity and screening uptake which is comparable with some [25], but not all studies [19]. A variety of other factors that we could not evaluate have been associated with increased mammography use [22,25] or initiating screening at an earlier age [19] including having a prior clinical breast examination [25], prior Pap test [25], high education level [25], family history of breast cancer [25], personal history of benign breast disease [25], speaking English [19], and having a female provider [22]. However, the majority of prior studies have evaluated associations with mammography receipt, rather than time to screening initiation.

Our longitudinal study is unique because we followed women with and without breast cancer screening in two large PROSPR primary care networks. Additionally, we used radiology reports and billing data to identify screening initiation rather than relying on self-report. However, limitations of this study should be considered when interpreting our findings. We could not evaluate the role of family history of breast cancer or other patient risk factors and we were limited by small sample sizes for some characteristics. Due to data

extraction methods, we were unable to determine the temporality of primary care visits and the 40th birthday. Consequently, screening initiation may have preceded primary care visits during the year of the 40th birthday for some women. In addition, because all women included in analyses had prior contact with primary care, findings cannot be generalized to those without prior visits. Nonetheless, we observed a statistically significant trend of an increasing number of visits during the year of the 40th birthday that was associated with more rapid screening uptake.

In summary, our results demonstrate that 1) breast cancer screening uptake occurs among a substantial portion of women between their 40th and 42nd birthday in two primary care networks, and 2) health insurance coverage, primary care providers, and health systems may be potentially modifiable areas that could influence screening initiation patterns. In the era of expanded health insurance access through the ACA, the demand for primary care providers to deliver services and counsel patients continues to increase. It is critical that multilevel interventions be considered that allow health systems to aid primary care provider teams with shared decision-making discussions, including breast cancer screening for women in their 40s. Future studies are required to confirm our findings, and if confirmed, to test possible interventions for shared decision interventions. Furthermore, additional research is needed to evaluate screening performance metrics among first-time screeners (e.g., cancer detection rate), to measure the influence of first-time screening results on subsequent screening behavior, and to calculate performance metrics after multiple years of screening. Breast cancer screening uptake in the US should continue to be monitored to measure response to policy changes and the sequelae of screening initiation; this will inform evaluations of screening at the population level and could ultimately improve the overall quality of breast cancer screening.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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ABBREVIATIONS

ACA	Affordable Care Act
BMI	Body Mass Index
BRFSS	Behavioral Risk Factor Surveillance System
BWH	Brigham and Women's Hospital

CI	Confidence Interval
DH	Dartmouth-Hitchcock Health System
EHR	Electronic Health Record
HR	Hazard Ratio
NCI	National Cancer Institute
PROSPR	Population-Based Research Optimizing Screening through Personalized Regimens
US	United States
USPSTF	United States Preventive Services Task Force

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Fig. 1.

Fig. 1a Unadjusted cumulative incidence curves of age at first breast cancer screening after turning 40 years of age by PROSPR primary care network

Fig. 1b Unadjusted cumulative incidence curves of age at first breast cancer screening after turning 40 years of age by health insurance type

Fig. 1c Unadjusted cumulative incidence curves of age at first breast cancer screening after turning 40 years of age by quartiles of ZIP code level annual median household income

Fig. 1d Unadjusted cumulative incidence curves of age at first breast cancer screening after turning 40 years of age by number of primary care visits during the year of the 40th birthday

Table 1

Characteristics of women turning 40 years of age (2011–2013)

Characteristics	Total eligible ^a (N=3,413) n (%)	Screening received ^a (N=1,098) n (%)	Kaplan-Meier estimated cumulative incidence at 2 years %
PROSPR primary care network			
Dartmouth-Hitchcock Health System	1992 (58.4)	548 (49.9)	39.8
Brigham and Women's Hospital	1421 (41.6)	550 (50.1)	62.9
Race/ethnicity			
Non-Hispanic white	2414 (70.7)	738 (67.2)	45.0
Non-Hispanic black	277 (8.1)	96 (8.7)	49.3
Hispanic	379 (11.1)	155 (14.1)	64.3
Non-Hispanic Asian/Pacific Islander	182 (5.3)	68 (6.2)	55.8
Non-Hispanic American Indian/c Native/multiple races/other race/unknown ^b	161 (4.7)	41 (3.7)	—
BMI (kg/m ²)			
<25	1062 (38.5)	372 (40.0)	53.4
25 – <30	732 (26.6)	243 (26.1)	50.0
30 – <35	473 (17.2)	164 (17.6)	51.4
35+	489 (17.7)	151 (16.2)	49.6
Unknown	657	168	
Health insurance			
Medicaid	374 (11.2)	107 (9.8)	41.4
Medicare	128 (3.8)	37 (3.4)	43.7
Commercial/private/other	2656 (79.3)	920 (84.6)	50.9
Uninsured	190 (5.7)	23 (2.1)	21.8
Unknown	65	11	
ZIP code level annual median household income (quartiles)			
Q1: \$ 52,000	845 (25.1)	228 (21.0)	45.2
Q2: \$ 52,001–\$ 69,000	875 (26.0)	289 (26.6)	45.5
Q3: \$ 69,001–\$ 87,000	830 (24.7)	281 (25.8)	50.1
Q4: \$ 87,001	812 (24.2)	290 (26.7)	50.3
Unknown	51	10	
Number of primary care visits in the calendar year			
0	1403 (41.1)	181 (16.5)	22.4
1 visit	2010 (58.9)	917 (83.5)	62.3
1 visit	913 (26.8)	383 (34.9)	59.5
2 visits	502 (14.7)	228 (20.8)	62.7
3+ visits	595 (17.4)	306 (27.9)	66.2
Unknown	0	0	
Charlson comorbidity index			
0	2645 (93.4)	795 (91.3)	43.8

Characteristics	Total eligible ^a (N=3,413)	Screening received ^a (N=1,098)	Kaplan-Meier estimated cumulative incidence at 2 years
	n (%)	n (%)	%
1	127 (4.5)	57 (6.5)	66.4
2+	60 (2.1)	19 (2.2)	40.9
Unknown	581	227	
Primary care provider type and specialty			
General internal medicine ^c	1979 (66.1)	725 (72.0)	55.1
Family and community medicine ^c	884 (29.5)	245 (24.3)	40.7
Obstetrics and gynecology; other ^c	32 (1.1)	6 (0.6)	—
Physician assistant, nurse, midwife	97 (3.2)	31 (3.1)	44.8
Unknown	421	91	

^aIncludes women with no prior breast cancer, or documented or self-reported breast imaging in the 2 years prior to the 40th birthday. A first screening exam is defined as an exam with an indication of screening.

^bGroups were combined for masking purposes due to cell sizes <5.

^cIncludes MDs, DOs, fellows, and residents.

Table 2

Associations between characteristics and breast cancer screening initiation after turning 40 years of age

Characteristics ^a	HR	95% CI	Adjusted HR ^b	95% CI
PROSPR primary care network				
Dartmouth-Hitchcock Health System	Reference		Reference	
Brigham and Women's Hospital	1.92	1.70–2.16	2.65	2.33–3.01
HR stratified by primary care network Adjusted HR stratified by primary care network ^c				
Characteristics ^a	HR	95% CI	HR ^c	95% CI
Race/ethnicity				
Non-Hispanic white	Reference			
Non-Hispanic black	0.96	0.76–1.20	—	
Hispanic	1.13	0.94–1.37	—	
Non-Hispanic Asian/Pacific Islander	1.16	0.90–1.49	—	
BMI (kg/m ²)				
<25	Reference			
25 – <30	0.92	0.79–1.09	—	
30 – <35	0.99	0.83–1.19	—	
35+	0.86	0.71–1.04	—	
Health insurance				
Commercial/private/other	Reference		Reference	
Medicaid	0.71	0.58–0.86	0.72	0.58–0.88
Medicare	0.70	0.51–0.98	0.55	0.39–0.77
Uninsured	0.34	0.22–0.51	0.37	0.25–0.57
ZIP code level annual median household income (quartiles)				
Q1: \$ 52,000	0.81	0.68–0.97	0.83	0.69–1.00
Q2: \$ 52,001–\$ 69,000	1.00	0.85–1.18	1.08	0.92–1.28
Q3: \$ 69,001– \$ 87,000	1.04	0.88–1.22	1.05	0.89–1.24
Q4: \$ 87,001	Reference		Reference	
ZIP code level annual median household income (dichotomous)				
\$ 52,000	0.80	0.69–0.93	0.79	0.68–0.92
> \$ 52,000	Reference		Reference	
Number of primary care visits in the calendar year				
0	Reference		Reference	
1 visit	4.80	4.09–5.64	4.99	4.23–5.89
1 visit	4.02	3.37–4.80	4.14	3.45–4.97
2 visits	5.16	4.24–6.29	5.35	4.36–6.55
3+ visits	6.23	5.16–7.51	6.78	5.58–8.23
p for trend ^d		p<0.0001		p<0.0001
Charlson comorbidity index				
0	Reference			

Characteristics ^a	HR	95% CI	Adjusted HR ^b	95% CI
1	1.23	0.93–1.63	—	
2+	0.76	0.48–1.20	—	
Primary care provider type and specialty				
General internal medicine	Reference			
Family medicine	0.84	0.70–1.01	—	
Physician assistant, nurse, midwife	0.90	0.63–1.30	—	

Abbreviations: CI=confidence interval, HR=hazard ratio

^aWomen were censored at the time of diagnostic imaging, cohort exit, or when turning 42 years of age, whichever occurred earlier.

^bAdjusted for number of primary care visits, median income, and health insurance status.

^cStratified by primary care network and adjusted for number of primary care visits, median income (quartiles), and health insurance status (except if they were the variable of interest). Having 1 primary care visit in the calendar year is stratified by primary care network and adjusted for median income (quartiles) and health insurance status.

^dP for trend is among those with at least one primary care visit during the calendar year of the 40th birthday.