Research Article

Cancer Epidemiology, Biomarkers & Prevention

Insurance-Based Differences in Time to Diagnostic Follow-up after Positive Screening Mammography

Danielle D. Durham[1], Whitney R. Robinson[1,2], Sheila S. Lee[3], Stephanie B. Wheeler[2,4], Katherine E. Reeder-Hayes[2,5], J. Michael Bowling[6], Andrew F. Olshan[1,2], and Louise M. Henderson[1,2,3]

Abstract

Background: Insurance may lengthen or inhibit time to follow-up after positive screening mammography. We assessed the association between insurance status and time to initial diagnostic follow-up after a positive screening mammogram.

Methods: Using 1995–2010 data from a North Carolina population-based registry of breast imaging and cancer outcomes, we identified women with a positive screening mammogram. We compared receipt of follow-up within 60 days of screening using logistic regression and evaluated time to follow-up initiation using Cox proportional hazards regression.

Results: Among 43,026 women included in the study, 73% were <65 years and 27% were 65+ years. Median time until initial diagnostic follow-up was similar by age group and insurance status. In the adjusted model for women <65, uninsured women experienced a longer time to initiation of diagnostic follow-up [HR, 0.47; 95% confidence interval (CI), 0.25–0.89] versus women with private insurance. There were increased odds of these uninsured women not meeting the Centers for Disease Control and Prevention guideline for follow-up within 60 days (OR, 1.59; 95% CI, 1.31–1.94). Among women ages 65+, women with private insurance experienced a faster time to follow-up (adjusted HR, 2.09; 95% CI, 1.27–3.44) than women with Medicare and private insurance. Approximately 10% of women had no follow-up by 365 days.

Conclusions: We found differences in time to initial diagnostic follow-up after a positive screening mammogram by insurance status and age group. Uninsured women younger than 65 years at a positive screening event had delayed follow-up.

Impact: Replication of these findings and examination of their clinical significance warrant additional investigation. *Cancer Epidemiol Biomarkers Prev; 25(11); 1474–82. ©2016 AACR.*

Introduction

Screening mammography has been associated with as much as a 20% reduction in breast cancer mortality among women ages 40 to 74 years (1, 2), and mammography remains the preferred method for breast cancer screening in the United States (1). An estimated 54% to 60% of breast cancers are detected via screening mammography (3–5), highlighting its importance in breast cancer detection. Approximately 10% of screening mammograms require additional follow-up imaging and about 2% require a biopsy (6, 7). A dimension of screening that may impact breast cancer mortality is the receipt of appropriate and timely follow-up after a positive screening mammogram, especially if the follow-up delays necessary treatment. Breast cancer screening via mammography is only effective in reducing mortality if followed by timely diagnosis and treatment.

Currently, the only U.S. guideline regarding the length of time in which follow-up should occur after a positive screening mammogram comes from the Centers for Disease Control and Prevention (CDC). The CDC guidelines recommend women with a positive screening mammogram complete diagnostic work-up within 60 days of the initial positive screen (8, 9). Delayed (>60 days, based on the CDC guideline, as defined in the literature) follow-up after a positive screening mammogram may contribute to disparities in breast cancer outcomes and subsequently mortality since follow-up times of 3 to 6 months has been associated with larger tumor size at diagnosis and reduced survival (10–14).

Many factors may contribute to prolonged initiation of diagnostic follow-up after a positive screening mammogram result (15). Healthcare system factors known to influence receipt of appropriate diagnostic follow-up include adequate communication with health care professionals, physician referral, and facility type (16, 17). Prior studies have investigated patient factors such as race, education, and rural/urban residence that influence diagnostic follow-up time (18). However, few studies have examined the influence of insurance on diagnostic follow-up time. Insurance status refers to whether someone is uninsured or insured and among those with insurance designates the specific insurance provider.

Although the impact of insurance status as a determinant of breast cancer care (access to screening, stage at diagnosis, receipt of

[1]Department of Epidemiology, UNC Gillings School of Public Health, The University of North Carolina at Chapel Hill, North Carolina. [2]Lineberger Comprehensive Cancer Center, The University of North Carolina at Chapel Hill, North Carolina. [3]Department of Radiology, UNC School of Medicine, Chapel Hill, North Carolina. [4]Department of Health Policy and Management, UNC Gillings School of Public Health, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina. [5]Division of Hematology/Oncology, UNC School of Medicine, Chapel Hill, North Carolina. [6]Department of Health Behavior, UNC Gillings School of Public Health, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

Corresponding Author: Louise M. Henderson, 3124 Bioinformatics Building, 130 Mason Farm Road, Campus Box 7515, Chapel Hill, NC 27599. Phone: 919-843-7799; Fax: 919-966-0525; E-mail: louise_henderson@med.unc.edu

doi: 10.1158/1055-9965.EPI-16-0148

treatment) has been well-documented (19–24), the effect of insurance status on time to diagnostic follow-up initiation after a positive screening mammogram is not well understood. Associations may vary by insurance status and prior studies often include members of a single insurance status or combine multiple insurance groups. The primary objective of this study is to assess the association between insurance status and the time to initiation of diagnostic follow-up after a positive screening mammogram in a large, racially diverse population-based breast cancer screening population.

Materials and Methods

Data and study population

We used data from the Carolina Mammography Registry (CMR), an NIH-funded, population-based breast imaging registry in North Carolina. CMR is an active member of the Breast Cancer Surveillance Consortium (BCSC) (25) and collects data from women undergoing breast imaging at community radiology facilities, from radiologists performing the imaging examinations, and from pathology data collected by the breast imaging facilities. The CMR data include patient demographics, patient risk factors (such as breast density and family history of breast cancer), the type of imaging performed, the reason for the examination, and the radiologists' assessment and recommendation for follow-up. These data are linked with cancer outcomes from the North Carolina Central Cancer Registry (NC-CCR) and abstracted hospital pathology reports as well as with vital status data from the State Center for Health Statistics.

This study includes data collected between 1995 and 2010 from women ages 40 and older undergoing screening mammography with non-missing insurance status and no personal history of breast cancer. At the time of the mammogram, the radiologist recorded whether the examination was a screening or diagnostic mammogram. A screening mammogram was defined using BCSC definitions (4, 26) and includes routine views of the breast among women without breast symptoms such as pain or lump. To be considered positive, the screening mammogram had to be assigned a Breast Imaging Reporting and Data System (BI-RADS) assessment of 0 (needs additional imaging), 4 (suspicious abnormality), 5 (highly suggestive of malignancy), or 3 (probably benign finding) coupled with the radiologist's recommendation for immediate follow-up (surgical consult, biopsy, or fine-needle aspiration) (26, 27). Among women with more than one positive screening mammogram in CMR, one positive screening exam was randomly selected. Women 65 years and older reporting no insurance were excluded from analyses due to small numbers ($n = 24$, <1% of the 65+ sample).

Exposure and outcome assessment

Insurance paying for the exam was self-reported by the women at the time of the screening mammogram and comprises the following categories: no insurance, Medicaid only, Medicare only, Medicare & Medicaid (usually referred to as "dual coverage"), Medicare & private, and private only. Initial diagnostic follow-up was defined as the first of subsequent breast imaging (such as diagnostic mammography, breast ultrasound, MRI) or breast biopsy following the positive screening mammogram. For each positive screening mammogram, we looked forward 1 year for subsequent imaging or biopsy and then ascertained the time until initial diagnostic follow-up as the number of days from the positive screening mammogram until the date of the first follow-up event, censoring at 365 days. A woman could have a follow-up time of zero days if the positive screening mammogram and the first diagnostic follow-up event were performed on the same day.

Covariates

Covariates of interest included demographic information as reported by the woman at the time of the mammogram using a standard patient questionnaire. These variables included: age (age at time of positive screening mammogram); race (black, white, Asian, Hispanic, American Indian, other); and education (less than high school diploma, high school graduate or equivalent, some college, college graduate).

An indicator of urban/rural patient residence was based on the zip code of the patient-provided address at the time of the positive screening mammogram. Breast density was reported at the time of the positive screening mammogram by the interpreting radiologist using BI-RADS breast density classifications of almost entirely fatty, scattered fibroglandular densities, heterogeneously dense, and extremely dense (28, 29). At the time of the screening mammogram, women self-reported family history of a first-degree relative with breast cancer and history of a breast biopsy. The facility at the time of screening mammography was categorized as Hospital, Radiology private office, Comprehensive cancer center, Hospital outpatient center, or Primary care. Primary care included OB/GYN office, mobile screening units, and multispecialty clinics. Guided by results from a systematic review of follow-up after positive screening mammography by Zapka and colleagues and a conceptual framework on cancer care delivery by Taplin and colleagues, we identified and selected covariates for inclusion in both the adjusted time-to-event models and the adjusted logistic regression models because these covariates represent potential confounders in the relationship between insurance status and time to follow-up after a positive screening mammogram (30, 31). In addition, previous studies identified the following covariates as risk factors for delays in follow-up after a positive screening mammography or for breast cancer: age, race (black non-Hispanic, white non-Hispanic, and other), education, breast density, history of breast biopsy, family history of breast cancer, and facility type (18, 31–34).

Statistical analysis

We described time to initial diagnostic follow-up for the study population by insurance status and age group at the time of the positive screening mammogram. Analyses were conducted separately for women younger than 65 years and for women 65 years and older at the time of the positive mammographic result because of the age-specific eligibility requirements of Medicare.

We calculated median time until initial diagnostic follow-up with interquartile range (IQR) and used the Kaplan–Meier estimator to construct time-to-event curves within strata of insurance using the first follow-up event as the endpoint (23). We confirmed the proportional hazards assumption by graphing the logs of the cumulative hazards. We then used the Cox proportional hazards regression model to estimate HRs and 95% confidence intervals (CI) to evaluate the association between insurance status and initial diagnostic follow-up after a positive screening mammogram. Women were administratively censored at 365 days after the positive screening mammogram if a follow-up event did not occur or at the time that the mammography facility at which they

Table 1. Demographic distribution of women ages 40 years and older receiving a positive screening mammogram between 1995–2010 by insurance status stratifying by women younger than 65 years and women 65 years and older

		Insurance status					
	All *n* (%)	**No insurance[a]** *n* (%)	**Medicaid only** *n* (%)	**Medicare only** *n* (%)	**Medicare & Medicaid** *n* (%)	**Medicare & private** *n* (%)	**Private only** *n* (%)
Age <65 y							
Total	31,194	916 (3)	934 (3)	634 (2)	475 (1)	592 (2)	27,643 (89)
Race/Ethnicity							
Black, non-Hispanic	3,916 (13)	144 (16)	374 (40)	165 (26)	178 (37)	108 (18)	2,947 (11)
White, non-Hispanic	24,969 (80)	665 (73)	458 (49)	423 (67)	269 (57)	444 (75)	22,710 (82)
Other	859 (3)	82 (9)	40 (4)	[b]	[b]	15 (3)	703 (3)
Unknown	1,450 (5)	25 (3)	62 (7)	[b]	[b]	25 (4)	1,283 (5)
Age, y							
40–44	7,307 (23)	212 (23)	276 (30)	64 (10)	62 (13)	35 (6)	6,658 (24)
45–49	7,040 (22)	220 (24)	204 (22)	98 (15)	97 (20)	72 (12)	6,349 (23)
50–54	6,648 (21)	184 (20)	184 (20)	121 (19)	105 (22)	109 (18)	5,945 (22)
55–59	5,590 (18)	144 (16)	159 (17)	165 (26)	109 (23)	162 (27)	4,851 (18)
60–64	4,609 (15)	156 (17)	111 (12)	186 (29)	102 (21)	214 (36)	3,840 (14)
Education							
<High school	1,580 (5)	140 (15)	227 (24)	107 (17)	141 (30)	59 (10)	906 (3)
High school/GED	6,692 (21)	295 (32)	273 (29)	204 (32)	142 (30)	183 (31)	5,595 (20)
Some college	7,286 (23)	206 (22)	167 (18)	130 (21)	64 (13)	140 (24)	6,579 (24)
College graduate	8,372 (27)	103 (11)	59 (6)	48 (8)	25 (5)	103 (17)	8,034 (29)
Unknown	7,264 (23)	172 (19)	208 (22)	145 (23)	103 (22)	107 (18)	6,529 (24)
Age 65+ y							
Total	11,832	—	192 (2)	2,617 (22)	753 (6)	7,087 (60)	1,183 (10)
Race/Ethnicity							
Black, non-Hispanic	1,226 (10)	—	46 (24)	363 (14)	285 (38)	422 (6)	110 (9)
White, non-Hispanic	9,883 (83)	—	132 (69)	2,115 (81)	408 (54)	6,245 (88)	983 (83)
Other	134 (1)	—	[b]	27 (1)	[b]	71 (1)	19 (2)
Unknown	589 (5)	—	[b]	112 (4)	[b]	349 (5)	71 (6)
Age, y							
65–69	4,342 (37)	—	80 (42)	920 (35)	222 (29)	2,354 (33)	766 (65)
70–74	3,320 (28)	—	49 (26)	753 (29)	204 (27)	2,086 (29)	228 (19)
75+	4,170 (35)	—	63 (33)	944 (36)	327 (43)	2,647 (37)	189 (16)
Education							
<High school	1,632 (14)	—	62 (32)	457 (17)	297 (39)	705 (10)	111 (9)
High school/GED	3,767 (32)	—	58 (30)	892 (34)	195 (26)	2,277 (32)	345 (29)
Some college	2,291 (19)	—	20 (10)	403 (15)	65 (9)	1,564 (22)	239 (20)
College graduate	1,579 (13)	—	17 (9)	267 (10)	25 (3)	1,106 (16)	164 (14)
Unknown	2,563 (22)	—	35 (18)	598 (23)	171 (23)	1,435 (20)	324 (27)

[a]Women reporting no insurance 65 years and older were removed from the models due to small sample size ($n = 24$).
[b]Cell counts < 11 have been suppressed.

received their positive screening mammogram stopped reporting data to the CMR (if applicable), whichever came first.

We also used multivariable logistic regression to estimate ORs and 95% CIs for time to initial follow-up beyond 60 days based on the CDC guidelines. In both sets of models, the referent group for women younger than 65 years was private insurance alone. The referent group in the models for ages 65 and older was Medicare & private; among the older women, it was the most populous category for this age group. These models included women who did not receive follow-up within the study window. All P values were 2-sided and α <0.05 was considered statistically significant. Statistical analyses were performed using SAS v9.2 (SAS Institute). This ancillary study of CMR data was conducted with approval from the Institutional Review Board at The University of North Carolina at Chapel Hill.

Results

In the study population, approximately 81% of women included in the study self-reported their race as non-Hispanic white and 12% reported non-Hispanic black (Table 1). The mean age for the study population was 57 years (SD, 12). The majority of women younger than 65 years of age reported having private insurance (89%) followed by Medicare plus private (18%). Although black women younger than 65 years represented 13% of the age group, they accounted for 16% of the uninsured in that age group. The majority (60%) of women 65 years and older reported Medicare & private insurance followed by Medicare only (22%).

For the study cohort, the median time until initial diagnostic follow-up after a positive screening mammogram was 12 days (IQR, 7–22 days). Women younger than 65 years with no insurance experienced a median follow-up of 16 days (IQR, 8–37 days) compared to women with private insurance, who had a median of 12 days (IQR, 7–21 days; Table 2). Among women 65 years and older, those with Medicare & Medicaid experienced a median follow-up of 14 days (IQR, 8–29 days), whereas women with private insurance experienced a median of 12 days (IQR, 7–21 days). The Kaplan–Meier survivor curves, stratified by insurance status for women younger than 65 years of age (Fig. 1) and those 65 years and older (Fig. 2), show differences by insurance status in initial follow-up time were observed for the 365-day study period ($P < 0.01$).

In the time-to-event analysis, approximately 10% of women had no follow-up in the study period (365 days) after their

Table 2. Median and mean time to initial diagnostic follow-up in days, proportion with follow-up greater than 60 days, and proportion with no follow-up for women ages 40 years and older receiving a positive screening mammogram between 1995–2010 by insurance status, stratified at 65 years of age

Insurance status	Median (IQR)[a]	Mean (SD)	Percentage with follow-up > 60 d	Percentage with no follow-up within 365 d
All	12 (7–22)	43 (116)	11.9	10.1
Age <65 y				
No insurance	16 (8–37)	62 (166)	17.5	13.8
Medicaid only	14 (7–27)	47 (121)	12.9	8.5
Medicare only	15 (8–28)	53 (159)	15.5	9.6
Medicare & Medicaid	14 (8–29)	60 (220)	14.0	9.5
Medicare & private	13 (7–24)	42 (80)	13.0	8.2
Private only	12 (7–21)	40 (108)	11.0	10.9
All, <65	12 (7–22)	41 (114)	11.4	10.8
Age 65+ y				
Medicare only	13 (7–26)	54 (135)	14.5	8.8
Medicare & Medicaid	14 (8–29)	55 (142)	15.9	8.8
Medicare & private	12 (7–21)	44 (118)	12.5	7.7
Private only	12 (7–21)	40 (87)	11.5	10.6
All, 65+	13 (7–22)	46 (121)	13.2	8.3

[a]IQR reported as a range; from the 25th percentile to the 75th percentile.

positive screening mammogram (Table 2). While the proportions of women who did and who did not receive follow-up during the study period differed statistically by race, age, education level, and breast density ($P < 0.0001$), the differences in proportions were small (Supplementary Table S1). Among women who received no follow-up during the study period, there were slight differences in ever receiving follow-up by age group. Women 65 years and older were more likely to receive follow-up within the study period of 365 days than women younger than 65 years (8% vs. 11% with no follow-up within 365 days, respectively).

In the adjusted time-to-event model for women younger than 65 years, when compared with women with private insurance, uninsured women experienced a longer time to initial diagnostic follow-up with HR of 0.47 (95% CI, 0.25–0.89; Table 3). Among women younger than 65 years, we did not observe statistically significant differences between private insurance only (the referent group) and the following insurance groups: Medicaid only, Medicare only, Medicare & Medicaid, and Medicare & private, although all but Medicare & private had HRs less than 1.0. In the adjusted model, among women 65 years and older, when compared with those with Medicare plus private insurance, women with private insurance experienced a faster time to initiation of follow-up with HR of 2.09 (95% CI, 1.27–3.44). Among women 65 years and older, we did not observe statistically significant differences between Medicare & private insurance (the referent group) and the following insurance groups: Medicare, and Medicare & Medicaid. In the model including all other covariates,

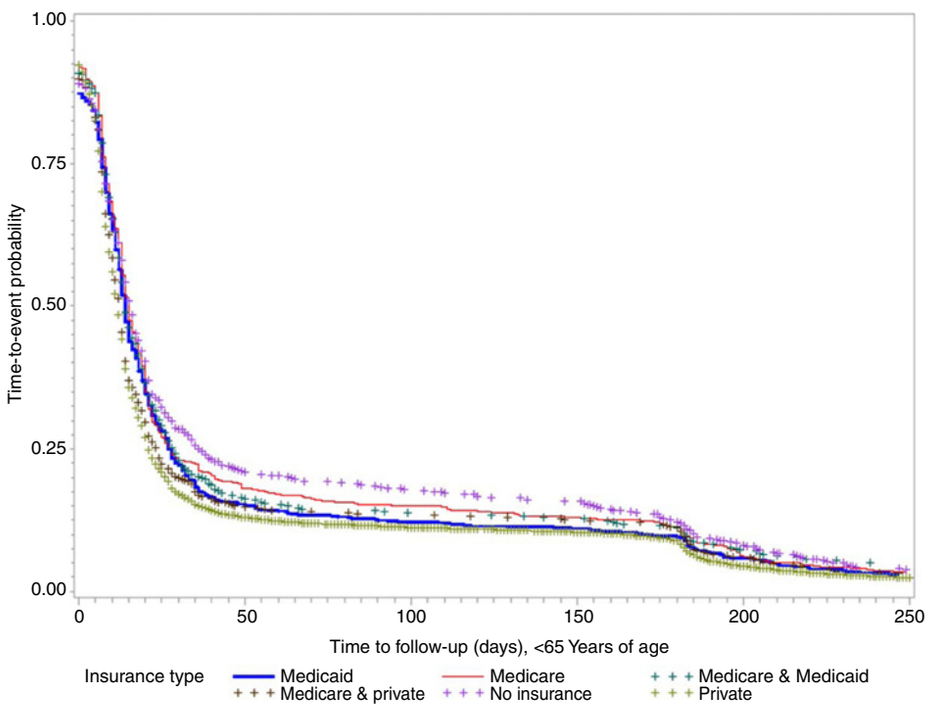

Figure 1.
Comparison of the Kaplan–Meier estimates of the time-to-event curve stratified by insurance status for women less than 65 years old receiving a positive screening mammogram between 1995–2010. Tick marks represent observations in time as each woman experiences the follow-up event.

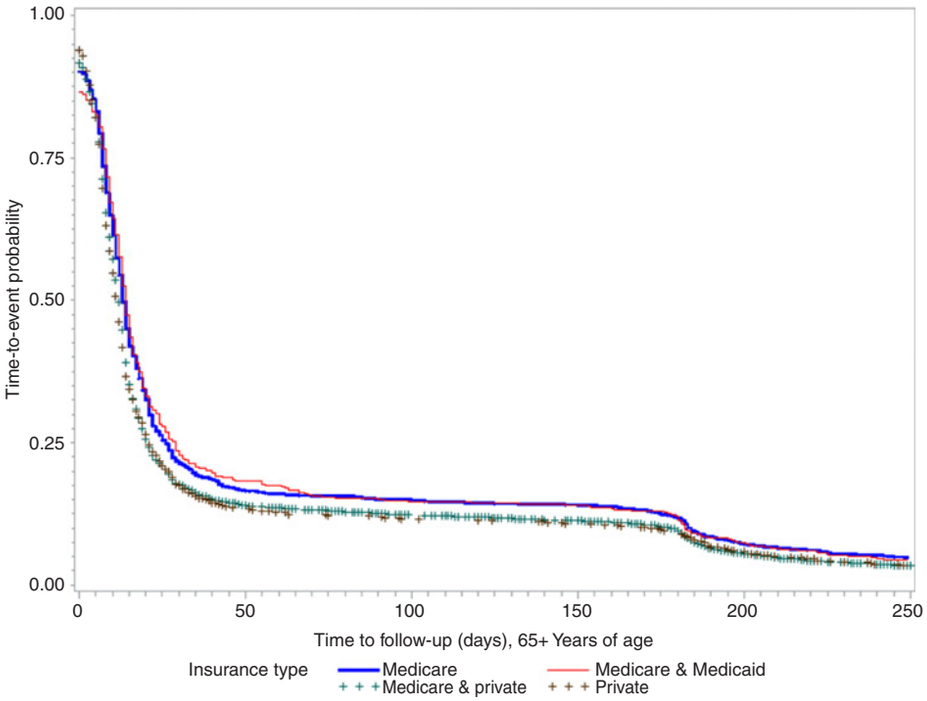

Figure 2.
Comparison of the Kaplan–Meier estimates of the time-to-event curve stratified by insurance status for women 65 years and older receiving a positive screening mammogram between 1995–2010. Tick marks represent observations in time as each woman experiences the follow-up event.

among women 65 years and older with an assessment of BI-RADS, 5 experienced a faster time to initial diagnostic follow-up when compared with women with an assessment of BI-RADS 0 in the same age category (HR, 1.62; 95% CI, 1.09–2.42). We did not observe statistically significant differences for BI-RADS assessment among women younger than 65 years.

In the logistic regression analysis, about 12% of all women in the study did not receive initial diagnostic follow-up within 60 days of their positive screening mammogram as recommended by CDC guidelines. This 12% includes women who received follow-up beyond 60 days and those who do not receive follow-up within 365 days (Table 2). Among women younger than 65 years, nearly 18% of women without insurance received initial diagnostic follow-up after 60 days compared with 11% of women with private insurance. Women 65 years and older were slightly more likely than younger women to have follow-up greater than 60 days (13%). Among women 65 years and older, women reporting Medicare & Medicaid were slightly more likely to receive initial follow-up after 60 days.

In the adjusted logistic regression model for women younger than 65 years, when compared with women with private insurance, uninsured women had increased odds of delay (OR, 1.59; 95% CI, 1.31–1.94; Table 4). No other insurance groups among women younger than 65 years indicated significant odds of delay. Among women 65 years and older, we did not observe statistically significant differences between Medicare & private insurance (the referent group) and the other insurance groups in adjusted models. We did not find modification of the insurance–delay relationship by educational status for either age group.

Discussion

We examined insurance as a predictor of time to initial diagnostic follow-up in a large population-based mammography

Table 3. Unadjusted and adjusted HR estimates and 95% CIs of the association between insurance status and time to initial diagnostic follow-up after a positive screening mammogram for women younger than 65 years and women 65 years and older between 1995–2010

	Unadjusted		Adjusted[b]	
Insurance status	**HR (95% CI)**	***P*[a]**	**HR (95% CI)**	***P*[a]**
Age <65 y				
No insurance	0.59 (0.33–1.06)	0.08	0.47 (0.25–0.89)	0.02
Medicaid only	0.75 (0.44–1.28)	0.28	0.81 (0.46–1.42)	0.46
Medicare only	0.86 (0.44–1.67)	0.65	0.95 (0.47–1.91)	0.88
Medicare & Medicaid	0.63 (0.32–1.24)	0.18	0.50 (0.24–1.02)	0.06
Medicare & private	2.16 (1.07–4.38)	0.03	1.81 (0.86–3.83)	0.12
Private only (referent)	1.00 (—)	—	1.00 (—)	—
Age 65+ y				
Medicare only	0.89 (0.66–1.20)	0.44	0.97 (0.70–1.34)	0.83
Medicare & Medicaid	0.79 (0.49–1.27)	0.33	0.99 (0.57–1.74)	0.99
Medicare & private (referent)	1.00 (—)	—	1.00 (—)	—
Private only	1.92 (1.22–3.03)	0.005	2.09 (1.27–3.44)	<0.01

[a]All *P* values are 2-sided, and $\alpha < 0.05$ was considered statistically significant.
[b]The adjusted model includes race, education, breast density, categorical age, history of breast biopsy, family history of breast cancer, and facility type.

Table 4. Unadjusted and adjusted OR estimates and 95% CIs of the association between insurance status and time to initial diagnostic follow-up of more than 60 days after a positive screening mammogram for women younger than 65 years and women 65 years and older between 1995–2010

	Unadjusted		Adjusted[b]	
Insurance status	**OR (95% CI)**	***P*[a]**	**OR (95% CI)**	***P*[a]**
Age <65 y				
No insurance	1.61 (1.38–1.89)	<0.0001	1.59 (1.31–1.94)	<0.0001
Medicaid only	0.97 (0.82–1.14)	0.70	1.00 (0.82–1.21)	0.96
Medicare only	1.19 (0.98–1.43)	0.08	1.21 (0.97–1.52)	0.09
Medicare & Medicaid	1.09 (0.88–1.36)	0.43	1.09 (0.85–1.42)	0.49
Medicare & private	0.95 (0.77–1.17)	0.62	1.10 (0.87–1.40)	0.43
Private only (referent)	1.00 (—)	—	1.00 (—)	—
Age 65+ y				
Medicare only	1.21 (1.08–1.35)	0.001	1.14 (0.99–1.30)	0.06
Medicare & Medicaid	1.29 (1.08–1.56)	0.006	0.96 (0.76–1.20)	0.73
Medicare & private (referent)	1.00 (—)	—	1.00 (—)	—
Private only	1.12 (0.96–1.31)	0.16	1.14 (0.95–1.36)	0.16

[a]All *P* values are 2-sided, and $\alpha < 0.05$ was considered statistically significant.
[b]The adjusted model includes race, education, breast density, categorical age, history of breast biopsy, family history of breast cancer, and facility type.

registry and found that among women younger than 65 years, women without insurance experienced a longer time to initial diagnostic follow-up compared to women with private insurance. It is important to note that the difference in days to initiation between the insurance groups is small and may not represent a clinically significant difference. Among women ages 65 and older, women with private only insurance experienced a faster time to initial diagnostic follow-up compared with women with Medicare and private insurance. These women may be more economically advantaged with increased access to care. In the multivariable logistic regression models, uninsured women younger than 65 years of age were 1.59 times more likely to experience a delay when compared with the privately insured in the same age group. There were no observed statistically significant associations between insurance status and delay among women 65 years of age and older.

Few population-based studies have examined the impact of insurance status and time until initial diagnostic follow-up after a positive screening mammogram. A study of time between initial consult and diagnosis reports HR estimates of 4 levels of insurance and the uninsured, but includes women with symptoms (35). Other studies focused on homogenous populations including, for example, only Medicaid beneficiaries (18, 36, 37). In many studies of breast cancer outcomes, Medicaid enrollment is a predictor of poor health outcomes (20, 35, 38, 39). In this study, we did not find that Medicaid insurance was associated with a longer time to initial diagnostic follow-up after a positive screening mammogram, regardless of age group.

Other studies combined insurance groups, specifically Medicare and Medicaid to create a public or government category and compared this to all others included in the study (33, 40–43). Similarly, another study grouped Medicaid and those without insurance (44), which may mask benefits in time to follow-up experienced by those with Medicaid. This may lead to less informative conclusions because eligibility requirements for government-sponsored insurance programs such as Medicare and Medicaid are largely based on specific guidelines for age, income status, and disability status (45, 46). In addition, the insurance categories may represent populations with varying barriers for seeking care such as disability or comorbidities. An urban hospital-based study found that women with private insurance reached resolution of their positive mammogram faster than those with government insurance, a combination of people with Medicare and Medicaid (47). A recent study of women enrolled in a patient navigation program assessing the impact of barriers to care after a positive screen, one of which was insurance, reported that women with an insurance barrier experienced a longer time to diagnostic follow-up after a positive screening mammogram (HR, 0.85; 95% CI, 0.74–0.97; ref. 48). Another study comparing those with no insurance to those with only hospitalization insurance found that insurance was not associated with completing diagnostic follow-up (49). While these studies provided helpful information regarding a broad effect of insurance on resolution of a positive mammogram, they do not provide information on how resolution of a positive screening mammogram may vary by specific categories of insurance.

Median follow-up times to initial diagnostic follow-up in the current study were similar to prior studies (40, 50, 51). Specifically, a study of women attending an urban academic medical center in a federally designated medically underserved area reported a median follow-up time (defined as days between the positive mammogram and additional imaging) of 14 days (40). However, this study did not investigate differences by insurance status. Other studies report median time to complete follow-up between 20 and 50 days (32, 33, 49, 52).

In the current time-to-event analysis, 10% of women had no initial diagnostic follow-up within 365 days of their positive screening mammogram. It is challenging to compare our results regarding no follow-up with other studies as many studies fail to describe women with no follow-up after a positive screening mammogram (32, 53, 54) or exclude these women from the analysis (55). It may be the case that women who never receive follow-up are different than those who are delayed but do eventually receive follow-up.

In the current study, nearly 12% of women did not receive initial diagnostic follow-up within 60 days after a positive screening mammogram. A study of CDC's National Breast and Cervical Cancer Early Detection screening program found that 20% of women did not receive any diagnostic follow-up within 60 days of a positive screening mammogram (37). Other studies of complete diagnostic follow-up after a positive screening mammogram report similar results: 20% to 40% of women receive diagnostic follow-up more than 60 days after a positive screening mammogram or fail to receive diagnostic follow-up entirely (36, 37, 52, 56, 57). These estimates are slightly higher than those reported in our study and may be explained by differences in study

populations, as these studies were conducted in hospitals or academic medical centers and our population represents women screened in community practices. Although there are no national or population-based estimates for the proportion of positive screening mammograms that do not receive diagnostic follow-up with which to compare, our study falls within the reported range (9%–50%) from other studies (30, 31, 57, 58).

It is uncertain if the differences of a few days, as illustrated by the median differences, in initial follow-up after a positive screening mammogram by insurance status represent variation of clinical significance. Medians may mask extreme differences in follow-up. We also provide results in terms of the dichotomous outcome of having received follow-up within 60 days, as recommended by the CDC. By presenting estimates from both sets of models by insurance type, we give more information about differences in delay. Recognizing potential delays experienced at follow-up and diagnosis may be important when considering the breast cancer care continuum and potential delays experienced at other points of care coordination such as treatment. As previously shown, delays in diagnosis may be indicative of delays in treatment (34).

The strengths of our study include the use of prospectively collected data, a diverse population, and large sample size. Moreover, the CMR data are longitudinal providing the opportunity to follow individual women receiving screening mammograms and subsequent breast imaging and biopsy. Prior studies were often limited by small sample sizes or focused on one insurance status and did not allow for examination by more insurance categories while also including the uninsured. In addition, previous studies frequently relied on administrative databases designed for billing purposes rather than research and thus lack crucial information on the mammogram result. Exclusive use of patient questionnaires or medical records may lack complete dates of services to ensure sufficient documentation of time until diagnostic follow-up. In contrast, the CMR data contain detailed information on breast imaging procedures performed including the date of procedure as well as the radiologists' interpretation of the mammogram.

Our study also has several limitations. Insurance status from the CMR is self-reported and may not be completely accurate. We are unable to confirm the payer for each imaging and biopsy received during the study period. However, other studies found that self-report of insurance payer can be fairly accurate for both mammography (59) and non-mammography settings (60, 61). It is also possible that some follow-up visits were not captured in the CMR if a woman received her diagnostic follow-up care outside of the CMR catchment area. There may be bias due to unmeasured confounding. Some factors that may influence healthcare outcomes are not collected by CMR such as income, co-morbidities, access to transportation, social support, etc. It is possible that these factors may impact the patient's screening behaviors such as the ability to undergo diagnostic procedures or the frequency with which they interact with the healthcare system and could explain the differences in follow-up observed in this study (62). Furthermore, patient-reported outcomes after a positive screening mammogram such as anxiety, fear, stress, satisfaction with care received at the time of the screening mammogram, and quality of life have been shown to impact delays in follow-up and while beyond the scope of our analyses should be considered in future work (16, 38, 43, 48, 58). Finally, we were unable to assess the potential interaction between insurance status and known factors associated with diagnostic delay (such as race and education) due to small numbers but this remains another important area of future work.

In summary, to maximize the benefits of screening mammography, it is important that women receive appropriate and timely follow-up after a positive screening mammogram, especially if the follow-up delays necessary treatment. In addition, it is important to understand how insurance impacts follow-up after a positive screening mammogram. We found differences in time to initial diagnostic follow-up after a positive screening mammogram by insurance status as well as by age group. Our findings that 8% to 14% of women with a positive screening mammogram do not receive follow-up within 365 days is concerning, as this may have a significant clinical impact on time to diagnosis and receipt of treatment. Future research on the variation in the proportion of women with no follow-up at 365 days by insurance status should be undertaken to further understand how to target groups experiencing longer time to follow-up.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: D.D. Durham, W.R. Robinson, S.B. Wheeler, K.E. Reeder-Hayes, J.M. Bowling, A.F. Olshan, L.M. Henderson

Development of methodology: D.D. Durham, S.S. Lee, S.B. Wheeler, K.E. Reeder-Hayes, J.M. Bowling, A.F. Olshan, L.M. Henderson

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): L.M. Henderson

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): D.D. Durham, W.R. Robinson, S.B. Wheeler, K.E. Reeder-Hayes, J.M. Bowling, A.F. Olshan, L.M. Henderson

Writing, review, and/or revision of the manuscript: D.D. Durham, W.R. Robinson, S.S. Lee, S.B. Wheeler, K.E. Reeder-Hayes, A.F. Olshan, L.M. Henderson

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): A.F. Olshan, L.M. Henderson

Study supervision: J.M. Bowling, L.M. Henderson

Grant Support

The study was supported by grants F31CA180755 (NCI NIH) to D.D. Durham, K01CA172717 (NCI NIH) to W.R. Robinson, and 5U01CA070040-15 (NCI NIH) and P01CA154292 (NCI NIH) to L.M. Henderson.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received February 19, 2016; revised July 28, 2016; accepted August 10, 2016; published online November 1, 2016.

References

1. Nasca PC, Pastides H. Fundamentals of cancer epidemiology. 2nd ed. Sudbury, MA: Jones and Bartlett Publishers; 2008.
2. Nelson HD, Tyne K, Naik A, Bougatsos C, Chan BK, Humphrey L, et al. Screening for breast cancer: an update for the U.S. Preventive Services Task Force. Ann Intern Med 2009;151:727–37.
3. Breen N, Yabroff KR, Meissner HI. What proportion of breast cancers are detected by mammography in the United States? Cancer Detect Prev 2007;31:220–4.
4. Weaver DL, Rosenberg RD, Barlow WE, Ichikawa L, Carney PA, Kerlikowske K, et al. Pathologic findings from the Breast Cancer Surveillance

Consortium: population-based outcomes in women undergoing biopsy after screening mammography. Cancer 2006;106:732–42.
5. Sprague BL, Gangnon RE, Hampton JM, Egan KM, Titus LJ, Kerlikowske K, et al. Variation in breast cancer-risk factor associations by method of detection: results from a series of case-control studies. Am J Epidemiol 2015;181:956–69.
6. Chiarelli AM, Halapy E, Nadalin V, Shumak R, O'Malley F, Mai V. Performance measures from 10 years of breast screening in the Ontario Breast Screening Program, 1990/91 to 2000. Eur J Cancer Prev 2006;15:34–42.
7. Paquette D. Performance of screening mammography in organized programs in Canada in 1996. The database management subcommittee to the national committee for the canadian breast cancer screening initiative. Can Med Assoc J 2000;163:1133–8.
8. National Breast and Cervical Cancer Early Detection Program (NBCCEDP): About The Program 2011 [cited 2016 April 26]. Available from: http://www.cdc.gov/cancer/nbccedp/about.htm.
9. National Breast and Cervical Cancer Early Detection Program (NBCCEDP) Screening Program Data: Interpretation and Use of Data 2011 [cited 2016 April 26]. Available from: http://www.cdc.gov/cancer/nbccedp/data/.
10. Richards MA, Smith P, Ramirez AJ, Fentiman IS, Rubens RD. The influence on survival of delay in the presentation and treatment of symptomatic breast cancer. Br J Cancer 1999;79:858–64.
11. Richards MA, Westcombe AM, Love SB, Littlejohns P, Ramirez AJ. Influence of delay on survival in patients with breast cancer: a systematic review. Lancet 1999;353:1119–26.
12. Ryerson AB, Miller JW, Eheman CR, Leadbetter S, White MC. Recent trends in U.S. mammography use from 2000–2006: a population-based analysis. Prev Med 2008;47:477–82.
13. Kothari A, Fentiman IS. Diagnostic delays in breast cancer and impact on survival. Int J Clin Pract 2003;57:200–3.
14. Sainsbury R, Johnston C, Haward B. Effect on survival of delays in referral of patients with breast-cancer symptoms: a retrospective analysis. Lancet 1999;353:1132–5.
15. Cancer Facts & Figures 2011. Atlanta, GA: American Cancer Society; 2011 [cited 2016 April 26]. Available from: http://www.cancer.org/acs/groups/content/@epidemiologysurveilance/documents/document/acspc-029771.pdf.
16. Yabroff KR, Breen N, Vernon SW, Meissner HI, Freedman AN, Ballard-Barbash R. What factors are associated with diagnostic follow-up after abnormal mammograms? Findings from a U.S. National Survey. Cancer Epidemiol Biomarkers Prev 2004;13:723–32.
17. Mandelblatt JS, Yabroff KR, Kerner JF. Equitable access to cancer services. Cancer 1999;86:2378–90.
18. Bobo JK, Shapiro JA, Schulman J, Wolters CL. On-schedule mammography rescreening in the national breast and cervical cancer early detection program. Cancer Epidemiol Biomarkers Prev 2004;13:620–30.
19. Roetzheim RG, Pal N, Tennant C, Voti L, Ayanian JZ, Schwabe A, et al. Effects of health insurance and race on early detection of cancer. J Natl Cancer Inst 1999;91:1409–15.
20. Halpern MT, Ward EM, Pavluck AL, Schrag NM, Bian J, Chen AY. Association of insurance status and ethnicity with cancer stage at diagnosis for 12 cancer sites: a retrospective analysis. Lancet Oncol 2008;9:222–31.
21. Ward E, Halpern M, Schrag N, Cokkinides V, DeSantis C, Bandi P, et al. Association of insurance with cancer care utilization and outcomes. CA Cancer J Clin 2008;58:9–31.
22. Hsia J, Kemper E, Kiefe C, Zapka J, Sofaer S, Pettinger M, et al. The Importance of health insurance as a determinant of cancer screening: evidence from the women's health initiative. Prev Med 2000;31:261–70.
23. Robbins AS, Lerro CC, Barr RD. Insurance status and distant-stage disease at diagnosis among adolescent and young adult patients with cancer aged 15 to 39 years: national cancer data base, 2004 through 2010. Cancer 2014;120:1212–9.
24. Robert Lukavsky MD, Jack Sariego MD. Insurance status effects on stage of diagnosis and surgical options used in the treatment of breast cancer. South Med J 2015;108:258–61.
25. Ballard-Barbash R, Taplin SH, Yankaskas BC, Ernster VL, Rosenberg RD, Carney PA, et al. Breast cancer surveillance consortium: a national mammography screening and outcomes database. Am J Roentgenol 1997;169:1001–8.
26. Breast Cancer Surveillance Consortium (BCSC). Data Dictionary and Standard definitions. [updated 2009 Sep 16; cited 2016 Apr 26] Available from:http://breastscreening.cancer.gov/data/elements.html#definitions.
27. Eberl MM, Fox CH, Edge SB, Carter CA, Mahoney MC. BI-RADS classification for management of abnormal mammograms. J Am Board Fam Med 2006;19:161–4.
28. Ciatto S, Houssami N, Apruzzese A, Bassetti E, Brancato B, Carozzi F, et al. Categorizing breast mammographic density: intra- and interobserver reproducibility of BI-RADS density categories. Breast 2005;14:269–75.
29. Sickles E, D'Orsi C, Bassett L. ACR BI-RADS® Atlas Breast Imaging Reporting and Data System. Reston, VA: American College of Radiology; 2013.
30. Zapka JM, Edwards HM, Chollette V, Taplin SH. Follow-up to abnormal cancer screening tests: considering the multilevel context of care. Cancer Epidemiol Biomarkers Prev 2014;23:1965–73.
31. Taplin SH, Yabroff KR, Zapka J. A multilevel research perspective on cancer care delivery: the example of follow-up to an abnormal mammogram. Cancer Epidemiol Biomarkers Prev 2012;21:1709–15.
32. Chang SW, Kerlikowske K, Napoles-Springer A, Posner SF, Sickles EA, Perez-Stable EJ. Racial differences in timeliness of follow-up after abnormal screening mammography. Cancer 1996;78:1395–402.
33. Elmore JG, Nakano CY, Linden HM, Reisch LM, Ayanian JZ, Larson EB. Racial inequities in the timing of breast cancer detection, diagnosis, and initiation of treatment. Med Care 2005;43:141–8.
34. Gorin SS, Heck JE, Cheng B, Smith SJ. Delays in breast cancer diagnosis and treatment by racial/ethnic group. Arch Intern Med 2006;166:2244–52.
35. Caplan LS, Helzlsouer KJ, Shapiro S, Freedman LS, Coates RJ, Edwards BK. System delay in breast cancer in whites and blacks. Am J Epidemiol 1995;142:804–12.
36. Eheman CR, Benard VB, Blackman D, Lawson HW, Anderson C, Helsel W, et al. Breast cancer screening among low-income or uninsured women: results from the national breast and cervical cancer early detection program, July 1995 to March 2002 (United States). Cancer Causes Control 2006;17:29–38.
37. Richardson LC, Royalty J, Howe W, Helsel W, Kammerer W, Benard VB. Timeliness of breast cancer diagnosis and initiation of treatment in the national breast and cervical cancer early detection program, 1996–2005. Am J Public Health 2010;100:1769–76.
38. Clark CR, Baril N, Kunicki M, Johnson N, Soukup J, Ferguson K, et al. Addressing social determinants of health to improve access to early breast cancer detection: results of the Boston REACH 2010 breast and cervical cancer coalition women's health demonstration project. J Womens Health 2009;18:677–90.
39. Coburn N, Fulton J, Pearlman DN, Law C, DiPaolo B, Cady B. Treatment variation by insurance status for breast cancer patients. Breast J 2008;14:128–34.
40. Press R, Carrasquillo O, Sciacca RR, Giardina EG. Racial/ethnic disparities in time to follow-up after an abnormal mammogram. J Womens Health 2008;17:923–30.
41. Ashing-Giwa KT, Gonzalez P, Lim JW, Chung C, Paz B, Somlo G, et al. Diagnostic and therapeutic delays among a multiethnic sample of breast and cervical cancer survivors. Cancer 2010;116:3195–204.
42. Gwyn K, Bondy ML, Cohen DS, Lund MJ, Liff JM, Flagg EW, et al. Racial differences in diagnosis, treatment, and clinical delays in a population-based study of patients with newly diagnosed breast carcinoma. Cancer 2014;100:1595–604.
43. Primeau S, Freund K, Ramachandran A, Bak S, Heeren T, Chen C, et al. Social service barriers delay care among women with abnormal cancer screening. J Gen Intern Med 2004;29:169–75.
44. Kwok J, Langevin SM, Argiris A, Grandis JR, Gooding WE, Taioli E. The impact of health insurance status on the survival of patients with head and neck cancer. Cancer 2010;116:476–85.
45. McWilliams JM, Zaslavsky AM, Meara E, Ayanian JZ. Impact of Medicare coverage on basic clinical services for previously uninsured adults. J Am Med Assoc 2003;290:757–64.
46. Sommers BD, Rosenbaum S. Issues in health reform: how changes in eligibility may move millions back and forth between Medicaid and insurance exchanges. Health Affair 2011;30:228–36.
47. Hoffman HJ, LaVerda NL, Levine PH, Young HA, Alexander LM, Patierno SR, et al. Having health insurance does not eliminate race/ethnicity-associated delays in breast cancer diagnosis in the District of Columbia. Cancer 2011;117:3824–32.
48. Katz ML, Young GS, Reiter PL, Battaglia TA, Wells KJ, Sanders M, et al. Barriers reported among patients with breast and cervical abnormalities in the patient navigation research program: impact on timely care. Womens Health Issues 2014;24:e155–e62.

49. Adams SA, Smith ER, Hardin J, Prabhu-Das I, Fulton J, Hebert JR. Racial differences in follow-up of abnormal mammography findings among economically disadvantaged women. Cancer 2009;115:5788–97.
50. Henson RM, Wyatt SW, Lee NC. The national breast and cervical cancer early detection program: a comprehensive public health response to two major health issues for women. J Public Health Manag Pract 1996;2:36–47.
51. Chiarelli AM, Mai V, Halapy EE, Shumak RS, O'Malley FP, Klar NS. Effect of screening result on waiting times to assessment and breast cancer diagnosis: results from the Ontario Breast Screening Program. Can J Public Health 2005;96:259–63.
52. Caplan LS, May DS, Richardson LC. Time to diagnosis and treatment of breast cancer: results from the national breast and cervical cancer early detection program, 1991–1995. Am J Public Health 2000;90:130–4.
53. Wernli KJ, Aiello Bowles EJ, Haneuse S, Elmore JG, Buist DSM. Timing of follow-up after abnormal screening and diagnostic mammograms. Am J Manag Care 2011;17:162–7.
54. Karliner LS, Ma L, Hofmann M, Kerlikowske K. Language barriers, location of care, and delays in follow-up of abnormal mammograms. Med Care 2012;50:171–8.
55. Rosenberg RD, Haneuse SJ, Geller BM, Buist DS, Miglioretti DL, Brenner RJ, et al. Timeliness of follow-up after abnormal screening mammogram: variability of facilities. Radiology 2011;261:404–13.
56. Lobb R, Allen JD, Emmons KM, Ayanian JZ. Timely care after an abnormal mammogram among low-income women in a public breast cancer screening program. Arch Intern Med 2010;170:521–8.
57. Jones B, Dailey A, Calvocoressi L, Reams K, Kasl S, Lee C, et al. Inadequate follow-up of abnormal screening mammograms: findings from the race differences in screening mammography process study (United States). Cancer Cause Control 2005;16:809–21.
58. Caplan LS, Helzlsouer KJ, Shapiro S, Wesley MN, Edwards BK. Reasons for delay in breast cancer diagnosis. Prev Med 1996;25:218–24.
59. Zapka JG, Bigelow C, Hurley T, Ford LD, Egelhofer J, Cloud WM, et al. Mammography use among sociodemographically diverse women: the accuracy of self-report. Am J Public Health 1996;86:1016–21.
60. Yu S-T, Chang H-Y, Lin M-C, Lin Y-H. Agreement between self-reported and health insurance claims on utilization of health care: a population study. J Clinical Epidemiol 2009;62:1316–22.
61. Neuman MI, Radeos MS, Yang A, Gordon JA, Camargo CA Jr. Does parental report of insurance status agree with hospital administrative data for children presenting to the ED? Am J Emer Med 2006;24:890–2.
62. Fair AM, Wujcik D, Lin JMS, Grau A, Wilson V, Champion V, et al. Obesity, gynecological factors, and abnormal mammography follow-up in minority and medically underserved women. J Womens Health 2009;18:1033–9.