

The Role of Social Determinants of Health in Self-Reported Access to Health Care Among Women Undergoing Screening Mammography

Louise M. Henderson, MSPH, PhD,¹ Ellen S. O'Meara, PhD,² Jennifer S. Haas, MD, MSc,³
Christoph I. Lee, MD, MS,⁴⁻⁶ Karla Kerlikowske, MD,^{7,8} Brian L. Sprague, PhD,^{9,10}
Jennifer Alford-Teaster, MA, MPH,^{11,12} and Tracy Onega, PhD^{11,12}

Abstract

Background: Social determinants of health (SDOH) contribute to health care disparities, with social and economic barriers often leading to difficulties in obtaining necessary care. We evaluated barriers to receiving health care, focusing on caretaker responsibilities, health insurance and cost, and transportation.

Materials and Methods: We included women ages ≥ 40 years receiving screening mammography across three Breast Cancer Surveillance Consortium registries from 2012 to 2017. Women self-reported social and financial barriers to receiving health care in the 12 months before their screening mammogram. We evaluated woman- and census-based community-level factors associated with reporting a barrier using multivariate logistic regression. We assessed interaction with urban versus nonurban residence using Wald tests.

Results: Among 393,430 women, 3.6% reported a barrier with a higher proportion in urban versus nonurban settings (3.9% [$n=11,977$] vs. 2.2% [$n=1,655$], respectively; $p<0.001$). Among women reporting a barrier, health care cost and/or no insurance was the most common (49.3%), and no transportation was the least common (7.8%). Compared with white women, odds of reporting barriers were higher among black (adjusted odds ratio [aOR]=1.30, 95% confidence interval [CI]: 1.16–1.44), Hispanic (aOR=1.66, 95% CI: 1.53–1.80), and other race (aOR=1.84, 95% CI: 1.65–2.04) women. Barriers were less likely in women with higher median household income (aOR=0.69, 95% CI: 0.61–0.79) or higher average health insurance costs (aOR=0.85, 95% CI: 0.74–0.98), but were more likely in high diversity index areas (aOR=1.28, 95% CI: 1.11–1.48).

Conclusions: Social and financial barriers exist based on race/ethnicity and SDOH related to income, insurance costs, and place of residence among women undergoing screening mammography. Breast imaging facilities could utilize information on these barriers to improve biennial screening adherence or ensure that women with abnormal findings obtain appropriate follow-up care through targeted interventions.

Keywords: social determinants of health, screening, mammography, access

Introduction

INCREASINGLY, SOCIAL DETERMINANTS OF HEALTH (SDOH), defined as environmental conditions in which people are born, live, learn, work, and age, are recognized as contrib-

uting to health-related disparities.¹ Healthy People 2020 developed five key areas of SDOH, including economic stability, education, social and community context, health and health care, and neighborhood and built environment.² Several initiatives at the federal and state level focus on

¹Epidemiology Research, Department of Radiology, The University of North Carolina, Chapel Hill, North Carolina, USA.

²Kaiser Permanente Washington Health Research Institute, Seattle, Washington, USA.

³Department of Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA.

⁴Department of Radiology, University of Washington School of Medicine, Seattle, Washington, USA.

⁵Department of Health Services, University of Washington School of Public Health, Seattle, Washington, USA.

⁶Hutchinson Institute for Cancer Outcomes Research, Seattle, Washington, USA.

Departments of ⁷Medicine and ⁸Epidemiology and Biostatistics, University of California, San Francisco, California, USA.

Departments of ⁹Surgery and ¹⁰Radiology, University of Vermont, Burlington, Vermont, USA.

Departments of ¹¹Biomedical Data Science and ¹²Epidemiology, Geisel School of Medicine at Dartmouth, Lebanon, New Hampshire, USA.

addressing SDOH within health care delivery systems.^{3,4} These initiatives aim to screen enrollees to assess health-related social needs and subsequently link enrollees with appropriate community services. Addressing SDOH will impact clinical outcomes, cost, and service utilization.⁵

Access to health care in the United States is unequal, with many not receiving the appropriate and timely care they need.⁶ Racial and ethnic minorities and people of low socioeconomic status are disproportionately represented among those with access concerns.⁷ While there has been some progress in reducing barriers to health care, disparities in access persist.⁸ Each encounter with the health care system is an opportunity to evaluate SDOH. Patients' difficulties or delays in obtaining necessary care likely reflect disadvantages in their SDOH, including educational opportunities, social and community responsibilities related to family, school, or work, health and health care cost or insurance, and their built environment, including transportation.²

Screening for SDOH in clinical settings is debated, as some providers feel ill equipped to address patients' social needs or feel that screening without opportunity for intervention is inadequate.^{9,10} However, Medicaid Managed Care Organizations are increasingly requiring the screening of enrollees for social needs, and, as part of the Affordable Care Act (ACA), not-for-profit hospitals are screening patients for SDOH.^{11,12} Evaluating SDOH may also be conducted as part of routine preventive care visits, such as at the time of screening mammography, to ensure that downstream, recommended follow-up care is more likely to occur. Hence, we compared self-reported social and financial barriers to health care, focusing on caretaker responsibilities (specifically examining family, school, or work responsibilities), health care insurance or health care cost, and transportation in the prior 12 months among women undergoing screening mammography.

Materials and Methods

Data sources and study population

For this study, we utilized the Breast Cancer Surveillance Consortium (BCSC), a National Cancer Institute (NCI)-funded network of mammography registries across the United States.¹³ We included BCSC data from women ages 40 and older who had a screening mammogram in 2012–2017 at 31 breast imaging facilities within 3 regional BCSC registries (Carolina Mammography Registry in North Carolina, the San Francisco Mammography Registry in the San Francisco Bay Area, and the Vermont Breast Cancer Surveillance System). Each registry and the Statistical Coordinating Center (SCC), which processed the pooled data, received institutional review board (IRB) approval for either active or passive consenting processes or a waiver of consent to enroll participants, link data, and perform analytic studies. All procedures were Health Insurance Portability and Accountability Act (HIPAA) compliant.

Measures

At the time of the screening mammogram, women's demographic and risk factor data were self-reported or collected by the imaging facility. Characteristics included race/ethnicity (white, black, Asian, Hispanic of any race, and other), education (less than high school graduate, high school

graduate or general education development (GED), some college or technical school, and college graduate), first degree family history of breast cancer, personal history of breast cancer, and time since prior mammogram (no prior mammogram, 0–11 months, 12–23 months, 24–35 months, 36–47 months, and 48 or more months). Using BCSC data, we also determined the use of other breast imaging services, such as ultrasound or magnetic resonance imaging, in the year before the screening mammogram.

Using residential address, we assigned community-level characteristics obtained through 2010 U.S. Census data from the ESRI Business Analyst application at the time of the screening mammogram.¹⁴ The community-level characteristics include block-level information for median household income, median health insurance costs, proportion with Internet access, and the unemployment rate, which were categorized into quartiles. Community-level characteristics at the census tract level include proportion of households in which no one aged 14 and over (1) speaks English only or (2) speaks a non-English language at home and speaks English "very well" (formerly called linguistic isolation¹⁵ and referred to here as the proportion of households in which no adult speaks English very well) and diversity index (the likelihood that two persons chosen at random from the same area belong to different racial or ethnic groups, ranging from 0 [no diversity] to 100 [complete diversity]).¹⁶ The proportion of households in which no adult speaks English very well was categorized as none versus any given the low proportion in the nonurban group. Diversity index was categorized into quartiles.

We classified each examination as urban or nonurban, based on the woman's address at the time of the screening examination, according to the Rural/Urban Commuting Area (RUCA) five category codes¹⁷: urban (1: urban focused), nonurban (2: large rural, 3: small rural, 4: isolated rural, or 5: other), or missing (9: unknown).

To evaluate barriers regarding access to health care, women were asked "Was there any time in the past 12 months when you needed to get health care but could not get it?" at the time of their screening mammogram. This question was included as part of a standard risk factor questionnaire given to women to complete as part of routine care and was administered by either self-report *via* paper or by a mammography technologist directly asking the woman. Those who reported a barrier were asked to indicate the reasons: family, school, or work responsibilities (too many responsibilities); cost of care or insurance coverage; travel or transportation; or other (check all that apply).

Statistical analysis

We compared the proportion of mammograms with a self-reported health care barrier in the prior 12 months by urban versus nonurban residence using chi-square tests. We evaluated woman- and community-level factors associated with having a barrier to health care services using logistic regression, including variables for BCSC registry, year of the screening mammogram, age, race/ethnicity, education, first degree family history of breast cancer, personal history of breast cancer, time since prior mammogram, other breast imaging in prior year, median household income, average health insurance costs, proportion with Internet access, unemployment rate, proportion of households in which no adult

TABLE 1. WOMAN AND COMMUNITY LEVEL FACTORS OF THE STUDY POPULATION BY URBAN AND NONURBAN LOCATION, BREAST CANCER SURVEILLANCE CONSORTIUM 2012–2017

	<i>All</i> ^a (N = 393,430), N (%)	<i>Urban</i> (N = 304,104), N (%)	<i>Nonurban</i> (N = 75,954), N (%)
Woman level factors			
Age group, years			
40–49	90,002 (22.9)	73,118 (24.0)	14,049 (18.5)
50–59	123,629 (31.4)	95,987 (31.6)	23,434 (30.9)
60–69	115,805 (29.4)	87,960 (28.9)	23,931 (31.5)
70–79	52,029 (13.2)	38,356 (12.6)	11,759 (15.5)
80+	11,965 (3.0)	8,683 (2.9)	2,781 (3.7)
Race/Ethnicity			
White	256,535 (65.5)	172,471 (56.9)	71,764 (94.8)
Black	14,985 (3.8)	14,210 (4.7)	668 (0.9)
Asian	75,587 (19.3)	74,907 (24.7)	489 (0.7)
Hispanic	32,547 (8.3)	30,807 (10.2)	1,403 (1.9)
Other	12,177 (3.1)	10,482 (3.5)	1,376 (1.8)
Missing	1,599	1,227	254
Education			
<High school graduate	30,436 (7.8)	27,057 (9.0)	2,637 (3.5)
High school graduate or GED	58,605 (15.0)	34,486 (11.4)	20,287 (26.8)
Some college	86,298 (22.1)	64,036 (21.2)	19,033 (25.2)
College graduate	214,957 (55.1)	175,869 (58.3)	33,679 (44.5)
Missing	3,134	2,656	318
First degree family history breast cancer			
No	318,827 (82.0)	249,184 (82.8)	59,302 (79.5)
Yes	69,976 (18.0)	54,949 (17.3)	15,297 (20.5)
Missing	4,627	2,971	1,355
Personal history of breast cancer			
No	362,370 (93.4)	278,622 (93.3)	71,101 (93.7)
Yes	25,486 (6.6)	20,020 (6.7)	4,758 (6.3)
Missing	5,574	5,462	95
Time since prior mammogram			
No prior mammogram	15,233 (4.2)	13,174 (4.7)	1,639 (2.2)
0–11 months	7,636 (2.1)	4,858 (1.7)	2,544 (3.5)
12–23 months	227,391 (62.0)	165,649 (59.0)	53,012 (72.2)
24–35 months	85,131 (23.2)	73,480 (26.2)	9,639 (13.1)
36–47 months	15,557 (4.2)	11,967 (4.3)	2,972 (4.1)
48+ months	15,999 (4.4)	11,496 (4.1)	3,605 (4.9)
Missing	26,483	23,480	2,543
Other breast imaging in prior year			
No	388,742 (98.8)	300,848 (98.9)	74,677 (98.3)
Yes	4,688 (1.2)	3,256 (1.1)	1,277 (1.7)
Community level factors			
Median household income in census block			
< \$54,450	81,114 (25.0)	30,204 (12.1)	42,867 (67.0)
\$54,452–74,787	80,350 (24.8)	60,055 (24.1)	18,132 (28.3)
\$74,816–101,408	80,590 (24.9)	77,850 (31.2)	2,430 (3.8)
> \$101,463	82,021 (25.3)	81,132 (32.6)	588 (0.9)
Missing	69,355	54,863	11,937
Average health insurance costs in census block			
< \$1,828	81,012 (25.0)	43,214 (17.3)	31,766 (49.6)
\$1,828–2,281	80,035 (24.7)	53,529 (21.5)	23,031 (36.0)
\$2,282–3,188	81,394 (25.1)	72,673 (29.2)	7,799 (12.2)
> \$3,188	81,634 (25.2)	79,825 (32.0)	1,421 (2.2)
Missing	69,355	54,863	11,937
Proportion with Internet access in census block			
<82	81,012 (25.0)	67,869 (27.2)	11,247 (17.6)
82–88	87,126 (26.9)	38,360 (15.4)	41,269 (64.4)
89–94	94,190 (29.1)	82,126 (32.9)	11,032 (17.2)
>94	61,766 (19.1)	60,966 (24.5)	496 (0.8)
Missing	69,246	54,783	11,910

(continued)

TABLE 1. (CONTINUED)

	<i>All</i> ^a (N=393,430), N (%)	<i>Urban</i> (N=304,104), N (%)	<i>Nonurban</i> (N=75,954), N (%)
Unemployment rate in census block			
<6.8	82,771 (25.5)	43,645 (17.5)	33,275 (52.0)
6.8–8.7	82,620 (25.5)	61,912 (24.8)	17,350 (27.1)
8.8–11.3	79,688 (24.6)	70,219 (28.2)	8,283 (12.9)
>11.3	78,996 (24.4)	73,465 (29.5)	5,109 (8.0)
Missing	69,355	54,863	11,937
Proportion with households in which no adult speaks English very well in census tract			
None	249,033 (76.8)	174,594 (70.0)	63,748 (99.5)
Any (>0%)	75,151 (23.2)	74,727 (30.0)	316 (0.5)
Missing	69,246	54,783	11,910
Diversity index in census tract			
<25	83,950 (25.9)	17,109 (6.9)	56,748 (88.7)
25–48	82,115 (25.3)	76,646 (30.8)	5,037 (7.9)
49–63	80,474 (24.8)	79,069 (31.7)	1,279 (2.0)
>63	77,536 (23.9)	76,417 (30.7)	953 (1.5)
Missing	69,355	54,863	11,937

^a“All” column includes 13,372 examinations with missing urban status; of these, 385 (2.9%) reported a barrier and 12,987 (97.1%) did not. GED, general education department.

speaks English very well, and diversity index. We report adjusted odds ratios (aORs) and 95% confidence intervals (95% CIs), accounting for correlation among examinations from the same woman using a robust sandwich estimator. We assessed the interaction of each factor with residence type (urban vs. nonurban) using a Wald test. Analyses were conducted using Stata (StataCorp. Stata Statistical Software: Release 15, 2017; StataCorp LLC, College Station, TX).

Results

Among the 393,430 women, 304,104 (77.3%) were classified as living in urban areas, 75,954 (19.3%) were classified as living in nonurban areas, and 13,372 (3.4%) had a missing RUCA code. Compared to the study population in nonurban areas, the study population living in urban areas had higher proportions of women who were younger, more racially diverse, and had higher educational levels (Table 1). A lower proportion of women living in urban areas had a family history of breast cancer, and a higher proportion had a prior mammogram within 12–23 months than women living in nonurban areas. In addition, urban women lived in areas with a higher proportion of higher median household income, higher average health insurance costs, more Internet access, higher unemployment rates, a higher proportion of households in which no adult speaks English very well, and a higher diversity index.

Overall, 3.6% of women reported a barrier to receiving health care in the 12 months before their screening mammogram, which was higher for women in urban areas versus those in nonurban areas (3.9% vs. 2.2%, $p < 0.001$, Table 2). The most frequently reported barrier to receiving needed health care was no insurance or health care cost, with approximately half of women reporting a barrier citing these reasons in both urban and nonurban women. Women living in urban areas were more likely to report barriers related to family, school, or work responsibilities compared with women living in nonurban areas (22.4% vs. 9.2%, respectively).

Among women who reported having a barrier to receiving health care, 13.3% reported no specific reason, 78.6% reported one reason, 6.5% reported two reasons, 1.1% reported three reasons, and 0.5% reported four reasons (Table 3). In women reporting two barriers ($n = 917$), no insurance or health care cost and too many responsibilities were the most common among both urban and nonurban women. For women reporting three barriers ($n = 148$), no insurance or health care cost, too many responsibilities, and no transportation was the most common combination of reasons regardless of residence type.

The proportion of women reporting a barrier to health care in the prior 12 months varied by patient- and community-level factors (Table 4). Regardless of urban or nonurban area of residence, women ages 60 and older were less likely to report a barrier than women ages 40–49. Other factors associated with being less likely to report a barrier to health care among women living in urban areas were: Asian versus white race (aOR = 0.80, 95% CI: 0.74–0.86), being a high school graduate or GED versus college graduate (aOR = 0.90, 95% CI: 0.83–0.98), having higher median household income (highest vs. lowest quartile: aOR = 0.70, 95% CI: 0.61–0.81), and having higher average health insurance costs (highest vs. lowest quartile: aOR = 0.82, 95% CI: 0.71–0.95). In nonurban dwelling women, older women were less likely to report health care access barriers (comparing ages 60–69 with ages 40–49, aOR = 0.59, 95% CI: 0.50–0.70), and having a higher proportion with Internet access in the census block (aOR = 0.22, 95% CI: 0.07–0.72) was also associated with being less likely to report a barrier to health care.

Several factors were associated with an increased likelihood of reporting a barrier to obtaining needed health care (Table 4). Regardless of residence, and compared with white women, Hispanic (aOR = 1.66, 95% CI: 1.53–1.80), and other race (aOR = 1.84, 95% CI: 1.65–2.04) women were more likely to report a barrier, whereas only in urban areas were black women more likely to report a barrier compared with white women (aOR = 1.29, 95% CI: 1.15–1.44). In nonurban

TABLE 2. SELF-REPORTED BARRIERS TO HEALTH CARE BY URBAN VERSUS NONURBAN RESIDENCE, BREAST CANCER SURVEILLANCE CONSORTIUM 2012–2017

	<i>All</i> , ^a N = 393,430		<i>Urban</i> , N = 304,104		<i>Nonurban</i> , N = 75,954		p ^b
	<i>No barrier</i> , N (%)	<i>Barrier</i> , N (%) ^c	<i>No barrier</i> , N (%)	<i>Barrier</i> , N (%) ^c	<i>No barrier</i> , N (%)	<i>Barrier</i> , N (%) ^c	
All	379,413 (96.4)	14,017 (3.6)	292,127 (96.1)	11,977 (3.9)	74,299 (97.8)	1,655 (2.2)	<0.001
Type of barrier ^d							
Too many responsibilities	N/A	2,877 (20.5)	N/A	2,688 (22.4)	N/A	152 (9.2)	
No insurance/health care cost		6,910 (49.3)		5,874 (49.0)		840 (50.8)	
No transportation		1,087 (7.8)		914 (7.6)		147 (8.9)	
Other reasons, not specified		2,698 (19.2)		2,424 (20.2)		195 (11.8)	
No reason given		1,868 (13.3)		1,341 (11.2)		445 (26.9)	

Boldface indicates statistical significance.

^aAll includes 13,372 examinations with missing urban or nonurban status.

^bp-Value from chi-square test comparing proportion reporting barriers in urban versus nonurban examinations.

^cSome women reported multiple barrier types, so the number of examinations with a barrier is smaller than the sum of specific types and the percentages sum to >100%.

^dBarrier type is based on self report at time of screening mammogram as described in methods section.

areas, women with some college versus college graduate were more likely to report a barrier (aOR = 1.24, 95% CI: 1.07–1.44). Women with a family history of cancer or a personal history of breast cancer were more likely to report a barrier to obtaining health care. Women who reported having a prior mammogram outside the 12–23 month time window were more likely to report a barrier to receiving health care. The proportion of women with a prior mammogram on schedule (*i.e.*, within 12–23 months) was 62.6% in those with

no barrier and 44.2% in those with a barrier. In addition, reporting of a barrier was more common in women living in urban areas where a higher proportion have Internet access (aOR = 1.12, 95% CI: 1.03–1.23) and a higher diversity index score (diversity index <63 vs. <25: aOR = 1.26, 95% CI: 1.08–1.48). In contrast, nonurban women living in areas with a high proportion with Internet access were less likely to report a barrier (aOR = 0.22, 95% CI: 0.07–0.72).

TABLE 3. NUMBER AND TYPES OF BARRIERS REPORTED BY URBAN VERSUS NONURBAN RESIDENCE, BREAST CANCER SURVEILLANCE CONSORTIUM, 2012–2017

	<i>All</i> , ^a (N = 14,017), N (%)	<i>Urban</i> (N = 11,977), N (%)	<i>Nonurban</i> (N = 1,655), N (%)
Number of reasons reported			
0	1,868 (13.3)	1,341 (11.2)	445 (26.9)
1	11,014 (78.6)	9,631 (80.4)	1,108 (66.9)
2	917 (6.5)	813 (6.8)	83 (5.0)
3	148 (1.1)	125 (1.0)	16 (1.0)
4	70 (0.5)	67 (0.6)	3 (0.2)
Combinations of reasons			
Two reasons reported	N = 917	N = 813	N = 83
No insurance/health care cost+Too many responsibilities	396 (43.2)	357 (43.9)	29 (34.9)
No insurance/health care cost+No transportation	143 (15.6)	122 (15.0)	19 (22.9)
No insurance/health care cost+Other	139 (15.2)	126 (15.5)	9 (10.8)
Too many responsibilities+No transportation	95 (10.4)	82 (10.1)	12 (14.5)
Too many responsibilities+Other	82 (8.9)	73 (9.0)	8 (9.6)
No transportation+Other	62 (6.8)	53 (6.5)	6 (7.2)
Three reasons reported	N = 148	N = 125	N = 16
No insurance/health care cost+Too many responsibilities+No transportation	74 (50.0)	62 (49.6)	10 (62.5)
No insurance/health care cost+Too many responsibilities+Other	34 (23.0)	33 (26.4)	0 (0)
No insurance/health care cost+No transportation+Other	30 (20.3)	20 (16.0)	6 (37.5)
Too many responsibilities+No transportation+Other	10 (6.8)	10 (8.0)	0 (0)

^aAmong examinations with a positive response to the question, “Was there any time in the past 12 months when you needed to get health care but could not get it?”.

TABLE 4. ASSOCIATION BETWEEN WOMAN AND COMMUNITY LEVEL FACTORS AND SELF-REPORTED BARRIERS TO HEALTH CARE, BREAST CANCER SURVEILLANCE CONSORTIUM 2012–2017

	<i>All</i>		<i>Urban</i>		<i>Nonurban</i>	
	<i>% with barrier</i>	<i>aOR^a (95% CI)</i>	<i>% with barrier</i>	<i>aOR^a (95% CI)</i>	<i>% with barrier</i>	<i>aOR^a (95% CI)</i>
Woman level factors						
Age group, years						
40–49	4.5	1.0	4.7	1.0	3.3	1.0
50–59	4.5	1.16 (1.09–1.23)	5.0	1.21 (1.01–1.11)	2.9	0.90 (0.77–1.05)
60–69	2.9	0.81 (0.76–0.86)	3.3	0.86 (0.66–0.73)	1.7	0.59 (0.50–0.70)
70–79	1.7	0.50 (0.45–0.55)	1.9	0.55 (0.37–0.44)	0.7	0.24 (0.17–0.32)
80+	1.2	0.36 (0.30–0.44)	1.4	0.40 (0.24–0.36)	0.7	0.22 (0.13–0.38)
Race/Ethnicity						
White	2.9	1.0	3.0	1.0	2.0	1.0
Black	6.1	1.30 (1.16–1.44)	6.2	1.29 (1.15–1.44)	2.1	1.05 (0.48–2.30)
Asian	3.3	0.80 (0.74–0.86)	3.3	0.80 (0.74–0.86)	3.3	1.31 (0.67–2.57)
Hispanic	7.0	1.66 (1.53–1.80)	7.0	1.64 (1.51–1.79)	5.6	1.98 (1.40–2.81)
Other	7.0	1.84 (1.65–2.04)	7.2	1.75 (1.56–1.96)	5.5	2.53 (1.84–3.47)
Education						
<High school graduate	4.8	1.11 (1.02–1.22)	5.0	1.09 (0.99–1.20)	2.7	1.23 (0.86–1.73)
High school graduate or GED	3.0	0.91 (0.84–0.98)	3.9	0.90 (0.83–0.98)	1.8	0.96 (0.82–1.13)
Some college	3.9	1.06 (1.00–1.12)	4.4	1.03 (0.97–1.10)	2.6	1.24 (1.07–1.44)
College graduate	3.3	1.0	3.6	1.0	2.1	1.0
Family history of breast cancer						
No	3.5	1.0	3.9	1.0	2.1	1.0
Yes	3.5	1.16 (1.09–1.23)	3.8	1.15 (1.08–1.23)	2.3	1.27 (1.09–1.48)
Personal history breast cancer						
No	3.6	1.0	3.9	1.0	2.2	1.0
Yes	3.0	1.35 (1.23–1.49)	3.3	1.35 (1.22–1.50)	1.8	1.43 (1.06–1.92)
Time since prior mammogram						
No prior mammogram	7.4	3.43 (1.34–8.79)	7.5	3.21 (1.23–9.17)	^b	^b
0–11 months	2.9	1.17 (0.99–1.38)	3.8	1.28 (1.07–1.54)	1.3	0.93 (0.64–1.35)
12–23 months	2.3	1.0	2.6	1.0	1.5	1.0
24–35 months	3.7	1.49 (1.41–1.57)	3.8	1.45 (1.37–1.53)	3.0	1.97 (1.68–2.31)
36–47 months	6.0	2.56 (2.36–2.78)	6.5	2.52 (2.31–2.76)	4.4	2.80 (2.27–3.46)
48+ months	7.8	3.37 (3.12–3.63)	8.8	3.43 (3.16–3.73)	5.0	3.00 (2.45–3.66)
Other breast imaging in prior year						
No	3.6	1.0	4.0	1.0	2.2	1.0
Yes	2.2	0.81 (0.64–1.03)	2.5	0.78 (0.59–1.02)	1.2	0.80 (0.46–1.37)
Community level factors						
Median household income in census block						
< \$54,450	3.0	1.0	4.7	1.0	1.9	1.0
\$54,452–74,787	3.4	0.88 (0.81–0.95)	3.9	0.87 (0.79–0.96)	1.8	0.97 (0.80–1.17)
\$74,816–101,408	3.3	0.78 (0.70–0.87)	3.4	0.79 (0.70–0.89)	2.1	0.89 (0.56–1.42)
> \$101,408	2.5	0.69 (0.61–0.79)	2.5	0.70 (0.61–0.81)	2.0	1.08 (0.33–3.55)
Average health insurance costs in census block						
< \$1,828	3.4	1.0	4.7	1.0	1.9	1.0
\$1,828–2,281	3.1	0.96 (0.89–1.04)	3.9	0.92 (0.84–1.01)	1.9	1.01 (0.87–1.18)
\$2,282–3,188	3.2	0.96 (0.87–1.06)	3.4	0.93 (0.83–1.04)	1.8	0.93 (0.71–1.22)
> \$3,188	2.5	0.85 (0.74–0.98)	2.5	0.82 (0.71–0.95)	1.9	0.64 (0.29–1.41)
Proportion with Internet access in census block						
<82	3.7	1.0	4.0	1.0	2.1	1.0
82–88	2.9	1.02 (0.96–1.10)	4.1	1.07 (0.99–1.16)	1.8	0.87 (0.74–1.03)
89–94	2.6	0.91 (0.84–1.00)	2.7	0.91 (0.83–1.00)	1.9	0.87 (0.67–1.13)
>94	3.3	1.11 (1.02–1.21)	3.3	1.12 (1.03–1.23)	2.4	0.22 (0.07–0.72)
Unemployment rate in census block						
<6.8	2.3	1.0	2.7	1.0	1.8	1.0
6.8–8.7	2.9	1.06 (0.98–1.13)	3.1	1.04 (0.96–1.13)	2.0	1.11 (0.96–1.29)
8.8–11.3	3.2	0.99 (0.92–1.07)	3.3	0.99 (0.91–1.08)	1.9	0.99 (0.78–1.24)
>11.3	4.0	1.01 (0.93–1.09)	4.2	1.02 (0.93–1.11)	1.9	0.83 (0.63–1.09)

(continued)

TABLE 4. (CONTINUED)

	<i>All</i>		<i>Urban</i>		<i>Nonurban</i>	
	<i>% with barrier</i>	<i>aOR^a (95% CI)</i>	<i>% with barrier</i>	<i>aOR^a (95% CI)</i>	<i>% with barrier</i>	<i>aOR^a (95% CI)</i>
Proportion with households in which no adult speaks English very well in census tract						
None	2.8	1.0	3.2	1.0	1.9	1.0
Any (>0%)	3.9	1.02 (0.96–1.08)	3.9	1.02 (0.96–1.08)	5.0	0.79 (0.33–1.92)
Diversity index in census tract						
<25	1.9	1.0	2.1	1.0	1.8	1.0
25–48	2.8	1.21 (1.06–1.39)	2.8	1.20 (1.03–1.39)	2.2	1.12 (0.76–1.64)
49–63	3.2	1.17 (1.02–1.35)	3.2	1.15 (0.99–1.35)	2.5	1.79 (0.98–3.24)
>63	4.5	1.28 (1.11–1.48)	4.5	1.26 (1.08–1.48)	3.5	0.96 (0.53–1.74)

Boldface values indicate statistical significance.

^aaOR: adjusted for all variables shown in table, as well as BCSC registry site and examination year. Examinations with missing covariates were excluded from the models.

^bNo examinations in this category were retained in the model due to missing covariates.

aOR, adjusted odds ratio; BCSC, Breast Cancer Surveillance Consortium; CI, confidence interval.

Discussion

In our study, among women undergoing routine screening mammography who reported a barrier, health care cost or no insurance were the most commonly reported barriers with about half of women in both urban and nonurban residence citing these reasons. Under the ACA, most private insurance plans and the Medicare program were required to eliminate cost sharing (*i.e.*, deductibles, out of pocket expenses, or co-payments) for preventive services recommended by the U.S. Preventive Services Task Force, including screening mammography. Prior studies have shown that cost sharing reduces the use of health services and deters use of preventive health care.^{18–21} While the ACA improved access to preventive care, grandfathered plans (those in existence before March 2010) are an exception as no significant changes were made to the grandfathered plans' coverage. In 2014, 26% of those in employee-based plans were in grandfathered plans. Furthermore, the 2014 Kaiser Survey Tracking Poll reported that 43% of the public were aware that the ACA eliminated out-of-pocket expense for preventive services.²² A study by the Kaiser Family Foundation found that 20% of women reported putting off or postponing preventive services in the prior year due to cost, with this varying substantially by insurance type (15% for insured, 52% for uninsured).²³

Prior studies found barriers to health care services among insured patients, particularly related to work and family responsibilities, long wait times, distrust of the medical system, and discrimination based on the type of insurance.^{24–33} In our study, we found that women living in urban areas with lower health insurance costs were more likely to report a barrier, even after adjusting for other potential confounding factors. Out-of-pocket health care costs may include co-payments, co-insurance, facility fees, and deductibles. It is possible that women have access to most preventive services *via* their insurance coverage, including screening mammography, but high deductibles and co-payments prevent women from obtaining advanced and subspecialty care. Interestingly, women with no prior mammogram or whose prior mammogram was ≥ 4 years ago were more than thrice as likely as women with a mammogram 1–2 years ago to report a barrier to receiving

health care, suggesting that barriers may contribute to nonguideline-adherent mammography screening intervals. The proportion of urban women with a prior mammogram was lower than the proportion of nonurban women (95.3% vs. 97.8%), which is consistent with urban women reporting more barriers than nonurban women (3.9% vs. 2.2%). It is likely that women who need to obtain health care but could not get it are facing barriers that would prevent them from obtaining first mammograms and on-schedule mammograms.

The least commonly reported barrier in our study was related to travel or transportation. Transportation to health care services has been reported to be more of a barrier to receiving health care in uninsured populations, even among those who have access to a safety net facility.³⁴ In our study, transportation is less of a barrier, which may be due to the fact that we included women who are able to attend a breast imaging facility for mammography screening.

Our finding that black and Hispanic women were more likely to report a barrier than white women highlights a well-documented disparity. However, data from the American Community Survey and the Behavioral Risk Factor Surveillance System from 2013 to 2015 found that disparities on three access measures (percentage of uninsured working adults, percentage who skipped health care because of cost, and the percentage without a usual health care provider) narrowed between whites and both blacks and Hispanics,³⁵ likely due, in part, to the ACA, which was passed in March 2010. We included data from 2012 to 2017, which spans the time period in which the ACA was passed, and it is possible that disparities may reduce over time. In our study, Asian women were less likely to report a barrier to health care than white women. In a study using 2008 Panel of the Survey of Income and Program Participation data, the disparity in health insurance coverage between white and minority women was driven by minority women's greater propensity to lose existing health insurance, but probability of losing insurance was lowest for Asian women.³⁶

Community-level factors associated with social and financial barriers to health care included median household income, average health insurance costs, proportion with Internet access, and higher diversity index. Our finding that

lower insurance costs were associated with reporting a barrier was unanticipated. It is possible that average health insurance costs are a proxy for the quality of the plan or perhaps a function of Medicaid participation in the area. This finding warrants further evaluation. We also found that the proportion with Internet access was differentially associated with reporting a barrier based on type of residence. In urban locations, those living in areas with a higher proportion with Internet access were more likely to report a barrier to health care, while in nonurban areas a high proportion with Internet access was associated with being 78% less likely to report a barrier. Over the last two decades, the Internet has allowed patients to obtain medical information through educational websites and also through direct interactions with providers.³⁷ A study utilizing National Health Interview Survey data from 2009 found an association of barriers to health care access and Internet use for health seeking information. Specifically, they found that patients with financial barriers to accessing health care searched online for general health information more often than those without barriers and that patients who were unable to obtain timely appointments used e-mail communications with providers.³⁸

While our study found that women living in urban areas with a higher diversity index were more likely to report a barrier to health care, we found no association for women living in nonurban areas. Prior studies examining the relationship between residential segregation (for which diversity index is a proxy) and health care service utilization found mixed results. Some studies have reported that disparities in health care use are related to the individual's race and the diversity index of the community.^{39,40} In contrast, another study reported that African Americans and Hispanics tend to perceive fewer health care barriers when they live in areas with people of the same race or ethnicity.⁴¹ Focusing specifically on rural areas, Caldwell et al. found that higher residential segregation was associated with not having a usual source of health care.⁴² Interestingly, both African Americans and Hispanics were more likely to report that their health care needs were met when they lived in highly segregated areas of the same race or ethnicity.⁴² In our study, among women living in nonurban areas, higher diversity index was not associated with barriers to health care. It is important to note that the diversity index was unequally distributed in the urban and nonurban groups with ~7% of urban and 89% of nonurban women living in areas with a diversity index of less than 25. In the United States, diversity index scores vary by geographic region, and we included three geographic areas. In 2010, the U.S. diversity index average was 60.6, and for our regions the diversity index was 61.4 in North Carolina, 73.2 in California, and 41.4 in Vermont.⁴³

Compared with other studies which found 12%–33% of patients self-reporting a barrier to obtaining health care,^{24,44–46} <4% of our study population reported a barrier to health care use in the prior 12 months. This is likely due to the fact that we asked women about barriers at the time of their screening mammogram, and thus, some barriers had been overcome in this group. Using data from the 2007 Health Tracking Household Survey (HTHS), Kullgren et al. analyzed data from 15,197 adults and found that 29% reported unmet or delayed health care in the previous 12 months.⁴⁴ The reasons for not receiving care included affordability (18.5%), accommodation (17.5%), availability (8.4%), accessibility (4.4%), and ac-

ceptability (4.0%). In comparison with our access question, transportation problems were reported for a similar proportion (0.4% in HTHS vs. 0.2% in BCSC), while competing commitments or responsibilities (13.9% in HTHS vs. 0.8% in BCSC) and cost or insurance concerns (18.5% in HTHS vs. 1.8% in BCSC) were higher in the HTHS study.

Limitations

Our study has several limitations. We asked women about social and financial barriers to health care in the 12 months before their screening mammogram visit. Hence, these women are able to access screening mammography services, indicating that they have overcome some barriers. Although there is potential utility for screening for SDOH in mammography screening settings where a large proportion of women seek regular care, our results suggest that women who attend screening have a low prevalence of access issues compared with other settings. Given this, it is likely that our study population is not representative of all women in the United States, but of those who obtain preventive services (higher proportion from urban areas, lower proportion minority, and higher socioeconomic population) in three geographic areas.

Conclusions

While we found that barriers to health care are low in women who have access to mammography screening, barriers do exist for a small subset of women and the barriers are associated with SDOH. The largest reported barrier was no insurance or health care cost, which may have implications for downstream workup from screening if abnormalities are detected. Breast imaging facilities could utilize information on barriers faced by screened women to improve biennial screening adherence and ensure that women with abnormal findings obtain appropriate follow-up care through targeted interventions to this subgroup of the population.

Acknowledgments

All statements in this report, including its findings and conclusions, are solely those of the authors and do not necessarily represent the views of the Patient-Centered Outcomes Research Institute (PCORI), its Board of Governors or Methodology Committee, nor those of the National Cancer Institute, the National Institutes of Health, or the Agency for Health Research and Quality. The authors thank the participating women, mammography facilities, and radiologists for the data they have provided for this study. You can learn more about the BCSC at: www.bsc-research.org

Author Disclosure Statement

L.M.H., E.S.O., J.S.H., B.L.S., J.A.T., and T.O. report no financial disclosures. C.I.L. has received grant funding from GE Healthcare for unrelated work and payment from the American College of Radiology for journal editorial board work. K.K. is an unpaid consultant for the STRIVE study at GRAIL.

Funding Information

This work was supported by the National Institutes of Health under National Cancer Institute (Grants P01 CA154292, U54 CA163303, HSN261201100031C) and a

Patient-Centered Outcomes Research Institute (PCORI) award (PCS-1504-30370).

References

1. WHO (World Health Organization). What are the social determinants of health? 2012. Available at: www.who.int/social_determinants/sdh_definition/en Accessed October 29, 2019.
2. Office of Disease Prevention and Health Promotion. Healthy People, 2020: Social Determinants of Health. Available at: <https://www.healthypeople.gov/2020/topics-objectives/topic/social-determinants-of-health> Accessed October 29, 2019.
3. Beyond Health Care: The Roles of Social Determinants in Promoting Health and Health Equity. The Kaiser Family Foundation 2018. Available at: <https://www.kff.org/disparities-policy/issue-brief/beyond-health-care-the-role-of-social-determinants-in-promoting-health-and-health-equity> Accessed October 29, 2019.
4. CDC Programs Addressing Social Determinants of Health. Centers for Disease Control and Prevention, 2016. Available at: <https://www.cdc.gov/socialdeterminants/cdcprograms/index.htm> Accessed October 29, 2019.
5. Commission on the Social Determinants of Health. Closing the gap in a generation: Health equity through action on the social determinants of health. Geneva: World Health Organization, 2008.
6. Healthy People 2020: Access to Health Services. Office of Disease Prevention and Health Promotion, U.S. Department of Health and Human Services. Available at: www.healthypeople.gov/2020/topics-objectives/topic/Access-to-Health-Services Accessed October 29, 2019.
7. Marmot M, Allen JJ. Social determinants of health equity. *Am J Public Health* 2014;104(Suppl 4):S517–S519.
8. CDC Health Disparities and Inequalities Report - United States, 2013. Morbidity and Mortality Weekly Report (MMWR) Supplement No. 3, Pg. 1–187, 2013. Available at: www.cdc.gov/mmwr/preview/ind2013_su.htm#HealthDisparities Accessed April 27, 2020.
9. Andermann A. Screening for social determinants of health in clinical care: Moving from the margins to the mainstream. *Public Health Rev* 2018;39:19.
10. Garg A, Boynton-Jarrett R, Dworkin PH. Avoiding the unintended consequences of screening for social determinants of health. *JAMA* 2016;316:813–814.
11. Gifford K, Ellis E, Edwards BC, et al. Medicaid moving ahead in uncertain times: Results from a 50-state Medicaid Budget Survey for state fiscal years 2017 and 2018. Washington, DC: Kaiser Family Foundation, 2017.
12. Deloitte Center for Health Solutions. Social determinants of health: How are hospitals and health systems investing in and addressing social needs? New York, NY: Deloitte, 2017.
13. Breast Cancer Surveillance Consortium, 2020. Available at: <https://bcsc-research.org> Accessed October 29, 2019.
14. ESRI. ArcGIS Business Analyst. 2014. Available at: www.esri.com/software/businessanalyst Accessed June 29, 2019.
15. Language Use and Linguistic Isolation: Historical Data and Methodological Issues. United States Census Bureau. Published January 26, 2007. Available at: <https://www.census.gov/library/working-papers/2007/adrm/ssm2007-02.htm>. Accessed April 27, 2020.
16. Diversity Index. United States Census Bureau, 2017. Available at: <https://catalog.data.gov/dataset/diversity-index> Accessed October 29, 2019.
17. WWAMI Rural Health Research Center, Department of Family Medicine, University of Washington Seattle, WA. Rural-Urban Commuting Area Codes. Available at: <http://depts.washington.edu/uwruca> Accessed October 29, 2019.
18. Rice T, Matsuoka KY. The impact of cost-sharing on appropriate utilization and health status: A review of the literature on seniors. *Med Care Res Rev* 2004;61:415–452.
19. Trivedi AN, Rakowski W, Ayanian JZ. Effect of cost sharing on screening mammography in Medicare health plans. *N Engl J Med* 2008;358:375–383.
20. Solanki G, Schaffler HH. Cost-sharing and the utilization of clinical preventive services. *Am J Prev Med* 1999;17:127–133.
21. Trivedi AN, Leyva B, Lee Y, et al. Elimination of cost sharing for screening mammography in medicare advantage plans. *N Engl J Med* 2018;378:262–269.
22. Kaiser Family Foundation 2020. Kaiser Health Tracking Poll: March 2014. Available at: <https://www.kff.org/health-reform/poll-finding/kaiser-health-tracking-poll-march-2014> Accessed March 6, 2020.
23. Kaiser Family Foundation 2020. Preventive Services Covered by Private Health Plans under the Affordable Care Act. Available at: <https://www.kff.org/health-reform/factsheet/preventive-services-covered-by-private-health-plans> Accessed March 6, 2020.
24. Institute of Medicine, Board on Health Sciences Policy. Unequal treatment: confronting racial and ethnic disparities in healthcare. Washington, DC: National Academy Press, 2003.
25. Diamant AL, Hays RD, Morales LS, et al. Delays and unmet need for health care among adult primary care patients in a restructured urban public health system. *Am J Public Health* 2004;94:783–789.
26. Decker SL. In 2011 nearly one-third of physicians said they would not accept new Medicaid patients, but rising fees may help. *Health Aff (Millwood)* 2012;31:1673–1679.
27. Decker SL. Two-thirds of primary care physicians accepted new Medicaid patients in 2011–12: A baseline to measure future acceptance rates. *Health Aff (Millwood)* 2013;32:1183–1187.
28. Bindman AB, Coffman JM. Calling all doctors: What type of insurance do you accept? *JAMA Intern Med* 2014;174:869–870.
29. Sommers AS, Paradise J, Miller C. Physician willingness and resources to serve more Medicaid patients: Perspectives from primary care physicians. *Medicare Medicaid Res Rev* 2011;1:1–18.
30. Allen H, Wright BJ, Harding K, Broffman L. The role of stigma in access to health care for the poor. *Milbank Q* 2014;92:289–318.
31. Allen EM, Call KT, Beebe TJ, McAlpine DD, Johnson PJ. Barriers to care and health care utilization among the publicly insured. *Med Care* 2017;55:207–214.
32. Call KT, McAlpine DD, Garcia CM, et al. Barriers to care in an ethnically diverse publicly insured population: Is health care reform enough? *Med Care* 2014;52:720–727.
33. Han X, Call KT, Pintor JK, Alarcon-Expinoza G, Simon AB. Reports of insurance-based discrimination in health care and its association with access to care. *Am J Public Health* 2015;105(Suppl 3):S517–S525.
34. Kamimura A, Panahi S, Ahmmad Z, Pye M, Ashby J. Transportation and other nonfinancial barriers among uninsured primary care patients. *Health Serv Res Manag Epidemiol* 2018;5:1–6.

35. Hayes SL, Riley P, Radley DC, McCarthy D. Reducing racial and ethnic disparities in access to care: Has the Affordable Care Act made a difference? *Common Wealth Fund Brief*. August 2017. Available at: https://www.commonwealthfund.org/sites/default/files/documents/___media_files_publications_issue_brief_2017_aug_hayes_racial_ethnic_disparities_after_aca_ib.pdf Accessed October 29, 2019.
36. Sohn H. Racial and ethnic disparities in health insurance coverage: Dynamics of gaining and losing coverage over the life course. *Popul Res Policy Rev* 2017;36:181–201.
37. Otte-Trojel T, de Bont A, Rundall TG, et al. How outcomes are achieved through patient portals: A realist review. *J Am Med Inform Assoc* 2014;21:751–757.
38. Bhandari N, Yunfeng S, Kyoungrae J. Seeking health information online: Does limited healthcare access matter? *J Am Med Inform Assoc* 2014;21:1113–1117.
39. Gaskin DJ, Dinwiddie GY, Chan KS, McCleary R. Residential segregation and disparities in health care services utilization. *Med Care Res Rev* 2012;69:158–175.
40. Kirby JB, Taliaferro G, Zuvekas SH. Explaining racial and ethnic disparities in health care. *Med Care* 2006;44:164–172.
41. Haas JS, Phillips KA, Sonneborn D, et al. Variation in access to health care for different racial/ethnic groups by the racial/ethnic composition of an individual's county of residence. *Med Care* 2004;42:707–714.
42. Caldwell JT, Ford CL, Wallace SP, Wang MC, Takahashi LM. Racial and ethnic residential segregation and access to health care in rural areas. *Health Place* 2017;43:104–112.
43. Reese-Cassal K. ESRI. 2014/2019 Esri Diversity Index. Published September 2014. Available at: <https://www.esri.com/library/whitepapers/pdfs/diversity-index-methodology.pdf> Accessed October 29, 2019.
44. Kullgren JT, McLaughlin CG, Mitra N, Armstrong K. Nonfinancial barriers and access to care for US adults. *Health Serv Res* 2012;47(Pt II):1.
45. Berkowitz SA, Hulberg AC, Hong C, et al. Addressing basic resource needs to improve primary care quality: A community collaboration programme. *BMJ Qual Saf* 2016; 25:164–172.
46. Ronksley PE, Sanmartin C, Quan H, et al. Association between chronic conditions and perceived unmet health care needs. *Open Med* 2012;6:e48–e58.

Address correspondence to:
Louise M. Henderson, MSPH, PhD
Epidemiology Research
Department of Radiology
The University of North Carolina
130 Mason Farm Road
Bioinformatics # 3124
Chapel Hill, NC 27599-7515
USA

E-mail: louise_henderson@med.unc.edu