Identify Factors for Insufficient (>2yr) Mammogram Screening among Oregonian Women

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Abstract

Purpose: Women with breast cancer diagnosed from mammogram screenings have a lower mortality risk than women diagnosed from symptoms. Currently, the U.S Preventive Services Task Force recommends biannual screening for women aged 50-74 years old. In this study, we aimed to identify factors associated with inadequate screening defined as “no mammogram screening within past 2 years” to guide cancer prevention and early detection efforts.

Methods: This study utilized area-based probabilistic sampling survey data, collected across Oregon in 2019. Dataset weights were calculated using a raking approach. Demographic and behavior information were collected with existing validated questionnaire items from national surveys. Weighted multivariable logistic regression analyses with missing-value imputations were conducted to identify factors associated with inadequate mammogram screening.

Results: The study included 254 women 50-74 years-old without previous breast or ovarian cancer history. 19.29% of the sample reported no mammogram within two years, including 1.57% with no previous mammograms. Following unadjusted analyses, the significant factors included education, occupation status, health insurance and smoking and were therefore included into the adjusted model. In the multivariate adjusted model education remained significant while occupation status, health insurance and smoking were no longer significant. Compared to women with a college graduate degree, women with less than college graduate degree were at higher risk of inadequate screening [OR (95% CI) =3.23 (1.54, 6.74)].

Conclusions: Lack of education was significantly associated with inadequate mammogram screening even after adjusting for occupation status, health insurance and smoking, which should prompt further outreach and education.

Introduction

According to the American Cancer Society’s biannual report, the female breast cancer incidence rate in the US has risen slightly (0.3%) over the most recent five-year period (2012–2016) (1). During 1998–2011, the annual mortality decrease was 1.9% but slowed to 1.3% between 2011 and 2017 (1). Breast cancer remains the second most common cause of cancer-related death, and the most common cancer diagnosed in women (excluding skin cancer) (1). Further, nearly 1 in 8 American women (13%) in their lifetime will be diagnosed with invasive breast cancer, and 1 in 39 women (3%) will die from it. (1)

Fortunately, breast cancer incidence and death risk can be mitigated through regular mammogram screenings (2). Women diagnosed with breast cancer following a screening mammogram are at a 39% lower risk of mortality than women diagnosed due to symptoms such as a breast lump, as screenings usually catches tumors at lower stages for earlier treatment with higher odds of success (3, 4). Currently, the United States Preventive Service Task Force (USPSTF) recommends biannual screening for those aged 50–74 years old (5). Thus, a two-year maximum between screenings should be observed. Yet, only

72.7% of White, 72.9% of Black, and 70.5% of Asian women nationally meet these guidelines, while the percentage among American Indians/Alaska Natives was even lower (6).

Some women cannot, or do not, participate in regular mammogram screening. One financially prohibitive factor is lack of health insurance; women with health insurance have a higher mammogram screening rate (75%) than women without (39%) (7). However, many insured women still do not get screened, pointing to additional factors like underinsurance, family income, and type or source of insurance (8, 9). Experiential and psychological factors may also play a role in mammogram screening rates. Pain and embarrassment associated with the mammographic protocol, lack of trust in healthcare or insufficient cultural competency of hospitals and doctors, fear of bad news, and reluctance due to perceived susceptibility to breast cancer have previously been cited as barriers (9–12). Other observed risk factors for failing to completing mammogram screenings include language barriers, lack of transportation, younger age, more recent health plan acquisition, and obesity (8, 10). Modesty norms amid differing cultural groups also contributes to differing screening adherence rates (12). Conversely, frequently reported motivators were perceived benefits of early detection for cancer management and the belief that mammograms can detect pre-symptomatic breast cancer (11).

In Oregon, incidence of female breast cancer in 2013–2017 was 125.5 (per 100,000), compared to the United States average of 125.9, with an *in situ* rate of 25.4 (per 100,000), compared to the national 29.8. According to the Behavioral Risk Factor Surveillance System (BRFSS) data, an average of 78.27 percent of women aged 50–74 years old have had a mammogram in the last two years (13). Given the efficacy of mammogram screenings at reducing the risk of death due to breast cancer, it is important to understand both the factors contributing to less frequent screening behaviors and actions that can mitigate them. In this study, we aim to identify factors associated with less frequent mammogram behavior (i.e. no mammogram within two years) in the studied Oregon population to help guide cancer prevention and early detection efforts, locally and on a wider scale.

Methods

Survey Overview

This study utilized data collected from a health assessment survey among Oregon adults (Understanding Cancer in Oregon; “U-Can Oregon”) aligned with similar work conducted at other NCI-designated cancer centers. The one-year U-Can Oregon project aimed to create infrastructure for conducting catchment area health assessment through both probabilistic (representative sample reached via U.S. mail, email or phone) and non-probabilistic (social media and community events) approaches. We present only methods and data from the probabilistic sample, from Oregon residents that were randomly selected from a randomly ordered list provided by Marketing System Group, in this paper.

We utilized a survey landing page on the OHSU website linked to with redirecting URLs. Recruitment was carried out mainly by mailed invitation. Our initial letter (in English and Spanish) went out to our

randomly selected Oregon residents on March 22, 2019 via a printing and mailing service in Portland (Ad-Mail, Inc.), followed by three subsequent letters or postcard mailings, with an offer to win one of ten \$100 gift cards along with the opportunity to complete the survey online. The unique email account ucanoregon@ohsu.edu and webpage (Commonspot URL) were used for recruitment and participant assistance.

The primary data collection included core demographic and behavioral measures identified by National Cancer Institute and other cancer center grantees, supplemented with Oregon-specific data collection. We aimed to obtain detailed data regarding knowledge, attitudes, and preferences toward cancer prevention, cancer control, clinical trial participation and information-seeking behaviors, to enhance the breadth of national and state data with additional targeted support. Our ultimate goal was to better identify health disparities, knowledge and perceptions from our diverse catchment area regarding cancer risk, nutrition, physical activity, genetic screening, and access to health information technology. The U-Can Oregon study was approved by the Oregon Health & Science University Institutional Review Board (IRB #STUDY00018473).

Study Sample

Figure 1 shows the sample flow of participants included in our analyses. Our original probability sample design was stratified by rural and urban status, collected via an address-based survey defined by census blocks. We established a professional service contract with the Marketing Services Group for a probability sample of 15,000 (~ 10,000 urban and 5,000 rural) Oregon addresses. A total of 779 eligible responses were collected, for a response rate of 5% (from an originally planned 10% response rate of ~ 1,500). We used email, postcards, and mail to recruit for and administer the survey. The online survey was administered via a recruitment and survey administration tool (Qualtrics International Inc., Provo, Utah and Seattle, Washington). The survey was available in English and Spanish on OHSU's Qualtrics survey platform. Respondents were asked their rural/urban residence, age, education, race/ethnicity, occupational status, weight without shoes, height without shoes, cancer history, health insurance status, and mammography history. For the current analyses, we included female respondents aged 50–74 years old without previous history of breast or ovarian cancer. Exclusion criteria included those outside the age range of 50–74 and/or identified as male, or lacked data on age, lifestyle or cancer attitudes and beliefs, or a history of breast cancer or ovarian cancer. A final sample of 254 women was analyzed in this study.

Outcomes and Covariates

This study utilized area-based probabilistic sampling survey data collected via the U-Can Oregon project in 2019, as described above. Our primary outcome for this paper is “Insufficient (> 2 year) Mammogram” identified from the question “How long has it been since you had your last mammogram?” given to respondents, informed by current screening guidelines. The six choices included within the past 1, 2, 3, or 5 years, as well as more than five years, or a preference to not answer. Weights for the dataset were calculated using a raking approach, an iterative form of post-stratification for the use of multiple variables with finer categories to refine weights. A weighted multivariable logistic regression analysis then

identified factors associated with no recent mammogram within 2 years, considered by this study as 'insufficient.' Covariates included urban or rural residence, race/ethnicity identification, education, marital status, occupation status, BMI, cancer history, insurance status, smoking, mammogram screening knowledge, and an array of cancer beliefs. A composite score for cancer beliefs was calculated based on 5 questions (Table 2), with higher total scores representative of more proactive, optimistic beliefs.

Table 1
Demographic Characteristics of Adult Oregon Women Participating in the Survey

Participant Characteristics	Probability Sample Unweighted	Probability Sample Weighted
	n (%)	
Rural/Urban Status (n = 254)		
Urban	153 (60.24)	468,402 (79.58)
Rural	101 (39.76)	120,161 (20.42)
Age Group (n = 254)		
50–64	127 (50.00)	390,278 (66.31)
65–74	127 (50.00)	198,285 (33.69)
Race/Ethnicity (n = 254)		
Non-Hispanic White	242 (95.28)	561,195 (95.35)
Others	12 (4.72)	27,368 (4.65)
Education (n = 251)		
Not college graduate	95 (37.85)	200,996 (34.62)
College graduate	156 (62.15)	379,596 (65.38)
Marital Status (n = 252)		
Married/Living as married	166 (65.87)	379,076 (65.22)
Divorced/widowed/separated	66 (26.19)	152,618 (26.26)
Never Married	20 (7.94)	49,545 (8.52)
Occupation Status ¹ (n = 251)		
Employed	84 (33.47)	230,163 (39.64)
Students/Retired	125 (49.80)	227,225 (39.14)
Unemployed	42 (16.73)	123,204 (21.22)
BMI (n = 237) ²		
Underweight/normal weight	91 (38.40)	233,268 (42.26)
Overweight	72 (30.38)	148,723 (26.94)
Obese	74 (31.22)	169,996 (30.80)

Participant Characteristics	Probability Sample Unweighted	Probability Sample Weighted
Ever Had Cancer (n = 252) ³		
Yes	63 (25.00)	140,684 (24.20)
No	189 (75.00)	440,554 (75.80)
Health Insurance (n = 252) ⁴		
Private	105 (41.67)	295,049 (50.39)
Public	131 (51.98)	248,113 (42.37)
Some other source/No insurance	16 (6.35)	42,424 (7.24)
Smoking (n = 254)		
Never smokers	160 (62.99)	373,484 (63.46)
Past or current smokers	94 (37.01)	215,079 (36.54)
Ever had mammogram (n = 254)		
Yes	250 (98.43)	578,670 (98.32)
No	4 (1.57)	9,893 (1.68)
Had mammogram in the previous 2 years (n = 254)		
Yes	205 (80.71)	470,156 (79.88)
No	49 (19.29)	118,407 (20.12)
<p>Note:</p> <p>1. "Unemployed" includes those disabled and homemaker.</p> <p>2. Inadequate sample size for underweight group (n < 5), so underweight and normal weight groups are combined.</p> <p>3. This study excluded women with history of breast cancer or ovarian cancer, therefore, history of cancer doesn't include these two cancer types.</p> <p>4. Private insurance includes "a plan purchased through an employer or union (plans purchased through another person's employer)" or "a plan that your or another family member buys on your own"; Public insurance includes "Medicare", "Medicaid or other state program" or "TRICARE (formerly CHAMPUS), VA, or Military", or "Alaska Native, Indian Health Service, Tribal Health Services".</p>		

Statistical Analyses

Demographic, behavioral and cancer beliefs data were regrouped depending on the sample size. Perceptions about the cause and prevention of cancer (cancer beliefs) were assessed from targeted questions (Table 2) and the previously mentioned composite score was calculated, for descriptive weighted analyses. For probability samples, the sampling weights were developed with both design weights and post-stratification non-response for each stratum, to represent the catchment area. Specifically, we submitted population control totals to support weight calculations by ICF International. ICF supplemented the OHSU population totals with 2017 American Cancer Society data for more refined age categories. A two-dimensional raking approach was implemented using post-stratification variables that included rural/urban residence by two-level age (18–64, 65+) by gender and three-level age (18–44, 45–64, and 65+). The SurveyFreq procedure in the SAS 9.4 system was used to calculate weighted frequencies and percentages of each variable in the probabilistic sample.

For analyses of factors in association with no mammogram in the previous 2 years, we used multivariable survey logistic regression incorporating survey weights (SurveyLogistic). The unadjusted logistic regression models (bivariate analyses) for age, marital status, race/ethnicity, education level, occupational status, history of cancer, insurance status, rural/urban residence, cancer beliefs, knowledge and attitudes were conducted separately. Each variable associated with insufficient (> 2 year) mammogram screening at $p < 0.10$ in the bivariate analyses (unadjusted model) was included in the multivariable logistic regression. Correlations between selected covariates in the multivariable logistic regression model were conducted and multicollinearity was examined through the Variance Inflation Factor and Tolerance. We used hot deck imputation method to impute missing values of the covariates in the model. This involved replacing the missing value with a randomly selected value from the pool of potential donor values (14). An approximate Bayesian bootstrap method was also used (14). All analyses used SAS 9.4 (SAS Institute Inc., Cary, NC). Statistical significance was determined using two-sided tests, and a $p \leq 0.05$ was considered statistically significant.

Results

Table 1 and Table 2 provide descriptive analyses of demographic, cancer belief, mammogram screening knowledge, and cancer attitude characteristics with weighted percentages for the survey respondents. The study included 254 women with a median age of 64.5 years. 19.29% of the sample lacked a mammogram within the previous 2 years, including 1.57% having no previous mammogram at all.

Table 3 shows the weighted logistic regression analyses among the eligible women using three different models. The unadjusted model shows results for each of the following individual variables: urban or rural residence, age, race/ethnicity, education, marital status, occupation status, BMI, cancer history, insurance status, smoking history, cancer beliefs, knowledge of mammogram screening starting age, and cancer attitudes. Education, occupation status, health insurance and smoking showed statistically significant associations with the outcome of inadequate mammogram screening. The multicollinearity diagnostic test did not show a threat of multicollinearity through tolerance and variance inflation factor. Therefore, education, occupation status, health insurance and smoking were included in the multivariable adjusted

model both with and without imputation on missing values. Before applying imputation, we found women with below a college graduate degree were at higher risk of inadequate screening [OR (95% CI) = 3.39 (1.60, 7.21)] compared to women with a college graduate degree. This significance persisted after applying imputation methods on the missing values. The corresponding statistics were [OR (95% CI) = 3.23 (1.54, 6.74)].

Table 2
Oregon Adult Women's Cancer-related Beliefs, Screening Knowledge, and Attitudes

Participant Characteristics	Probability Sample Unweighted	Probability Sample Weighted
Cancer Beliefs	n (%)	
There are so many different recommendations about preventing cancer, it's hard to know which ones to follow (n = 237)		
Agree	163 (68.78)	380,918 (68.68)
Disagree	74 (31.22)	173,677 (31.32)
Cancer is most often caused by a person's behavior or lifestyle (n = 249)		
Agree	127 (51.00)	283,183 (49.17)
Disagree	122 (49.00)	292,749 (50.83)
It seems like everything causes cancer (n = 252)		
Agree	116 (46.03)	272,684 (46.57)
Disagree	136 (53.97)	312,902 (53.43)
When I think about cancer, I automatically think about death (n = 253)		
Agree	121 (47.83)	294,933 (50.42)
Disagree	132 (52.17)	289,967 (49.58)
There's not much you can do to lower your chances of getting cancer (n = 254)		
Agree	27 (10.63)	52,439 (8.91)
Disagree	227 (89.37)	536,124 (91.09)
Composite score of cancer beliefs (n = 231) ¹		
5–7	8 (3.46)	16,199 (2.98)
8–11	106 (45.89)	258,116 (47.57)
12–15	92 (39.83)	208,902 (38.50)
16–20	25 (10.82)	59,433 (10.95)

Participant Characteristics	Probability Sample Unweighted	Probability Sample Weighted
Knowledge of mammogram screening starting age (n = 239)		
Correct	185 (77.41)	438,352 (78.74)
Incorrect	54 (22.59)	118,348 (21.26)
Cancer Attitudes		
Compared to other people your age, how likely are you to get cancer in your lifetime (n = 248)		
Less likely	74 (29.84)	170,665 (29.51)
Same	124 (50.00)	285,051 (49.29)
More likely	50 (20.16)	122,641 (21.21)
I'd rather not know my chance of getting cancer (n = 247)		
Agree	56 (22.67)	138,014 (24.14)
Disagree	191 (77.33)	433,665 (75.86)
<p>Note:</p> <p>1. Composite score calculated from 5 questions listed above with 4 Likert scale response: "Strongly agree, somewhat agree, somewhat disagree and strongly disagree. The table presents "Agree" category which includes "Strongly agree" and "somewhat agree"; the "Disagree" category includes "somewhat disagree" and "strongly disagree" responses. The range is from 0–20.</p>		

Table 3

Logistic Regression for Insufficient (> 2 year) Mammogram Screening among women 50–74 years old among Probability Sample

Participant Characteristics	<i>Unadjusted OR (95% CI)</i>	<i>Adjusted OR (95% CI) ¹</i>	<i>Adjusted OR (95% CI) with Imputed Missing Values ²</i>
Urban Rural Status			
Urban	1.00 (ref)	□	□
Rural	0.82 (0.40, 1.68)	□	□
Age (1-year old increase)	1.00 (0.95, 1.05)	□	□
Race/Ethnicity			
Non-Hispanic White	1.00 (ref)	□	□
Non-White	0.72 (0.15, 3.59)	□	□
Education			
College graduate	1.00 (ref)	1.00 (ref)	1.00 (ref)
Not college graduate	3.84 (1.88, 7.86)	3.39 (1.60, 7.21)	3.23 (1.54, 6.74)
Marital Status			
Married/Living as married	1.00 (ref)	□	□
Divorced/widowed/separated	1.64 (0.76, 3.57)	□	□
Never Married	1.61 (0.49, 5.35)	□	□
Occupation Status			
Employed	1.00 (ref)	1.00 (ref)	1.00 (ref)
Students/Retired	1.32 (0.57, 3.05)	1.10 (0.35, 3.47)	1.16 (0.41, 3.33)
Unemployed	2.95 (1.16, 7.48)	1.53 (0.48, 4.91)	1.90 (0.62, 5.80)
BMI			
Under/Normal weight	1.00 (ref)	□	□
Overweight	1.05 (0.46, 2.42)	□	□

Participant Characteristics	<i>Unadjusted OR (95% CI)</i>	<i>Adjusted OR (95% CI) ¹</i>	<i>Adjusted OR (95% CI) with Imputed Missing Values ²</i>
Obese	0.99 (0.41, 2.39)	□	□
Ever Had Cancer			
No	1.00 (ref)	□	□
Yes	0.59 (0.25, 1.38)	□	□
Health Insurance			
Private	1.00 (ref)	1.00 (ref)	1.00 (ref)
Public	1.97 (0.92, 4.24)	1.77 (0.61, 5.16)	1.33 (0.49, 3.55)
Other source/No insurance	5.67 (1.66, 19.35)	3.94 (0.89, 17.38)	2.81 (0.64, 12.33)
Smoking			
Never smokers	1.00 (ref)	1.00 (ref)	1.00 (ref)
Past or current smokers	2.11 (1.05, 4.25)	1.24 (0.61, 2.54)	1.61 (0.79, 3.29)
Cancer Belief score (1-point increase)	1.05 (0.93, 1.18)	□	□
Knowledge of Mammogram Starting Age			
Correct	1.00 (ref)	□	□
Incorrect	0.98 (0.42, 2.31)	□	□
Compared to other people your age, how likely are you to get cancer in your lifetime ³			
Less likely	0.81 (0.35, 1.85)	□	□
Same	1.00 (ref)	□	□
More likely	1.33 (0.55, 3.20)	□	□
I'd rather not know my chance of getting cancer			
Agree	1.00 (ref)		

Participant Characteristics	Unadjusted OR (95% CI)	Adjusted OR (95% CI) ¹	Adjusted OR (95% CI) with Imputed Missing Values ²
Disagree	0.68 (0.31, 1.51)	□	□
<p>Note:</p> <p>1. Variables included in the adjusted model were based on unadjusted model results. Each variable associated with Insufficient (> 2 year) Mammogram Screening at p < 0.10 in the bivariate analyses (unadjusted model) was included in the multivariable logistic regression.</p> <p>2. Hot deck imputation method was used to impute missing values of the covariates in the model.</p> <p>3. The cancer belief score is a composite score calculated from 5 questions listed above with 4 Likert scale: “Strongly agree, somewhat agree, somewhat disagree and strongly disagree. The table presents Agree category which includes “Strongly agree” and “somewhat agree”; the “Disagree” category includes “somewhat disagree” and “strongly disagree” responses. The range is from 0–20. It is calculated as a continuous variable in the logistic regression model.</p>			

Discussion

In this survey study conducted in Oregon through random sampling, our major finding was that lack of college degree education was associated with no mammogram screening in the previous two years, supporting existing findings. This is a clinically relevant modifiable risk factor, as screening attendance also predicted outcomes of breast cancer itself.

Education is a commonly used proxy variable for socioeconomic status (SES) (15, 16) and is less likely than other variables to be influenced by diseases in adulthood (17). During 2015–2019, the percentage of the population 25 years and older with at least a college graduate degree increased to 32.1% compared to 27.5% from 2005–2019 (18). Other SES factors in our study, including occupation status and health insurance, were also significantly correlated with education and suggest additional significant disparities in timely use of mammogram screening between SES groups in Oregon.

Our finding is consistent with a previous meta-analysis that women with highest education were more likely to adhere to breast cancer screening guidelines (19). In contrast, lower education was associated with other breast cancer risk factors such as smoking (20), decreased physical activity (21), and obesity (22). Therefore, improving mammogram use through targeting people with lower education may necessitate a multi-faceted approach to address lifestyle habits, pre-existing health conditions, and environmental and psychological factors to eliminate disparities due to education.

Women may refrain from engaging in breast cancer presentational mammogram screening due to lack of knowledge regarding the risks of breast cancer. In a study examining women’s views on breast cancer primary prevention and sources of health care information, 75% of women aged 50–74 years would prefer to receive health information from within, as opposed to outside, health care settings (23).

Therefore, further incorporating breast cancer risk assessments into the primary health care settings may improve mammogram usage.

While there is existing research that has shown evidence of higher education being linked with higher risk of breast cancer (24–26), in particular, *in situ* breast cancer (26), these findings must be considered within context. Beyond the reproductive factors such as nulliparity status and age at first birth, women with more education tend to undergo more frequent mammogram screenings, and consequently have more opportunities to detect cancer in screening and receive cancer diagnoses at earlier stages.

Our finding that women with lower education participated less in mammography screening supports calls for increased outreach efforts to these women. Research has suggested reluctance towards preventative care, from cancer screenings to annual wellness visits, could stem from perceptual factors such as anticipated shaming by medical professionals and perceptions related to SES status. In a qualitative study on how SES status affects patient perceptions of health care, most subjects believed that their SES influenced the health care they received (27). Additionally, physicians perceive and treat patients of low SES differently than those of high SES (28), but few acknowledge or notice their susceptibility to this implicit bias (29). Given that attitudes and biases of healthcare provider's may affect clinical decision-making including appropriate mammogram screening recommendations, the lower rates of mammogram screening among lower SES women reflect the impact of not only patient attitudes and experiences, but also those of the providers making medical recommendations and orders.

We also identified lack of insurance as another potentially significant risk factor in the unadjusted model. Although the significance disappeared after adjusting for education, perhaps due to our small sample size, the magnitude of the association was consistent with current literature associating lack of insurance with lower screening rates (30). Further, in insured women, lower family income has been associated with lower screening rates; a Medicare study reported women with a family income under the federal poverty level screened at a depressed rate of 51% (8, 9). Additionally, those with fee-for-service care are less likely to screen than peers in health maintenance organizations, and those with public insurance are less likely than peers with private insurance (9). Further investigation into this association with a larger population can further support this connection.

Notably, we found no difference between our urban and rural populations. This may reflect successful efforts to encourage screening in rural Oregon, given previous literature has suggested a disparity and encouraged intervention (31, 32). Also, neither mammogram screening knowledge nor perception of cancer beliefs and cancer attitudes were associated with insufficient screening, suggesting that external factors such as access to health care or lack of health care provider recommendation or guidance may play more critical roles.

The results from this study are helpful in identifying intervention points to improve timely mammogram screening among the general public. These interventions may target both the general public at the eligible screening age as well as healthcare providers. While educating the women who need mammogram screening and lack adequate education on the risks posed by breast cancer may encourage some to

change their screening behaviors, others may not or cannot change their behaviors. Health behaviors theories, including the Theory of Care Seeking Behavior, were developed to explain the reasons why people do or do not participate in health promotional programs such as mammogram screening (33). These theories are valuable in understanding and promoting participation in mammogram screening from its broader construct by incorporating habitual and external factors (34). From the perspective of healthcare providers, strategies for supporting and engaging women with lower educational attainment should be emphasized and implemented broadly in the healthcare setting to reduce harmful yet unintended stigmatization by healthcare providers that leads to less preventative care participation (35). These strategies include but are not limited to using non-judgmental vocabulary, and avoiding shame, blame or guilt.

Our study has many strengths, including the use of multiple survey administration and recruitment methodologies and analyses with a weighting strategy. Our limitations include low response rate and the lack of minority population participation. The latter may indicate inaccurate representation of the catchment area's general population, and our study had a slightly higher proportion of respondents with health care coverage than the Center for Disease Control's (CDC's) Behavioral Risk Factor Surveillance System (BRFSS) Oregon's estimates as well. Further investigation should also account for gender and race discordance between patient and provider to inform methods to increase both rates of screening recommendation and participation.

Conclusions

Our study identifies that lower education level was significantly associated with no mammogram in the previous 2 years among screening-age women in Oregon. Interventions to promote routine mammogram screening behaviors should more sensitively support and encourage women with lower education and thereby SES level to participate.

Abbreviations

ACR, American College of Radiology; ACS, American Cancer Society; USPSTF, United States Preventive Service Task Force; BMI, body mass index; BRFSS, Behavioral Risk Factor Surveillance System; CDC, Center for Disease Control; 95% CI: 95% confidence interval; NCI, National Cancer Institute; NHIS: National Health Interview Survey; OHSU, Oregon Health & Science University; OR, Odds Ratio; U-Can Oregon, Understanding Cancer in Oregon.

Declarations

Statements: Our study has not been published elsewhere nor has it been submitted simultaneously for publication elsewhere.

Statement of Potential Conflicts of Interest: The authors reported no potential conflict of interest.

Author contributions: Z Zhang was the primary investigator of the current analysis study; she conducted the primary analyses. JY Lim reviewed and revised the analyses. Z Zhang, G Curran, K Xu together wrote the first draft of the manuscript. J Shannon, PE Farris, and Z Zhang obtained funding and performed administrative, technical, or material support of the original parental study. All authors have interpreted the results and critically revised the manuscript for valuable intellectual content.

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DATA AVAILABILITY

The dataset analyzed and code used are available from the corresponding author on reasonable request.

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Figures

Figure 1

Analytic Sample Size of Probabilistic Sample Flow Chart