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Impact of BMI on Prevalence of Dense Breasts by Race and Ethnicity

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Abstract

Background.—Density notification laws require notifying women of dense breasts with dense breast prevalence varying by race/ethnicity. We evaluated whether differences in body mass index (BMI) account for differences in dense breasts prevalence by race/ethnicity.

Methods.—Prevalence of dense breasts (heterogeneously or extremely dense) according to Breast Imaging Reporting and Data System and obesity (BMI >30 kg/m^2) were estimated from 2,667,207 mammography examinations among 866,033 women in the Breast Cancer Surveillance Consortium from January 2005 through April 2021. Prevalence ratios (PR) for dense breasts relative to overall prevalence by race/ethnicity were estimated by standardizing race/ethnicity prevalence in the BCSC to the 2020 U.S. population, and adjusting for age, menopausal status, and BMI using logistic regression.

Results.—Dense breasts were most prevalent among Asian women (66.0%) followed by non-Hispanic/Latina (NH) White (45.5%), Hispanic/Latina (45.3%), and NH Black (37.0%) women. Obesity was most prevalent in Black women (58.4%) followed by Hispanic/Latina (39.3%), NH White (30.6%) and Asian (8.5%) women. The adjusted prevalence of dense breasts was 19% higher (PR=1.19, 95%CI=1.19–1.20) in Asian women, 8% higher (PR=1.08, 95%CI=1.07–1.08) in Black women, the same in Hispanic/Latina women (PR=1.00, 95%CI=0.99–1.01), and 4% lower (PR=0.96, 95%CI=0.96–0.97) in NH White women relative to the overall prevalence.

Conclusion.—Clinically important differences in breast density prevalence are present across racial/ethnic groups after accounting for age, menopausal status, and BMI.

Impact.—If breast density is the sole criterion used to notify women of dense breasts and discuss supplemental screening it may result in implementing inequitable screening strategies across racial/ethnic groups.

Keywords

Breast density; body mass index; race/ethnicity

Introduction

Having dense breasts (heterogeneously or extremely dense) is a strong, well-established risk factor that increases invasive (1,2), interval (3–5), and advanced (6,7) breast cancer risk, and reduces mammography sensitivity (8,9). Breast density notification laws have been enacted in at least 38 states and a national density notification law will be enacted September 10, 2024 that will inform all women if their breasts are nondense or dense and that dense breasts can mask tumors and increase breast cancer risk (10). Dense breasts are common (11), and studies have shown that the distribution of breast density categories varies across racial and ethnic groups (12,13). For example, Asian women are more likely to have dense breasts than non-Hispanic/Latina (NH) White women (1), and some studies show that Black and Hispanic/Latina women are less likely to have dense breasts than NH White women (14–17).

Body mass index (BMI) is inversely associated with breast density (11); accounting for BMI strengthens the association between breast density and breast cancer risk (18). Racial/ethnic differences in breast density may be confounded by BMI since obesity varies widely across groups with more than 50% of Black women being obese compared with less than 10% of Asian women (13,19). Additionally, being overweight/obese is a risk factor for breast cancer and women who are both overweight/obese and have dense breasts are at highest breast cancer risk (15,18,20).

Prior studies reporting breast density by race/ethnicity have been limited by small sample sizes, reporting results only for limited number of racial/ethnic groups, and reporting results for breast density and BMI separately, not jointly (14,16,21–31). Whether differences in BMI account for racial/ethnic differences in the prevalence of dense breasts is not well understood. We used the large, racially, ethnically, and geographically diverse Breast Cancer Surveillance Consortium (BCSC) cohort to estimate and compare prevalence of dense breasts by race/ethnicity adjusting for age, menopausal status, and BMI.

Materials and Methods

Study Setting, Data Sources, and Participants

This report follows STROBE reporting guidelines for cohort studies. Prospective data were collected at 7 U.S.-based BCSC registries (www.bcsc-research.org): Carolina Mammography Registry, Kaiser Permanente Washington, Metro Chicago Breast Cancer Registry, New Hampshire Mammography Network, Sacramento Area Breast Imaging Registry, San Francisco Mammography Registry, and Vermont Breast Cancer Surveillance System. Registries collect individual-level characteristics and clinical information from community radiology facilities and link to state or regional cancer registries and pathology databases for complete capture of breast cancer diagnoses. We included all digital mammography and digital breast tomosynthesis screening examinations from 140 BCSC facilities performed from January 2005 to April 2021 among women aged 40–74 years without a personal history of breast cancer; non-missing information on Breast Imaging Reporting and Data System (BI-RADS) breast density and BMI; and who self-identified as Hispanic/Latina (of any race) or non-Hispanic/Latina Asian, Black, or White. We excluded women who self-identified as another race or as having multiple races. The final study population included 2,667,207 BI-RADS breast density measurements from 866,033 women interpreted.

BCSC registries and the Statistical Coordinating Center received Institutional Review Board approval for active or passive consenting processes or a waiver of consent to enroll participants, link, and pool data, and perform analysis. Procedures were Health Insurance Portability and Accountability Act compliant, and a Federal Certificate of Confidentiality protects the identities of participants.

Measures, Definitions, and Outcomes

Age, height, weight, menopausal status, race, and ethnicity were collected from self-administered health history questionnaires or extracted from electronic health records at the time of each mammography examination. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2) and categorized as underweight (<18.5), normal weight (18.5–24.9), overweight (25.0–29.9), obesity class I (30.0–34.4), and obesity class II/III (≥35.0) (32). Postmenopausal status included women who reported periods that stopped naturally, had both ovaries removed, were age 60 years or older, or had no period for ≥365 days. Pre/perimenopausal status included women who reported continued menstrual periods, were not sure if periods had stopped, had their last menstrual period <365 days ago, or used hormonal birth control. Women who could not be classified using these definitions were considered postmenopausal if age ≥52 years or pre/perimenopausal if age <52 years.

Primary outcomes were a dichotomized density as dense (heterogeneously dense or extremely dense) versus nondense (almost entirely fatty or scattered fibroglandular densities) breasts, which is typically utilized for breast density reporting laws, and the four BI-RADS breast density categories recorded by the radiologist as part of clinical practice as almost entirely fatty, scattered fibroglandular densities, heterogeneously dense, or extremely dense (33).

Statistical Analysis

We summarized the study cohort characteristics by race/ethnicity, inversely weighting frequencies by the total number of observations each woman contributed to the study, giving an effective sample size equal to the number of women. We plotted the age-standardized joint distribution of BI-RADS breast density and BMI by race/ethnicity, inversely weighing by the total number of observations each woman contributed. We used age-standardized pairwise Mantel-Haenszel (MH) and Cochran-Mantel-Haenszel (CMH) tests of significance to test if the distribution of breast density within BMI strata differed by race/ethnicity and to test if the joint distribution of breast density and BMI differed by race/ethnicity.

We used logistic regression to model the probability of having dense vs. nondense breasts and polytomous logistic regression with a generalized-logit link to estimate the distribution of the 4 breast density categories to model the probabilities of having dense vs. nondense breasts and the 4 breast density categories as a function of race/ethnicity, fitting 3 sequential models: unadjusted; adjusted for age (linear and quadratic) and menopausal status; and additionally adjusted for BMI (linear and quadratic). We used predictive margins to compute race/ethnicity-specific estimates of the density probabilities, standardizing to the overall cohort distribution for the adjustment variables (34). We estimated the race and ethnicity-specific distribution in the U.S. from the 2020 census (https://data.census.gov/cedsci/table?q=Race%20and%20Ethnicity&g=0100000US&tid=DECENNIALPL2020.P2) and used model-predicted probabilities for each density category and racial/ethnic group in the BCSC to calculate prevalence ratios (PR) of each breast density category for each racial/ethnic group relative to the estimated overall prevalence for the U.S. population; 95% confidence intervals (CI) were computed using 10,000 non-parametric bootstrap (35) iterations clustered at the woman level and selecting one random observation per woman, which showed good convergence for the mean prevalence ratio estimates.

Statistical analyses were performed using SAS/STAT version 14.2 (Cary, NC), R version 4.1.2, and RStudio version 2021.9.1.372. Tests of statistical significance used a two-sided alpha of 0.05.

Data availability

Study protocol and statistical code available on request, please contact kpwa.scc@kp.org with specific queries. Data set available after study aims of funded grants through 2027 are addressed and with appropriate approval from the Breast Cancer Surveillance Consortium Steering Committee. The data underlying this article will be shared on reasonable request to the corresponding author and BCSC with appropriate regulatory approvals.

Results

NH White women constituted 67.8% of the cohort, followed by Asian (12.8%), NH Black (11.8%), and Hispanic/Latina (7.5%) women (Table 1). Age distributions were generally similar across racial/ethnic groups, except a larger proportion of Hispanic/Latina women were age 40–49. Asian women had the largest prevalence of dense breasts (65.9%) followed by NH White (45.5%), Hispanic/Latina (45.2%), and NH Black (36.9%) women. Obesity was most prevalent in NH Black women (58.4%) followed by Hispanic/Latina (39.3%), NH White (30.6%), and Asian (8.5%) women.

The age-adjusted distribution of breast density within each BMI category (Figure 1) and the joint distribution of breast density and BMI were significantly different across racial/ethnic groups (Supplemental Figure S1) (all p-values <0.0001). Asian women had the highest prevalence of dense breasts within each BMI category. NH Black and Hispanic/Latina women had lower prevalence of dense breasts within the underweight and normal BMI categories compared to White women, but higher prevalence within overweight and obese I/II/III categories. There was an inverse relationship between BMI and breast density for all racial/ethnic groups.

Results were largely unchanged with partial adjustment for age and menopausal status, with larger changes after additional adjustment for BMI (Table 2). Relative to the overall population, Asian women had a higher prevalence of dense breasts in both unadjusted and adjusted models. The fully adjusted prevalence of dense breasts was 19% higher (PR=1.19, 95%CI=1.19–1.20) in Asian women, 8% higher (PR=1.08, 95%CI=1.07–1.08) in NH Black women, (PR=1.00, 95%CI=0.99–1.01) the same in Hispanic/Latina women, and 4% lower (PR=0.96, 95%CI=0.96–0.97) in White women relative to the overall prevalence.

When examining results by the four density categories, unadjusted PRs for heterogeneously dense (PR=1.31, 95%CI=1.30–1.32) and extremely dense (PR=2.17, 95%CI=2.14–2.20) breasts in Asian women increased minimally to PR=1.35 (95%CI=1.34–1.35) and PR=2.25 (95%CI=2.22–2.29) after adjustment for age and menopause, but decreased substantially to PR=1.16 (95%CI=1.15–1.16) and PR=1.48 (95%CI=1.45–1.50) after additional adjustment for BMI (Figure 2 and Supplemental Table S1). NH Black women had lower unadjusted prevalence of heterogeneously dense (PR=0.87, 95%CI=0.87–0.88) and extremely dense (PR=0.50, 95%CI=0.48–0.51) breasts than the overall population, but following full adjustment for age, menopausal status, and BMI, they had higher prevalence of heterogeneously dense (PR=1.08, 95%CI=1.08–1.09) and extremely dense breasts (PR=1.02, 95%CI=0.99–1.05) than the overall population (Figure 2 and Supplemental Table S1). Hispanic/Latina women had a similar prevalence of dense breasts as the overall population in both unadjusted and adjusted models, but their lower prevalence of extremely dense breasts attenuated somewhat from unadjusted (PR=0.79, 95%CI=0.77–0.81) to fully adjusted (PR=0.89, 95%CI=0.86–0.91) models. NH White women were significantly more likely to have almost entirely fatty and significantly less likely to have heterogeneously or extremely dense breasts after adjustment for age, menopausal status, and BMI, though absolute differences were small.

Discussion

Among more than 2.6 million breast density measurements from 140 US-based radiology facilities in the BCSC, we found clinically important differences in the prevalence of dense breasts across racial/ethnic groups that remained after adjusting for age, menopausal status, and BMI. Given BMI and breast density are both risk factors for breast cancer (13,36) and the strength of their association with breast cancer varies by racial/ethnic groups (1), considering these prevalence differences may be important for estimating breast cancer risk in racial/ethnic groups and reporting breast density results to women.

The goal of breast density notification laws is to identify women at increased risk of breast cancer and masked tumors that may benefit from supplemental imaging. State laws do not consider other breast cancer risk factors, such as BMI, and the Food & Drug Administration (FDA) Mammography Quality and Standards Act Final Rule has proposed to only report if women have dense or nondense breasts (10). Some have suggested that under current state notification laws, the use of BI-RADS breast density alone may result in suboptimal risk stratification and recommendations for supplemental imaging (5,37–39,40). Our study suggests that Asian women are most likely to have dense breasts with associated density notification letters suggesting consideration of supplemental imaging, whereas Black women are less likely to have dense breasts which do not trigger letters suggesting consideration of supplemental imaging. Specifically, Asian women are most likely to be notified of dense breasts irrespective of adjustment for BMI, whereas Black women are less likely to be notified of dense breasts if density is not adjusted for BMI. Studies indicate disparities already exist such that non-Hispanic White women are more likely to have supplemental imaging for dense breasts than non-Hispanic Black or Asian women which may lead to disparities in cancer outcomes (39, 41). Additionally, advanced cancer rates after mammography are higher in Black women (7) and interval rates are lower in Asian women (42). Reporting breast cancer risk that incorporates breast density and BMI would better identify women at highest risk of a missed or advanced cancer for discussion of supplemental imaging rather than using breast density alone as the sole criterion (5,7,38) with the result of potentially more equitable receipt of supplemental imaging.

BI-RADS breast density is a qualitative measure of the relative proportion of fibroglandular and fat tissue on mammograms that is inversely associated with BMI. Dense volume is a quantitative measure of the volume of fibroglandular tissue that can be measured with commercial software and is minimally influenced by BMI or increased among overweight and obese women (18,27,43). Volpara and Quantra are FDA approved commercial software used in clinical practice to assess volumetric breast density. Although Asian women have the highest prevalence of BI-RADS dense breasts, they have the lowest dense volume (43). Thus, many Asian women, in whom a large proportion have dense BI-RADS breast density and normal BMI, may be inappropriately notified, and recommended for supplemental imaging recommendations under current notification laws based on BI-RADS breast density alone. Dense volume is a strong predictor of interval and advanced cancers, and, if used for density notification, would more accurately identify women at risk for a missed cancer than BI-RADS breast density unadjusted for BMI (44,45).

Five studies have examined BI-RADS breast density by race/ethnicity considering age, menopausal status, and BMI. McCarthy et al. reported that Black women had higher breast density than White women across all quantitative measures of breast density and no difference in the qualitative BI-RADS density distribution by race (27). Moore et al. compared Black and White women and found Black women had a higher odds of extremely dense breasts than White women (46). Oppong et al. compared BI-RADS breast density in non-Hispanic/Latina White, Black, and Hispanic/Latina women and found Hispanic/Latina women have the highest density followed by Black and non-Hispanic/Latina White women (28). One study examined Asian, Black, non-Hispanic White, and Hispanic/Latina women and compared dense breasts to almost entirely fatty breasts and found Asian and Black women have higher odds of dense breasts than Hispanic/Latina and NH White women, which have similar odds of dense breasts (12). A recent study observed the lowest prevalence of extremely dense breasts among American Indian and Alaska native women and the greatest prevalence of extremely dense breasts among Chinese women (47). Our results extend the literature by assessing BI-RADS breast density in the BCSC cohort, a large representative sample of U.S. women, and report that the adjusted prevalence of dense breasts is highest in Asian and Black women compared to Hispanic and White women after adjusting for BMI. These results are consistent with a study that measured the same four racial/ethnic groups but assessed odds of extremely dense breasts rather than prevalence of the four density categories (12).

Our study strengths include the large, geographically, and racially/ethnically diverse BCSC cohort, which is broadly representative of the U.S. population and has larger sample sizes than many other studies for the four largest U.S. racial and ethnic groups. Our analysis included both digital mammography and digital breast tomosynthesis, which reflect recent clinical practice. We have previously reported that BI-RADS breast density categories were similar on digital breast tomosynthesis exams compared to digital mammography exams (48). We also have demonstrated that density agreement on digital breast tomosynthesis vs. digital mammography is high based on women with both examinations less than 36 months apart (49).

Our study has limitations. Even with a very large study cohort and multiple observations per woman, some estimated CIs were wide due to small sample sizes for NH Black and Hispanic/Latina women in the underweight category or for Asian women in the obese I/II/III categories, but sample sizes were still larger than many other studies. We were unable to evaluate quantitative measures of breast density; however, BI-RADS breast density is the most commonly collected density measure in clinical practice in the U.S., triggers density notification laws, and is used in several major breast cancer risk prediction models (36,50,51). We were not able to analyze other measures of adiposity, such as central adiposity, waist-to-hip ratios, or visceral versus subcutaneous fat distribution, and BMI was primarily self-reported, but there is good overall agreement between self-reported and measured height, weight, and BMI (52). Also, BMI measures in the BCSC cohort have associations with breast cancer consistent with the literature (38), suggesting self-reported height and weight in the BCSC reflect height and weight measures in published studies. We did not consider other factors that are correlated with breast density, such as a family history of breast cancer, but this association is weaker compared to age and BMI, reduced by controlling for age and BMI (11), and does not vary by race/ethnicity (53). However, caution should be used in extrapolating the results of this study to populations that vary markedly in such characteristics.

Conclusions

Clinically important differences in the prevalence of dense breasts across racial/ethnic groups remain after adjusting for BMI. The probability of dense breasts assessed by BI-RADS compared to the overall U.S. population for Asian women was attenuated but remained high following adjustment for BMI. The probability of dense breasts in NH Black women increased after adjustment for BMI. Hispanic/Latina women had significantly lower probability of extremely dense breasts compared to the general population with and without adjustment for BMI. Current density notification laws that only require notification of breast density may intensify racial/ethnic disparities when assessing eligibility for supplemental imaging if they do not consider the joint effects of BMI and breast density on risk of a missed or advanced cancer. Differences in the distribution of breast density by race/ethnicity following adjustment for BMI has important implications for equity in breast density notification, access to supplemental imaging, and estimating population breast cancer risk. Directly calculating risk of mammography failure such as advanced breast cancer risk (7) that incorporates race/ethnicity, breast density, and BMI is warranted and could mitigate potential disparities in recommending supplemental imaging.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1:

Distribution of Breast Imaging Reporting and Data System breast density categories within body mass index categories by race and ethnicity age-adjusted and inversely weighted for the number of mammograms per woman. Panels according to race and ethnicity.

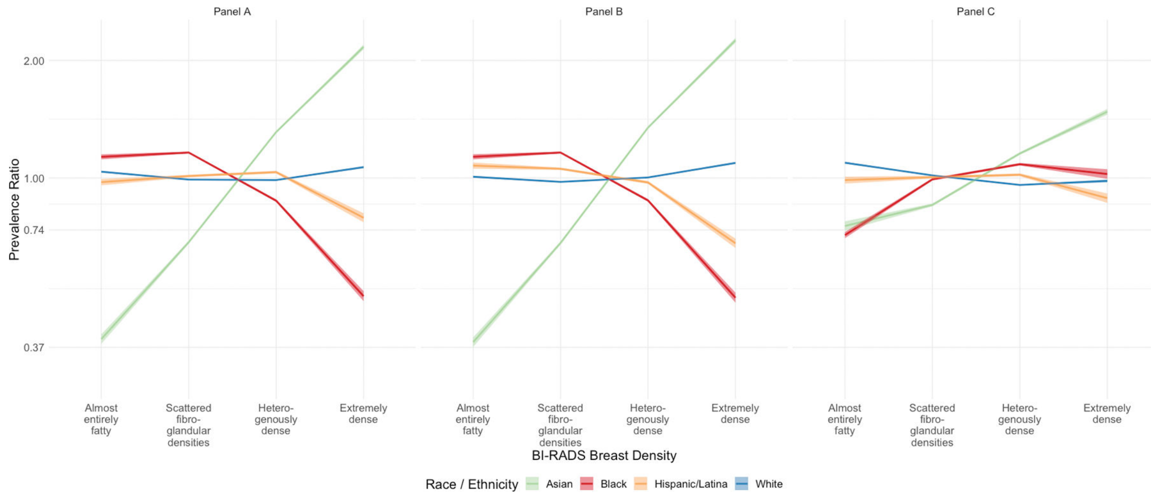

Figure 2:

Prevalence ratios and 95% bootstrap confidence intervals for polytomous BI-RADS breast density category by race and ethnicity. Graph A is unadjusted, Graph B is adjusted for age (linear and quadratic) and menopausal status, and Graph C is adjusted for age (linear and quadratic) and menopausal status, and body mass index (linear and quadratic).

Table 1.

Characteristics of 2,667,207 observations from 866,033 women in the study cohort by race/ethnicity.

*

	NH Asian N = 111,209 %	NH Black N = 102,388 %	Hispanic/Latina N = 65,117 %	NH White N = 587,320 %
Age Group (years)				
40–49	32.1	28.2	40.2	28.6
50–59	34.4	33.8	33.1	32.7
60–69	26.4	27.3	20.2	28.2
70–74	7.0	10.7	6.4	10.6
Menopausal status				
Pre/perimenopausal	40.6	38.5	48.2	36.6
Postmenopausal	59.4	61.5	51.8	63.4
BI-RADS breast density				
Almost entirely fatty	4.2	12.4	10.7	11.3
Scattered fibroglandular densities	29.9	50.7	44.1	43.2
Heterogeneously dense	49.9	33.3	39.4	37.6
Extremely dense	16.1	3.7	5.9	7.9
Body mass index (kg/m^2)				
Underweight (<18.5)	3.5	0.6	0.7	1.5
Normal (18.5–24.9)	61.9	13.5	25.6	39.3
Overweight (25.0–29.9)	26.1	27.5	34.4	28.7
Obese I (30.0–34.9)	6.5	26.1	22.8	16.6
Obese II/III (≥35.0)	2.0	32.3	16.5	14.0
BI-RADS breast density measures per woman				
1	40.5	36.6	41.0	32.3
2	23.5	22.6	23.2	19.7
3	13.3	13.5	13.1	12.7
4	8.4	9.3	8.3	9.6
5 or more	14.2	17.9	14.3	25.6

Abbreviations: NH, non-Hispanic/Latina; kg, kilograms; m, meters; BI-RADS, Breast Imaging Reporting and Data System.

*Frequencies are inversely weighted by the number of observations per woman and rounded.

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Table 2.

Prevalence ratios and 95% bootstrap confidence intervals for BI-RADS dense versus nondense breasts by race and ethnicity.

Model	Race/ethnicity	Nondense PR	Dense PR
Unadjusted[a]	NH Asian	0.62 (0.62, 0.63)	1.45 (1.44, 1.46)
	NH Black	1.16 (1.15, 1.16)	0.81 (0.81, 0.82)
	Hispanic/Latina	1.00 (1.00, 1.01)	0.99 (0.99, 1.00)
	NH White	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)
Partially adjusted[b]	NH Asian	0.62 (0.62, 0.63)	1.48 (1.47, 1.49)
	NH Black	1.15 (1.15, 1.16)	0.82 (0.81, 0.82)
	Hispanic/Latina	1.06 (1.05, 1.07)	0.93 (0.92, 0.93)
	NH White	0.98 (0.98, 0.99)	1.02 (1.02, 1.02)
Fully adjusted[c]	NH Asian	0.84 (0.83, 0.85)	1.19 (1.19, 1.20)
	NH Black	0.93 (0.93, 0.94)	1.08 (1.07, 1.08)
	Hispanic/Latina	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)
	NH White	1.03 (1.03, 1.03)	0.96 (0.96, 0.97)

Abbreviations: NH, non-Hispanic/Latina; BI-RADS, Breast Imaging Reporting and Data System. PR, prevalence ratio=prevalence of racial/ethnic and density group relative to overall Breast Cancer Surveillance Consortium study population standardized to the US population

[a]Unadjusted race/ethnicity.

[b]Additionally adjusted for age (linear and quadratic) and menopausal status.

[c]Additionally adjusted for body mass index (linear and quadratic).