Published in final edited form as:
Cancer Epidemiol Biomarkers Prev. 2018 April ; 27(4): 446–453. doi:10.1158/1055-9965.EPI-17-0009.

Factors associated with false positive results on screening mammography in a population of predominantly Hispanic women

Julia E. McGuinness[1,*], **William Ueng**[2,*], **Meghna S. Trivedi**[1,3], **Hae Seung Yi**[4], **Raven David**[5], **Alejandro Vanegas**[1,3], **Jennifer Vargas**[1,3], **Rossy Sandoval**[3], **Rita Kukafka**[5,6], and **Katherine D. Crew**[1,2,3]

[1]Department of Medicine, College of Physicians and Surgeons, Columbia University, New York, NY 10032

[2]Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY 10032

[3]Herbert Irving Comprehensive Cancer Center, Columbia University, New York, NY 10032

[4]Department of Health and Behavior Studies, Teachers College, Columbia University, New York, NY 10027

[5]Department of Biomedical Informatics, College of Physicians and Surgeons, Columbia University, New York, NY 10032

[6]Department of Sociomedical Sciences, Mailman School of Public Health, Columbia University, New York, NY 10032

Abstract

Background—Potential harms of screening mammography include false positive results, such as recall breast imaging or biopsies.

Methods—We recruited women undergoing screening mammography at Columbia University Medical Center in New York, NY. They completed a questionnaire on breast cancer risk factors and permitted access to their medical records. Breast cancer risk status was determined using the Gail model and a family history screener. High-risk was defined as a 5-year invasive breast cancer risk of ≥1.67% or eligible for *BRCA* genetic testing. False positive results were defined as recall breast imaging (BIRADS score of 0, 3, 4, or 5) and/or biopsies that did not yield breast cancer.

Results—From November 2014 to October 2015, 2,361 women were enrolled and 2,019 were evaluable, of whom 76% were Hispanic and 10% non-Hispanic white. Fewer Hispanic women met high-risk criteria for breast cancer than non-Hispanic whites (18.0% vs. 68.1%), but Hispanics more frequently engaged in annual screening (71.9% vs. 60.8%). Higher breast density (heterogeneously/extremely dense vs. mostly fat/scattered fibroglandular densities) and more

Corresponding author: Katherine D. Crew, MD MS, 161 Fort Washington Ave, 10-1072, New York, NY 10032, Tel: 212-305-1732, Fax: 212-305-0178, kd59@cumc.columbia.edu.
*First authors who contributed equally

The authors declare no potential conflicts of interest.

frequent screening (annual vs. biennial) were significantly associated with false positive results (odds ratio [OR]=1.64, 95% confidence interval [CI]=1.32–2.04 and OR=2.18, 95% CI=1.70–2.80, respectively).

Conclusion—We observed that women who screened more frequently or had higher breast density were at greater risk for false positive results. Additionally, Hispanic women were screening more frequently despite having a lower risk of breast cancer compared to whites.

Impact—Our results highlight the need for risk-stratified screening to potentially minimize the harms of screening mammography.

Keywords

breast cancer; screening mammography; false positive results; Hispanic; epidemiology

Introduction

Screening mammography has been an accepted method of breast cancer screening in the U.S. for decades. Universal screening mammography results in increased cancer detection rate and a reduction in breast cancer mortality compared to clinical breast exams alone (1). Among women aged 50–74 years, biennial screening mammography confers a 25.8% relative risk reduction in breast cancer mortality (2). However, guidelines for screening mammography in the U.S. remain controversial, with differing recommendations from major medical organizations. In 2013, the American Cancer Society (ACS) recommended that women begin screening annually at age 45, with the transition to biennial screening at age 55; in addition, women aged 40 to 45 should be given the option to start screening annually (3). In contrast, the United States Preventive Services Task Force (USPSTF) recommends that average-risk women start screening biennially at age 50 (4).

Much of the debate about screening mammography arises from an increasing awareness of the risks of false positive results, defined as recall breast imaging or biopsy not yielding breast cancer. Of particular interest are the psychological effects of false-positive mammography, with studies showing consistently higher scores of psychological distress in women with false positive results, persisting up to 12 months (5), and even similar levels of distress in women with false positive results as those with breast cancer diagnoses (6). In addition, false positive results incur considerable financial consequences, with an estimated cost in the U.S. of approximately $2.8 billion between 2012 and 2013 and an average $200 out of pocket cost to patients (7).

In the U.S., the likelihood of a false positive screening mammogram is substantial. For annual mammography, the probability of a false positive recall mammogram was 16.3% for a woman's first screening mammogram and 9.6% for subsequent mammogram, and the probabilities of a false positive biopsy at these screenings were 2.5% and 1.0%, respectively (8). The cumulative probability of false positive studies over 10 years for annual screening ranges from 43.1% to 61.3% (8–11). There are several variables that alter such probabilities, however. Biennial screening decreases these cumulative probabilities to 29–42% (8) (10), contributing to the recent ACS and USPTSF recommendations to extend screening intervals to biennially. In addition, younger age (particularly age 40–45), dense breasts, and breast cancer risk factors increase the probability of a false positive result (12).

There is a dearth of information, however, regarding false positive mammography in minorities, particularly for the Hispanic population. Adherence to screening mammography programs is a particular concern in this population, especially after a false positive mammogram. In one study, Hispanic women were less likely to continue with screening mammography after experiencing a false positive result (13). Rates of false positive mammograms are higher at facilities serving "vulnerable" populations (*i.e.,* lower educational attainment, racial/ethnic minorities, and limited income), perhaps reflecting the concern that these patients might be less likely to follow-up after an abnormal study and are at greater risk of diagnosis with cancer at presentation (14). There is a need, therefore, to more closely examine the rates of and contributions to false positive mammography in these populations in order to tailor screening recommendations to their unique needs.

In this study, we aim to further examine the relationships between mammographic breast density, breast cancer risk status, age, and frequency of screening to false positive results on screening mammograms in a predominantly Hispanic population.

Materials and Methods

Study Description and Study Population

We conducted a retrospective cohort study called the Know Your Risk: Assessment at Screening (KYRAS) for breast cancer study. Women were approached for enrollment during routine screening mammography at the Avon Breast Imaging Center at Columbia University Medical Center (CUMC) in New York, NY. They completed a questionnaire on sociodemographic characteristics and breast cancer risk factors and gave consent to access their electronic health records (EHR) for research purposes. The inclusion criteria for this analysis include: 1) Women, age ≥18 years, 2) English or Spanish-speaking, 3) No previous diagnosis of breast cancer, 4) Providing permission to access EHR information. The study was approved by the Institutional Review Board at CUMC.

Survey Variables

Patient-administered questionnaire—Participants completed a one-time comprehensive survey on demographic characteristics and breast cancer risk factors including family history of breast and ovarian cancer. We collected information on age (dichotomized as less than 50 years and 50 or older), highest educational level (less than 8 years of education, 8–11 years [without graduating high school], high school graduation or General Equivalency Diploma (GED), vocational or technical school or military training, some college or university classes but no degree, associate's or bachelor's degree, graduate degree, post-graduate degree, or professional degree), race (white, black, Asian [Chinese, Japanese, Filipino, Hawaiian, Other Pacific Islander, Other Asian-American], Native American or Alaskan Native, other), ethnicity (Hispanic, not Hispanic), and Jewish ancestry (Ashkenazi, Sephardi, both). We also calculated body mass index (BMI) using the subject's self-reported height and weight, categorizing BMI as underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), or obese (≥30.0 kg/m^2).

We collected information on additional breast cancer risk factors, including first-degree family history of breast cancer, age of menarche, first live birth (if applicable), and history of breast biopsy (including number of biopsies and presence of atypia) to calculate 5-year and lifetime absolute risk of invasive breast cancer according to the Gail breast cancer risk assessment tool (BCRAT) (15). We were unable to calculate breast cancer risk in women <35 years of age or those with a prior history of breast cancer, ductal or lobular carcinoma *in situ*, as the Gail model does not produce a reliable risk calculation for these women. Additionally, we utilized a modified Six-Point Scale family history screener to determine eligibility for genetic testing for breast cancer susceptibility genes (16). This model accounts for first and second-degree family history of breast and ovarian cancer, age at diagnosis (before or after age 50), bilateral breast cancer, male breast cancer, and Ashkenazi Jewish descent (16). We dichotomized risk status as high risk or low/average risk for analysis. High risk status for breast cancer was defined as having a greater than 1.66% 5-year risk or 20% lifetime risk of invasive breast cancer based upon the Gail model, or a score of 6 or greater on the modified Six-Point Scale, which indicates eligibility for *BRCA* genetic testing.

We also collected information on the women's breast cancer risk perceptions and their breast cancer screening behaviors. We asked about the participant's perceived risk of getting breast cancer (very low, moderately low, neither low nor high, moderately high, very high) and perceived risk compared to other women (much lower, about the same, much higher) (17). Lastly, we assessed self-reported mammography screening frequency (yearly, every 1–2 years, every 2–3 years, other) to determine screening behaviors.

Electronic Health Record Data—We collected the participants' mammography and biopsy results from the EHR. From the radiology reports, we retrieved information on breast density, frequency of screening, number of mammograms, follow-up time since first mammogram, and recall imaging dating back to 1989.

Mammographic breast density was assessed qualitatively by radiologists using a standardized Breast Imaging Reporting and Data System (BIRADS) classification system: 1) "mostly fatty" (<25% density) or "scattered areas of fibroglandular density" (25–50%), defined as low breast density, and 2) "heterogeneously dense" (51–75%) or "extremely dense" (>75%), defined as high breast density. For analysis, we used the breast density category for the woman's latest mammogram.

Frequency of screening was determined in the EHR by calculating the median number of days between mammograms. Frequency was categorized as yearly, biennial, or every 3+ years. If the median screening interval was between 274 days (9 months) and 548 days (18 months), then it was coded as yearly screening; a median interval between 548 days (18 months) and 913 days (30 months) was coded as biennial screening (12, 18). If individuals had more than 913 days between their mammograms, then they were coded as screening every 3+ years, which is considered as non-compliant according to both the ACS and USPSTF screening guidelines (3, 4). If the interval between breast imaging was less than

274 days (9 months), then it was coded as recall breast imaging. If this data was not available, we used the woman's self-reported response in the KYRAS questionnaire, which was also categorized as yearly, biennial, or every 3+ years. If the woman was having her first screening mammogram at the time of enrollment, screening frequency was not documented.

All of the breast pathology reports were reviewed by a medically trained coder (JEM) and were categorized as: 1) non-proliferative breast disease, 2) proliferative breast disease without atypia, 3) atypical hyperplasia, 4) lobular carcinoma *in situ*, 5) ductal carcinoma *in situ*, 6) invasive breast cancer, or 7) non-diagnostic. A false positive biopsy was defined as any breast biopsy not yielding breast cancer.

Outcome of Interest

The primary outcome of interest was a false positive result on screening mammography, defined as recall breast imaging or biopsy not resulting in breast cancer. Recall imaging was defined as receiving a BIRADS score of 0, 3, 4, or 5 on the screening mammogram without resulting in invasive breast cancer or ductal carcinoma *in situ*. Category 0 indicates a need for additional imaging evaluation, Category 3 recommends a follow-up time of 6 months, Category 4 indicates a suspicious abnormality, and Category 5 is highly suggestive of malignancy (19). False positive biopsies were defined as any breast biopsy that did not result in invasive breast cancer or ductal carcinoma *in situ*. This is consistent with the definitions of false positive results on screening mammography used in prior literature (20).

Statistical Analysis

Descriptive statistics were generated for baseline variables of interest. We conducted univariate analyses using the chi-square test to examine the relationship of each of the exposures of interest (age, race/ethnicity, education, breast cancer risk status, breast density, and frequency of screening mammograms) with the outcome of interest (ever had recall breast imaging or biopsy) to determine significant relationships (p-value<0.1). After identifying the significant predictors, we used multivariable logistic regression models to examine the magnitude and direction of association. We also controlled for race/ethnicity, BMI, and total years of follow-up since first documented mammogram in the EHR. The covariates were selected based upon the 10% rule and biological significance. If the odds ratio between each variable of interest and the outcome of interest changed by more than 10% after including the covariate into the univariate model, it was considered to be a potential confounder, and thus included in the final multivariable model. All analyses were conducted using SAS version 9.3 (Cary, NC).

Results

Baseline Characteristics

From November 2014 to October 2015 (Figure 1), of 13,023 women who presented for mammography screening at CUMC, 2,757 (21.2%) women were approached for enrollment into the KYRAS study and 396 (14.3%) refused participation. Of the 2,361 enrolled participants, 2,335 (98.9%) had complete questionnaire data. For our analysis, we excluded those who had a previous diagnosis of breast cancer (N=42), refused access to their electronic health record (EHR) for research purposes (N=102), or were missing EHR information (N=172). Our final sample consisted of 2,019 women.

The baseline characteristics by race/ethnicity of the study population are described in Table 1. Based upon data collected from the EHR, the study population was similar in demographic and clinical characteristics to the remaining screening cohort not enrolled in the KYRAS study (Supplemental Table 1). The median age of the participants was 59 years (range, 29–91). Seventy-six percent of the study population was Hispanic, 10% non-Hispanic white, 10% non-Hispanic black, and 4% other. A large percentage of our population was identified as meeting high-risk criteria for breast cancer either by the Gail model (17.7%), by their eligibility for *BRCA* genetic testing (11.7%), or by either criteria (24.7%). Approximately 18% of the Hispanic women were considered high risk for breast cancer, compared to 68% of non-Hispanic white women, 31% non-Hispanic black women, and 29% other. Twenty-four percent of the non-Hispanic white women were of Ashkenazi Jewish descent, and a large proportion of these (51%) met family history criteria for *BRCA* genetic testing.

We were able to obtain screening frequency data from the EHR for 84% of our population. In these women, self-reported screening frequency showed a statistically significant correlation ($p = 0.0339$) with EHR screening frequencies using the Kendall's tau-b correlation method. Therefore, for the other 16% of women who were missing EHR screening frequencies, we assumed that their self-reported screening frequency was equivalent to their actual screening frequency. Among participants, 69% screened yearly, 17% screened biennially, 10% screened every 3+ years, and 4% of women were screening for the first time. Despite having lower breast cancer risk, Hispanic women presented for screening mammography more frequently, with 72% screening yearly compared to 61%, 64%, and 52% screening yearly among non-Hispanic whites, non-Hispanic blacks, and other women, respectively.

With a median follow-up of 8.9 years (range, 0–26) since their first documented mammogram in the EHR, the women had a median of 7 mammograms (range, 1–27). About 53% of the women in our analysis had at least one false positive result on their screening mammograms (Table 2): 52% of them had at least one recall breast imaging and 12% of them had at least one biopsy that did not result in breast cancer. For the women who had a false positive biopsy, 55.0% had nonproliferative breast lesions, 27.5% had proliferative disease without atypia, 7.2% had atypical hyperplasia, 6.8% had nondiagnostic findings, and 3.5% had other benign findings. In addition, 4 women had newly diagnosed screen detected breast cancer on the mammogram conducted between November 2014 to October 2015, including 2 invasive breast cancers and 2 cases of ductal carcinoma *in situ*.

Factors Associated with Ever Having a False Positive Result

In univariate analysis, age, frequency of screening, and breast density were significantly associated with ever having a false positive result (Table 3). After controlling for total years of follow up, age, race/ethnicity, BMI, breast density, and breast cancer risk status, frequency of mammographic screening and breast density were significantly associated with having a false positive result on a screening mammogram. Those who screened annually had

2.18 times the odds of having a false positive result compared to those who screened biennially (odds ratio [OR]=2.18; 95% confidence interval [CI]=1.70–2.80). Having dense breasts was associated with a greater than 60% increased risk of having a false positive result compared to women with less dense breasts (OR=1.64; 95% CI=1.32–2.04). We also found that for every year of screening follow-up there was an 8% increase in the likelihood of having a false positive result (OR=1.08; 95% CI=1.07–1.10). Older women (50 years or older) tended to have a lower risk for having a false positive result compared to women aged less than 50 years, after controlling for known confounders (OR=0.80; 95% CI=0.62–1.02). However, this association was not significant.

Factors Influencing Screening Frequency

We compared women who screened annually vs. biennially by sociodemographic and clinical factors, and examined the relationship between age, race/ethnicity, breast cancer risk status, education, and perceived breast cancer risk with screening frequency. In the univariate analysis, we found that none of these factors was significantly associated with screening frequency (Table 4). In the multivariable logistic regression model, we found that only race was significantly associated with screening behaviors, after controlling for the covariates. Hispanic women were more likely to screen annually compared to non-Hispanic white women (OR=1.92; 95% CI=1.17–3.15). In fact, all minority populations were more likely to screen annually compared to non-Hispanic white women (Table 4).

Discussion

We identified specific factors associated with having a false positive result on a screening mammogram and described the magnitude of these relationships. Fifty-three percent of the women in our study received a false positive result over a median follow-up time of 8.9 years. This finding is in agreement with recent models that predict that 61.3% of women who screen annually will have a false positive result over 10 years (8). Through the combination of self-reported information and data extracted from the EHR, we found that more frequent mammography screening and higher breast density were significantly associated with having a false positive result on a screening mammogram, after controlling for BMI, years of follow-up, and race/ethnicity. Women who screened annually were 2.18 times more likely to have a false positive result compared to those who screened biennially, and those who had denser breasts were 1.64 times more likely to have a false positive result compared to women with less dense breasts.

Our finding that more frequent screening is associated with increased false positive mammography results is consistent with those of similar studies, which showed lower cumulative rates of false positives in women over a 10-year period with biennial vs. annual screening (8, 10, 18, 21). These studies have driven the recent changes in USPSTF and ACS guidelines for screening mammography in average-risk women, and our results further reinforce this.

While prior studies investigating the role of age in false positive mammography have shown the highest rate of false positive results among younger women aged 40 to 49, with rates decreasing with increasing age, our multivariable analysis did not show that age was a significant predictor of false positives in our study population (12). Younger women have denser breasts, and other studies have similarly demonstrated that after controlling for breast density, age was no longer significantly associated with having a false positive result (22, 23). Our univariate analysis supports this, as age was initially significantly associated with having a false positive mammogram, but after controlling for breast density and screening duration, this relationship was attenuated.

In our subgroup analysis, we found that Hispanic women tended to be at lower breast cancer risk compared to non-Hispanic white women. However, Hispanic women were actually screening more frequently than non-Hispanic white women (71.9% of Hispanic vs. 60.8% of non-Hispanic white women screening annually). In light of the concerns regarding false positives, these women may actually be exposing themselves to unnecessary harms. Previous studies examining mammography trends in Hispanic women have primarily been focused on increasing uptake and reducing barriers to access breast cancer screening (24–28). Consequently, much of the work has been to remove these barriers and improve screening adherence in this population (29). While these efforts have done much to increase screening uptake, we must also consider the potential harms of over-screening in this population, including decreased willingness to continue with future screening mammography after false positive results (13). Future efforts should therefore be focused on education of both patients and providers in risk-stratification of Hispanic women to inform appropriate screening intervals in this population.

There are several limitations to our study. First, this is a retrospective study and we did not assess changes in screening patterns over time as recommendations have been updated. However, the majority of women self-reported screening annually, which was confirmed in their medical record. Second, we utilized the Gail breast cancer risk model to calculate risk in our participants, which was developed in non-Hispanic white women and has not been well-validated in Hispanic populations (15). Third, we recruited participants from a population actively engaged in screening mammography at an academic medical center. Therefore, there may be selection bias for women who were more likely to be compliant with screening practices and have access to the medical system. Finally, we conducted a single institution study at an urban academic medical center and our results may not be generalizable to screening populations in other geographic regions.

Our study has several strengths, however. One is that we explored breast density specifically as a variable of interest, which could be a useful marker to inform women about how they should approach their own screening choices (30, 31). Another unique aspect of our study is our predominantly Hispanic population, a population that has been underrepresented in studies of screening mammography and breast cancer risk assessment. Additional strengths include our large sample size and use of a comprehensive questionnaire that thoroughly assessed breast cancer risk and genetic testing eligibility in individuals.

In summary, our study identified frequency of screening mammography and breast density as variables influencing rates of false positive results in a predominantly Hispanic population in New York City, both reinforcing the findings of prior studies and contributing new data for an under-studied population. Hispanic women were more likely to undergo annual screening mammography despite lower breast cancer risk compared to non-Hispanic white women. Futures studies should aim to identify interventions to inform providers and patients on breast cancer risk and appropriate mammography screening intervals, in order to reduce the rates of false positive mammography results and thus minimize the potential harms of screening.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Grant Support: The study was supported by the National Cancer Institute (grant R01 CA177995-01A1) and the Avon Foundation for Women.

References

1. Yen AM, Tsau HS, Fann JC, Chen SL, Chiu SY, Lee YC, et al. Population-Based Breast Cancer Screening With Risk-Based and Universal Mammography Screening Compared With Clinical Breast Examination: A Propensity Score Analysis of 1429890 Taiwanese Women. JAMA oncology. 2016; doi: 10.1001/jamaoncol.2016.0447
2. Mandelblatt JS, Stout NK, Schechter CB, vd Broek, Miglioretti DL, Krapcho, et al. Collaborative Modeling of the Benefits and Harms Associated with Different U.S. Breast Cancer Screening Strategies. Annals of internal medicine. 2016; 164(4):215–25. http://www.annals.org. DOI: 10.7326/M15-1536 [PubMed: 26756606]
3. Oeffinger KC, Fontham ET, Etzioni R, Herzig A, Michaelson JS, Shih YC, et al. Breast Cancer Screening for Women at Average Risk: 2015 Guideline Update From the American Cancer Society. Jama. 2015; 314(15):1599–614. DOI: 10.1001/jama.2015.12783 [PubMed: 26501536]
4. Siu AL. Force USPST. Screening for Breast Cancer: U.S. Preventive Services Task Force Recommendation Statement. Annals of internal medicine. 2016; 164(4):279–96. DOI: 10.7326/M15-2886 [PubMed: 26757170]
5. Bolejko A, Hagell P, Wann-Hansson C, Zackrisson S. Prevalence, Long-term Development, and Predictors of Psychosocial Consequences of False-Positive Mammography among Women Attending Population-Based Screening. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2015; 24(9):1388–97. DOI: 10.1158/1055-9965.EPI-15-0060
6. Brodersen J, Siersma VD. Long-term psychosocial consequences of false-positive screening mammography. Annals of family medicine. 2013; 11(2):106–15. DOI: 10.1370/afm.1466 [PubMed: 23508596]
7. Ong MS, Mandl KD. National expenditure for false-positive mammograms and breast cancer overdiagnoses estimated at $4 billion a year. Health affairs. 2015; 34(4):576–83. DOI: 10.1377/hlthaff.2014.1087 [PubMed: 25847639]
8. Hubbard RA, Kerlikowske K, Flowers CI, Yankaskas BC, Zhu W, Miglioretti DL. Cumulative probability of false-positive recall or biopsy recommendation after 10 years of screening mammography: a cohort study. Ann Intern Med. 2011; 155(8):481–92. DOI: 10.7326/0003-4819-155-8-201110180-00004 [PubMed: 22007042]
9. Elmore JG, Barton MB, Moceri VM, Polk S, Arena PJ, Fletcher SW. Ten-Year Risk of False Positive Screening Mammograms and Clinical Breast Examinations. New England Journal of Medicine. 1998; 338(16):1089–96. [PubMed: 9545356]
10. Braithwaite D. Screening Outcomes in Older US Women Undergoing Multiple Mammograms in Community Practice: Does Interval, Age, or Comorbidity Score Affect Tumor Characteristics or False Positive Rates? J Natl Cancer Inst. 2013; 106:334–41.

11. Christiansen CL, Wang F, Barton MB, Kreuter W, Elmore JG, Gelfand AE, et al. Predicting the Cumulative Risk of False-Positive Mammograms. Journal of the National Cancer Institute. 2000; 92(20):1657–66. [PubMed: 11036111]
12. Nelson HD, O'Meara ES, Kerlikowske K, Balch S, Miglioretti D. Factors Associated With Rates of False-Positive and False-Negative Results From Digital Mammography Screening: An Analysis of Registry Data. Annals of internal medicine. 2016; 164(4):226–35. DOI: 10.7326/M15-0971 [PubMed: 26756902]
13. Jafri NF, Ayyala RS, et al. Screening Mammography: Does Ethnicity Influence Patient Preferences for Higher Recall Rates Given the Potential for Earlier Detection of Breast Cancer? Radiology. 2008; 249(3):785–91. [PubMed: 18941163]
14. Goldman LE, Walker R, Miglioretti DL, Smith-Bindman R, Kerlikowske K. National Cancer Institute Breast Cancer Surveillance C. Accuracy of diagnostic mammography at facilities serving vulnerable women. Medical care. 2011; 49(1):67–75. DOI: 10.1097/MLR.0b013e3181f380e0 [PubMed: 20966780]
15. Gail MH, Brinton LA, Byar DP, Corle DK, Green SB, Schairer C, et al. Projecting individualized probabilities of developing breast cancer for white females who are being examined annually. J Natl Cancer Inst. 1989; 81(24):1879–86. Epub 1989/12/20. [PubMed: 2593165]
16. Joseph G, Kaplan C, Luce J, Lee R, Stewart S, Guerra C, et al. Efficient identification and referral of low-income women at high risk for hereditary breast cancer: a practice-based approach. Public Health Genomics. 2012; 15(3–4):172–80. Epub 2012/04/11 000336419 [pii]. DOI: 10.1159/000336419 [PubMed: 22488460]
17. Gurmankin Levy A, Shea J, Williams SV, Quistberg A, Armstrong K. Measuring perceptions of breast cancer risk. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2006; 15(10):1893–8. DOI: 10.1158/1055-9965.EPI-05-0482
18. Kerlikowske K, Zhu W, Hubbard RA, Geller B, Dittus K, Braithwaite D, et al. Outcomes of screening mammography by frequency, breast density, and postmenopausal hormone therapy. JAMA internal medicine. 2013; 173(9):807–16. DOI: 10.1001/jamainternmed.2013.307 [PubMed: 23552817]
19. Breast Cancer Surveillance Consortium. BCSC Glossary of Terms. BCSC; 2010.
20. Henderson LM, Hubbard RA, Sprague BL, Zhu W, Kerlikowske K. Increased Risk of Developing Breast Cancer after a False-Positive Screening Mammogram. Cancer epidemiology, biomarkers & prevention : a publication of the American Association for Cancer Research, cosponsored by the American Society of Preventive Oncology. 2015; 24(12):1882–9. DOI: 10.1158/1055-9965.EPI-15-0623
21. Mandelblatt JS, Cronin KA, Bailey S, Berry DA, de Koning HJ, Draisma G, et al. Effects of mammography screening under different screening schedules: model estimates of potential benefits and harms. Annals of internal medicine. 2009; 151(10):738–47. DOI: 10.7326/0003-4819-151-10-200911170-00010 [PubMed: 19920274]
22. Lehman CD, White E, Peacock S, Drucker MJ, Urban N. Effect of age and breast density on screening mammograms with false-positive findings. AJR Am J Roentgenol. 1999; 173(6):1651–5. DOI: 10.2214/ajr.173.6.10584815 [PubMed: 10584815]
23. Checka CM, Chun JE, Schnabel FR, Lee J, Toth H. The relationship of mammographic density and age: implications for breast cancer screening. AJR Am J Roentgenol. 2012; 198(3):W292–5. DOI: 10.2214/AJR.10.6049 [PubMed: 22358028]
24. Shoemaker ML, White MC. Breast and cervical cancer screening among Hispanic subgroups in the USA: estimates from the National Health Interview Survey 2008, 2010, and 2013. Cancer Causes Control. 2016; 27(3):453–7. DOI: 10.1007/s10552-016-0718-5 [PubMed: 26809510]
25. Austin LT, Ahmad F, McNally MJ, Stewart DE. Breast and cervical cancer screening in Hispanic women: a literature review using the health belief model. Womens Health Issues. 2002; 12(3):122–8. [PubMed: 12015184]
26. Gorin SS, Heck JE. Cancer screening among Latino subgroups in the United States. Preventive medicine. 2005; 40(5):515–26. DOI: 10.1016/j.ypmed.2004.09.031 [PubMed: 15749133]

27. Wallace PM, Torres S, Beltran J, Cohen-Boyar R. Views of mammography screening among U.S. Black and Hispanic immigrant women and their providers. Health Care Women Int. 2014; 35(10): 1181–200. DOI: 10.1080/07399332.2013.862794 [PubMed: 24274768]

28. Engelman KK, Cizik AM, Ellerbeck EF, Rempusheski VF. Perceptions of the screening mammography experience by Hispanic and non-Hispanic White women. Womens Health Issues. 2012; 22(4):e395–401. DOI: 10.1016/j.whi.2012.04.006 [PubMed: 22658890]

29. Coronado GD, Jimenez R, Martinez-Gutierrez J, McLerran D, Ornelas I, Patrick D, et al. Multi-level Intervention to increase participation in mammography screening: inverted exclamation markFortaleza Latina! study design. Contemp Clin Trials. 2014; 38(2):350–4. DOI: 10.1016/j.cct.2014.06.008 [PubMed: 24952281]

30. Mandelson MT, Oestreicher N, Porter PL, White D, Finder CA, Taplin SH, et al. Breast density as a predictor of mammographic detection: comparison of interval- and screen-detected cancers. J Natl Cancer Inst. 2000; 92(13):1081–7. [PubMed: 10880551]

31. Kolb TM, Lichy J, Newhouse JH. Comparison of the performance of screening mammography, physical examination, and breast US and evaluation of factors that influence them: an analysis of 27,825 patient evaluations. Radiology. 2002; 225(1):165–75. DOI: 10.1148/radiol.2251011667 [PubMed: 12355001]

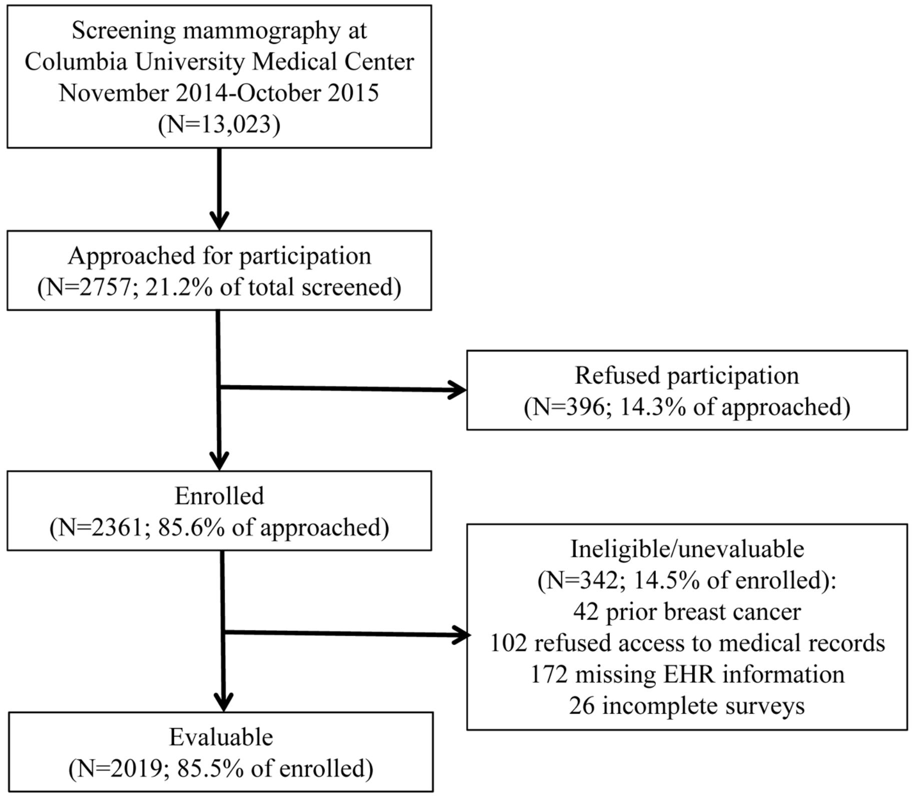

Figure 1.

CONSORT Diagram of Women Recruited to Know Your Risk: Assessment at Screening (KYRAS) study (November 2014–October 2015)

Table 1

Baseline characteristics by race/ethnicity of women undergoing screening mammography and enrolled in the Know Your Risk: Assessment at Screening (KYRAS) study (N=2019) at Columbia University Medical Center, New York, NY (November 2014–October 2015)

Variable, N=2019 (%)	Hispanic N=1542 (76.4%)	Non-Hispanic White N=204 (10.1%)	Non-Hispanic Black N=194 (9.6%)	Other N=79 (3.9%)	p-value
Age (years)					<0.0001
<50	313 (20.3)	60 (29.4)	53 (27.3)	34 (43.0)	
50+	1229 (79.7)	144 (70.6)	141 (72.7)	45 (57.0)	
Education					<0.0001
High school diploma or less	1114 (72.2)	23 (11.3)	67 (34.6)	25 (31.7)	
Some college	207 (13.4)	17 (8.3)	54 (27.8)	16 (20.3)	
College diploma	162 (10.5)	59 (28.9)	48 (24.7)	16 (20.3)	
Graduate/professional degree	59 (3.8)	105 (51.5)	25 (12.9)	22 (27.7)	
Body mass index (BMI, kg/m^2)					<0.0001
Underweight (<18.5)	17 (1.1)	8 (3.9)	2 (1.0)	4 (5.1)	
Normal weight (18.5–24.9)	399 (25.9)	87 (42.7)	38 (19.6)	38 (48.1)	
Overweight (25–29.9)	595 (38.6)	56 (27.4)	59 (30.4)	14 (17.7)	
Obese (30+)	531 (34.4)	53 (26.0)	95 (49.0)	23 (29.1)	
Breast density *					0.0004
Low breast density	1109 (71.9)	125 (61.3)	132 (68.0)	44 (55.7)	
High breast density	433 (28.1)	79 (38.7)	62 (32.0)	35 (44.3)	
Frequency of screening mammography **					<0.0001
Annually	1109 (71.9)	124 (60.8)	125 (84.4)	41 (51.9)	
Biennially	247 (16.0)	38 (18.6)	35 (18.0)	15 (19.0)	
Every 3+ years	138 (9.0)	26 (12.8)	27 (13.9)	15 (19.0)	
First mammogram	48 (3.1)	16 (7.8)	7 (3.6)	8 (10.1)	
High-risk for breast cancer					
5-year Gail risk score ≥1.67%	168 (10.9)	125 (61.3)	48 (24.7)	17 (21.5)	<0.0001
Eligible for *BRCA* genetic testing	164 (10.6)	44 (21.6)	18 (9.3)	11 (13.9)	0.0003

* Breast density was dichotomized as low [almost entirely fatty (<25% density) or scattered areas of fibroglandular density (25–50%)] or high [heterogeneously dense (51–75%) or “extremely dense” (>75%)]

**Yearly screening frequency was determined as a median of 9 to 18 months between screening mammograms. Biennial screening frequency was determined as a median of >18 to 30 months between screening mammograms. Every 3+ years was determined as greater than a median of 30 months between screening mammograms

Table 2

Baseline characteristics stratified by having at least one false positive result, recall breast imaging or biopsy not yielding breast cancer, on screening mammography. Know Your Risk: Assessment at Screening (KYRAS) study (N=2019), New York, NY (November 2014–October 2015)

Characteristic N=2019	Had a False Positive Result N=1075 (53.2%)	Never Had a False Positive Result N=944 (46.8%)	p-value
Age, years			0.0442
Less than 50 years old	226 (21.0)	234 (24.8)	
50 years or older	849 (79.0)	710 (75.2)	
Race/ethnicity			0.3431
Hispanic	837 (77.9)	705 (74.7)	
Non-Hispanic white	105 (9.8)	99 (10.5)	
Non-Hispanic black	93 (8.7)	101 (10.7)	
Other	40 (3.7)	39 (4.1)	
Body mass index, kg/m^2			0.0455
Underweight (<18.5)	18 (1.7)	13 (1.4)	
Normal weight (18.5–24.9)	308 (28.7)	254 (26.9)	
Overweight (25–29.9)	405 (37.7)	319 (33.8)	
Obese (≥30)	344 (32.0)	358 (37.9)	
Frequency of screening *			<0.0001
Annual	836 (77.8)	563 (59.6)	
Biennial	139 (12.9)	196 (20.8)	
Every 3+ years	69 (6.4)	137 (14.5)	
First mammogram	31 (2.9)	48 (5.1)	
Breast density **			0.0002
Low breast density	712 (66.2)	698 (73.9)	
High breast density	363 (33.8)	246 (26.1)	
Breast cancer risk status ***			0.0583
Low or average risk	791 (73.6)	729 (77.2)	
High risk	284 (26.4)	215 (22.8)	

* Yearly screening frequency was determined as a median of 9 to 18 months between screening mammograms. Biennial screening frequency was determined as a median of >18 to 30 months between screening mammograms. Every 3+ years was determined as greater than a median of 30 months between screening mammograms.

** Breast density was dichotomized as low [almost entirely fatty (<25% density) or scattered areas of fibroglandular density (25–50%)] or high [heterogeneously dense (51–75%) or “extremely dense” (>75%)]

*** High breast cancer risk status for breast cancer was determined as having greater than 1.66% 5-year risk or 20% lifetime risk based upon the Gail model or a score of 6 or greater on the modified Six-Point Scale, which indicates eligibility for *BRCA* genetic testing.

Table 3

Univariate analyses and multivariable model of factors associated with ever having a false positive result on a screening mammogram, controlling for total years of follow-up.

	Univariate Models		Multivariable Model	
Characteristic	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Age, years				
Less than 50	Ref		Ref	
50 or Older	1.24 (1.01, 1.53)	0.0444	0.80 (0.62, 1.02)	0.0749
Race/Ethnicity				
Hispanic	1.12 (0.84, 1.50)	0.4495	1.22 (0.88, 1.71)	0.2371
Non-Hispanic white	Ref		Ref	
Non-Hispanic black	0.87 (0.59, 1.29)	0.4812	1.06 (0.69, 1.63)	0.7855
Other	0.97 (0.58, 1.63)	0.8994	1.27 (0.73, 2.21)	0.4076
Body Mass Index, kg/m^2				
Underweight	1.14 (0.55, 2.38)	0.7226	1.26 (0.59, 2.71)	0.5505
Normal weight	Ref		Ref	
Overweight	1.05 (0.84, 1.31)	0.6846	1.09 (0.86, 1.38)	0.4814
Obese	0.79 (0.63, 0.99)	0.0404	0.88 (0.69, 1.12)	0.3055
Screening Frequency				
Annual	2.09 (1.64, 2.67)	<0.0001	2.18 (1.70, 2.80)	<0.0001
Biennial	Ref		Ref	
Every 3+ Years	0.71 (0.50, 1.20)	0.0639	0.82 (0.56, 1.19)	0.2863
First Mammogram	0.91 (0.55, 1.50)	0.7144	1.43 (0.84, 2.45)	0.1922
Breast Density				
Low Breast Density	Ref		Ref	
High Breast Density	1.45 (1.19, 1.75)	0.0002	1.64 (1.32, 2.04)	<0.0001
Breast Cancer Risk Status				
Low or Average Risk	Ref		Ref	

	Univariate Models		Multivariable Model	
Characteristic	OR (95% CI)	p-value	OR (95% CI)	p-value
High Risk	1.22 (0.99, 1.49)	0.0585	1.14 (0.91, 1.44)	0.2528

Table 4

Univariate analyses and multivariable model of factors associated with annual vs. biennial screening mammography

	Univariate Models		Multivariable Model	
Characteristic	**OR (95% CI)**	**p-value**	**OR (95% CI)**	**p-value**
Age, years				
Less than 50	Ref		Ref	
50 or Older	1.33 (1.00, 1.78)	0.0541	1.31 (0.97, 1.77)	0.0776
Race/Ethnicity				
Hispanic	1.38 (0.93, 2.03)	0.1075	1.92 (1.17, 3.15)	0.0099
Non-Hispanic White	Ref		Ref	
Non-Hispanic Black	1.10 (0.65, 1.85)	0.7345	1.43 (0.81, 2.53)	0.2181
Non-Hispanic Other	0.84 (0.42, 1.68)	0.6157	1.10 (0.53, 2.28)	0.8001
Breast Cancer Risk Status				
Low or Average Risk	Ref		Ref	
High Risk	1.06 (0.81, 1.40)	0.6597	1.17 (0.85, 1.61)	0.3279
Education				
High School Diploma or Less	Ref		Ref	
Some College	0.82 (0.58, 1.41)	0.2332	0.92 (0.65, 1.31)	0.6591
College Diploma	1.03 (0.72, 1.49)	0.8582	1.29 (0.87, 1.91)	0.2128
Graduate/Professional School	1.07 (0.70, 1.64)	0.747	1.56 (0.94, 2.61)	0.0858
Perceived Risk				
Low or Average Perceived Risk	Ref		Ref	
High Perceived Risk	1.05 (0.70, 1.57)	0.816	1.12 (0.73, 1.71)	0.602