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Between-Race Differences in Supplemental Breast Cancer Screening Before and After Breast Density Notification Law

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Abstract

Guidelines recommend supplemental breast cancer screening for women at increased breast cancer risk; however, the passage of breast density notification laws may lead to supplemental screening that is incongruent with women's risk. We examined supplemental screening (ie, MRI, ultrasound, or tomosynthesis within 6 months of screening mammogram) among a sample of 2,764 African American (AA) and 691 European American (EA) women with negative or benign screening mammograms for whom we had data from both before and after implementation of breast density notification laws in the state of Michigan. Results indicated a 5-fold increase (from 0.14% to 0.7% of women) in supplemental screening among screen-negative women after passage of the law, driven in large part by an increase in supplemental screening among AA women. Breast density was more predictive of supplemental screening and had a marginally greater explanatory role in between-race differences in supplemental screening after passage of the law. Subgroup analyses ($n = 250$) indicated that whereas 5-year breast cancer risk was positively associated with supplemental screening before the law and negatively associated after the law for EA women, 5-year risk was not associated with supplemental screening either before or after passage of the law for AA women. Our findings suggest that whereas passage of the breast density notification laws may have motivated supplemental screening among AA women in particular, it lessened the consideration of breast cancer risk in supplemental screening decision making.

Keywords

Breast density notification; between-race differences; supplemental breast cancer screening; African Americans

INTRODUCTION

Breast density (ie, more fibroglandular relative to fatty breast tissue) confers increased breast cancer risk—women with dense breasts (ie, BI-RADS density c and d) can be more than 4

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times as likely to be diagnosed with breast cancer compared with those with least dense breasts [1–5]. More than half of the United States has implemented mandatory breast density notification laws to ensure that women are informed of their own breast density and associated breast cancer risk [6,7], and similar legislation is pending in several states [8,9]. Despite little consensus as to the utility among women who are not at higher risk of breast cancer, supplemental breast cancer screening via modalities with increased sensitivity in dense breasts (eg, MRI, ultrasound, and tomosynthesis) [10–13] have demonstrably increased after the passage of notification laws [14–19].

Most breast cancer screening guidelines recommend supplemental screening for women at high breast cancer risk (eg, >20% lifetime risk) [20–23]. Screening MRI is recommended as an adjunct to screening mammography either simultaneously or in alternating 6-month intervals, with adjunct ultrasound recommended for women who cannot tolerate MRI [22,23]. However, a lack of evidence in support of adjunct screening MRI *solely* because of clinical indications (eg, breast density) precludes the use of breast density as a sole determinant of supplemental screening with MRI [24]. Some guidelines recommend adjunct screening with ultrasound for women with dense breasts, particularly if they are at intermediate (15%–20% lifetime) breast cancer risk [21]; however, others suggest that all women with dense breasts should receive adjunct ultrasound [20]. The variability and lack of consensus regarding supplemental screening for non-high-risk women with dense breasts presents challenges for physicians' follow-up recommendations—the introduction of breast density notification legislation compounds these challenges. Breast density likely informed decision making about supplemental screening before adoption of breast density laws; however, we expect that its role was amplified after adoption of notification legislation (hypothesis 1).

Despite apparent convergence of breast cancer incidence rates [25,26], European American (EA) women have historically had higher breast cancer incidence rates than African American (AA) women [26,27]. This may be because of between-race differences in the distribution of breast cancer risk factors [28, cf 29] and suggests that EA women may be supplementally screened at a higher rate (hypothesis 2). Though evidence remains inconsistent [30,31], some data suggest that breast density is, on average, lower among AA compared with EA women [32–35]. Because breast density is a risk factor that may be a determinant of supplemental screening referrals, between-race differences in breast density should partially explain between-race differences in supplemental screening rates (hypothesis 3). We will explore exploratory hypothesis 1 whether adoption of notification legislation moderates the magnitude of the explanatory role of breast density in between-race differences and exploratory hypothesis 2 effects of racial group and breast density on the association between breast cancer risk and supplemental screening. We examined support for our hypotheses among a sample of women who presented for screening mammograms and for whom we had data both before and after passage of the breast density notification law.

METHODS

Participants

Data were collected from 2,764 AA and 691 EA women who had a screening mammogram at a comprehensive cancer center's breast clinic in midtown Detroit, Michigan, between September 12, 2014, and May 29, 2015, who returned for at least one screening mammogram after July 1, 2015 (Michigan's adoption of breast density notification law) up until December 31, 2016, and who were clinical BI-RADS assessment category 1 (negative findings) or 2 (benign findings) at each screening mammogram. We recorded the type of examination (eg, screening versus diagnostic; modality) and the results (eg, BIRADS assessment; BIRADS density) of each examination from the breast clinic's database. Women who returned for breast MRI, ultrasound, or tomosynthesis within 6 months and 2 weeks (194 days) of their screening mammogram were coded as having received supplemental breast cancer screening. The study was approved by the Wayne State University institutional review board.

Breast Density, Demographic, and Risk Factor Data Collection

We classified women as having dense breasts if they were BIRADS category c (heterogeneously dense) or d (extremely dense); otherwise, women were classified as having nondense breasts. Age and race were available from the breast clinic database. Body mass index (BMI) was abstracted for a random sample of 1,580 women from medical records within 1 year of the screening mammogram. BMI was imputed for the remaining women using multivariate imputation by chained equations using the "mice" package in R (R Foundation for Statistical Computing, Vienna, Austria; <https://cran.r-project.org/>). Predictor variables were race, BIRADS breast density (a, b, c, or d), age at examination, and city-level socioeconomic status variables (median income; percent below poverty level; percent insured) from 2014 US census data (<https://www.census.gov/data.html>).

In light of our available resources, we abstracted breast cancer risk factors from intake forms for a subgroup of women (n = 250) to examine associations between breast cancer risk and supplemental screening. All women who were supplementally screened at any time were matched 1:3 on racial group, breast density, BMI (<25; 25 and <30; 30), and age group (<55; 55) with women who were never supplementally screened. We abstracted the following breast cancer risk factors at each screening occasion: age at menarche; age at first live birth; personal history of breast cancer; number of first-degree relatives diagnosed with breast cancer; and prior benign breast biopsy. With the addition of women's age, we estimated 5-year breast cancer risk (expressed as a percentage) with the BCRA: Breast Cancer Risk Assessment (Version 1.02015) package in R.

Statistical Analyses

We grouped screening events by whether they took place before or after the law's adoption and used lavaan [36,37] with R to examine our research question with multigroup path analysis. A representation of the path model is presented in Figure 1. We fit linear probability models with weighted least squares estimation and robust standard errors. Women's breast density classification may change over time because of age or radiologists'

assessments; hence, we included breast density at the time of imaging in the models. For hypothesis 1 we examined parameter invariance for the direct effect of breast density on supplemental screening (ie, we compared a restricted model with equality constraints on the direct effect to a fully variant model with no equality constraints). Significant improvement in model fit, evaluated with a scaled χ^2 difference test, indicates that parameters differed between group (ie, before and after the law). For hypothesis 2 we examined whether there was a direct effect of racial group on supplemental screening at both times. For hypothesis 3 we examined whether the indirect effect of breast density (ie, products of paths a and b in Fig. 1) was statistically significant using bootstrapped parameter estimates (500 draws). We explored parameter invariance of the components of the indirect effect of breast density exploratory hypothesis 1. Using the subgroup, we fit 2 (race) by 2 (supplemental screening) analyses of variance (ANOVAs) to explore racial differences in associations between supplemental screening and breast cancer risk, before and after the notification law, separately for women with and without dense breasts (exploratory hypothesis 2).

RESULTS

Descriptive

The sample ($n = 3,455$) was 80% AA with a mean age of 60.21 ($SD = 10.46$), and age did not differ by race. Most women (72%) had consistently nondense breasts, and 19% were consistently dense; density increased for 3% and decreased for 6% of women between pre- and post-notification law screenings. One-way ANOVA indicated that breast density was associated with age ($F_{3,3435} = 39.60$, $P < .01$): youngest women (mean [M] = 56.63, standard error [SE] = 0.43) had consistently dense breasts, oldest women ($M = 61.36$, $SE = .20$) had consistently nondense breasts, and women whose breast density increased or decreased were between the two age groups ($M = 59.04$ and 58.08 , respectively). Breast density was also associated with race ($\chi^2[3] = 26.31$, $P < .01$): more EA women had consistently dense breasts compared with AA women (25.3% versus 16.9%, respectively). There were no between-race differences among women whose breast density increased or decreased.

Rates of supplemental breast cancer screening increased (0.14% versus 0.70%) after passage of the breast density notification law. Supplemental screening rates, contingent on race, breast density, and time of screening, are presented in Table 1—note the between-race convergence in supplemental screening rates among women with dense breasts.

Effect of Breast Density Notification Law

Model fit for the fully variant model was good ($\chi^2[2] = 2.53$, not significant; $TLI = 1.00$; $CFI = 1.00$; $RMSEA = 0.00$, 95% confidence interval = 0.00, 0.04; $SRMR < .01$). Direct effects are presented in Table 2. Women with dense breasts were more likely to be supplementally screened both before and after the law; however, the result of our test of hypothesis 1 (scaled $\chi^2[1] = 5.93$, $P < .05$) indicated that the direct effect of breast density was significantly different after the law (0.029) compared with before (0.008). In support of hypothesis 2, AA women were less likely to be supplementally screened both before and after the notification law, and invariance tests indicated no difference in magnitude of the

between-race difference over time. In support of hypothesis 3, significant indirect effects of breast density (before law = -0.001 , $P = .05$; after law = -0.002 , $P < .01$) indicated that the between-race difference was partially and consistently because of AA women having less dense breasts compared with EA women. The test of exploratory hypothesis 1 suggested that the magnitude of the parameters that comprised the indirect effect marginally differed before and after the law (scaled $\chi^2[2] = 5.18$, $P < .10$), most likely attributable to the larger effect of breast density (see hypothesis 1 results).

Association Between Supplemental Screening, Racial Group, and Breast Cancer Risk

Prenotification Law.—ANOVA results indicated a between-race difference in breast cancer risk among women without dense breasts ($F_{1,96} = 4.02$, $P < .05$); EA women were at higher risk compared with AA women ($M = 2.22$ versus 1.58 , respectively). Among women with dense breasts, significant main effects of race and supplemental screening ($F_{1,146} = 12.09$ and 12.88 , respectively, $P < .01$) were qualified by a significant interaction ($F_{1,146} = 18.69$, $P < .01$). Follow-up t tests indicated that AA women's breast cancer risk did not differ by supplemental screening ($M = 1.20$ versus 1.35), whereas breast cancer risk was significantly greater for EA women who were supplementally screened ($M = 2.80$ versus 1.18 , $t[44] = 4.87$, $P < .01$).

Postnotification Law.—There were significant main effects of race and supplemental screening ($F_{1,110} = 5.46$ and 4.14 , respectively, $P < .05$) among women without dense breasts; EA women ($M = 2.30$ versus 1.69) and women who were supplementally screened ($M = 2.26$ versus 1.7) were at higher risk. Among women with dense breasts, a main effect of supplemental screening ($F_{1,132} = 4.11$, $P < .05$) was qualified by a significant interaction with race ($F_{1,132} = 5.49$, $P < .05$). AA women's breast cancer risk did not differ by supplemental screening ($M = 1.31$ and 1.35), whereas breast cancer risk was significantly lower among EA women who were supplementally screened ($M = 1.44$ versus 0.80 , $t[34] = 2.00$, $P = .05$).

DISCUSSION

We examined how the adoption of breast density notification laws affected the association between breast density and supplemental breast cancer screening in a Michigan breast clinic. Results showed a 5-fold postlaw increase in supplemental screening rates, attributable to the increase in the proportion of AA women who were supplementally screened after adoption of the law. Additionally, the association between breast density and supplemental screening was amplified after the law, indicating a change in the extent to which breast density was considered as a clinical indicator for supplemental screening referrals. With the exception of the ACR recommendation of supplemental ultrasound as an adjunct to mammogram for intermediate-risk women with dense breasts [21], routine supplemental screening for screen-negative women with dense breasts is not recommended unless women are otherwise at high risk for breast cancer [12,24,38–40]. These data indicate that, as a result of the notification laws, screen-negative women who are not at high risk may be prescribed supplemental screening.

After adoption of the notification law, the association between breast cancer risk and supplemental screening reversed for EA women with dense breasts, and there continued to be no similar association for AA women with dense breasts despite a greater proportion being supplementally screened. This pattern underscores failures to holistically consider breast cancer risk when making decisions about supplemental screening referrals. We examined the same women in the same clinic before and after adoption of the notification law; hence, the same breast cancer risk factors should ostensibly predict supplemental screening recommendations at both times. Communications with the breast clinic's directors precluded any changes in clinic practices that accounted for between-time or between-race differences in supplemental screening rates. Therefore, changes probably occurred outside of the breast clinic at the practices of women's referring physicians. Prior studies have demonstrated considerable variation in physicians' knowledge of breast density notification legislation, in comfort discussing relevant implications with their patients, and in supplemental screening referrals after breast density notification laws [41–43]. These physician-level differences likely account for variation in patient-level behaviors, particularly because physician recommendations predict women's screening behaviors [44,45]. Our findings highlight the need to examine the *joint* role of patients and physicians in supplemental screening decision making after receipt of breast density notifications.

Between-race differences in supplemental screening, both before and after the law, were partially because of fewer AA women having dense breasts compared with EA women and because of higher breast cancer risk for EA women. However, inasmuch as the convergence of supplemental screening rates among women with dense breasts suggests an egalitarian outcome of breast density notification laws, it also signaled converging inconsistency between breast cancer risk and supplemental screening. AA women with dense breasts rely more on physician recommendations [46], and lack of physician recommendations diminish mammography utilization among AA women [47–50]. Hence, we suspect that physicians were less likely to discuss breast density and associated risks or to refer appropriate AA women with dense breasts for supplemental screening before the notification law [51], resulting in little association between risk and supplemental screening for AA women with dense breasts. After the notification law, more AA women with dense breasts were supplementally screened; however, it was not because they were at higher risk. Breast density notifications may have led to convergence in the types of conversations that both EA and AA women had with their physicians, leading to convergence in supplemental screening referrals regardless of actual breast cancer risk. Future studies ought to examine how supplemental screening rates continue to evolve as women and their physicians gain more familiarity with breast density and breast cancer risk and whether more supplemental screening yields more breast cancer tumor detection [16–18].

Limitation

Our sample was from a single breast imaging facility at a hospital in the city of Detroit, Michigan. Because the clinic receives screening mammogram and supplemental screening referrals from a variety of practices in and around the city of Detroit and from Wayne county (where Detroit is located) and the surrounding counties, and because referrals for supplemental screening likely originate from primary care physicians and gynecologists

outside of the screening facility, it is unlikely that the findings are unduly influenced by any idiosyncrasies of the imaging facility itself. Nonetheless, replication of these results in other regions, and with data from nonacademic hospitals, will increase confidence in generalizability.

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TAKE-HOME POINTS

- Rates of supplemental screening among women with dense breasts increased after passage of breast density notification laws in Michigan, driven in large part by increases in supplemental screening among AA women with dense breasts.
- Breast density was more strongly related to supplemental screening after the law.
- Passage of the notification law attenuated the association between breast cancer risk and supplemental screening.

Fig 1.

We regressed supplemental imaging onto breast density, racial group, body mass index (BMI), and age (latter two rescaled by dividing by 10 and then mean centered), and regressed breast density onto racial group; as such, racial group had both a direct path (c) and an indirect path (product of a and b) to supplemental screening. We specified correlations between racial group and BMI, breast density and BMI, and breast density and age (correlations excluded from figure to facilitate presentation).

Table 1.

Supplemental BC screening before and after law by race and BD status

Breast Density	African American or Black			European American or White		
	No Supplemental Screening		Supplemental Screening	No Supplemental Screening		Supplemental Screening
	n	%		n	%	
Before law						
Nondense	2,112	99.8	5	465	98.7	6
Dense	631	99.2	5	212	96.8	7
After law						
Nondense	2,203	99.6	9	486	98.2	9
Dense	530	96.2	21	186	96.4	7

BC = breast cancer; BD = breast density.

Table 2.

Direct effects on the probability of supplemental BC screening before and after BD notification law

Predictors	Before BD Notification Law		After BD Notification Law	
	Estimate	SE	Estimate	SE
Supplemental screening				
Dense breasts	0.008 [*]	0.005	0.029 [†]	0.007
African American	-0.015 [‡]	0.005	-0.013 [‡]	0.006
BMI	0.000	0.002	0.004	0.003
Age	-0.002	0.001	-0.007 [‡]	0.002
Dense breasts				
African American	-0.087 [‡]	0.019	-0.081 [‡]	0.019

BC = breast cancer; BD = breast density; BMI = body mass index; SE = standard error.

^{*} $P < .10$.[‡] $P < .05$.[†] $P < .01$.