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

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\section*{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.

\section*{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...
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 ≤ 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 become 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 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 2

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

| Number of Mammograms/ Women | Negative BI-RAD 1–3 | Positive BI-RAD 4–6 | P-value |
|-----------------------------|--------------------|---------------------|--------|
| Total                       | 1,419              | 1,390               | 29 (2.0) |
| Age                         |                    |                     |        |
| 40–49                       | 641                | 625 (97.5)          | 16 (2.5) | 0.53 |
| 50–59                       | 546                | 537 (98.3)          | 9 (1.7)  |
| 60–64                       | 178                | 174 (97.6)          | 4 (2.3)  |
| 65+                         | 54                 | 54 (100.0)          | 0 (0.0)  |
| Race/Ethnicity              |                    |                     |        |
| White                       | 346                | 338 (97.7)          | 8 (2.3)  | 0.40 |
| 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                    |                    |                     |        |
| 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           |                    |                     |        |
| High                        | 385                | 378 (98.2)          | 7 (1.8)  | 0.83 |
| Low                         | 1,034              | 1,012               | 22 (2.1) |
| Family History              |                    |                     |        |
| 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*                 |                    |                     |        |
| Yes                         | 532                | 517 (97.2)          | 15 (2.8) |
| No                          | 459                | 451 (98.3)          | 8 (1.7)  |
| Missing                     | 310                | 304 (98.1)          | 6 (1.9)  | 0.30 |

*The compliance variable included only women age 42 years and older (n = 1,301). A women age 42 years and older (n = 1,301) 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 40–49                        | 0.70       | (0.27, 1.81) | 0.46 |
| 50–59                            | 0.93       | (0.20, 2.95) | 0.70 |
| 65+                              | <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, 0.20) | 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).
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 homogeneous in terms of socioeconomic status, given that interested individuals were required to have a household income ≤ 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 (Iqlab 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 (Iqlab 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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Morgan Kassabian: Writing – original draft, Writing & editing, Methodology, Visualization. Samson Olowolaja: 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 is necessary |

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

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