ARTICLE IN PRESS

American Journal of
Preventive Medicine

RESEARCH ARTICLE

Urbanicity, Income, and Mammography-Use Disparities Among American Indian Women

Eric W. Christensen, PhD,[1,2] Casey E. Pelzl, MPH,[1] Bhavika K. Patel, MD,[3] Ruth C. Carlos, MD, MS,[4] Elizabeth Y. Rula, PhD[1]

Introduction: Reported breast cancer screening among American Indian women is consistently below that of White women. The last claims-based trends were from 1991 to 2001. This study updates mammography trends for American Indian women and examines the impact of race, urbanicity, and income on long-term mammography use.

Methods: This was a multi-year (2005−2019), retrospective study of women aged 40−89 years using a 5% sample of Medicare fee-for-service beneficiaries residing in Arizona, California, New Mexico, Oklahoma, and Washington. This study used multivariable logistic regression to examine the impact of urbanicity and income on receiving mammography for American Indian women compared with that for White women. Analyses were conducted in 2022.

Results: Overall, annual age-adjusted mammography use declined from 205 per 1,000 in 2005 to 165 per 1,000 in 2019. The slope of these declines was significantly steeper (difference = −2.41, $p<0.001$) for White women (−3.06) than for American Indian women (−0.65). Mammography-use odds across all urbanicity categories were less for American Indian women than for White women compared with those of their respective metropolitan counterparts (e.g., rural: 0.96, 95% CI=0.77, 1.20 for American Indian women and 1.47, 99% CI=1.39, 1.57 for White women). Although residing in higher-income communities was not associated with mammography use for American Indian women, it was 31% higher for White women (OR=1.31, 99% CI=1.28, 1.34).

Conclusions: The disparity in annual age-adjusted mammography use between American Indian and White women narrowed between 2005 and 2019. However, the association of urbanicity and community income on mammography use differs substantially between American Indian and White women. Policies to reduce disparities need to consider these differences.
Am J Prev Med 2023;000(000):1−10.

INTRODUCTION

Among women, breast cancer is the most common cancer, with mortality second only to that of lung cancer.[1] Despite its high survivability with early detection and treatment,[2] regular breast cancer screening use among American Indian (AI) and Alaska Native (AN) women are consistently lower than that among women of other race/ethnicity (referred to as race in the remaining part of this article), resulting in less timely access to treatment.[3−12] In addition, AI women are more likely to have invasive breast cancer at a younger age[13] and a higher rate of late-stage breast cancer at diagnosis than White women, which leads to worse outcomes,[14,15] and the mortality rate of AI women varies regionally across the U.S.[16] Not surprisingly, there are substantial differences in mammography use regionally, by urbanicity, and by race.[17]

From the [1]Harvey L. Neiman Health Policy Institute, Reston, Virginia; [2]Health Services Management, University of Minnesota, St Paul, Minesota; [3]Department of Radiology, Mayo Clinic Arizona, Phoenix, Arizona; and [4]Division of Abdominal Radiology, University of Michigan, Ann Arbor, Michigan

Address correspondence to: Eric W. Christensen, PhD, Harvey L. Neiman Health Policy Institute, 1892 Preston White Drive, Reston VA 20191. E-mail: echristensen@neimanhpi.org.

0749-3797/$36.00
https://doi.org/10.1016/j.amepre.2023.01.013

The reasons for mammography disparities may include differences in premammography health, age, socioeconomic factors, health insurance providers or lack of insurance, out-of-pocket costs, access/proximity to providers, and sources of care.[7−12,18−22] For AI women, cultural factors, trust, and knowledge about mammography also impact mammography use.[6,8,18,23−25]

Considering these observations, this study had 2 objectives. The first is to provide an update on mammography trends for AI women during the 2005−2019 period using Medicare fee-for-service claims data. The last trend study using claims data that included AI women was for the 1991−2001 period.[11] The Centers for Disease Control and Prevention most recently provided mammography trends by race from 1987 through 2018 on the basis of the National Health Interview Survey[3]; however, it has been shown that self-reported mammography use is substantially higher than the use observed in claims data.[11,26] Other studies that report screening use by race are also based on survey data.[7,10,19] The second objective was to examine disparities in mammography use between AI and White women across the spectrum of urbanicity (metropolitan to rural) and income. This analysis focused on the 5 states with the largest AI populations with Medicare fee-for-service insurance. These states cover the spectrum from large cities to rural areas with substantial differences in community income.

METHODS

Study Population

This study did not meet the standards of human subject research and was deemed exempt by the Advarra IRB. This was a retrospective study (2005−2019) of mammography use using a nationally representative 5% sample of Medicare fee-for-service beneficiaries generated by the Centers for Medicare and Medicaid Services. Data for 2020 were not included owing to the impact of coronavirus disease 2019 (COVID-19) on mammography use. Women aged 40−89 years with known race residing in Arizona, California, New Mexico, Oklahoma, and Washington were included in this study. Although women aged <40 and >89 years undergo mammography, those aged 40−89 years age align with various screening guidelines. These states were selected given the objective to examine disparities in mammography use for AI women compared with those for White women or women of other races (Asian, Black, Hispanic, other). In the Medicare data, these 5 states had the most AI women with Medicare fee-for-service insurance. Furthermore, Medicare data group AI and AN into a single category. Hence, by focusing on these 5 states, those classified by Medicare as AI/AN are likely AI rather than AN women.[27] The analysis focused on AI women given the cultural factors that influence AI mammography use and differences in federal legal history between AIs and ANs (such as the history of AI mistreatment before Alaska was purchased).[6,8,18,23−25,28]

Given that Medicare data do not explicitly include income and urbanicity, average community income per capita and urbanicity of each woman's community were derived from publicly available data sets. Using each woman's ZIP code, community income was assigned using Internal Revenue Service data. Urbanicity (metropolitan, micropolitan, small town, rural) was also assigned by ZIP code on the basis of rural−urban commuting areas. Women with missing urbanicity were excluded from this study. For each year, beneficiaries who had screening mammography were identified using the following Current Procedural Terminology/Healthcare Common Procedure Coding System codes: 76,092; 77,057; 77,063; 77,067; and G0202.

Measures

The primary outcome of interest was the receipt of any screening mammography during the study period. The primary exposure of interest was the beneficiary's race (White, AI, or other race). Medicare data do not separately track race and ethnicity but include them in a single variable using administrative data to identify race. Race was stratified as White, AI, and other race (Asian, Black, Hispanic, other) given the race categories that Medicare provides. Other covariates included age group (40−49, 50−64, 65−74, 75−89 years), Charlson comorbidity index[29] (CCI) (0, 1, ≥2), urbanicity (metropolitan, 50,000+ population; micropolitan, 10,000−49,999; small town, 2,500−9,999; rural, <2,500), community per capita income (dichotomized as above or below 2019 average per capita income, $34,103), state, and first year in the study.[30]

Statistical Analysis

This study employed multivariable logistic regression analysis to assess the beneficiary-level impact of race, urbanicity, and community income on the odds of a beneficiary having mammography at any point during the study period. Hence, the regression analysis examined beneficiary-level mammography use over an extended period rather than an annual cross-sectional analysis. This analysis was repeated for subsamples by race and state. For analyses of subsamples ≥10,000, statistical significance was assigned at α=0.01 owing to the large sample size. For AI women, α=0.05 was used for statistical significance because this subsample was <10,000.

This study tested for significant linear trends in annual age-adjusted mammogram use by race (further stratified by urbanicity and state) across the 15-year study using linear regression. Age-adjusted use was computed on the basis of age categories defined previously. Beta estimates, R^2-values, and p-values are presented on each graph to show the directionality, goodness of fit, and statistical significance for each calculated linear regression. For this trend analysis, the value for each year represents the average annual age-adjusted mammography use for that year by race and urbanicity.

RESULTS

The study included 457,476 women with a mean (SD) age of 68.4 (9.2) years at their first instance in the study. Of these, 78.2% were White, 1.5% were AI, and 20.3% were of other races. AI women were younger than White women or women of other races (mean age [SD]=65.6 [10.2], 68.8 [9.2], and 67.1 [9.2], respectively). The average number of years of Medicare fee-for-service coverage over this 15-year study period was 7.7 (7.7 for White, 8.1 for AI, and 7.6 for other women). Most women (61.8%) had no mammogram at any time during the study period. Annually, the average percentage of women with mammography was 18.2% (19.5% for White, 15.9% for AI, and 13.4% for other women). By state, Oklahoma, New Mexico, and Arizona had the highest proportions of AI women in their populations: 7.5%, 5.6%, and 2.3%, respectively.

Over the study period, age-adjusted mammogram use declined from 205 per 1,000 in 2005 to 165 per 1,000 in 2019. Mammography use declined among metropolitan populations, regardless of race (Figure 1). From 2005 to 2019, annual age-adjusted mammography use per 1,000 declined significantly for White women ($\beta = -3.06$, $p<0.001$) and women of other races ($\beta = -3.28$, $p<0.001$) with no significant change for AI women ($\beta = -0.65$, $p=0.202$) (Figure 1); differences in the slope of these declines compared with those for AI women were significant (difference= −2.41, $p<0.001$ for White women; difference= −2.64, $p<0.001$ for women of other race). In micropolitan areas, White women ($\beta = -3.71$, $p<0.001$) and women of other races ($\beta = -4.35$, $p<0.001$) saw reduced mammography use over time, whereas AI women saw no statistically significant change ($\beta = -1.31$, $p=0.200$). In rural areas, annual mammogram use dropped among White women ($\beta = -2.30$, $p<0.001$) and rose among AI women ($\beta=2.76$, $p<0.001$).

The state-level analyses showed a decline in annual age-adjusted mammography use per 1,000 for White women in all states (Appendix Figure 1, available online). Among AI women, age-adjusted mammogram use rose significantly for residents of Arizona ($\beta=3.57$, $p<0.001$), dropped for residents of California ($\beta = -3.37$, $p=0.008$) and Washington ($\beta = -4.40$, $p=0.011$), and showed no statistically significant change for residents of New Mexico ($\beta=1.35$, $p=0.115$) and Oklahoma ($\beta = -0.17$, $p=0.855$).

Controlling for covariates, the multivariable analysis found that AI women (OR=0.87; 99% CI=0.81, 0.93) and women of other races (OR=0.86; 99% CI=0.84, 0.87) had lower odds of undergoing mammography than White women (Table 2). Women residing in Arizona (OR=1.25; 99% CI=1.22, 1.29), New Mexico (OR=1.16; 99% CI=1.11, 1.21), Oklahoma (OR=1.46; 99% CI=1.42, 1.51), and Washington (OR=1.41; 99% CI=1.37, 1.44) had greater odds of undergoing mammography than women in California. Women in micropolitan (OR=1.63; 99% CI=1.58, 1.69), small towns (OR=1.43; 99% CI=1.36, 1.50), and rural areas (OR=1.40; 99% CI=1.33, 1.49) had greater odds of mammography than women residing in metropolitan areas. Those in communities with an above-average per capita income had 27% greater odds of mammography than women in communities with below-average income (OR=1.27; 99% CI=1.25, 1.30). Women with at least 1 comorbidity had over twice the odds of undergoing mammography as those with no comorbidities (CCI=0), w (CCI=1, OR=3.04 [99% CI=2.96, 3.12]; CCI≥2, OR=2.36 [99% CI=2.30, 2.41]).

The results of the multivariable subanalyses by race group differed from the results for the entire sample (Table 3). For example, White women and women of other races in micropolitan areas compared with those in metropolitan areas had 66% (OR=1.66; 99% CI=1.60, 1.71) and 67% (OR=1.67; 99% CI=1.49, 1.87) greater odds, respectively, of undergoing mammography. The odd for similar women of the AI race was 23% (OR=1.23; 95% CI=1.02, 1.48). Contrastingly, there was no evidence that AI women in small towns (OR=1.06; 95% CI=0.87, 1.28) or rural areas (OR=0.96; 95% CI=0.77, 1.20) had odds of mammography different from those of metropolitan AI women, whereas White women in small towns (OR=1.48; 99% CI=1.41, 1.56) and rural areas (OR=1.47; 99% CI=1.39, 1.57) had significantly greater odds of mammography than their metropolitan counterparts. As for community income, both White women (OR=1.31; 99% CI=1.28, 1.34) and women of other race (OR=1.16; 99% CI=1.11, 1.20) residing in above-average income communities had greater odds of mammography than similar women in below-average income communities. In contrast, there was no evidence that income impacted mammography use for AI women (OR=0.95; 95% CI=0.78, 1.16). Mammography-use odds for those with multiple comorbidities (CCI≥2) was less for AI than for White women or women of other races compared with those of their respective counterparts without comorbidities (CCI=0): 1.33 (95% CI=1.12, 1.59) for AI women, 2.28 (99% CI=2.22, 2.35) for White women, and 2.79 (99% CI=2.65, 2.94) for women of other race.

The multivariable subanalyses by state (Appendix Table 1, available online) show that AI women had lower odds of undergoing mammography in Arizona than White women (OR=0.77; 99% CI=0.66, 0.91). There were no differences between AI and White women in the other states. The impact of urbanicity varied across states. Specifically, those in rural areas had greater odds of mammography in California (OR=1.89; 99% CI=1.72, 2.08), New Mexico (OR=1.54; 99% CI=1.32, 1.80), Washington (OR=1.28; 99% CI=1.12, 1.46), and Oklahoma (OR=1.12; 99% CI=1.00, 1.26) than women in

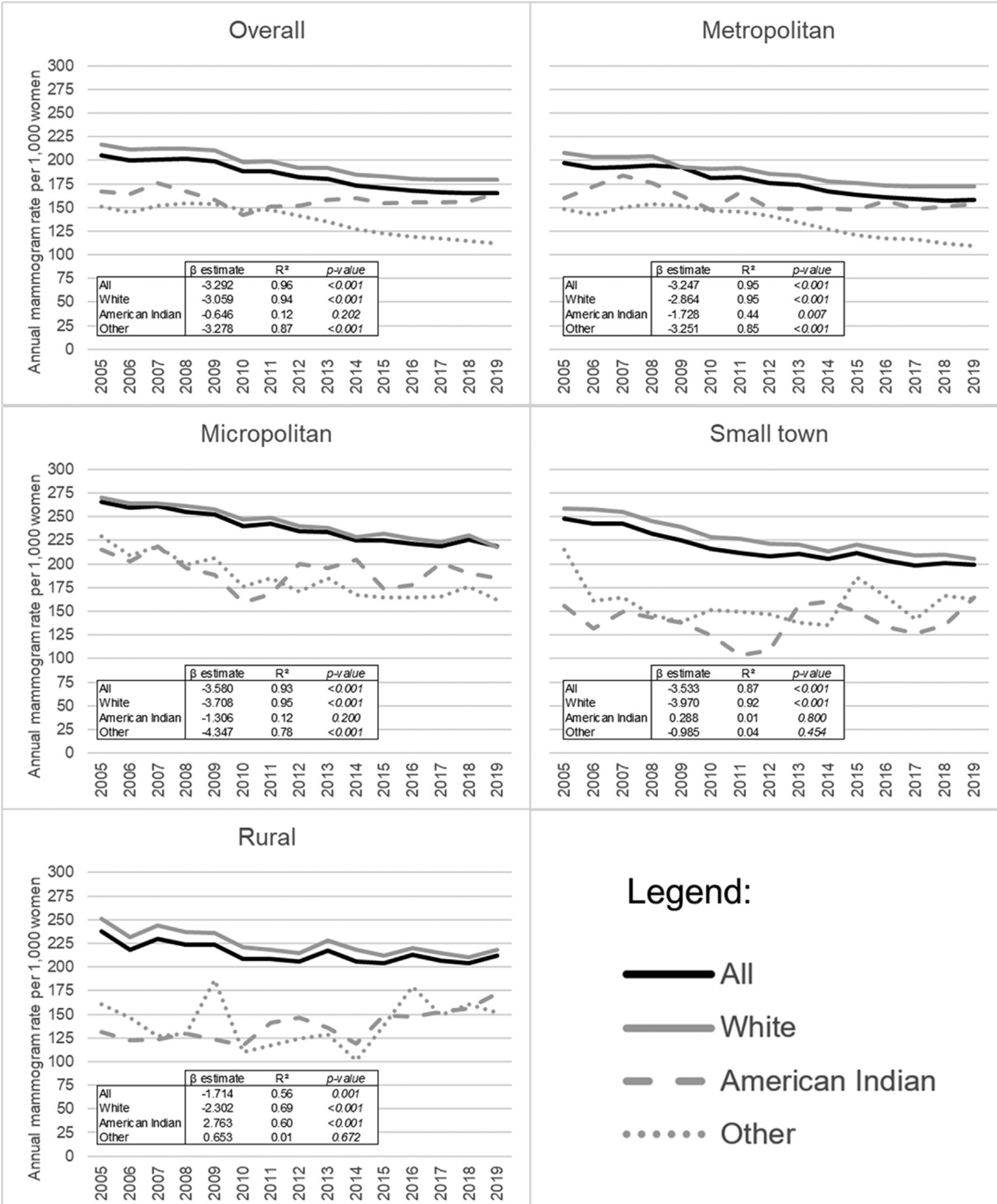

Figure 1. Annual age-adjusted mammography use, by race and urbanicity, 2005−2019.
Other race includes Asian, Black, Hispanic, and other.

metropolitan areas. There was no difference in Arizona (OR=0.94; 99% CI=0.78, 1.13). Women living in above-average income communities had greater odds of receiving mammography in Arizona (OR=1.47; 99% CI=1.40, 1.55), California (OR=1.29; 99% CI=1.26, 1.32), New Mexico (OR=1.14; 99% CI=1.04, 1.26), and Oklahoma (OR=1.26; 99% CI=1.18, 1.35) than women living in communities with below-average income. There was no difference in Washington (OR=1.01; 99% CI=0.96, 1.07).

Table 1. Descriptive Statistics for the Study Population, Overall and by Race Group

Parameter	Overall	White	American Indian	Other race
n (%)	457,476	357,527 (78.2)	6,851 (1.5)	93,098 (20.3)
First year of coverage in data set				
2005	206,797	168,113 (81.3)	3,074 (1.5)	35,610 (17.2)
2006	14,534	11,150 (76.7)	247 (1.7)	3,137 (21.6)
2007	14,851	11,609 (78.2)	219 (1.5)	3,023 (20.4)
2008	16,650	12,938 (77.7)	270 (1.6)	3,442 (20.7)
2009	15,566	12,032 (77.3)	258 (1.7)	3,276 (21.0)
2010	15,243	11,743 (77.0)	240 (1.6)	3,260 (21.4)
2011	17,430	13,432 (77.1)	293 (1.7)	3,705 (21.3)
2012	18,368	14,105 (76.8)	274 (1.5)	3,989 (21.7)
2013	19,925	14,764 (75.4)	320 (1.6)	4,511 (23.0)
2014	19,110	14,411 (75.4)	309 (1.6)	4,390 (23.0)
2015	19,772	14,692 (74.3)	343 (1.7)	4,737 (24.0)
2016	19,148	14,224 (74.3)	308 (1.6)	4,616 (24.1)
2017	20,083	14,633 (72.9)	315 (1.6)	5,135 (25.6)
2018	20,285	15,032 (74.1)	218 (1.1)	5,035 (24.8)
2019	20,014	14,619 (73.0)	163 (0.8)	5,232 (26.1)
State				
Arizona	59,747	53,004 (88.7)	1,376 (2.3)	5,367 (9.0)
California	281,740	203,555 (72.2)	1,065 (0.4)	77,120 (27.4)
New Mexico	18,824	15,784 (83.8)	1,052 (5.6)	1,988 (10.6)
Oklahoma	36,612	30,996 (84.7)	2,747 (7.5)	2,869 (7.8)
Washington	60,553	54,188 (89.5)	611 (1.0)	5,754 (9.5)
Age, years				
40−49	1,960	13,637 (69.5)	641 (3.3)	5,352 (27.3)
50−64	40,107	28,969 (72.2)	1,101 (2.8)	10,037 (25.0)
65−74	286,990	223,872 (78.0)	3,898 (1.4)	59,220 (20.6)
75−89	110,749	91,049 (82.2)	1,211 (1.1)	18,489 (16.7)
CCI				
0	324,816	257,607 (79.3)	4,179 (1.3)	63,030 (19.4)
1	50,260	38,541 (76.7)	1,109 (2.2)	10,610 (21.1)
2+	61,318	45,990 (75.0)	1,390 (2.3)	13,938 (22.7)
Unknown	21,082	15,389 (73.0)	173 (0.8)	5,520 (26.2)
Urbanicity				
Metropolitan	396,338	303,862 (76.7)	3,208 (0.8)	89,268 (22.5)
Micropolitan	36,925	32,754 (88.7)	1,453 (3.9)	2,718 (7.4)
Small town	14,195	12,163 (85.7)	1,302 (9.2)	730 (5.1)
Rural	10,018	8,748 (87.3)	888 (8.9)	382 (3.8)
Community income				
Same as or lower than the national mean	206,132	150,802 (73.2)	5,613 (2.7)	49,717 (24.1)
Higher than national mean	251,344	206,725 (82.2)	1,238 (0.5)	43,381 (17.3)
Any screening mammogram during the study period				
Yes	174,658	140,786 (80.6)	3,050 (1.7)	30,822 (17.6)
No	282,818	216,741 (76.6)	3,801 (1.3)	62,276 (22.0)
Mean person-years of enrollment (SD)	7.7 (4.6)	7.7 (4.6)	8.1 (4.5)	7.6 (4.6)
Mean mammograms per beneficiary (SD)	1.4 (2.6)	1.5 (2.7)	1.3 (2.2)	1.0 (2.1)
Median mammograms per beneficiary (IQR)	0 (0−2)	0 (0−2)	0 (0−2)	0 (0−1)

Notes: Year is an indicator variable for the first year the woman was in the data. The age category represents the age of the beneficiary at the end of the first year she was in our data. Community income represents per capita income by ZIP code. All variables were significantly different across race groups ($p<0.001$). Women of other races include Asian, Black, Hispanic, and other women.
CCI, Charlson comorbidity index.

Table 2. Multivariable Logistic Regression for Adjusted Odds of Receiving a Mammogram, All Races

Parameter	OR (99% CI)
First year present in the study (Ref: 2005)	
2006	0.878 (0.837, 0.921)
2007	0.858 (0.819, 0.900)
2008	0.812 (0.776, 0.849)
2009	0.758 (0.724, 0.795)
2010	0.724 (0.691, 0.759)
2011	0.763 (0.730, 0.797)
2012	0.743 (0.711, 0.775)
2013	0.752 (0.721, 0.784)
2014	0.784 (0.752, 0.818)
2015	0.756 (0.725, 0.789)
2016	0.736 (0.704, 0.769)
2017	0.664 (0.634, 0.695)
2018	0.528 (0.503, 0.554)
2019	0.496 (0.449, 0.549)
Expected mammograms	1.249 (1.240, 1.258)
State (Ref: California)	
Arizona	1.252 (1.221, 1.285)
New Mexico	1.158 (1.109, 1.209)
Oklahoma	1.463 (1.415, 1.511)
Washington	1.407 (1.372, 1.443)
Race (Ref: White)	
American Indian	0.866 (0.809, 0.928)
Other race	0.855 (0.837, 0.874)
Age, years (Ref: 40−49)	
50−64	0.704 (0.668, 0.741)
65−74	1.037 (0.994, 1.082)
75−89	0.807 (0.769, 0.847)
CCI (Ref: 0)	
1	3.039 (2.959, 3.121)
2+	2.355 (2.299, 2.414)
Unknown	0.445 (0.402, 0.492)
Urbanicity (Ref: metropolitan)	
Micropolitan	1.634 (1.583, 1.686)
Small	1.425 (1.358, 1.496)
Rural	1.404 (1.327, 1.486)
Community income > national mean (Ref: ≤ national mean)	1.273 (1.250, 1.296)

Notes: N=457,476. Year is an indicator variable for the first year the woman was in the data. Expected mammograms are calculated according to USPSTF biennial screening guidelines for women aged 50−74 years. The age category represents the age of the beneficiary at the end of the first year she was in our data. Community income represents per capita income by ZIP code.
CCI, Charlson comorbidity index; USPSTF, U.S. Preventive Services Task Force.

DISCUSSION

This study found that for women with Medicare fee-for-service insurance residing in the 5 states with the highest proportions of AI women, the annual age-adjusted mammography use declined from 205 per 1,000 in 2005 to 165 per 1,000 in 2019. Over this period, the annual White−AI screening gap narrowed because the annual mammography use decline was concentrated in White women. Despite this narrowing gap, screening use for AI women remained lower than for White women.

The annual mammography use in this study was lower than previously published estimates for Medicare fee-for-service beneficiaries, which range from 21% for AI women to 35% for White women in 2021.[17] That study found substantial geographic variation in mammography use; the 5 states included in this analysis all showed relatively lower use than the national average. Data from the 2005 to 2018 National Health Interview Surveys report biennial mammography use at approximately 67%[3]; however, studies based on survey data have been found to overstate mammography use.[11,26] Furthermore, over the 15-year study period, 61.8% of women did not have any mammograms. Hence, annual screenings were concentrated in a minority of beneficiaries, indicating a need to broaden the reach of screening to more women rather than just increasing the frequency of those currently being screened, particularly among AI women.

Public health goals are broader than eliminating racial disparities. These goals would include eliminating any disparity such as those owing to urbanicity and income. Concerningly, the effect of urbanicity and income on mammography use varied by race. Hence, in addition to mitigating racial disparities generally, racial gradients in urbanicity and income disparities also need mitigation. In aggregate, women in micropolitan, small towns, or rural areas were more likely to undergo mammography at some point during the study than women residing in metropolitan areas. However, this effect is primarily driven by an increased likelihood of White women undergoing screening even as the urban−rural gradient increased. This may be due in part to longer travel times for AI women.[31] Medicare represents the leading revenue source for rural hospitals, which operate on small to negative margins.[32] Effects of Medicare reimbursement stagnation may be felt more acutely by rural providers, suggesting that increasing rurality should be associated with a decline in service receipt, contrary to this study's findings. Although encouraging, these unmeasured drivers of increased mammography receipt among White women do not appear to extend to those of other races as rurality increased, indicating persistent disparity in service delivery.

Similarly, women residing in communities with above-average income were more likely to undergo mammography. However, just as with urbanicity, this

Table 3. Multivariable Logistic Regressions for Adjusted Odds of Receiving a Mammogram, by Race

	White (*n*=357,527)	American Indian (*n*=6,851)	Other race (*n*=93,098)
Parameter	OR (99% CI)	OR (99% CI)	OR (99% CI)
First year present in the study (Ref: 2005)			
2006	0.840 (0.795, 0.887)	0.647 (0.448, 0.936)	1.052 (0.948, 1.168)
2007	0.825 (0.782, 0.870)	0.867 (0.586, 1.283)	0.993 (0.893, 1.104)
2008	0.792 (0.752, 0.833)	1.005 (0.707−1.429)	0.876 (0.792, 0.969)
2009	0.734 (0.696−0.774)	0.899 (0.625, 1.292)	0.840 (0.758, 0.931)
2010	0.706 (0.669, 0.745)	0.842 (0.581, 1.218)	0.788 (0.710, 0.873)
2011	0.755 (0.718, 0.793)	0.812 (0.581, 1.136)	0.782 (0.709, 0.862)
2012	0.735 (0.700, 0.771)	0.743 (0.527, 1.045)	0.767 (0.697, 0.843)
2013	0.750 (0.715, 0.786)	0.897 (0.652, 1.234)	0.747 (0.682, 0.818)
2014	0.797 (0.759, 0.836)	0.940 (0.680, 1.300)	0.728 (0.663, 0.800)
2015	0.755 (0.719, 0.792)	0.831 (0.605, 1.140)	0.752 (0.686, 0.825)
2016	0.746 (0.709, 0.785)	0.830 (0.591, 1.165)	0.693 (0.628, 0.764)
2017	0.690 (0.655, 0.727)	0.554 (0.383, 0.801)	0.588 (0.532, 0.650)
2018	0.555 (0.525, 0.586)	0.483 (0.305, 0.766)	0.437 (0.391, 0.489)
2019	0.515 (0.461, 0.575)	0.611 (0.259, 1.441)	0.411 (0.320, 0.529)
Expected mammograms*	1.253 (1.243, 1.264)	1.343 (1.272, 1.418)	1.231 (1.211, 1.251)
State (Ref: California)			
Arizona	1.291 (1.256, 1.326)	0.667 (0.525, 0.848)	1.037 (0.953, 1.128)
New Mexico	1.145 (1.092, 1.199)	0.995 (0.776, 1.275)	1.252 (1.093, 1.433)
Oklahoma	1.477 (1.425, 1.530)	1.144 (0.928, 1.410)	1.344 (1.204, 1.501)
Washington	1.414 (1.376, 1.452)	1.074 (0.811, 1.423)	1.388 (1.283, 1.502)
Age, years (Ref: 40−49)			
50−64	0.692 (0.651, 0.736)	0.656 (0.485, 0.886)	0.770 (0.695, 0.853)
65−74	1.151 (1.095, 1.211)	0.705 (0.551, 0.902)	0.816 (0.751, 0.888)
75−89	0.920 (0.869, 0.974)	0.598 (0.438, 0.815)	0.545 (0.493, 0.603)
CCI (Ref: 0)			
1	3.003 (2.913, 3.095)	1.715 (1.423, 2.068)	3.424 (3.230, 3.630)
2+	2.282 (2.220, 2.347)	1.332 (1.120, 1.586)	2.790 (2.646, 2.943)
Unknown	0.447 (0.399, 0.500)	0.465 (0.195, 1.110)	0.452 (0.352, 0.579)
Urbanicity (Ref: metropolitan)			
Micropolitan	1.655 (1.601, 1.711)	1.230 (1.022, 1.481)	1.670 (1.490, 1.872)
Small	1.480 (1.405, 1.559)	1.056 (0.869, 1.283)	1.359 (1.096, 1.685)
Rural	1.473 (1.387, 1.565)	0.963 (0.774, 1.198)	1.052 (0.777, 1.423)
Community income > national mean (Ref: ≤ national mean)	1.309 (1.282, 1.335)	0.951 (0.779, 1.160)	1.156 (1.111, 1.203)

Note: Year is an indicator variable for the first year the woman was in the data. Expected mammograms are calculated according to USPSTF biennial screening guidelines for women aged 50−74 years. The age category represents the age of the beneficiary at the end of the first year she was in our data. Community income represents per capita income by ZIP code.
CCI, Charlson comorbidity index; USPSTF, U.S. Preventive Services Task Force.

aggregate association was not uniform across race categories. White women and women of other races in communities with above-average income were more likely to have mammography than their counterparts in communities with below-average income. For AI women, community income had no impact on mammography use. There may be unique cultural or structural access barriers to care among AI women that community income cannot overcome. Attention to these barriers is necessary to improve the provision of breast screening services among this population.

Studies show that cultural factors among AI women, such as comfort with discussing mammography, the degree of their connection to their Nativeness, fatalism, and reliance on traditional healers, are associated with lower mammography use.[8,18,23,24,33] Cultural factors may exert more influence than income on screening use.[6−8,18,23−25,33] In addition, other unmeasured social determinants of health, such as food or housing insecurity and transportation, may also contribute to differences in the influence of community income on screening use.

There have been numerous programs and initiatives to improve mammography use among AI women.[34−39] Suggested interventions include door-to-door education, free or low-cost mammography, and transportation support.[21] Such programs are typically local, are resource intensive, and may be funded through targeted grants; they are not reimbursed, with the exception of mobile mammography. Providers may choose to engage in such work, but such efforts are hindered by a lack of reimbursement.

If the observed disparities for AI women are to be mitigated, health policy and reimbursement must support it. For example, the Indian Health Services (IHS) has been chronically underfunded relative to needs.[40] That poses challenges because higher mammography use is positively associated with receiving other care from an IHS facility and having comorbidities, whereas it is negatively associated with patient distance from IHS facilities.[41] Because the IHS is a provider and not an insurer, when funds are exhausted, access to care may be curtailed for some services,[21] leading to reduced mammography use for women reliant on the IHS for care.[42]

Several studies have shown that those with public insurance had lower screening use than those with private insurance and that those without insurance were lower still.[7,10,20,43] A strength of this study was the elimination of screening differences owing to varying insurance types, which is associated with racial disparities in late-stage breast cancer.[44] The Medicare reimbursement rate for digital mammography increased only by 2.3% between 2005 and 2019 ($135.29−$138.39), and accounting for inflation, it declined by 21.9%. Even without this insurance confounder, Medicare reimbursement cannot be considered in isolation because the private−-public payer mix also influences access. For example, the private-pay-to-Medicare reimbursement ratio for hospital care increased from 2.36 in 2015 to 2.41 in 2017.[45] Such a trend incentivizes prioritizing mammography capability in areas where the economics are more favorable.

Limitations

This study has limitations. First, Medicare race data group AI/AN women into a single category. Because this study specifically focused on AI women, it only included women from 5 western states for which these women were most likely AI women. Second, because this study was focused on 5 states, it may not be generalizable to AI women residing in other states. Third, this study's results were based on the Medicare fee-for-service population and may not be representative of women with other insurance types, including Medicare Advantage. The role of provider recommendations for screening mammography in women on the basis of age cannot be ascertained from claims data. Finally, this study used community income as an instrument for actual income and may not be representative of actual income.

CONCLUSIONS

Although health policy should strive to eliminate all disparities, this paper has focused on disparities specific to AI women and discussed reimbursement and cultural factors associated with these disparities. Specifically, this study found racial gradients in mammography use for both urbanicity and income disparities. Future research should examine these racial gradients for AI women more fully to inform policy. Such information may inform policies to mitigate disparities. Similarly, this study found that community income had no impact on mammography use for AI women. This may indicate that although income is generally a protective factor in cancer screening, there are other factors, likely systemic, that may dominate screening decisions in the AI communities. Policies that may address these cultural barriers to screening are needed.

ACKNOWLEDGMENTS

There was no funding for this study.

No financial disclosures were reported by the authors of this paper.

CREDIT AUTHOR STATEMENT

Eric W. Christensen: Conceptualization, Methodology, Validation, Writing − original draft. Casey E. Pelzl: Methodology, Formal analysis, Writing − original draft, Visualization. Bhavika K. Patel: Conceptualization, Writing − review and editing. Ruth C. Carlos: Writing − review and editing. Elizabeth Y. Rula: Supervision, Conceptualization, Writing − review and editing.

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2023.01.013.

REFERENCES

1. American Cancer Society. Cancer facts & figures. https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2022/2022-cancer-facts-and-figures.pdf. Published 2022. Accessed October 15, 2022.
2. Berry DA, Cronin KA, Plevritis SK, et al. Effect of screening and adjuvant therapy on mortality from breast cancer. *N Engl J Med.* 2005;353(17):1784–1792. https://doi.org/10.1056/NEJMoa050518.
3. National Center for Health Statistics. Use of mammography among women aged 40 and over, by selected characteristics: United States, selected years 1987−2018. https://www.cdc.gov/nchs/hus/contents2019.htm#Table-033. Published 2019.Accessed October 15, 2022.

4. Tangka FK, Subramanian S, Mobley LR, et al. Racial and ethnic disparities among state Medicaid programs for breast cancer screening. *Prev Med.* 2017;102:59–64. https://doi.org/10.1016/j.ypmed.2017.06.024.
5. Roubidoux MA, Richards B, Honey NE, Begay JA. Adherence to screening among American Indian women accessing a mobile mammography unit. *Acad Radiol.* 2021;28(7):944–949. https://doi.org/10.1016/j.acra.2021.03.014.
6. Daley CM, Filippi M, James AS, et al. American Indian community leader and provider views of needs and barriers to mammography. *J Community Health.* 2012;37(2):307–315. https://doi.org/10.1007/s10900-011-9446-7.
7. Breen N, Gentleman JF, Schiller JS. Update on mammography trends: comparisons of rates in 2000, 2005, and 2008. *Cancer.* 2011;117(10):2209–2218. https://doi.org/10.1002/cncr.25679.
8. Hodge FS. Breast cancer−screening behavior among rural California American Indian women. *Am Indian Cult Res J.* 2009;33(3):35–42. https://doi.org/10.17953/aicr.33.3.bjw34l55v72q44n1.
9. Eberth JM, Huber JC, Rene A. Breast cancer screening practices and correlates among American Indian and Alaska Native women in California, 2003. *Womens Health Issues.* 2010;20(2):139–145. https://doi.org/10.1016/j.whi.2009.12.004.
10. Breen N, A Cronin KA, Meissner HI, et al. Reported drop in mammography: is this cause for concern? *Cancer.* 2007;109(12):2405–2409. https://doi.org/10.1002/cncr.22723.
11. Kagay CR, Quale C, Smith-Bindman R. Screening mammography in the American elderly. *Am J Prev Med.* 2006;31(2):142–149. https://doi.org/10.1016/j.amepre.2006.03.029.
12. Giuliano A, Papenfuss M, De Guernsey De Zapien J, Tilousi S, Nuvayestewa L. Breast cancer screening among southwest American Indian women living on-reservation. *Prev Med.* 1998;27(1):135–143. https://doi.org/10.1006/pmed.1997.0258.
13. Hendrick RE, Monticciolo DL, Biggs KW, Malak SF. Age distributions of breast cancer diagnosis and mortality by race and ethnicity in US women. *Cancer.* 2021;127(23):4384–4392. https://doi.org/10.1002/cncr.33846.
14. Li CI, Malone KE, Daling JR. Differences in breast cancer stage, treatment, and survival by race and ethnicity. *Arch Intern Med.* 2003;163(1):49–56. https://doi.org/10.1001/archinte.163.1.49.
15. Mobley LR, Tangka FKL, Berkowitz Z, et al. Geographic disparities in late-stage breast cancer diagnosis rates and their persistence over time. *J Womens Health (Larchmt).* 2021;30(6):807–815. https://doi.org/10.1089/jwh.2020.8728.
16. White A, Richardson LC, Li C, Ekwueme DU, Kaur JS. Breast cancer mortality among American Indian and Alaska Native women, 1990−2009. *Am J Public Health.* 2014;104(Suppl 3):S432–S438 (suppl 3). https://doi.org/10.2105/AJPH.2013.301720.
17. Centers of Medicare & Medicaid Services. Breast cancer screening disparities in Medicare beneficiaries. https://www.cms.gov/files/document/bcs-october2022-datasnapshot.pdf. Published January 2021. Accessed February 9, 2023.
18. Tolma EL, Stoner JA, Li J, Kim Y, Engelman KK. Predictors of regular mammography use among American Indian women in Oklahoma : a cross-sectional study. *BMC Womens Health.* 2014;14(101):101. https://doi.org/10.1186/1472-6874-14-101.
19. Coughlin SS, Uhler RJ, Blackman DK. Breast and cervical cancer screening practices among American Indian and Alaska Native women in the United States, 1992−1997. *Prev Med.* 1999;29(4):287–295. https://doi.org/10.1006/pmed.1999.0537.
20. Hall IJ, Tangka FKL, Sabatino SA, Thompson TD, Graubard BI, Breen N. Patterns and trends in cancer screening in the United States. *Prev Chronic Dis.* 2018;15(7):E97. https://doi.org/10.5888/pcd15.170465.
21. Jerome-D'Emilia B, Gachupin FC, Suplee PD. A systematic review of barriers and facilitators to mammography in American Indian/Alaska Native women. *J Transcult Nurs.* 2019;30(2):173–186. https://doi.org/10.1177/1043659618793706.
22. Sequist TD, Cullen T, Bernard K, Shaykevich S, Orav EJ, Ayanian JZ. Trends in quality of care and barriers to improvement in the Indian Health Service. *J Gen Intern Med.* 2011;26(5):480–486. https://doi.org/10.1007/s11606-010-1594-4.
23. Canales MK, Geller BM. Moving in between mammography: screening decisions of American Indian women in Vermont. *Qual Health Res.* 2004;14(6):836–857. https://doi.org/10.1177/1049732304265845.
24. Miller BC, Bowers JM, Payne JB, Moyer A. Barriers to mammography screening among racial and ethnic minority women. *Soc Sci Med.* 2019;239(August):112494. https://doi.org/10.1016/j.socscimed.2019.112494.
25. Partin MR, Korn JE, Slater JS. Questionable data and preconceptions: reconsidering the value of mammography for American Indian women. *Am J Public Health.* 1997;87(7):1100–1102. https://doi.org/10.2105/AJPH.87.7.1100.
26. Johnson CS, Archer J, Campos-Outcalt D. Accuracy of pap smear and mammogram self-reports in a Southwestern Native American tribe. *Am J Prev Med.* 1995;11(6):360–363. https://doi.org/10.1016/S0749-3797(18)30413-6.
27. DeVoe JF, Darling-Churchill KE, Snyder TD. Status and trends in the education of American Indians and Alaska natives: 2008. https://nces.ed.gov/pubs2008/2008084.pdf. Published September 2008. Accessed October 15, 2022.
28. Shelton BL. Legal and historical roots of health care for American Indians and Alaska natives in the United States. https://www.kff.org/wp-content/uploads/2013/01/legal-and-historical-roots-of-health-care-for-american-indians-and-alaska-natives-in-the-united-states.pdf. Published February 2004. Accessed October 15, 2022.
29. Austin SR, Wong YN, Uzzo RG, Beck JR, Egleston BL. Why summary comorbidity measures such as the Charlson comorbidity index and Elixhauser score work. *Med Care.* 2015;53(9):e65–e72. https://doi.org/10.1097/MLR.0b013e318297429c.
30. United States Census Bureau. S1902 Mean income in the past 12 months (in 2019 inflation-adjusted dollars), 2019&tid=ACSST5Y2019.S1902. American Community Survey 5-Year Estimates. https://data.census.gov/table?q=per+capita+income&tid=ACSST5Y2019.S1902. Published 2019. Accessed October 15, 2022.
31. Onega T, Hubbard R, Hill D, et al. Geographic access to breast imaging for US women. *J Am Coll Radiol.* 2014;11(9):874–882. https://doi.org/10.1016/j.jacr.2014.03.022.
32. Schlidt E, Wilkinson C. Medicare reimbursement in rural America. *N Atl Rural Heal Assoc Policy Br.* 2021:1–5. https://www.ruralhealth.us/NRHA/media/Emerge_NRHA/Advocacy/Policy%20documents/NRHA-Policy-Brief-Medicare-Reimbursement-in-Rural-America.pdf. Publised February 2021. Accessed February 9, 2023.
33. Ndikum-Moffor FM, Braiuca S, Daley CM, Gajewski BJ, Engelman KK. Assessment of mammography experiences and satisfaction among American Indian/Alaska Native women. *Womens Health Issues.* 2013;23(6):395–402. https://doi.org/10.1016/j.whi.2013.08.003.
34. Brown SR, Joshweseoma L, Saboda K, Sanderson P, Ami D, Harris R. Cancer screening on the Hopi reservation: a model for success in a Native American community. *J Community Health.* 2015;40(6):1165–1172. https://doi.org/10.1007/s10900-015-0043-z.
35. Chilton JA, Downing C, Lofton M, et al. Circle of sisters: raising awareness of Native American women to breast cancer. *J Health Care Poor Underserved.* 2013;24(3):1167–1179. https://doi.org/10.1353/hpu.2013.0116.
36. Gupta S, Roos LL, Walld R, Traverse D, Dahl M. Delivering equitable care: comparing preventive services in Manitoba. *Am J Public Health.* 2003;93(12):2086–2092. https://doi.org/10.2105/AJPH.93.12.2086.
37. Lantz PM, Orians CE, Liebow E, et al. Implementing women's cancer screening programs in American Indian and Alaska Native populations. *Health Care Women Int.* 2003;24(8):674−696. https://doi.org/10.1080/07399330390227481.

38. Sinicrope PS, Bauer MC, Patten CA, et al. Development and evaluation of a cancer literacy intervention to promote mammography screening among Navajo women: a pilot study. *Am J Health Promot*. 2020;34 (6):681–685. https://doi.org/10.1177/0890117119900592.Development.
39. Tolma EL, Engelman K, Stoner JA, et al. The design of a multi-component intervention to promote screening mammography in an American Indian community: the Native Women's Health Project. *AIMS Public Heal*. 2016;3(4):933–955. https://doi.org/10.3934/publichealth.2016.4.933.
40. Warne D, Frizzell LB. American Indian health policy: historical trends and contemporary issues. *Am J Public Health*. 2014;104(Suppl 3): S263–S267 (suppl 3). https://doi.org/10.2105/AJPH.2013.301682.
41. Wingo PA, King J, Swan J, et al. Breast cancer incidence among American Indian and Alaska Native women: US, 1999−2004. *Cancer*. 2008;113(5):1191–1202 (suppl). https://doi.org/10.1002/cncr.23725.
42. Gonzales KL, Harding AK, Lambert WE, Fu R, Henderson WG. Perceived experiences of discrimination in health care: a barrier for cancer screening among American Indian women with type 2 diabetes. *Womens Health Issues*. 2013;23(1):e61–e67. https://doi.org/10.1016/j.whi.2012.10.004.
43. White A, Thompson TD, White MC, et al. Cancer screening test use - United States, 2015. *MMWR Morb Mortal Wkly Rep*. 2017;66(8):201–206. https://doi.org/10.15585/mmwr.mm6608a1.
44. Ko NY, Hong S, Winn RA, Calip GS. Association of insurance status and racial disparities with the detection of early-stage breast cancer. *JAMA Oncol*. 2020;6(3):385–392. https://doi.org/10.1001/jamaoncol.2019.5672.
45. White C, Whaley C. Prices paid to hospitals by private health plans are high relative to Medicare and vary widely. https://www.rand.org/pubs/research_reports/RR3033.html. Published 2019. Accessed October 15, 2022.