Obesity and Mammography: A Systematic Review and Meta-Analysis

Nisa M. Maruthur, MD, MHS[1,2]*, Shari Bolen, MD, MPH*[1]*, Frederick L. Brancati, MD, MHS*[1,2,3]*, and Jeanne M. Clark, MD, MPH*[1,2,3]

[1]Division of General Internal Medicine, The Johns Hopkins University School of Medicine, Baltimore, MD, USA; [2]Welch Center for Prevention, Epidemiology, and Clinical Research, The Johns Hopkins University School of Medicine, Baltimore, MD, USA; [3]Department of Epidemiology, The Johns Hopkins University Bloomberg School of Public Health, Baltimore, MD, USA.

BACKGROUND: Obese women experience higher postmenopausal breast cancer risk, morbidity, and mortality and may be less likely to undergo mammography.

OBJECTIVES: To quantify the relationship between body weight and mammography in white and black women.

DATA SOURCES AND REVIEW METHODS: We identified original articles evaluating the relationship between weight and mammography in the United States through electronic and manual searching using terms for breast cancer screening, breast cancer, and body weight. We excluded studies in special populations (e.g., HIV-positive patients) or not written in English. Citations and abstracts were reviewed independently. We abstracted data sequentially and quality information independently.

RESULTS: Of 5,047 citations, we included 17 studies in our systematic review. Sixteen studies used self-reported body mass index (BMI) and excluded women <40 years of age. Using random-effects models for the six nationally representative studies using standard BMI categories, the combined odds ratios (95% CI) for mammography in the past 2 years were 1.01 (0.95 to 1.08), 0.93 (0.83 to 1.05), 0.90 (0.78 to 1.04), and 0.79 (0.68 to 0.92) for overweight (25–29.9 kg/m^2), class I (30–34.9 kg/m^2), class II (35–39.9 kg/m^2), and class III (≥40 kg/m^2) obese women, respectively, compared to normal-weight women. Results were consistent when all available studies were included. The inverse association was found in white, but not black, women in the three studies with results stratified by race.

CONCLUSIONS: Morbidly obese women are significantly less likely to report recent mammography. This relationship appears stronger in white women. Lower screening rates may partly explain the higher breast cancer mortality in morbidly obese women.

KEY WORDS: obesity; mammography; screening; systematic review.
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INTRODUCTION

Breast cancer remains the second leading cause of cancer death among women in the United States[1]. Screening mammography reduces breast cancer mortality[2–6], and current guidelines recommend mammography every 1–2 years for women over 40 years of age[7,8].

Obesity has increased over the past 2 decades among women in the US[9] and has disparate effects on pre- and postmenopausal breast cancer. Excess body weight may actually decrease the risk of premenopausal breast cancer[10,11], but the relationship between obesity and premenopausal breast cancer mortality is ambiguous[11,12]. However, obesity is an important risk factor for both the development of[10,11,13–15] and mortality from[16–19] postmenopausal breast cancer. Obesity may also worsen breast cancer morbidity, including risk of breast cancer recurrence[20], contralateral breast cancer[21], wound complications after breast surgery[22], and lymphedema[23,24].

The mechanism by which obesity leads to poorer prognosis of breast cancer is not well understood and may be related to tumor characteristics, hormonal mechanisms, suboptimal diet and physical activity, or delay in diagnosis[16]. Studies of the relationship between obesity and stage at breast cancer diagnosis are conflicting[25,26].

Several observational studies suggest that obese women may be less likely to report recent mammography[27–39], but the relationship between obesity and screening mammography remains unclear[40–43]. Some studies suggest the problem may be confined to white women[31–33,36].

Therefore, we conducted a systematic review and meta-analysis to determine whether overweight or obese women are less likely to have recent mammography than their normal-weight counterparts. We also studied the effect of race on the relationship between weight and recent mammography.

Preliminary results from this project were presented in a poster at the 2007 Society of General Internal Medicine national meeting in Toronto on April 26, 2007.

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METHODS

Search Strategy

Our overall search strategy addressed a broader question regarding the association between obesity and screening for breast, cervical, and colon cancer. For this study, we searched the PubMed, CINAHL, and Cochrane Library electronic databases from inception to July 2008 to identify original articles evaluating the relationship between body weight and recent mammography in the US using search terms for breast cancer screening, breast cancer, and body weight (Appendix Table 5). We manually searched the references of included articles and the tables of contents of 11 key medical journals from August 2006 through November 2006 and then updated our manual search from April 2008 to July 2008. General medical, cancer, women's health, and prevention journals were selected based on the origin of the included articles and the topic itself to avoid missing articles due to any delays in electronic indexing. Searchers were physician investigators and included a senior obesity researcher (J.M.C.), an investigator with systematic review experience (S.B.), and a post-doctoral epidemiology trainee with relevant clinical experience (N.M.M). Two reviewers conducted title and abstract reviews independently. If a title was selected by either investigator, it was advanced to abstract review. Title and abstract reviews were designed to be sensitive; if there was any question of an article exploring weight as a predictor of screening upon title or abstract review, we advanced the article to the next level of review. Of 273 abstracts, there were 62 conflicts (23%) in abstract review, which we resolved by consensus through discussion. Disagreements usually pertained to misreading on the part of one of the investigators, and disagreements in judgment were rare.

Study Selection

We included published original articles if they reported the prevalence of mammography by body weight in adults ≥18 years of age and were written in English. We defined original articles as articles in which the authors analyzed raw data and thus excluded reviews, commentaries, editorials, and consensus statements. We excluded studies conducted outside of the US since other countries may have different screening guidelines and resources, and the relationship between weight and mammography might differ based on cultural norms. We also excluded studies of screening in special populations since there may be different screening expectations for some populations (e.g., participants presenting to a cancer screening clinic, HIV-positive patients, those with a history of breast cancer, and those involved in a study of interventions to improve screening). Two investigators reviewed articles independently. Of 101 articles, there were 3 disagreements (3%), which were resolved through discussion.

Data Abstraction and Quality Assessment

Two reviewers sequentially abstracted the data on population characteristics, the exposure, and the outcome using standardized data abstraction forms. Two studies included body mass index (BMI) in models when exploring determinants of screening, but did not explicitly report mammography prevalence by BMI; the authors kindly provided these results[34,39].

Two reviewers evaluated study quality independently using a quality form (Appendix A) based on the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) Statement, Checklist of Essential Items version 3 (September 2005)[44], which was published recently[45]. We assumed that the importance of any confounding variable varied according to study design. Therefore, we did not expect each study to handle confounding in the same fashion and assessed quality as being adequate, fair, or inadequate on an individual basis. We resolved disagreements in data abstraction and quality evaluation through discussion.

Data Synthesis and Analysis

First, we created tables to describe all studies qualitatively. We reported results of adjusted analyses when available. In order to obtain generalizable combined estimates for the association between weight and mammography, we conducted unstratified meta-analyses and meta-analyses stratified by white and black race for studies that: (1) had nationally representative data and (2) reported BMI in five standard categories according to the World Health Organization[46] and the National Institutes of Health[47]: (normal: 18.5–24.9 kg/m^2, overweight: 25–29.9 kg/m^2, class I obesity: 30–34.9 kg/m^2, class II obesity: 35–39.9 kg/m^2, and class III obesity: ≥ 40 kg/m^2). We contacted the authors of articles that did not report results for mammography by BMI in five standard categories; two authors provided the quantitative results requested[28,40]. Two authors were unable to provide quantitative results stratified by race[30,33].

Using the DerSimonian and Laird method[48], we used random-effects models to calculate combined odds ratios and 95% confidence intervals for mammography by BMI category using normal BMI as the reference category. For the study that reported adjusted proportions[33], we calculated odds ratios. We converted the relative risk to an odds ratio[49] for another study[32]. One study provided results stratified by race only[31], and we included the results from the white and black cohorts separately in our main and race-specific analyses.

We tested for heterogeneity using the I^2 statistic[50] with an I^2 value of >50% signifying "substantial heterogeneity"[51]. We chose a random-effects model as a more conservative approach to account for potential between-study variability.

We tested for publication bias using the tests of Begg and Mazumdar[52] and Egger and colleagues[53]. All analyses were completed using STATA (StataCorp. 2005. Stata Statistical Software: Release 9. College Station, TX: StataCorp LP).

We conducted several sensitivity analyses. We examined the effect of the removal of any one study on the combined estimate for the unstratified analyses. Also, two[35,37] of the seven studies[30–33,35,37,38] that were based on nationally representative data and reported BMI in five categories used the same 2000 National Health Interview Survey (NHIS) data but performed slightly different analyses. We included the study with more conservative results in the main meta-analysis[35]. We included the other, less conservative estimate from the other study[37] in a separate analysis. In another analysis, we included all studies that provided BMI in five standard categories regardless of whether they were nationally representative.

RESULTS

Literature Search Results

Of 5,047 titles identified in the overall search, 17 articles met our inclusion criteria and addressed mammography (Fig. 1). Seven[30–33,35,37,38] of the 17 studies were sufficiently homogeneous (i.e., used nationally representative survey data and provided information for mammography by five standard categories of BMI) to include in the unstratified meta-analyses. Two of these studies were based on the same 2000 NHIS data[35,37]; thus, six studies were included in our main meta-analyses. Five nationally-representative studies[30–33,35] reported race-stratified analyses, and two of these[30,33] did not report the necessary quantitative results to allow their inclusion in the meta-analyses; thus, we included three studies in our race-stratified meta-analysis. Six studies were not nationally representative and were conducted in primarily non-white populations[34,39,40,42,43] or reported race-stratified results[36].

Study Characteristics

The 17 included studies, which comprised approximately 276,034 participants, are described in Tables 1 and 2. Sixteen studies were cross-sectional[27–38,40–43], and one was longitudinal[39]. All studies used BMI as the measure of excess body weight. Thirteen studies defined the outcome as mammography in the last 2 years[28–33,35–38,40,42,43], two as mammography in the last year[27,34], one as mammography in the last 3 years[41], and one as mammography every 2 years over a 6-year period[39].

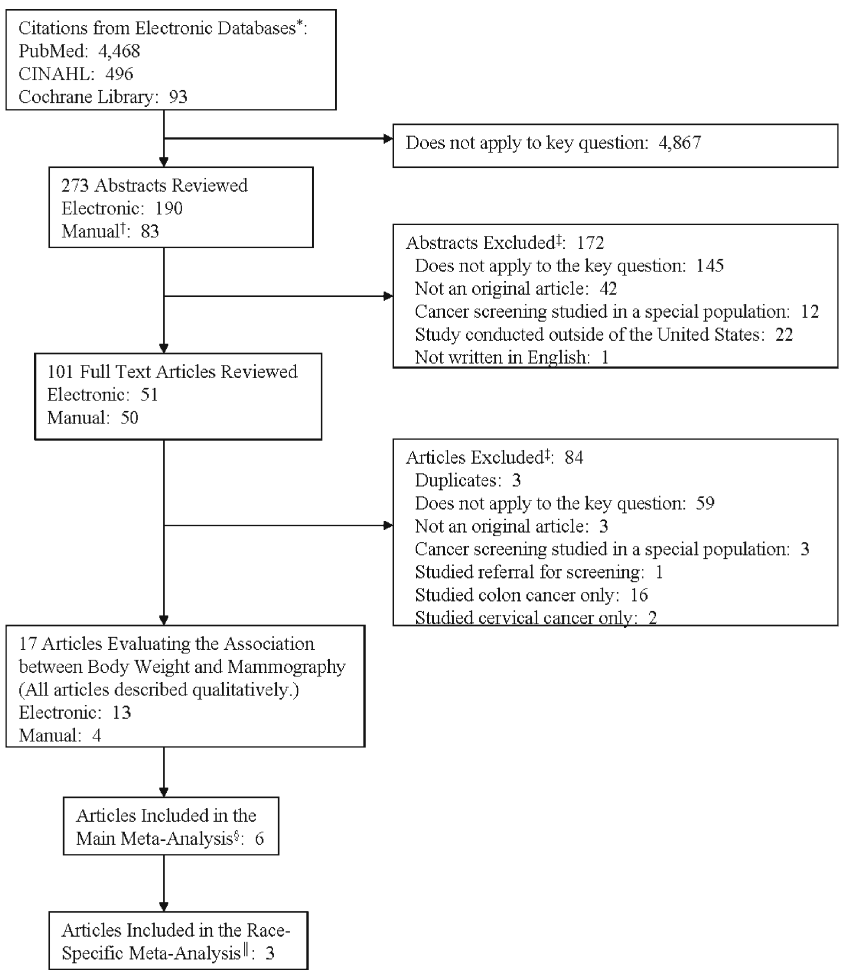

Figure 1. Study flow diagram. *Search terms for breast cancer, cervical cancer, colon cancer, body weight, breast cancer screening, cervical cancer screening, and colon cancer screening were used to conduct the search of electronic databases. Specific terms are provided in Appendix Table 5. †Manual searching involved searching of references of included and key articles and searching of tables of contents of the following journals: Cancer, Journal of General Internal Medicine, Annals of Internal Medicine, Obesity, Ethnicity and Disease, Cancer Detection and Prevention, Journal of Health Care for the Poor and Underserved, Preventing Chronic Disease, Journal of Women's Health, American Journal of Public Health, Preventive Medicine, and American Journal of Epidemiology. ‡Reasons for exclusion add up to more than abstracts or articles excluded since reviewers could have more than one reason for exclusion. §Studies included in the main meta-analysis reported nationally-representative results in five standard body mass index categories (normal 18–24.9 kg/m^2, overweight 25–29.9 kg/m^2, class I obesity 30–34.9 kg/m^2, class II obesity 35–39.9 kg/m^2, class III obesity ≥ 40 kg/m^2). A seventh study[37] met these criteria, but was based on the same data as another study[35] and therefore was only included in a sensitivity analysis. ‖Studies included in the race-specific meta-analysis reported nationally representative results in five standard body mass index categories (normal 18–24.9 kg/m^2, overweight 25–29.9 kg/m^2, class I obesity 30–34.9 kg/m^2, class II obesity 35–39.9 kg/m^2, class III obesity ≥40 kg/m^2).

Table 1. Description of Studies Included in Qualitative and Quantitative Analyses*

Author, year	Study population	Mean age, y (range)	Race/ethnicity (%)	Exclusion criteria
Amonkar et al. 2002[27]	9,908 respondents to the 1997 BRFSS	NR (40–80+)	White 83.8%; black 15%; Asian/Pacific Islander 0.4%; American Indian 0.4%; other 0.4%	<40 years of age
Amy et al. 2006[28]	338 respondents to survey available in clothing stores, a convention, magazine, and research database	45(21–80)†	White 68%‡	<40 years of age, BMI<25 kg/m^2
Berz et al. 2008§[38]	105,899 respondents to the 2004 BRFSS	59.3(40–99)†	White 75.2%; black 7.3%; Hispanic 9.7%; others 7.8%‡	<40 years of age, missing BMI, mammography response, or any confounding variable
Cohen et al. 2007 (36)	25,060 participants in the Southern Community Cohort Study	NR (42–70+)†	White 25.2%; black 74.8%	<42 or >79 years of age, BMI<18.5 kg/m^2, not black or white, diagnosis of breast cancer, treatment for cancer in last year, missing BMI or mammography use, not English-speaking
Coughlin et al. 2004[29]	49,564 respondents to the 1999 BRFSS	NR	NR	<40 years of age
Ferrante et al. 2006[40]	1,809 patients in 3 urban New Jersey academic family medicine practices from 2000–2003	53.4(40–74)†	Hispanic 50%; black 36%‡	<40 or ≥75 years of age, breast or cervical cancer, pregnant, missing weight, no visit in 12 months before index visit, new patient
Ferrante et al. 2007[37]	8,289 respondents to the 2000 NHIS	NR(40–74)†	White 31.3%; black 26%; Hispanic 28.7%; other 14%‡	<40 or ≥75 years of age, BMI<18.5 kg/m^2
Fontaine et al. 1998[41]	3,105 respondents to the 1992 NHIS	46.2(18–97)†	White 79.9%‡	NR
Fontaine et al. 2001§[30]	38,682 respondents to the 1998 BRFSS	47.7† (NR)	White 84.4%; non-white 15.6%	<40 years of age
Gorin et al. 2001[42]	408 respondents to Harlem Survey from 46 blocks in Central Harlem in 1991	NR	NR‖	<40 or >65 years of age, not English-speaking, unable to answer questions
Ostbye et al. 2005§[31]	8,449 participants in the Health and Retirement Study (1996, 2000 waves)	NR(50–64)¶	White 82%; black 18%¶	Lack of response to 1996 and/or 2000 waves of HRS
Rosenberg et al. 2005[39]	14,706 participants in the Black Women's Health Study 1995–2001	NR(40–69)†	Black 100%	<40 years of age, not African American, lack of valid address, lack of completion of survey
Satia et al. 2007[43]	405 enrollees in cancer risk behavior surveillance study in North Carolina in 2003	NR(41–70)	Black 100%	<40 years of age, not African American, not on Department of Motor Vehicles roster in one six counties in North Carolina
Wee et al. 2000§[33]	3,077 respondents to the 1994 NHIS	62	White 81%; black 10%	<50 or >75 years of age
Wee et al. 2004§[32]	5,277 respondents to 1998 NHIS Sample Adult and Prevention questionnaires	61(50–75)	White 80%; black 10%; Hispanic/Asian/ other 10%	<50 or >70 years of age
Winkleby et al. 2003[34]	169 women responding to a community random-digit-dial survey in Monterey California	NR(18–64)†	Latino 100%	<40 years of age, not Latino, not living in Monterey County, California
Zhu et al. 2006§[35]	9,188 respondents to the 2000 NHIS	NR(40–80)†	White 83.7%; black 16.3%	<40 or >80 years of age, not white or black, history of breast cancer, mammography for reason other than screening

**Characteristics of participants included in the main analysis unless otherwise noted*
†*Mean age and range from overall study*
‡*Race from overall study*
§*Studies included in the main, unstratified meta-analysis*
‖ *Authors stated, "…majority of women in the survey were non-Hispanic blacks."*
¶*From 1996 wave of Health and Retirement Study*
BRFSS, Behavioral Risk Factor Surveillance System; NR, not reported; BMI, body mass index; NHIS, National Health Interview Survey; HRS, Health and Retirement Study

Ten[27,29–33,35,37,38,41] of the 17 studies (59%) were based on nationally representative surveys, the NHIS, Behavioral Risk Factor Surveillance System (BRFSS), or Health and Retirement Survey. Most subjects were white. Reported absolute screened proportions ranged from 53.2% to 85.6%[29,30,32–34,36–41,43].

Sixteen of the 17 studies[27–39,41–43] (94%) relied on self-reported BMI and mammography. Fourteen studies accounted for confounding adequately[27,29–41], and one study did not adjust for any confounding factors[28]. Reported survey response rates ranged from 55% to 88%. Eight studies did

Table 2. Results of Studies Included in Qualitative and Quantitative Analyses

Author, year	BMI (kg/m^2)*	Outcome assessment	Outcome measure	Outcome estimate (95% CI)†	Adjustments
Amonkar et al. 2002[27]	Self-report, standard 2 categories	Self-report of mammogram in last year	OR	0.81 (0.69 to 0.95)	Age, race, education, marital status, residential status, smoking, health status, health-care utilization
Amy et al. 2006[28]	Self-report, standard 5 categories‡	Self-report of mammogram in last 2 years	Proportion	Overweight 94%, class I 82%, class II 80%, class III 78% P=0.24§	None
Berz et al. 2008‖[38]	Self report, standard 5 categories	Self-report of screening mammogram in last 2 years	OR	Normal 1.00, overweight 1.08 (1.01 to 1.15), class I 1.08 (0.99 to 1.18), class II 1.10 (0.98 to 1.25), class III 0.97 (0.84 to 1.13)	Age, race, education, income, smoking, general health perception
Cohen et al. 2007[36]	Self-report, standard 5 categories	Self-report of mammogram in last 2 years	OR	*Whites:* normal 1.00, overweight 0.89 (0.76 to 1.05), class I 0.99 (0.83 to 1.18), class II 0.96 (0.78 to 1.18), class III 0.70 (0.56 to 0.87) *Blacks:* normal 1.00, overweight 1.12 (1.00 to 1.25), class I 1.25 (1.12 to 1.40), class II 1.22 (1.07 to 1.38), class III 1.06 (0.93 to 1.21)	Age, education, income, smoking status, number of live births, co-morbid conditions, family history of breast cancer, time since last physician visit, type of insurance
Coughlin et al. 2004[29]	Self-report, BMI categories: >18.5-<25, 25–30, >30	Self-report of mammogram in last 2 years	Adjusted proportion	>18.5-<25: 76.0% (75.1 to 76.8), 25–29: 76.6% (75.7 to 77.5), >30: 74.6% (73.5 to 75.8) P<0.001¶	Age, race, education, marital status, income, employment, smoking, physical activity, alcohol, use of preventive services, number of children, number of persons in household, health status, diabetes, physician visit in last year, insurance
Ferrante et al. 2006[40]	Chart review, standard 5 categories‡	Mammogram in last 2 years recorded in chart	OR	Normal 1.00, overweight 1.61 (1.03 to 2.54), class I 1.32 (0.84 to 2.07), class II 1.92 (1.12 to 3.28), class III 1.53 (0.88 to 2.65)	Age, race, marital status, smoking, co-morbid conditions, physician visits, insurance
Ferrante et al. 2007[37]	Self-report, standard 5 categories	Self-report of mammogram in last 2 years	OR	Normal 1.00, overweight 0.95 (0.81 to 1.10), class I 1.01 (0.83 to 1.23), class II 0.79 (0.60 to 1.05), class III 0.50 (0.37 to 0.68)	Age, race/ethnicity, education, marital status, smoking, vitamin use, number of visits, contact with primary care doctor, family history of breast cancer, insurance
Fontaine et al. 1998[41]	Self-report, BMI groups: 25 (reference), 35, and 40	Self-report of no mammogram in last 3 years#	OR	25: 1.0, 35: 0.81 (0.59 to 1.12), 45: 0.73 (0.45 to 1.19)	Age, race, education, income, smoking status, insurance status
Fontaine et al. 2001‖[30]	Self-report, standard 5 categories	Self-report of no mammogram in last 2 years#	OR	Normal 1.00, overweight 1.00 (0.94 to 1.07), class I 1.12 (1.02 to 1.23), class II 1.13 (0.98 to 1.30), class III 1.32 (1.09 to 1.59)	Age, race, smoking, insurance
Gorin et al. 2001[42]	Self-report, BMI categories: ≤27.3 and >27.3	Self-report of mammogram in last 2 years	OR	Not overweight: 1.00, overweight: 3.60 (0.57 to 22.64)	Age, marital status, employment, fruit/vegetable intake, insurance
Ostbye et al. 2005‖[31]	Self-report, standard 5 categories	Self-report of mammogram in last 2 years	OR	*Whites:* normal 1.00, overweight 0.90 (0.78 to 1.05), class I 0.73 (0.60 to 0.88), class II 0.69 (0.51 to 0.93), class III 0.59 (0.40 to 0.88) *Blacks:* normal 1.00, overweight 1.13 (0.79 to 1.62), class I 0.97 (0.65 to 1.45), class II 1.03 (0.61 to 1.76), class III 1.07 (0.60 to 1.92)	Age, education, marital status, income, smoking, physical activity, health status, co-morbid conditions, physician visits, hospitalization, insurance
Rosenberg et al. 2005[39]	Self-report, standard 5 categories‡	Self-report of mammogram every 2 years from 1995–2001	OR	Normal 1.00, overweight 1.09 (0.98 to 1.22), class I 1.08 (0.95 to 1.23), class II 1.13 (0.95 to 1.34), class III 0.96 (0.79 to 1.16)	Age, education, region, income, neighborhood SES score, childcare responsibilities, smoking, multivitamins, Pap smear, cystic breast disease, breast self exam, hormone use, family history of breast cancer, insurance

(*continued on next page*)

Table 2. (continued)

Author, year	BMI (kg/m²)*	Outcome assessment	Outcome measure	Outcome estimate (95% CI)†	Adjustments
Satia et al. 2007[43]	Self-report, BMI categories: normal 18.5–24.9, overweight 25–29.9, obese >30	Self-report of mammogram in last 2 years	OR	Normal 1.00, overweight 1.5 (0.6 to 3.6), obese 0.5 (0.2 to 1.3) P=0.39**	Age, education, BMI
Wee et al. 2000‖[33]	Self-report, standard 5 categories	Self-report of mammogram in last 2 years	Adjusted difference in proportion	Normal 0, overweight -2.8 (-6.7 to 0.9), class I -5.3 (-11.1 to 0.5), class II -4.5 (-12.5 to 3.4), class III -8.8 (-22.9 to 5.3)	Age, race, education, marital status, region of country, health status, health-care use, hospitalization, days in bed, insurance type, physician specialty
Wee et al. 2004‖[32]	Self report, standard 5 categories	Self-report of mammogram in last 2 years	RR	Normal 1.00, overweight 1.01 (0.95 to 1.06), class I 0.99 (0.91 to 1.05), class II 0.89 (0.77 to 1.01), class III 0.88 (0.71 to 1.01)	Age, race, education, marital status, region of country, health-care access, health status, co-morbid conditions, mobility, hospitalization
Winkleby et al. 2003[34]	Self-report, standard 5 categories‡	Self-report of mammogram in last year	OR	Normal 1.00, overweight 1.03 (0.41 to 2.62), class I 0.85 (0.25 to 2.89), class II 2.94 (0.42 to 20.61), class III 0.59 (0.06 to 5.79)	Age, education, marital status, years in US
Zhu et al. 2006‖[35]	Self-report, standard 5 categories	Self-report of no screening mammogram in last 2 years**	OR	Normal 1.00, overweight 0.9 (0.8 to 1.1), class I 0.9 (0.8 to 1.1), class II 1.0 (0.8 to 1.3), class III 1.3 (1.0 to 1.8)	Age, race, education, marital status, income, employment, smoking, alcohol, skin cancer exam, health status, co-morbid conditions, days in bed, need for special equipment, functional limitations, home health-care, recent surgery, status of walking, moving, lifting, and carrying, medical care visits, insurance

*Standard two categories of BMI: non-obese <30 kg/m² and obese ≥30 kg/m²; standard five categories of BMI: normal 18–24.9 kg/m², overweight 25–29.9 kg/m², class I obesity 30–34.9 kg/m², class II obesity 35–39.9 kg/m², class III obesity ≥ 40 kg/m²
†Adjusted results reported with the exception of Amy et al.[28]
‡Obtained data in standard five categories upon request from author
§Result of chi-square test
‖ Studies included in main, unstratified meta-analysis
¶Unclear which statistical test used by authors to obtain reported P value
#Study used lack of mammogram as an outcome
**P value for trend
BMI, body mass index; CI, confidence interval; OR, odds ratio; SES, socioeconomic status; RR, relative risk

not report missing data[27,31,32,35,37,39,41,43], seven had <10% missing data[28–30,32,34,36,42], and two reported >20% missing data[38,40]. All studies provided an adequate exposure description, and all but one[27] provided an adequate outcome description. Ten studies used nationally representative surveys[27,29–33,35,37,38,41], and 14 did not report the validity of the surveys used[27,29–33,35–39,41–43]. See Table 3.

Quantitative Assessment of Mammography by BMI

Fourteen[27–39,43] of 17 studies reported an inverse association between recent mammography and increasing BMI that was statistically significant in five[27,29,31,36,37]. Seven studies[30–33,35,37,38] used nationally representative surveys with BMI in five standard categories. Using the six studies based on unique data, class III obesity was inversely associated with the likelihood of having recently undergone mammography compared to women with a normal BMI. The seventh study by Ferrante et al.[37] was excluded from the main analysis because it was based on the same data as the study by Zhu et al.[35]. Combined odds ratios for mammography (95% confidence interval) by BMI category were 1.01 (0.95 to 1.08), 0.93 (0.83 to 1.05), 0.90 (0.78 to 1.04), and 0.79 (0.68 to 0.92) for overweight, class I, class II, and class III obese women, respectively, compared to women with a normal BMI (Fig. 2). We found statistical evidence of heterogeneity for the class I and II obesity categories; I^2 statistics were 41%, 74%, 59%, and 42% for the overweight, and class I, II, and III obesity categories, respectively. The exclusion of any one study did not change the results of the meta-analyses substantially (data not shown). No statistically significant publication bias was found, although evaluation was limited by the relatively small number of studies.

Sensitivity Analyses

We obtained similar results when we excluded the article by Zhu et al.[35] and instead included the article by Ferrante et al.[37], which used the same data. Results were also similar when we included all nine studies with BMI in five categories

Table 3. Quality Review of Included Studies*

Author	Missing data	Exposure description	Outcome description	Confounding	Validity	Response rate
Amonkar et al. 2002[27]	NR	Adequate	Fair	Adequate	NR†	NR
Amy et al. 2006[28]	<10%	Adequate	Adequate	Inadequate	Fair	NR
Berz et al. 2008[38]	>20%	Adequate	Adequate	Adequate	NR†	NR
Cohen et al. 2007[36]	<10%	Adequate	Adequate	Adequate	NR	NR
Coughlin et al. 2004[29]	None	Adequate	Adequate	Adequate	NR†	55.2%
Ferrante et al. 2006[40]	>20%	Adequate	Adequate	Adequate	N/a	N/a
Ferrante et al. 2007[37]	NR	Adequate	Adequate	Adequate	NR‡	72%
Fontaine et al. 1998[41]	NR	Adequate	Adequate	Adequate	NR‡	87%
Fontaine et al. 2001[30]	<10%	Adequate	Adequate	Adequate	NR†	NR
Gorin et al. 2001[42]	None	Adequate	Adequate	Fair	Referred to other reference for details of Harlem Survey used	72%
Ostbye et al. 2005[31]	NR	Adequate	Adequate	Adequate	NR§	84.7%
Rosenberg et al. 2005[39]	NR	Adequate	Adequate	Adequate	NR	61.7%
Satia et al. 2007[43]	NR	Adequate	Adequate	Fair	NR	17.5%
Wee et al. 2000[33]	NR	Adequate	Adequate	Adequate	NR‡	94% for NHIS overall; 88% for supplement‖
Wee et al. 2004[32]	<10%	Adequate	Adequate	Adequate	NR‡	90% for NHIS overall; 73% for Family Core and supplement¶
Winkleby et al. 2003[34]	<10%	Adequate	Adequate	Adequate	Fair	87%
Zhu et al. 2006[35]	NR	Adequate	Adequate	Adequate	NR‡	72%

*Quality rating based on scale: inadequate, fair, adequate

†Study based on the Behavioral Risk Factor Surveillance System

‡Study based on the National Health Interview Survey

§Study based on the Health and Retirement Study

‖ Participants given an additional questionnaire regarding preventive health-care service use

¶Participants given additional questionnaires inquiring about height, weight, medical conditions, sociodemographics, health status, health-care utilization, health habits, tobacco use, physical activity, functional status, and cancer screening

NR, not reported; NHIS, National Health Interview Survey

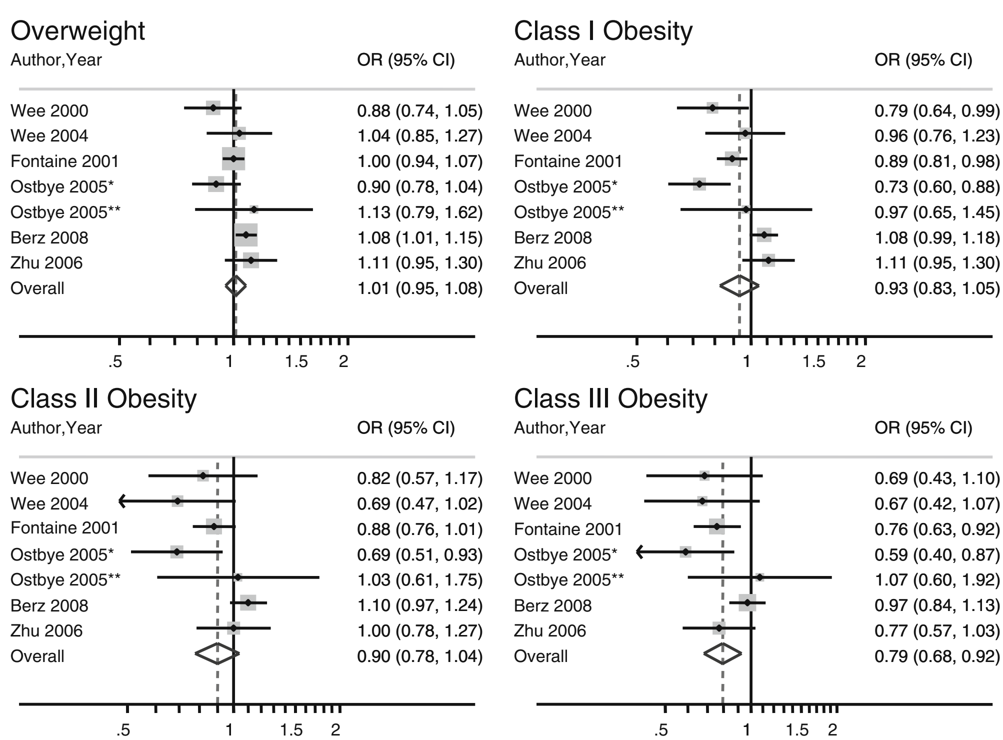

Figure 2. Meta-analyses of nationally representative studies with BMI in five categories. Note: Included studies: [30–33,35,38]; BMI categories: overweight 25–29.9 kg/m^2, class I obesity 30–34.9 kg/m^2, class II obesity 35–39.9 kg/m^2, class III obesity ≥40 kg/m^2. *Data from analysis of white women. **Data from analysis of black women. BMI, body mass index; OR, odds ratio; CI, confidence interval.

Table 4. Combined Odds Ratios for Mammography by BMI for Race-Stratified Analyses*†

BMI category	Combined odds ratios (95% CI)	I^2 (%)‡
White women		
Normal	1.00 (reference)	
Overweight	0.98 (0.85 to 1.13)	49
Class I obesity	0.84 (0.69 to 1.02)	60
Class II obesity	0.73 (0.56 to 0.95)	47
Class III obesity	0.67 (0.53 to 0.84)	0
Black women		
Normal	1.00 (reference)	
Overweight	1.28 (1.03 to 1.60)	0
Class I obesity	1.38 (0.90 to 2.12)	54
Class II obesity	1.46 (0.76 to 2.80)	66
Class III obesity	0.91 (0.62 to 1.33)	0

*Studies included:[31,32,35]. Additional studies[30,33] evaluated the interaction between race and BMI, but did not provide the quantitative results necessary for inclusion in our meta-analyses. Fontaine et al. in 2001[30] provided a P value (P=0.908) for the interaction between race and mammography, and Wee et al.[33] reported adjusted rate differences, suggesting a possible decline in screening with BMI among white women, but not among black women. We contacted the authors, but were unable to obtain further results

†Adjusted odds ratios used in analysis

‡I^2 Statistic is a measure of heterogeneity with an I^2 >50% signifying "substantial heterogeneity"[51]

BMI, body mass index

including three that were not based on nationally representative surveys (data not shown)[30–36,38,40].

Effect of Race

Five nationally representative studies[30–33,35] evaluated the effect of race on the relationship between BMI and recent mammography. Compared to women with a normal BMI, meta-analyses of the three race-stratified studies using five categories of BMI[31,32,35] revealed an inverse association between class II and III obesity and recent mammography for white women, but a positive association between overweight and recent mammography among black women (Table 4). We found statistical evidence of heterogeneity for class I obesity in the analyses for white women and for class I and II obesity in the analyses for black women. There was no statistical evidence of publication bias.

Four studies conducted in primarily non-white populations did not find a statistically significant association between BMI and recent mammography[34,39,42,43]. One study based on a chart review of patients (86% non-white) of urban family practices reported an increased odds of recent mammography among overweight and class II obese patients compared to patients with a normal BMI[40]. A study of baseline data from the Southern Community Cohort Study found that compared to women with a normal BMI, white women with class III obesity were less likely to report recent mammography, but overweight and class I and II obese black women were more likely to report recent mammography[36].

DISCUSSION

This systematic review demonstrates an inverse relationship between class I, II, and III obesity and recent mammography that was statistically significant for class III obesity. Compared to their lean counterparts, women with class III obesity were 20% less likely to report recent mammography. In white women, we found a statistically significant negative association between class II and III obesity and being up-to-date with mammography. We did not find this association between BMI and mammography among black women.

Two of the three studies that did not report an inverse association between recent mammography and increasing BMI were not nationally representative. One was a chart review from family practices in New Jersey with primarily non-white patients[40], and the other was a Harlem survey among mostly non-Hispanic blacks[42]. The findings of these two studies are consistent with the results of our meta-analyses in which we observed no significant inverse relationship between obesity and mammography in non-whites. The third negative study[41] included women <40 years of age. These results may be confounded by age since younger women are more likely to have a lower BMI[54] and to report a lower prevalence of mammography since it is not routinely recommended for them.

Obese women may experience several possible barriers to mammography. Prior data show that obese women may delay medical care[55] because of poor self-esteem and body image, embarrassment[29,30,55,56], a perceived lack of respect from health-care providers, or to avoid unwanted weight loss advice[28]. Obesity may be a marker for sub-optimal health behavior in general, of which lack of mammography is simply one facet[30,33]. Also, beliefs regarding cancer screening may vary by BMI[33]. There could be physical limitations to obtaining mammography for obese women, but obesity is associated with a higher content of fat in the breast tissue that actually increases the sensitivity of mammography for detecting breast cancer[57,58]. Finally, obesity is associated with lower socioeconomic status[59], which may decrease access to preventive care.

There are also many physician-related factors that may decrease screening mammography among obese women. Obesity-related co-morbid conditions may hinder referral for purely preventive services[41,60,61]. In addition, providers have reported difficulty and inadequate resources and education in providing care for obese women[28]. Finally, physicians may have biases against obese women, resulting in less screening[62–64].

Obesity did not appear to affect the report of recent mammography in black women. This may be due to racial differences in obesity-related body image[65–67]. In particular, it has been reported that overweight or obese white, but not black, women were more likely to feel worthless, which may impact willingness to undergo mammography[32]. Black women may have a similar risk of developing breast cancer[68,69], but higher breast cancer mortality[21,68–71]. They tend to present with a higher stage of breast cancer[69,71], which has been linked to (1) less follow-up for abnormal exams[72], (2) higher rates of obesity[72–75], (3) socioeconomic factors[76], (4) cultural beliefs (e.g., belief in herbal treatments)[76], and possibly, lower likelihood of screening[77–79], although this is controversial[68,80–82]. Our findings, the first meta-analyses by race, suggest that rates of mammography in black women do not vary significantly by BMI.

We included only 6 of 17 studies in our meta-analyses based on the provision of unique nationally representative data and BMI in five standard categories. However, 14 of the 17 studies reported a negative association between BMI and report of mammography. Also, we obtained similar results when we included all nine studies that reported BMI in five standard categories.

Most of the included studies were cross-sectional and cannot establish causality, but it is unlikely that failure to undergo mammography would contribute to weight gain. Also, we relied on the use of observational studies, which are susceptible to residual and unmeasured confounding. In particular, socioeconomic factors and health behaviors may confound the relationship between obesity and breast cancer and are difficult to account for fully. Although we did not find publication bias, we had limited power with a small number of studies. However, our search also included articles in which body weight was not the primary exposure, and thus, the potential for publication bias should be low.

The included studies used self-report of BMI as the measure of body weight, which has several limitations: It may underestimate obesity, especially in women[83], but may also overestimate obesity, especially in blacks[83]. Self-report of height and weight may differ by survey type (telephone versus in-person), age, and BMI[84]. Overall, the included studies may have placed more obese participants into less obese categories, which would bias our results toward the null or result in finding an inverse association in overweight or milder obesity. However, the overall qualitative association between body weight and mammography would be unchanged.

Most of the included studies also relied upon self-report of mammography. A recent meta-analysis found that self-report of mammography had a sensitivity of 93% and specificity of 62%[85]. While this study reported similar sensitivities for self-reported mammography in blacks and whites, the specificity of self-reported mammography was only 49% among blacks[85]. Thus, mammography results are likely inflated above their actual rates with the degree of inflation higher for blacks. There is no evidence that the accuracy of self-report of mammography varies by BMI, but if it does, our results would also be biased.

The included studies did not stratify on menopausal status, but only one study included women under the age of 40 years[41]. It seems unlikely that menopausal status would affect willingness to be screened in women over age 40. While the relationship between obesity and premenopausal breast cancer risk and mortality is unclear[10–12], obesity increases postmenopausal breast cancer risk[10,11,13–15] and mortality[16–19].

Finally, our search strategy may have been susceptible to selection bias given that we included a small number of full articles from the total citations reviewed, we manually searched only 11 key journals, and we had limited success obtaining full results from contacted authors. However, the qualitative results matched our meta-analytic results, we included no new articles from the manual search of 11 journals, and we were very sensitive in promoting a title or abstract to full article review (i.e., if an article discussed risk factors associated with mammography, we promoted that to full article review). Additionally, we re-reviewed a random sample of 2.5% of the full articles excluded at title review and 5% of the full articles excluded at abstract review and did not find any additional articles that satisfied our inclusion criteria.

Our study also has several strengths. This is the first systematic review with meta-analyses exploring the relationship between obesity and mammography and the only one to examine the effect of race on this association. We comprehensively searched multiple electronic databases in addition to manual searching. Also, we contacted authors for data leading to additional results from four studies. Finally, the meta-analyses were based on nationally representative surveys and thus are generalizable to the US population.

The main implication of our study is that a lack of routine screening mammography may explain some of the increased breast cancer mortality in obese postmenopausal women. Clinicians should be aware of this disparity in evaluating their own practices. Future research should determine why obese women are less likely to report recent mammography, including the investigation of a lack of health care access due to perceived bias or lack of insurance as a possible cause and explore whether there are consistent differences by race.

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Corresponding Author: *Nisa M. Maruthur, MD, MHS; 2024 E. Monument St., Ste-2–500, Baltimore, MD 21287, USA (e-mail: maruthur@jhmi.edu).*

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APPENDIX

Table 5. Electronic Database Search Terms*

PubMed	
Keywords	**MeSH terms**
Breast cancer(s); breast neoplasm(s); breast tumor(s); neoplasm(s), breast; tumor(s), breast; cancer(s), breast; cancer(s) of breast; cancer(s) of the breast; mammary carcinoma(s) of breast; mammary carcinoma(s), human; carcinoma(s), mammary human; human mammary carcinoma(s); mammary neoplasm(s), human; human mammary neoplasm(s); neoplasm(s), human mammary; mammary neoplasm(s), human	Breast neoplasms
Breast cancer screening; mammogram; mammography; mammographies; screening mammography; screening for breast cancer	Mammography
Body weight(s); weight; obesity; adiposity; body mass index; Quetelet index; BMI; overweight; body measure(s); measure(s), body; index, body mass; index, Quetelet; Quetelet's index; Quetelets index; body weights and measures	Body weights and measures
Cancer screening	
CINAHL	
Keywords	**CINAHL headings**
Breast cancer, breast neoplasms	Breast neoplasms
Breast cancer screening, mammography, mammogram	Mammography
BMI, body mass index, obesity, Quetelet index	Body weights and measures
Cancer screening	Cancer screening
Cochrane	
Search all text	**MeSH terms**
Breast cancer, breast neoplasms	Breast neoplasms
Breast cancer screening, mammography, mammogram	Mammography
BMI, body mass index, Quetelet index	Body weights and measures
Cancer screening	

*Our overall search strategy addressed a broader question regarding the association between obesity and screening for breast, cervical, and colon cancer. This study focuses on the relationship between weight and mammography

APPENDIX A

Obesity and Cancer Screening
Quality Assessment Form
Reviewer: _________
Author/Year: __________
Ref ID: _____
*Please check one answer for each question.

INTRODUCTION

1. Were objectives and pre-specified hypotheses reported?

_ adequate (objectives and pre-specified hypotheses were reported)
_ fair (objectives specified but hypotheses not clearly stated)
_ inadequate (minimal or no description)

METHODS

2. Was the study setting described?

_ adequate (setting, location, and dates of data collection stated)
_ fair (setting, location, and dates of data collection stated incompletely)
_ inadequate (minimal or no description)

3. Was the study population described?

_ adequate (There was a complete description of methods of selection and exclusion criteria OR statement that all eligible patients enrolled.)
_ fair (There was an incomplete description of methods of selection and exclusion criteria. Would be difficult to replicate with the information provided)
_ inadequate (minimal or no description)

4. How was the study population selected?

_ random sampling
_ convenience sampling
_ consecutive selection
_ other purposive sampling
_ other (please specify.): ___________
_ not described

5. Was there information on excluded or non-participating subjects?

_ adequate (All reasons for exclusion or lack of participation noted OR no exclusions.)
_ fair (There was some discussion of this topic, but not sufficient to allow replication.)
_ inadequate (no description)

6. Was the exposure well-described?

_ adequate (exposure explicitly defined, and method of measurement described)
_ fair (exposure described incompletely)
_ inadequate (no description)

7. Was the outcome well-described?

_ adequate (outcome explicitly defined, and method of measurement described)
_ fair (outcome described incompletely)
_ inadequate (no description)

8. If the study involved medical record review, was there standardized data abstraction?

_ yes (please specify.) ______________________________
_ no
_ not described
_ other (please specify) ______________________________
_ not applicable

9. If the study involved medical record review, was there blinding of abstractors to the study question?

_ yes
_ no
_ not described
_ not applicable
_ other (please specify) ______________________________

10. If the study involved medical record review, was there a description of handling of disagreements?

_ not applicable
_ adequate (method for handling of disagreements described completely)
_ fair (method for handling of disagreements described incompletely)
_ poor (method for handing of disagreements not described)

11. If data abstracted from medical records, was inter- and intra-rater reliability described?

_ not applicable
_ inter-rater reliability

_ yes

_ kappa (please list) _______
_ other (please list) _______

_ no
_ other (please specify) __________

_ intra-rater reliability

_ yes

_ kappa (please list) _______
_ other (please list) _______

_ no
_ other (please specify) __________

12. If the study used a survey, was the survey response rate reported?

_ not applicable
_ not reported
_ rate reported (please list) __________________________

13. Were key baseline characteristics ascertained?
I. age
II. sex
III. comorbidity
IV. socioeconomic factors
V. family history
VI. race
VII. smoking status

_ adequate (0–2 applicable categories not described)
_ fair (2–3 applicable categories not described)
_ inadequate (>3 applicable categories not described)

14. How did the study report the numbers of individuals at each stage of the study? (e.g., number of potentially eligible, examined for eligibility, confirmed eligible, included in the study, completed follow-up, and analyzed)

_ adequate
_ fair (one of the above not described)
_ inadequate (>1 not described)

15. For what percentage of participants were there missing data?

_ none
_ <10%
_ 10–20%
_ >20%
_ not reported
_ n/a

16. Was there a discussion of sample size rationalization?

_ adequate (Practical and statistical considerations were described.)
_ fair (Rationale for sample size was discussed incompletely.)
_ inadequate (Rationale for sample size not discussed.)

17. Were statistical analyses clearly described?

_ adequate (described for all analyses)
_ fair (described for some analyses)
_ inadequate (not described)

18. For main analyses, were numbers of individuals experiencing the outcome reported?

_ adequate (numbers provided or can be calculated for outcomes)
_ fair (proportions but not numbers provided for outcomes)
_ inadequate (no enumeration of outcome provided)

19. For main analyses, are there estimates and a measure of variability (e.g., standard error, standard deviation, confidence intervals) reported?

_ adequate (estimates and variability reported)
_ fair (estimates and p-value or test statistic reported)
_ inadequate (estimate only reported)

20. Were confounding factors treated adequately?

_ adequate (Adjustments were made for most or all potential confounders.)
_ fair (Adjustments were made for most confounders.)
_ inadequate (There were minimal or no adjustments for confounding.)

21. Were methods for use of quantitative variables explained?

_ adequate (description of covariates present)
_ inadequate (description of covariates not present)

CONFLICTS OF INTEREST

22. Were sources of funding identified?

_ adequate (source of funding or no funding specified)
_ poor (funding not described)

Other comments on study quality:
____
____
____