Receipt of Screening Mammography by Insured Women Diagnosed With Breast Cancer and Impact on Outcomes

Marissa B. Lawson, MD[1]; Christoph I. Lee, MD, MS[1,2]; Daniel S. Hippe, MS[1]; Shasank Chennupati, PharmD, MPH[2]; Catherine R. Fedorenko, MMSc[2]; Kathleen E. Malone, PhD, MPH[3]; Scott D. Ramsey, MD, PhD[2,3]; and Janie M. Lee, MD, MSc[1,2]

ABSTRACT

Background: The purpose of this study was to determine factors associated with receipt of screening mammography by insured women before breast cancer diagnosis, and subsequent outcomes. **Patients and Methods:** Using claims data from commercial and federal payers linked to a regional SEER registry, we identified women diagnosed with breast cancer from 2007 to 2017 and determined receipt of screening mammography within 1 year before diagnosis. We obtained patient and tumor characteristics from the SEER registry and assigned each woman a socioeconomic deprivation score based on residential address. Multivariable logistic regression models were used to evaluate associations of patient and tumor characteristics with late-stage disease and nonreceipt of mammography. We used multivariable Cox proportional hazards models to identify predictors of subsequent mortality. **Results:** Among 7,047 women, 69% (n=4,853) received screening mammography before breast cancer diagnosis. Compared with women who received mammography, those with no mammography had a higher proportion of late-stage disease (34% vs 10%) and higher 5-year mortality (18% vs 6%). In multivariable modeling, late-stage disease was most associated with nonreceipt of mammography (odds ratio [OR], 4.35; 95% CI, 3.80–4.98). The Cox model indicated that nonreceipt of mammography predicted increased risk of mortality (hazard ratio [HR], 2.00; 95% CI, 1.64–2.43), independent of late-stage disease at diagnosis (HR, 5.00; 95% CI, 4.10–6.10), Charlson comorbidity index score ≥1 (HR, 2.75; 95% CI, 2.26–3.34), and negative estrogen receptor/progesterone receptor status (HR, 2.09; 95% CI, 1.67–2.61). Nonreceipt of mammography was associated with younger age (40–49 vs 50–59 years; OR, 1.69; 95% CI, 1.45–1.96) and increased socioeconomic deprivation (OR, 1.05 per decile increase; 95% CI, 1.03–1.07). **Conclusions:** In a cohort of insured women diagnosed with breast cancer, nonreceipt of screening mammography was significantly associated with late-stage disease and mortality, suggesting that interventions to further increase uptake of screening mammography may improve breast cancer outcomes.

J Natl Compr Canc Netw 2021;19(10):1156–1164
doi: 10.6004/jnccn.2020.7801

[1]Department of Radiology, University of Washington School of Medicine; and [2]Hutchinson Institute for Cancer Outcomes Research, and [3]Division of Public Health Sciences, Fred Hutchinson Cancer Research Center, Seattle, Washington.

Background

Over the last several decades, breast cancer mortality in the United States has declined substantially.[1,2] This decrease has been attributed in part to screening mammography and its ability to detect localized asymptomatic breast cancers that can be treated with curative intent.[3–6]

Many socioeconomic factors influence whether women participate in screening mammography and have the associated improved outcomes.[7] Lack of insurance coverage has been established as an important barrier to cancer screening and is associated with significant disparities in outcomes.[8,9] Since legislation has established insurance coverage of screening mammography with no out-of-pocket costs, rates of screening mammography have increased among women aged 50 to 74.[10] However, Henley et al[9] found that although uninsured women had the lowest rates of screening mammography (35.4% vs 60%–75% among women with public or private insurance), even insured women failed to meet the Healthy People 2020 target of 81.1%.

Given the influence of insurance status on both uptake of cancer screening and downstream outcomes, and suboptimal observed screening rates among insured women, we examined a cohort of women to determine the proportion who received guideline-recommended screening mammography before breast cancer diagnosis when lack of insurance coverage was not a barrier.[11–14] We sought to identify associations between receipt of screening mammography, among other predictors, and the intermediate outcome of late-stage disease at diagnosis and the longer-term outcome of mortality. In addition, we sought to determine predictors of nonreceipt of screening mammography to identify factors that remain a barrier to screening mammography despite insurance coverage. Ultimately, these objectives may inform the


See JNCCN.org for supplemental online content.

development of interventions aimed at increasing adherence to screening mammography guidelines and improve outcomes.

Patients and Methods

Study Cohort

We performed a retrospective cohort study involving women diagnosed with breast cancer between January 1, 2007, and December 31, 2017. Insurance enrollment data from regional commercial insurers (Premera Blue Cross and Regence Blue Shield) and Medicare were linked with cancer registry records from the Cancer Surveillance System, which includes 13 counties in western Washington state and reports data as part of the national SEER network.[15,16] Insurance claims were extracted for eligible women during the study period. This HIPAA-compliant study received Fred Hutchinson Institutional Review Board approval to link registry and commercial insurance data and to perform analyses.

The study cohort included women aged 40 to 74 years at the time of primary breast cancer diagnosis who had continuous insurance enrollment from 13 months before diagnosis to 6 months after diagnosis, for a total of 19 months of continuous insurance enrollment. Exclusion criteria included women who (1) had a prior diagnosis of any cancer, (2) were diagnosed with breast cancer by autopsy or death certificate, (3) were missing a diagnosis year, (4) were diagnosed before 2007 or after 2017, or (5) had missing AJCC stage. Our exclusion criteria reflect standard practices used in tumor registry survival analyses and study period.

Clinical, demographic, and primary tumor data obtained from the regional cancer registry included age, year of breast cancer diagnosis, race/ethnicity, stage according to the 7th edition of the *AJCC Cancer Staging Manual*, and receptor status (estrogen receptor [ER], progesterone receptor [PR], and HER2/neu).[17] In our analyses, late-stage disease was defined as AJCC stage IIB or greater.[18] Cancer registry data included linkage with the National Death Index for determination of vital status. ICD-9-CM and ICD-10-CM diagnosis codes from insurance claims identified women with a documented positive family history of breast cancer (V16.3 in ICD-9-CM, Z80.3 in ICD-10-CM) and documented breast cancer–-specific genetic mutation (V84.02 in ICD-9-CM, Z15.01 in ICD-10-CM).[19,20] In addition, validated ICD-9-CM and ICD-10-CM coding algorithms were used to assign each woman a Charlson comorbidity index (CCI) score.[21] Residential zip codes at the time of diagnosis were obtained from the tumor registry and were used to assign each woman an area deprivation index (ADI) score[22] and rural-urban commuting area code (RUCA).[23] The ADI is a measure of socioeconomic disadvantage at the census block level, ranked 1 through 10, with 10 being the most disadvantaged decile. This index is a composite of variables that assess factors including educational attainment, income, and housing at an area level and correlate with mortality disparities.[24] RUCA codes classify US census tracts using measures of urbanization, population density, and daily commuting from the decennial census.[23]

We used CPT and HCPCS codes from insurance claims data to determine receipt of bilateral screening mammography in the 13 months before breast cancer diagnosis (supplemental eTable 1, available with this article at JNCCN.org).[25,26] The specific CPT and HCPCS codes for film, digital, or digital breast tomosynthesis screening mammography included 76092, 77057, 77067, 77063, and G0202. In addition, we used the following ICD codes to identify patients with screening encounters: Z12.31, V76.11, and V76.12.

Statistical Analysis

We compared clinical and tumor characteristics between women diagnosed with cancer who received screening mammography before diagnosis and those who did not. We used multivariable logistic regression analysis to evaluate the following potential predictors of nonreceipt of screening mammography: age, race/ethnicity, family history, genetic predisposition, CCI score, RUCA, and ADI. We then performed univariable and multivariable logistic regression models to evaluate the following potential predictors of late-stage disease: prior receipt of screening mammography, age, race/ethnicity, ER/PR status, HER2 status, family history, genetic predisposition, CCI score, RUCA, and ADI.

We used the Kaplan-Meier estimator to estimate survival over the follow-up period. Death dates from the tumor registry were used to calculate overall mortality during the follow-up period. Women who were alive at the end of the follow-up period on December 31, 2017, were censored. The log-rank test was used to compare survival between women who received screening mammography before diagnosis and those who did not. We used a multivariable Cox proportional hazards model to estimate hazard ratios (HRs) for the following predictors of all-cause mortality: receipt of screening mammography, age, race/ethnicity, late-stage disease, ER/PR status, HER2 status, family history, genetic predisposition, CCI score, RUCA, and ADI. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc). A 2-sided P value $<.05$ was considered statistically significant.

Results

After applying the inclusion and exclusion criteria, we included 7,047 women in our study cohort (Figure 1). Demographic and tumor characteristics of the cohort are detailed in Table 1. Median age at breast cancer

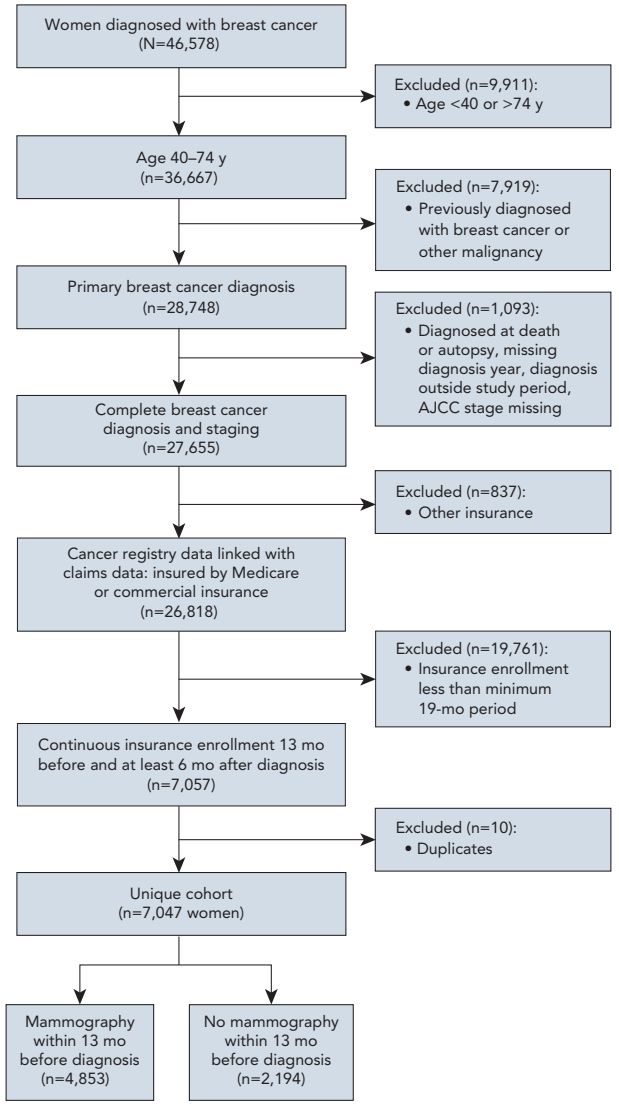

Figure 1. Diagram of study cohort.

diagnosis was 61 years (interquartile range [IQR], 53–69 years), and most women were non-Hispanic White (n=6,156; 87%). Overall, 69% (n=4,853) of women received screening mammography before breast cancer diagnosis. In the cohort, 62% (n=4,383) of women were covered by commercial insurance, 30% (n=2,084) were covered by Medicare, and the remaining 8% (n=580) were covered by both. Median follow-up time from breast cancer diagnosis to censorship or death was 3.75 years (IQR, 1.96–5.54 years).

In women who received screening mammography, 86.4% (4,193/4,853) of tumors were ER/PR-positive (Table 1). This favorable characteristic was lower in women who did not receive screening mammography (1,781/2,194 [81.2%]; difference of 5.2% [95% CI, 3.3%–7.2%]). Only a small proportion of women had HER2-positive tumors, with a higher proportion in women who did not receive screening mammography (11.8% [n=258/2,194] vs 7.0% [n=340/4,853]; difference of 4.8% [95% CI, 3.2%–6.3%]). Compared with women who received screening mammography, those with no screening had a higher proportion of late-stage disease at diagnosis (34.0% [n=751/2,194] vs 10.0% [n=474/4,853]; difference of 24.0% [95% CI, 22.0%–27.0%]).

Multivariable modeling showed nonreceipt of screening mammography was associated with younger age (40–49 vs 50–59 years; odds ratio [OR], 1.69; 95% CI, 1.45–1.96) and increasing ADI (OR, 1.05 per decile increase; 95% CI, 1.03–1.07) (Table 2). Women with a positive family history of breast cancer were more likely to have received screening mammography than those without a family history (OR, 0.69; 95% CI, 0.62–0.76). After multivariable analysis, race/ethnicity, RUCA, and genetic predisposition to breast cancer were not significantly associated with late-stage disease at diagnosis or death.

Univariable analysis showed late-stage breast cancer was associated with nonreceipt of screening mammography before diagnosis, increasing ADI, decreasing income quartile, no family history of breast cancer, predisposing genetic mutation, and comorbidity ($P<.05$). In multivariable modeling of 7,004 women (43 women excluded because of missing ADI data), late-stage disease at diagnosis was most strongly associated with nonreceipt of mammography (OR, 4.35; 95% CI, 3.80–4.98) (Table 3). Increasing ADI decile (OR per increasing decile, 1.05; 95% CI, 1.02–1.08) remained a significant predictor of late-stage disease, as did tumor characteristics of negative ER/PR status (OR, 1.71; 95% CI, 1.41–2.06) and positive HER2 status (OR, 1.39; 95% CI, 1.13–1.70). Late-stage disease was inversely associated with a positive family history of breast cancer (OR, 0.86; 95% CI, 0.74–0.99).

Five-year survival among women who received screening mammography was 94% (95% CI, 93%–95%) versus 82% (95% CI, 79%–84%) among those without screening mammography ($P<.0001$) (Figure 2). The Cox proportional hazards model of mortality indicated that nonreceipt of screening mammography predicted increased risk of all-cause mortality (HR, 2.00; 95% CI, 1.64–2.43), independent of the prognostic factors of late-stage disease at diagnosis (HR, 5.00; 95% CI, 4.10–6.10), CCI score ≥1 (HR, 2.75; 95% CI, 2.26–3.34), negative ER/PR status (HR, 2.09; 95% CI, 1.67–2.61), and ADI (HR, 1.06; 95% CI, 1.02–1.10) (Table 4).

Discussion

In a cohort of insured women in western Washington state, we found that women without receipt of screening

Table 1. Clinical and Tumor Characteristics of Study Cohort

Characteristic	n (%)	No Mammography n (%)	Received Mammography n (%)
Total	7,047 (100)	2,194 (31)	4,853 (69)
Age, y			
40–49	1,323 (19)	547 (25)	776 (16)
50–59	1,858 (26)	565 (26)	1,293 (27)
60–69	2,505 (36)	686 (31)	1,819 (37)
≥70	1,361 (19)	396 (18)	965 (20)
Race/Ethnicity			
White	6,156 (87)	1,871 (85)	4,285 (88)
Black	176 (2)	53 (2)	123 (3)
Hispanic (any race)	115 (2)	43 (2)	72 (1)
Asian/Pacific Islander	522 (7)	192 (9)	330 (7)
AI/AN and other/unknown	78 (1)	35 (2)	43 (1)
Diagnosis year			
2008–2011	1,543 (22)	482 (22)	1,061 (22)
2012–2014	2,959 (42)	914 (42)	2,045 (42)
2015–2017	2,545 (36)	798 (36)	1,747 (36)
AJCC stage (7th ed)			
Early (0–IIa)	5,822 (83)	1,443 (66)	4,379 (90)
Late (≥IIb)	1,225 (17)	751 (34)	474 (10)
ER/PR			
Positive	5,974 (85)	1,781 (81)	4,193 (86)
Negative	763 (11)	318 (14)	445 (9)
Unknown	310 (4)	95 (4)	215 (4)
HER2			
Positive	598 (8)	258 (12)	340 (7)
Negative	4,319 (61)	1,423 (65)	2,896 (60)
Unknown	2,130 (30)	513 (23)	1,617 (33)
Family history			
No	3,841 (55)	1,313 (60)	2,528 (52)
Yes	3,206 (45)	881 (40)	2,325 (48)
Genetic susceptibility			
No[a]	6,829 (97)	2,115 (96)	4,714 (97)
Yes	218 (3)	79 (4)	139 (3)
Insurer			
Commercial	4,383 (62)	1,380 (63)	3,003 (62)
Medicare	2,084 (30)	701 (32)	1,383 (28)
Commercial and Medicare	580 (8)	113 (5)	467 (10)
CCI score			
0	5,790 (82)	1,804 (82)	3,986 (82)
≥1	1,246 (18)	383 (17)	863 (18)
RUCA			
Metropolitan[b]	5,501 (78)	1,692 (77)	3,809 (78)
Metropolitan commuting[c]	826 (12)	263 (12)	563 (12)

(*continued on next page*)

Table 1. Clinical and Tumor Characteristics of Study Cohort (cont.)

Characteristic	n (%)	No Mammography n (%)	Received Mammography n (%)
Micropolitan[d] and micropolitan commuting[c]	501 (7)	168 (8)	333 (7)
Small town,[e] small town commuting,[c] and rural	219 (3)	71 (3)	148 (3)
ADI (decile)			
1 (least disadvantaged)	1,535 (22)	433 (20)	1,102 (23)
2	1,038 (15)	304 (14)	734 (15)
3	984 (14)	301 (14)	683 (14)
4	863 (12)	272 (12)	591 (12)
5	739 (11)	247 (11)	492 (10)
6	590 (8)	178 (8)	412 (8)
7	415 (6)	142 (6)	273 (6)
8	359 (5)	118 (5)	241 (5)
9	273 (4)	114 (5)	159 (3)
10 (most disadvantaged)	208 (3)	71 (3)	137 (3)

Abbreviations: ADI, area deprivation index; AI/AN, American Indian/Alaska Native; CCI, Charlson comorbidity index; ER, estrogen receptor; PR, progesterone receptor; RUCA, rural-urban commuting area.
[a]All women without ICD-9-CM or ICD-10-CM codes documenting a breast cancer–specific genetic susceptibility, including women who with a negative test result for a genetic susceptibility, who did not undergo genetic testing and those who otherwise lacked ICD documentation of genetic susceptibility.
[b]Population ≥50,000.
[c]>10% commute into area.
[d]Population 10,000–49,999.
[e]Population 2,500–9,999.

mammography in the 13 months before breast cancer diagnosis experienced 3 times higher rates of both late-stage disease at diagnosis and 5-year mortality. Increased mortality risk was independent of late-stage disease at diagnosis and woman-level comorbidities. Our results are consistent with a meta-analysis of prior randomized controlled trials and observational studies evaluating the effect of screening mammography in eligible women. Nelson et al[5] found that unscreened women aged ≥50 years had greater odds of late-stage cancer. Across all age groups, unscreened women also had an increased risk of breast cancer mortality. We included women diagnosed from 2007 to 2017 to evaluate contemporary receipt of screening mammography, with 36% of our study cohort receiving breast cancer diagnoses from 2015 to 2017. As a result of more recent diagnosis dates, these women contributed fewer years of follow-up to the survival analysis. Although our median follow-up time was 3.75 years, survival analysis indicates divergence of survival curves and confidence intervals beyond approximately 2 years, indicating significantly different survival between women who did and did not receive screening mammography.

Our study results highlight nonreceipt of screening mammography as a strong and independent predictor of adverse outcomes even among women with private insurance and/or Medicare coverage, consistent with prior published reports.[27–29] Cole et al[27] found that insurance coverage had a greater mortality reduction effect in cancers typically detected with screening than in those without widely adopted screening tests. A study of the National Cancer Database showed that women diagnosed with breast cancer who had private insurance were less likely to be diagnosed with stage III or IV breast cancer and had lower risk of 5-year mortality than those who were uninsured or insured by Medicaid.[28] Similarly, in the Texas Cancer Registry, uninsured women were more likely to be diagnosed with advanced-stage breast cancer and had higher mortality risk than privately insured women.[29] In our study cohort, although most (69%) screening-eligible, insured women received screening mammography before breast cancer diagnosis, almost one-third of women did not. This leaves room for improvement when the benefit from screening has been clearly shown.[5]

Of the predictors of poor outcomes identified in our analysis, nonreceipt of screening mammography is the factor most amenable to modification. In keeping with previous studies, our analysis showed that negative ER/PR and positive HER2 tumor receptor status were both associated with late-stage disease at diagnosis and decreased long-term mortality.[30–32] We also found that neighborhood-level ADI was an independent predictor of late-stage disease and increased risk of mortality. This finding corroborates another study showing that women residing in the highest ADI quintile regions were more likely to have late-stage

Table 2. Multivariable Model of Nonreceipt of Screening Mammography

Variable	OR (95% CI)	*P* Value
Age, y		**<.001**
40–49	1.69 (1.45–1.96)	
50–59	Ref	
60–69	0.82 (0.72–0.94)	
≥70	0.88 (0.75–1.03)	
Race/Ethnicity		.21
White	Ref	
Black	0.90 (0.65–1.26)	
Hispanic (any race)	1.20 (0.81–1.77)	
Other/Unknown[a]	1.18 (0.99–1.42)	
Family history		**<.001**
No	Ref	
Yes	0.69 (0.62–0.76)	
Genetic susceptibility		.07
No	Ref	
Yes	1.31 (0.98–1.75)	
CCI score		.73
0	Ref	
≥1	1.03 (0.89–1.18)	
RUCA		.83
Metropolitan[b]	Ref	
Metropolitan commuting[c]	1.06 (0.90–1.24)	
Micropolitan[d] and micropolitan commuting[c]	1.07 (0.87–1.32)	
Small town,[e] small town commuting,[c] and rural	1.07 (0.79–1.45)	
ADI	1.05 (1.03–1.07)	**<.001**

Bold indicates statistically significant *P* value.
Abbreviations: ADI, area deprivation index; CCI, Charlson comorbidity index; OR, odds ratio; RUCA, rural-urban commuting area.
[a]Includes Asian/Pacific Islander and American Indian/Alaska Native.
[b]Population ≥50,000.
[c]>10% commute into area.
[d]Population 10,000–49,999.
[e]Population 2,500–9,999.

Table 3. Multivariable Model of Late-Stage Breast Cancer at Diagnosis[a]

Variable	OR (95% CI)	*P* Value
Screening mammography		**<.001**
No	4.35 (3.80–4.98)	
Yes	Ref	
Age, y		**.01**
40–49	0.87 (0.71–1.06)	
50–59	Ref	
60–69	0.86 (0.72–1.02)	
≥70	0.70 (0.57–0.87)	
Race/Ethnicity		.06
White	Ref	
Black	0.95 (0.62–1.46)	
Hispanic (any race)	1.29 (0.81–2.07)	
Other/Unknown[b]	0.73 (0.57–0.94)	
ER/PR status		**<.001**
Positive	Ref	
Negative	1.71 (1.41–2.06)	
Unknown	2.09 (1.40–3.10)	
HER2 status		**<.001**
Positive	1.39 (1.13–1.70)	
Negative	Ref	
Unknown	0.27 (0.22–0.33)	
Family history		**.031**
No	Ref	
Yes	0.86 (0.74–0.99)	
Genetic susceptibility		.06
No	Ref	
Yes	1.42 (0.99–2.03)	
CCI score		.10
0	Ref	
≥1	1.16 (0.97–1.38)	
RUCA		.09
Metropolitan[c]	Ref	
Metropolitan commuting[d]	0.79 (0.63–0.98)	
Micropolitan[e] and micropolitan commuting[d]	0.81 (0.62–1.06)	
Small town,[f] small town commuting,[d] and rural	0.86 (0.58–1.28)	
ADI	1.05 (1.02–1.08)	**<.001**

Bold indicates statistically significant *P* value.
Abbreviations: ADI, area deprivation index; CCI, Charlson comorbidity index; ER, estrogen receptor; OR, odds ratio; PR, progesterone receptor; RUCA, rural-urban commuting area.
[a]N=7,004, excluding 43 women with missing ADI data.
[b]Includes Asian/Pacific Islander and American Indian/Alaska Native.
[c]Population ≥50,000.
[d]>10% commute into area.
[e]Population 10,000–49,999.
[f]Population 2,500–9,999.

breast cancer at diagnosis and lower rates of screening mammography.[33]

Although nonreceipt of screening is a potentially modifiable predictor of late-stage disease and long-term mortality, we found that it is mediated by both woman-level factors and factors external to an individual woman. Our logistic regression analysis shows that nonreceipt of screening mammography was associated with women's residence in neighborhoods of increasing ADI (ie, the most disadvantaged areas). The OR of nonreceipt of screening mammography across each ADI decile increase was 1.05, which translates to women living in the most disadvantaged decile census blocks having 55%

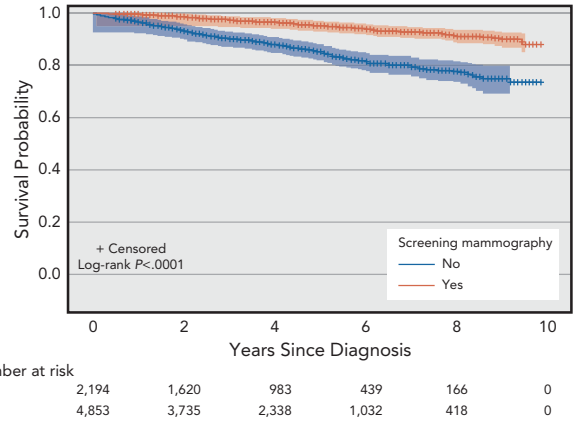

Figure 2. Survival over the course of 10 years. Women who were alive at the end of the follow-up period were censored on December 31, 2017.

greater odds of not receiving screening mammography than women living in the least disadvantaged decile census blocks. Similarly, Kurani et al[34] showed that the odds of a woman completing recommended screening mammography were lower for individuals living in the highest ADI census block group quintile. Overall, this association with ADI highlights that population-level determinants continue to play a role in health disparities even when an important individual-level barrier (lack of insurance coverage) is removed.

Other predictors of nonreceipt of screening mammography included younger age and negative family history of breast cancer. Younger age (40–49 years) as a significant predictor of nonreceipt of screening mammography may be a result of women adhering to the US Preventive Services Task Force guidelines, which recommend initiating routine screening mammography in average-risk women at age 50 years and selective screening for women aged 40 to 49 years.[35] However, the literature reports varied effects on use of screening mammography in women aged 40 to 49 years after the US Preventive Services Task Force 2009 update.[36,37] In our cohort, patients with a positive family history of breast cancer were more likely to receive screening mammography, which is consistent with findings reported by Taplin et al.[38] This trend may be related to greater adherence to screening guidelines in the setting of perceived increased risk of breast cancer. The lack of corresponding association between genetic susceptibility to breast cancer and receipt of screening may be related to women obtaining testing for genetic mutations after breast cancer diagnosis, although this temporal sequence could not be determined from our claims data. It is also possible that women with an undiagnosed breast cancer–specific genetic mutation may

Table 4. Cox Model of Overall Mortality

Variable	HR (95% CI)	*P* Value
Screening mammography		**<.001**
No	2.00 (1.64–2.43)	
Yes	Ref	
Age, y		**<.001**
40–49	0.70 (0.50–0.98)	
50–59	Ref	
60–69	1.63 (1.27–2.08)	
≥70	2.00 (1.52–2.63)	
Race/Ethnicity		.09
White	Ref	
Black	1.55 (0.95–2.51)	
Hispanic (any race)	1.08 (0.57–2.03)	
Other/Unknown[a]	0.68 (0.44–1.05)	
AJCC stage (7th ed)		
Early (0–IIa)	Ref	**<.001**
Late (≥IIb)	5.00 (4.10–6.10)	
ER/PR status		**<.001**
Positive	Ref	
Negative	2.09 (1.67–2.61)	
Unknown	3.98 (2.65–5.98)	
HER2 status		**<.001**
Positive	0.72 (0.53–0.98)	
Negative	Ref	
Unknown	0.51 (0.38–0.67)	
Family history		**.004**
No	Ref	
Yes	0.75 (0.62–0.91)	
Genetic susceptibility		.67
No	Ref	
Yes	1.13 (0.64–2.00)	
CCI score		**<.001**
0	Ref	
≥1	2.75 (2.26–3.34)	
RUCA		.29
Metropolitan[b]	Ref	
Metropolitan commuting[c]	1.25 (0.95–1.64)	
Micropolitan[d] and micropolitan commuting[c]	1.06 (0.76–1.47)	
Small town,[e] small town commuting,[c] and rural	0.78 (0.48–1.29)	
ADI	1.06 (1.02–1.10)	**<.001**

Bold indicates statistically significant *P* value.
Abbreviations: ADI, area deprivation index; CCI, Charlson comorbidity index; ER, estrogen receptor; HR, hazard ratio; PR, progesterone receptor; RUCA, rural-urban commuting area.
[a]Includes Asian/Pacific Islander and American Indian/Alaska Native.
[b]Population ≥50,000.
[c]>10% commute into area.
[d]Population 10,000–49,999.
[e]Population 2,500–9,999.

have been miscategorized if they were never tested or if the presence of a genetic mutation was not documented using ICD diagnosis codes.

Our study has limitations. For complete capture of women who received screening mammography in the 13 months before diagnosis, we required 19 months of continuous insurance enrollment, which resulted in the exclusion of a substantial proportion of otherwise eligible women with breast cancer. It is possible that women who opted for a biennial screening strategy may have been included in the nonreceipt of screening group, despite participation in routine screening.[39,40] In the context of a prior report comparing outcomes of biennial versus annual screening, which indicated that premenopausal women receiving biennial screening were more likely to have tumors with less favorable prognostic characteristics,[18] our results highlighting an association between younger age and nonreceipt of screening are also in keeping with premenopausal women receiving screening at biennial intervals and may represent an opportunity to discuss annual screening intervals for younger women.

Our analysis also did not include whether a woman had a wellness or preventive care visit before diagnosis, which may be associated with receipt of screening mammography. Extending the period of required continuous enrollment beyond 19 months to include a wellness or preventive care visit before screening mammography would have further excluded women from our study. Nonetheless, exclusion of this predictor is a limitation of this study. Other inherent limitations of insurance claims data analyses are related to missing data. For example, claims data do not include information on test results, which limits assessment of whether the breast cancers in our cohort were detected by screening mammography. We also did not have detailed information about variation across plans offered by private insurers, such as whether women were enrolled in high-deductible plans. Although screening mammography qualifies as preventive care covered without copays as mandated by the Affordable Care Act, high deductibles for diagnostic evaluations have been associated with delays in diagnosis, which may contribute to adverse outcomes.[41] Given the undercapture of initiation and adherence to medical treatment regimens, especially adjuvant endocrine therapy in both claims data and the SEER database, we chose to exclude treatment variables as predictors in the survival analysis.[42–45] Finally, our cohort was racially homogeneous and composed of very few individuals living in rural or high ADI areas, limiting power to detect significant differences. We did not find a significant association between rurality and screening uptake, despite Heller et al[46] demonstrating significantly lower screening rates in rural and urban counties with populations <20,000. Although Henley et al[9] found that the Health People 2020 screening target for mammography (81.1%) was not met in any racial group or in either rural or metropolitan locations, screening declined by >10% from 2008 to 2015 among Asian and rural women compared with a <5% decline in other racial or geographic groups.

Conclusions

In a cohort of insured women with breast cancer, nonreceipt of screening mammography before diagnosis was a significant and modifiable predictor of late-stage disease at diagnosis and subsequent mortality. Given the association of socioeconomic deprivation with nonreceipt of screening mammography, efforts aimed at increasing uptake of screening mammography will likely benefit from multilevel design and implementation to improve screening adherence and population-level outcomes.

Submitted August 15, 2020; final revision received December 20, 2020; accepted for publication December 21, 2020.

Published online July 30, 2021.

Author contributions: *Data acquisition:* J.M. Lee, Malone, Ramsey. *Data analysis:* Lawson, C.I. Lee, Hippe, Chennupati, Fedorenko, Malone, J.M. Lee. *Manuscript preparation:* All authors.

Disclosures: Dr. C.I. Lee has disclosed receiving grant/research support from and serves on a data safety monitoring board for GRAIL, Inc., and receives royalties from McGraw Hill, Inc., Wolters Kluwer, and Oxford University Press. Mr. Hippe has disclosed receiving grant/research support from GE Healthcare, Philips Healthcare, Canon Medical Systems USA, and Siemens Healthineers. Dr. J.M. Lee has disclosed receiving grant/research support from GE Healthcare. The remaining authors have disclosed that they have no financial interests, arrangements, affiliations, or commercial interests with the manufacturers of any products discussed in this article or their competitors.

Funding: Research reported in this publication was supported by the NCI of the NIH under award number P30 CA015704-43 (J.M. Lee).

Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

Correspondence: Janie M. Lee, MD, MSc, Seattle Cancer Care Alliance, 1144 Eastlake Avenue East, LG2-200, Seattle, WA 98109.
Email: jmlee58@uw.edu

References

1. Guo F, Kuo YF, Shih YCT, et al. Trends in breast cancer mortality by stage at diagnosis among young women in the United States. Cancer 2018;124:3500–3509.
2. Henley SJ, Ward EM, Scott S, et al. Annual report to the nation on the status of cancer, part I: national cancer statistics. Cancer 2020;126: 2225–2249.
3. Kaplan HG, Malmgren JA, Atwood MK, et al. Effect of treatment and mammography detection on breast cancer survival over time: 1990-2007. Cancer 2015;121:2553–2561.
4. 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: 1784–1792.

5. Nelson HD, Fu R, Cantor A, et al. Effectiveness of breast cancer screening: systematic review and meta-analysis to update the 2009 U.S. Preventive Services Task Force recommendation. Ann Intern Med 2016;164:244–255.
6. Plevritis SK, Munoz D, Kurian AW, et al. Association of screening and treatment with breast cancer mortality by molecular subtype in US women, 2000-2012. JAMA 2018;319:154–164.
7. Lobb R, Ayanian JZ, Allen JD, et al. Stage of breast cancer at diagnosis among low-income women with access to mammography. Cancer 2010;116:5487–5496.
8. Selvin E, Brett KM. Breast and cervical cancer screening: sociodemographic predictors among White, Black, and Hispanic women. Am J Public Health 2003;93:618–623.
9. Henley SJ, Thomas CC, Lewis DR, et al. Annual report to the nation on the status of cancer, part II: progress toward Healthy People 2020 objectives for 4 common cancers. Cancer 2020;126:2250–2266.
10. Nelson HD, Weerasinghe R, Wang L, et al. Mammography screening in a large health system following the U.S. Preventive Services Task Force recommendations and the Affordable Care Act. PLoS One 2015;10:e0131903.
11. U.S. Preventive Services Task Force. Final recommendation statement. Breast cancer: screening. Accessed October 27, 2020. Available at: https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/breast-cancer-screening
12. Oeffinger KC, Fontham ET, Etzioni R, et al. Breast cancer screening for women at average risk: 2015 guideline update from the American Cancer Society. JAMA 2015;314:1599–1614.
13. Abbott BC, Duncan EF, Grady HI, et al. NCCN Clinical Practice Guidelines in Oncology: Breast Cancer. Version 1.2018. Accessed March 15, 2018. To view the most recent version, visit NCCN.org
14. Lee CH, Dershaw DD, Kopans D, et al. Breast cancer screening with imaging: recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of clinically occult breast cancer. J Am Coll Radiol 2010;7:18–27.
15. Fred Hutchinson Cancer Center. Cancer surveillance system (CSS). Accessed June 23, 2020. Available at: https://www.fredhutch.org/en/research/divisions/public-health-sciences-division/research/epidemiology/cancer-surveillance-system.html
16. National Cancer Institute. Surveillance, Epidemiology, and End Results Program. Accessed June 23, 2020. Available at: https://seer.cancer.gov
17. Edge SB, Byrd DR, Compton CC, et al., eds. AJCC Cancer Staging Manual, 7th ed. New York, NY: Springer; 2010.
18. Miglioretti DL, Zhu W, Kerlikowske K, et al. Breast tumor prognostic characteristics and biennial vs annual mammography, age, and menopausal status. JAMA Oncol 2015;1:1069–1077.
19. International Statistical Classification of Diseases and Related Health Problems 10th Revision. Accessed June 23, 2020. Available at: https://icd.who.int/browse10/2019/en
20. International Classification of Diseases: Ninth Revision. Basic Tabulation List With Alphabetic Index. Geneva, Switzerland: WHO; 1978.
21. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–383.
22. Kind AJ, Jencks S, Brock J, et al. Neighborhood socioeconomic disadvantage and 30-day rehospitalization: a retrospective cohort study. Ann Intern Med 2014;161:765–774.
23. U.S. Department of Agriculture, Economic Research Service. Documentation: 2010 Rural-Urban Commuting Area (RUCA) codes. Accessed January 19, 2020. Available at: https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/documentation/
24. Singh GK. Area deprivation and widening inequalities in US mortality, 1969-1998. Am J Public Health 2003;93:1137–1143.
25. American Medical Association. CPT overview and code approval. Accessed June 23, 2020. Available at: https://www.ama-assn.org/practice-management/cpt/cpt-overview-and-code-approval
26. Centers for Medicare and Medicaid Services. HCPCS coding questions. Accessed June 23, 2020. Available at: https://www.cms.gov/Medicare/Coding/MedHCPCSGenInfo/HCPCS_Coding_Questions
27. Cole AP, Lu C, Krimphove MJ, et al. Comparing the association between insurance and mortality in ovarian, pancreatic, lung, colorectal, prostate, and breast cancers. J Natl Compr Canc Netw 2019;17:1049–1058.
28. Ward E, Halpern M, Schrag N, et al. Association of insurance with cancer care utilization and outcomes. CA Cancer J Clin 2008;58:9–31.
29. Zhang Y, Franzini L, Chan W, et al. Effects of health insurance on tumor stage, treatment, and survival in large cohorts of patients with breast and colorectal cancer. J Health Care Poor Underserved 2015;26:1336–1358.
30. Donegan WL. Tumor-related prognostic factors for breast cancer. CA Cancer J Clin 1997;47:28–51.
31. Seshadri R, Firgaira FA, Horsfall DJ, et al. Clinical significance of HER-2/neu oncogene amplification in primary breast cancer. J Clin Oncol 1993;11:1936–1942.
32. Howlader N, Cronin KA, Kurian AW, et al. Differences in breast cancer survival by molecular subtypes in the United States. Cancer Epidemiol Biomarkers Prev 2018;27:619–626.
33. Anderson RT, Yang TC, Matthews SA, et al. Breast cancer screening, area deprivation, and later-stage breast cancer in Appalachia: does geography matter? Health Serv Res 2014;49:546–567.
34. Kurani SS, McCoy RG, Lampman MA, et al. Association of neighborhood measures of social determinants of health with breast, cervical, and colorectal cancer screening rates in the US Midwest. JAMA Netw Open 2020;3:e200618.
35. Siu AL, U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med 2016;164:279–296
36. Qin X, Tangka FK, Guy GP Jr, et al. Mammography rates after the 2009 revision to the United States Preventive Services Task Force breast cancer screening recommendation. Cancer Causes Control 2017;28:41–48.
37. Wang AT, Fan J, Van Houten HK, et al. Impact of the 2009 US Preventive Services Task Force guidelines on screening mammography rates on women in their 40s. PLoS One 2014;9:e91399.
38. Taplin SH, Ichikawa L, Yood MU, et al. Reason for late-stage breast cancer: absence of screening or detection, or breakdown in follow-up? J Natl Cancer Inst 2004;96:1518–1527.
39. Rosenberg RD, Haneuse SJ, Geller BM, et al. Timeliness of follow-up after abnormal screening mammogram: variability of facilities. Radiology 2011;261:404–413.
40. Sprague BL, Miglioretti DL, Lee CI, et al. New mammography screening performance metrics based on the entire screening episode. Cancer 2020;126:3289–3296.
41. Wharam JF, Zhang F, Wallace J, et al. Vulnerable and less vulnerable women in high-deductible health plans experienced delayed breast cancer care. Health Aff (Millwood) 2019;38:408–415.
42. Chlebowski RT, Kim J, Haque R. Adherence to endocrine therapy in breast cancer adjuvant and prevention settings. Cancer Prev Res (Phila) 2014;7:378–387.
43. Farias AJ, Du XL. Association between out-of-pocket costs, race/ethnicity, and adjuvant endocrine therapy adherence among Medicare patients with breast cancer. J Clin Oncol 2017;35:86–95.
44. Sheppard VB, He J, Sutton A, et al. Adherence to adjuvant endocrine therapy in insured black and white breast cancer survivors: exploring adherence measures in patient data. J Manag Care Spec Pharm 2019;25:578–586.
45. Noone AM, Lund JL, Mariotto A, et al. Comparison of SEER treatment data with Medicare claims. Med Care 2016;54:e55–64.
46. Heller SL, Rosenkrantz AB, Gao Y, et al. County-level factors predicting low uptake of screening mammography. AJR Am J Roentgenol 2018;211:624–629.

See JNCCN.org for supplemental online content.

JNCCN

National Comprehensive Cancer Network®

JOURNAL OF THE NATIONAL COMPREHENSIVE CANCER NETWORK

Supplemental online content for:

Receipt of Screening Mammography by Insured Women Diagnosed With Breast Cancer and Impact on Outcomes

Marissa B. Lawson, MD; Christoph I. Lee, MD, MS; Daniel S. Hippe, MS; Shasank Chennupati, PharmD, MPH; Catherine R. Fedorenko, MMSc; Kathleen E. Malone, PhD, MPH; Scott D. Ramsey, MD, PhD; and Janie M. Lee, MD, MSc

J Natl Compr Canc Netw 2021;19(10):1156–1164

eTable 1: Medical Codes Used to Identify Variables

eTable 1. Medical Codes Used to Identify Variables

Variable	Code	Type of Code	Description
Breast, mammogram	76092	CPT	Screening mammography, bilateral (ended 2007)
	77057	CPT	Screening mammography, bilateral (ended 2007)
	77067	CPT	Screening mammography, bilateral (2-view study of each breast), including CAD when performed
	77063	CPT	Screening digital breast tomosynthesis, bilateral
	G0202	HCPCS	Screening mammography, producing direct digital image, bilateral, all views
	Z12.31	ICD-10-CM	Encounter for screening mammogram for malignant neoplasm of breast
	V76.11	ICD-9-CM	Screening mammogram for high-risk patient
	V76.12	ICD-9-CM	Other screening mammogram
Family history	Z80.3	ICD-10-CM	Family history of malignant neoplasm of breast
	V16.3	ICD-9-CM	Family history of malignant neoplasm of breast
Genetic susceptibility	Z15.01	ICD-10-CM	Genetic susceptibility to malignant neoplasm of breast
	V84.01	ICD-9-CM	Genetic susceptibility to malignant neoplasm of breast

Abbreviation: CAD, computer-assisted detection.