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The association between rurality, sociodemographic characteristics, and mammogram screening outcomes among a sample of low-income uninsured women

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ABSTRACT

Studies have found a positive association between adherence to mammography screening guidelines and early detection of breast cancer lesions, yet the proportion of women who get screened for breast cancer remains below national targets. Previous studies have found that mammography screening rates vary by sociodemographic factors including race/ethnicity, income, education, and rurality. It is less known whether sociodemographic factors are also related to mammography screening *outcomes* in underserved populations. Thus, with a particular interest in rurality, we examined the association between the sociodemographic characteristics and mammography screening outcomes within our sample of 1,419 low-income, uninsured Texas women who received grant-funded mammograms between 2013 and 2019 (n = 1,419). Screening outcomes were recorded as either negative (Breast Imaging Reporting and Data System (BI-RADS) classification 1–3) or positive (BI-RADS classification 4–6). When we conducted independency tests between sociodemographic characteristics (age, race/ethnicity, rurality, county-level risk, family history, and screening compliance) and screening outcomes, we found that none of the factors were significantly associated with mammogram screening outcomes. Similarly, when we regressed screening outcomes on age, race/ethnicity, and rurality via logistic regression, we found that none were significant predictors of a positive screening outcome. Though we did not find evidence of a relationship between rurality and mammography screening outcomes, research suggests that among women who do screen positive for breast cancer, rural women are more likely to present with later stage breast cancer than urban women. Thus, it remains important to continue to increase breast cancer education and access to routine cancer screening for rural women.

1. Introduction

Although much progress has been made in screening and detection rates, breast cancer still remains the most common form of cancer among American women (American Cancer Society, 2021). It is estimated that one in every eight American women will develop breast cancer over the course of their lifetime (Breast Cancer Risk in American Women, 2020).

Studies have indicated that there is a positive association between adherence to mammography screening guidelines and early detection of breast cancer lesions (Blanchard et al., 2004; Bleyer and Welch, 2012). Smigal et al. (2006) found that among women diagnosed with breast cancer, 40 to 50% had not had breast mammography screening within the past year (Smigal et al., 2006).

The Healthy People 2030 objective C-05 is to increase the proportion of women who get screened for breast cancer based on the most recent guidelines to 77.1%. (Cancer, 2021) Currently, the prevalence of breast mammography screening is about 5% below the desired target, and it

Abbreviations: BI-RADS, Breast Imaging Reporting and Data System; RUCAs, Rural-Urban Commuting Areas; ACOG, American College of Obstetricians and Gynecologists.

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has remained virtually unchanged over the past 15 years. (White et al., 2017) Suggested explanations for this variation include disparities in screening prevalence among ethnic groups, women of varying socioeconomic status, and birth origin. (White et al., 2017) Specifically, research has shown that mammography screening adherence is likely to be lower among women who are not of the White race, as well as among those who are uninsured, low income or have limited education, and among women who were born outside of the United States, particularly those who have lived in the U.S. for fewer than ten years. (American Cancer Society, 2021; White et al., 2017) In addition, rurality has been shown to have an impact on breast cancer screening rates (Henley et al., 2020; Tran and Tran, 2019). In particular, one recent study found that rurality had a small, but statistically significant negative effect on a woman's self-reported response to "ever having a mammogram" and "having a recent mammogram" (Tran and Tran, 2019).

To better understand disparities that exist in mammography screening outcomes among these underserved populations, we examined the sociodemographic characteristics of women who were screened for breast cancer in a grant-subsidized breast cancer screening and prevention program. Sociodemographic covariates included age, compliance to current screening guidelines, and county-level risk for breast cancer, family history, rurality, and race/ethnicity. Consequently, we examined the relationship between the sociodemographic characteristics of our study population and their mammography screening outcomes. To our knowledge, this is the first study examining the relationship between mammography screening outcomes and our primary variable of interest, level of rurality, in a low-income uninsured population.

2. Materials and methods

2.1. Data source

We conducted a retrospective review and statistical analysis of mammography screening data obtained from a grant-funded mammography screening project implemented at a university-affiliated family medicine clinic in central Texas. The dataset was provided under Texas A&M Institutional Review Board protocol 2013-0885D related to grant awards PP130090 and PP170037 from the Cancer Prevention and Research Institute of Texas.

2.2. Study sample

The total population served by the grant consisted of low-income, uninsured women ($n = 1,657$; household income $\leq$ 250% of federal poverty level) in a 17-county region of Texas who received free mammography screening between 2013 and 2019. Although the grant's target population consisted of women aged 40 years and older; younger women with a self-reported family history of breast cancer or those who had been recommended by a physician for mammography following clinical breast exam were also eligible for the program. This group of women (those younger than age 40) were excluded from analyses conducted as part of this study ($n = 108$) due to their inherently higher risk of receiving a positive screening outcome.

Our final study sample was composed of 1,419 initial mammogram outcomes (i.e., one per each unique woman served by the grant). Notably, while some women had received multiple free mammograms over the course of the 6-year observation period, only outcomes from their first routine mammogram met inclusion criteria for this study. The decision to exclude results from additional/future tests was made due to that, as structured, within our dataset there was no definitive way to systematically identify whether additional mammograms were additional routine screenings, screenings to clarify inconclusive results, or screenings used to confirm abnormal results. Our primary concern was that including the latter group, in particular, could obscure the true relationship between sociodemographic factors and outcomes of initial routine mammograms. In addition, sociodemographic information was collected from patients upon their initial intake into the grant program, rather than prior to every procedure. Thus, the likelihood that our key independent variables could became inaccurate increased with each additional (i.e., future) mammogram.

2.3. Outcome variable

Screening outcomes for all participants were recorded using the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) (see Appendix A) (Sickles et al., 2013). Screening outcomes were categorized into three groups, 0, 1–3, and 4–6. BI-RADS scores of 0 were considered incomplete and required follow-up, BI-RADS scores 1–3 were classified a negative outcome, and BI-RADS 4–6 were classified as positive outcomes, those with suspicious findings and required additional follow-up. Only women with definitive screening results were included in our final sample, so that all incomplete screening outcomes (BI-RADS 0) ($n = 137$) were excluded from our analysis, resulting in a final sample size of 1,419 women. Thus, for this study, screening outcomes were classified as a dichotomous variable (BI-RADS classification 1–3 = 1, BIRADS classification 4–6 = 0).

2.4. Independent variables

The main independent variable of interest was the level of rurality of a patient's residence, which was defined using a four-category summary measure of the Rural-Urban Commuting Areas (RUCAs) classification system: urban, large rural, small rural, and isolated. Race/ethnicity was grouped into four categories: White, Black, Hispanic, and other (i.e., Asian, American Indian/Alaskan Natives and Native Hawaiian/Pacific Islander). We used the American College of Obstetricians and Gynecologists (ACOG) (Mango et al., 2017) mammogram screening guidelines to determine compliance/non-compliance with screening guidelines. ACOG recommends screening mammograms at least biennially for women aged 40 to 74. Hence, to measure compliance, we only used data from women aged 42 years and older ($n = 1,301$) to avoid classifying women younger than 42 as non-compliant. Patients within this group were classified as compliant if they reported having a mammogram within the past two years and non-compliant otherwise. To determine county-level risk for breast cancer, we followed a similar process found in the breast cancer screening literature, (Brooks et al., 2013) wherein a county was classified as "high risk" if it had a breast cancer mortality rate higher than the average breast cancer mortality rate in Texas (Texas Cancer Registry, 2021) and if the percentage of persons living in poverty was higher than the state-wide average. (QuickFacts, 2021) Though, as a robustness check, we replicated our analysis with these variables included as individual covariates, rather than as a composite measure.

2.5. Analysis

Frequencies of screening outcomes were cross-tabulated to determine the percentage distribution across all age groups, race/ethnicities, levels of rurality, compliance to stipulated screening regimen, county-level risk for breast cancer, and family history. To examine the relationship between screening outcomes and patients' sociodemographic characteristics, we conducted a Pearson Chi-Square Test with the significance level set at 0.05 (see Table 1). Additionally, screening outcomes were regressed on age, race/ethnicity, rurality and county-level risk via logistic regression to explore each independent variable's ceteris paribus effect on the likelihood of receiving a positive screening outcome (BI-RADS 4–6). Reference categories used include the 40–49 age group for age, "White" for race/ethnicity, and "urban" for rurality. Two risk factors, family history and screening compliance, were determined to have too much missing data (17% and 23%, respectively) to include in the regression model, since observations with any missing data would be automatically dropped from the sample when the model

Table 1
Sociodemographic Characteristics of Low Income, Uninsured Women by their Mammographic Screening Outcomes (2013–2019).

	Number of Mammograms/ Women	Negative BI-RAD 1-3[a] n (%)	Positive BI-RAD 4-6[b] n (%)	P-value
Total	**1,419**	**1,390 (98.0)**	**29 (2.0)**	
Age				0.53
40–49	641	625 (97.5)	16 (2.5)	
50–59	546	537 (98.3)	9 (1.7)	
60–64	178	174 (97.8)	4 (2.3)	
65+	54	54 (100.0)	0 (0.0)	
Race/Ethnicity				0.40
White	346	338 (97.7)	8 (2.3)	
Black	205	202 (98.5)	3 (1.5)	
Hispanic	679	667 (98.2)	12 (1.7)	
Other	13	12 (92.3)	1 (7.7)	
Missing	176	171 (97.2)	5 (2.8)	
Rurality				0.47
Urban	839	821 (97.9)	18 (2.1)	
Large Rural	44	42 (95.5)	2 (4.6)	
Small Rural	241	238 (98.8)	3 (1.2)	
Isolated	284	279 (98.2)	5 (1.8)	
Missing	11	10 (90.9)	1 (9.1)	
County-level Risk				0.83
High	385	378 (98.2)	7 (1.8)	
Low	1,034	1,012 (97.9)	22 (2.1)	
Family History				0.12
Yes	208	202 (97.1)	6 (2.9)	
No	906	892 (98.5)	14 (1.6)	
Unknown	69	66 (95.7)	3 (4.4)	
Missing	236	230 (97.5)	6 (2.5)	
Compliance*				0.30
Yes	532	517 (97.2)	15 (2.8)	
No	459	451 (98.3)	8 (1.7)	
Missing	310	304 (98.1)	6 (1.9)	

*The compliance variable included only women age 42 years and older (n = 1,301). A women age 42 + years who had not had a mammogram screening in more than two years was classified as non-compliant.

Table 2
Multi Variable Logistic Regression.

Sociodemographic Characteristics	BI-RAD 4–6 Versus 1–3 (Positive Screening Outcome Compared to Negative)		
	Odds ratio	*95% CI*	*P-value*
Age			
50–59 vs 40–49	0.70	(0.27, 1.81)	0.46
60–64 vs 40–49	0.93	(0.20, 2.95)	0.70
65 + vs 40–49	<0.001*	(<0.001, >999.999)*	0.98
Race/Ethnicity			
Black vs White	0.73	(0.18, 2.87)	0.65
Hispanic vs White	0.64	(0.24, 1.72)	0.38
Other vs White	4.06	(0.44, 37.65)	0.22
Rurality			
Large Rural vs Urban	2.48	(0.52, 11.80)	0.26
Small Rural vs Urban	0.20	(0.02, 1.72)	0.14
Isolated vs Urban	0.66	(0.15, 3.00)	0.59
Living Risk			
Yes vs. No	1.69	(0.41, 7.05)	0.47

*Point estimates of the odds ratio and associated 95% CI could not be computed for women 65 + vs 40–49 due to lack of variation in the dependent variable (all women in the 65 + age category had a negative screening outcome).

is estimated. Odds ratios for each of four independent variables from the model are reported in Table 2. All statistical analyses were conducted in SAS software, version 9.4. (SAS Institute Inc, 2016)

3. Results

3.1. Descriptive characteristics

Table 1 provides descriptive statistics for our sample of women aged 40 or older (n = 1,419) who received mammograms through our grant-funded program between 2013 and 2019 and whose tests resulted in a definitive screening outcome (BI-RADS 1–3 or BI-RADS 4–6). Most of the study sample were between age 40 and 59 years at the time of their first mammogram screening with our program (45% were in the 40–49 age group and 38% were 50–59). More than half of the women (56%) who elected to self-report their ethnicity identified as Hispanic, roughly one quarter (28%) reported their race as White, and 16% reported their race as Black. More than two-thirds (73%) of the study sample resided in a low-risk county, while about 27% of the population studied resided in counties categorized as high-risk. About 18% of the women who shared information about their family history of breast cancer reported that someone in their family had been diagnosed with breast cancer. Of the total women aged 42 years and older who responded to questions related to their last mammogram screening (n = 991), roughly 54% had been screened in the past two years, while 46% of the respondents had not been.

3.2. Relationship between screening outcomes and sociodemographic variables

When we conducted independency tests between the sociodemographic characteristics and screening outcomes, we found that none of the included sociodemographic factors (age, race/ethnicity, rurality, county-level risk, family history, nor screening compliance) were significantly associated with the mammogram screening outcomes (Table 1).

Similarly, when we regressed age, race/ethnicity, and rurality on screening outcomes via multivariate logistic regression, we found that all else equal, none of the included covariates (age, race/ethnicity, rurality, county-level risk) were significant predictors of a positive screening outcome (Table 2).

In addition, we conducted a robustness check of the analyses described above wherein the two components of county-level risk, the county-level average breast cancer mortality rate and the county-level poverty rate, were included as separate covariates rather than as a single composite measure. We found that this alternative specification did not change the interpretation of the results.

4. Discussion

We found that after controlling for differences in age, race/ethnicity, county-level risk, family history, and screening compliance, increased level of rurality did not place a woman at a significantly higher risk of receiving a positive breast cancer screening outcome within our population of low-income uninsured women. These results are consistent with recent findings by Moss et al., which suggest that differences in breast cancer incidence by geographic location is mediated by socioeconomic status and density of primary care physicians (Moss et al., 2017). Our sample is inherently characterized by low socioeconomic status due to having met the financial need requirements in order to be served by our grant. In addition, most reside in counties that are either wholly or partially designated as medically underserved, is largely homogenous in terms of the factors that Moss, Liu, and Feuer found to be the most significant predictors of breast cancer incidence.

Like any study, ours is not without limitations. First, our study is limited by a relatively small sample size. This was due in part to a need to exclude 137 screenings with inconclusive results (BI-RADS 0) as well as those from 108 women who did receive services through our program but who were below the age of 40 and who would have introduced sample selection bias due to being at inherently higher risk of receiving a positive screening outcome. Another important consideration is that our sample consisted of women that were largely homogenous in terms of socioeconomic status, given that interested individuals were required to have a household income $\leq$ 250% of federal poverty level as well as be uninsured to be eligible to receive grant-funded screening services. Further, results from our grant-funded program, wherein screenings were provided with no out-of-pocket costs better describe a "free screen" scenario, than a "real world" scenario, wherein lack of affordability may play a large role in whether or not to pursue screening, as well as screening outcomes. Altogether, the unique characteristics of our sample may limit the generalizability of our results to other populations.

Finally, it is possible that the aforementioned limitations may have played a role in our inability to uncover a significant effect for some of the covariates included in our model. In particular, we were surprised to find that neither age nor race/ethnicity were significantly associated with screening breast cancer screening outcomes, given that research suggests that older women and non-Hispanic White women are at a greater risk of developing breast cancer (American Cancer Society, 2021; Breast Cancer Risk in American Women, 2020; White et al., 2017; Moss et al., 2017). In the United States, the overall median age of breast cancer diagnosis is 60, and the rate is lower for non-Hispanic white women, who are typically diagnosed at age 55 (Iqbal et al., 2015). Our sample of women was relatively young (83.6% younger than 60), making it difficult to capture this effect. Regarding race/ethnicity, research suggests that among White women, non-Hispanic women are at a significantly higher risk of being diagnosed with Stage I breast cancer, relative to Hispanic women (Iqbal et al., 2015). While not statistically significant, our results did support this finding. It is possible that with a larger sample size, variation would be sufficiently reduced as to have statistical confidence in this result.

Though we did not find that rurality was a significant predictor of positive breast cancer screening outcomes among our specific sample of low-income and racially/ethnically diverse women, previous research has found that among women who do screen positive for breast cancer, rural women are more likely to present with higher stage breast cancer than their urban counterparts (Obeng-Gyasi et al., 2020). In light of these disparities downstream, it remains vitally important to continue to increase breast cancer education and access to routine cancer screening for rural women.

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CRediT authorship contribution statement

Morgan Kassabian: Writing – original draft, Writing – review & editing, Methodology, Visualization. **Samson Olowolaju:** Formal analysis, Software, Data curation, Writing – original draft, Writing – review & editing, Visualization, Conceptualization. **Marvellous Akinlotan:** Conceptualization, Methodology, Writing – review & editing, Writing – original draft. **Anna Lichorad:** Funding acquisition, Investigation, Resources, Project administration, Writing – review & editing. **Robert Pope:** Funding acquisition, Investigation, Resources, Project administration, Writing – review & editing. **Brandon Williamson:** Funding acquisition, Investigation, Resources, Project administration, Writing – review & editing. **Scott Horel:** Data curation, Software, Conceptualization, Writing – review & editing. **Jane N. Bolin:** Funding acquisition, Supervision, Project administration, Resources, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A:. BI-RADS classification and diagnosis inference (Sickles et al., 2013; Brooks et al., 2013).

BI-RADS classifications	Diagnosis	Diagnosis inference
0	Incomplete	Mammogram or ultrasound did not give the radiologist enough information to make a clear diagnosis; follow-up imaging is necessary
1	Negative	There is nothing to comment on; routine screening recommended
2	Benign	A definite benign finding: routine screening recommended
3	Probably benign	Findings that have a high probability of being benign (>98 %); six-month short interval follow-up
4	Suspicious abnormality	Not characteristic of breast cancer, but reasonable probability of being malignant; biopsy
5	Highly suspicious of malignancy	Lesion that has a high probability of being malignant (>=95 %); biopsy
6	Known biopsy proven malignancy	Lesions known to be malignant that are being imaged prior to definitive treatment; assure that treatment

Source (Sickles et al., 2013; Brooks et al., 2013).

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