Obesity and Mammography: A Systematic Review and Meta-Analysis

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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/m²), class I (30–34.9 kg/m²), class II (35–39.9 kg/m²), and class III (≥40 kg/m²) 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 States1. Screening mammography reduces breast cancer mortality2–4, and current guidelines recommend mammography every 1–2 years for women over 40 years of age7,8.

Obesity has increased over the past 2 decades among women in the US9 and has disparate effects on pre- and postmenopausal breast cancer. Excess body weight may actually decrease the risk of premenopausal breast cancer10,11, but the relationship between obesity and premenopausal breast cancer mortality is ambiguous11,12. However, obesity is an important risk factor for both the development of10,11,13–15 and mortality from16–19 postmenopausal breast cancer. Obesity may also worsen breast cancer morbidity, including risk of breast cancer recurrence20, contralateral breast cancer21, wound complications after breast surgery22, and lymphedema23,24.

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 diagnosis16. Studies of the relationship between obesity and stage at breast cancer diagnosis are conflicting25,26.

Several observational studies suggest that obese women may be less likely to report recent mammography27–39, but the relationship between obesity and screening mammography remains unclear40–43. Some studies suggest the problem may be confined to white women31–33,36.

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.
METHODS

Search Strategy

Our overall search strategy addressed a broader question regarding the association between obesity and screening for breast, cervical, and colorectal 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 the origin of the included articles and the topic itself to avoid missing articles due to any delays in electronic indexing. Our overall search strategy addressed a broader question regarding the association between obesity and screening for breast, cervical, and colorectal 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 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. Two reviewers evaluated study quality independently using a quality form (Appendix A). The quality of each study was assessed using the STrengthening the Reporting of Observational studies in Epidemiology (STROBE) Statement, Checklist of Essential Items version 3 (September 2005), which was published recently. 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 where 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 and the National Institutes of Health: normal; 18.5–24.9 kg/m², overweight: 25–29.9 kg/m², class I obesity: 30–34.9 kg/m², class II obesity: 35–39.9 kg/m², and class III obesity: ≥ 40 kg/m². 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. Two authors were unable to provide quantitative results stratified by race.

Using the DerSimonian and Laird method, 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, we calculated odds ratios. We converted the relative risk to an odds ratio for another study. One study provided results stratified by race only, 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 I² statistic with an I² value of >50% signifying “substantial heterogeneity.” 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 and Egger and colleagues. 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 of the seven studies 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. We included the other, less conservative estimate from the other study 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 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; thus, six studies were included in our main meta-analyses. Five nationally-representative studies reported race-stratified analyses, and two of these 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 or reported race-stratified results.

Study Characteristics

The 17 included studies, which comprised approximately 276,034 participants, are described in Tables 1 and 2. Sixteen studies were cross-sectional, and one was longitudinal. All studies used BMI as the measure of excess body weight. Thirteen studies defined the outcome as mammography in the last 2 years, two as mammography in the last year, two as mammography in the last 3 years, and one as mammography every 2 years over a 6-year period.
Sixteen of the 17 studies\(^{27–39,41–43}\) (94\%) relied on self-reported BMI and mammography. Fourteen studies accounted for confounding adequately\(^{27–29,41–43}\) and one study did not adjust for any confounding factors\(^{28}\). Reported survey response rates ranged from 55\% to 88\%. Eight studies did}

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\%\(^{29,30,32–34,36–41,43}\).

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Table 1. Description of Studies Included in Qualitative and Quantitative Analyses\(^*\)

| Author, year | Study population | Mean age, y (range) | Race/ethnicity (%) | Exclusion criteria |
|--------------|------------------|---------------------|--------------------|-------------------|
| Anonkar 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, and research database | 45(21–80)\(^{†}\) | White 68%\(^{†}\) | <40 years of age, BMI<25 kg/m\(^2\) |
| Beetz et al. 2008\(^{29}\) | 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, BMI<25 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 |
| Cohen et al. 2007 (36) | 25,060 participants in the Southern Community Cohort Study | NR (42–70+)\(^{†}\) | White 25.2%; black 74.8% | <40 years of age |
| Coughlin et al. 2007\(^{29}\) | 49,564 respondents to the 1999 BRFSS | NR | White 84.4%; non-white 15.6% | <40 years of age |
| Ferrante et al. 2006\(^{10}\) | 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\(^{27}\) | 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\(^{31}\) | 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 Hospital Survey from 46 blocks in Central Harlem in 1991 | NR | NR\(^{3}\) | <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)\(^{2}\) | White 82%; black 18%\(^{3}\) | 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 |
| Wei et al. 2009\(^{33}\) | 3,077 respondents to the 1994 NHIS | 62 | White 81%; black 10% | <50 or >75 years of age |
| Wei 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

\(^{3}\) Race from overall study

\(^{4}\) Studies included in the main, unstratified meta-analysis

\(^{5}\) Authors stated, “...majority of women in the survey were non-Hispanic blacks.”

\(^{6}\) 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
Table 2. Results of Studies Included in Qualitative and Quantitative Analyses

| Author, year | BMI (kg/m²)* | Outcome assessment | Outcome measure | Outcome estimate (95% CI)* | Adjustments |
|--------------|--------------|--------------------|-----------------|----------------------------|-------------|
| Amonkar et al. 200227 | 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. 200630 | 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. 200831 | 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. 200736 | 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. 200430 | 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, 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 status, smoking, co-morbid conditions, physician visits, insurance |
| Ferrante et al. 200640 | 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/ethnicity, education, marital status, smoking, vitamin use, number of visits, contact with primary care doctor, family history of breast cancer, insurance status, smoking, co-morbid conditions, physician visits, insurance status |
| Fontaine et al. 199841 | Self-report, BMI groups: 25 (reference), 35, and 40 | Self-report of 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. 200130 | 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. 200142 | 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. 200531 | 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. 200530 | 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)
Because it was based on the same data as the study by Zhu et al., 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; I² 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. and instead included the article by Ferrante et al., which used the same data. Results were also similar when we included all nine studies with BMI in five categories.
| Author               | Missing data | Exposure description | Outcome description | Confounding | Validity | Response rate |
|----------------------|--------------|----------------------|---------------------|-------------|----------|---------------|
| Amonkar et al. 2002  | NR           | Adequate             | Fair                | Adequate    | NR†      | NR            |
| Amy et al. 2006      | <10%         | Adequate             | Adequate            | Adequate    | Fair     | NR            |
| Berz et al. 2008     | >20%         | Adequate             | Adequate            | Adequate    | NR†      | NR            |
| Cohen et al. 2007    | <10%         | Adequate             | Adequate            | Adequate    | NR       | NR            |
| Coughlin et al. 2006 | None         | Adequate             | Adequate            | Adequate    | N/a      | N/a           |
| Ferrante et al. 2006 | >20%         | Adequate             | Adequate            | Adequate    | NR‡      | 72%           |
| Ferrante et al. 2007 | NR           | Adequate             | Adequate            | Adequate    | NR†      | NR            |
| Fontaine et al. 1998 | NR           | Adequate             | Adequate            | Adequate    | 87%      | NR            |
| Fontaine et al. 2001 | <10%         | Adequate             | Adequate            | Adequate    | NR†      | NR            |
| Gorin et al. 2001    | None         | Adequate             | Adequate            | Fair        | Referred to other reference for details of Harlem Survey used |
| Ostbye et al. 2005   | NR           | Adequate             | Adequate            | Adequate    | NR§      | 87%           |
| Rosenberg et al. 2005| NR           | Adequate             | Adequate            | Adequate    | NR       | 61.7%         |
| Satia et al. 2007    | NR           | Adequate             | Adequate            | Adequate    | NR       | 94% for NHIS overall;
|                      |              |                      |              |            | N/A       | 88% for supplement† |
| Wee et al. 2004      | <10%         | Adequate             | Adequate            | Adequate    | NR†      | 90% for NHIS overall;
|                      |              |                      |              |            | NR         | 73% for Family Core and supplement¶ |
| Winkleby et al. 2003 | None         | Adequate             | Adequate            | Fair        |          | 87%           |
| Zhu et al. 2006      | 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 additional questionnaires 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

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**Table 3. Quality Review of Included Studies**

| Author               | Missing data | Exposure description | Outcome description | Confounding | Validity | Response rate |
|----------------------|--------------|----------------------|---------------------|-------------|----------|---------------|
| Amonkar et al. 2002  | NR           | Adequate             | Fair                | Adequate    | NR†      | NR            |
| Amy et al. 2006      | <10%         | Adequate             | Adequate            | Adequate    | Fair     | NR            |
| Berz et al. 2008     | >20%         | Adequate             | Adequate            | Adequate    | NR†      | NR            |
| Cohen et al. 2007    | <10%         | Adequate             | Adequate            | Adequate    | NR       | NR            |
| Coughlin et al. 2006 | None         | Adequate             | Adequate            | Adequate    | N/a      | N/a           |
| Ferrante et al. 2006 | >20%         | Adequate             | Adequate            | Adequate    | NR‡      | 72%           |
| Ferrante et al. 2007 | NR           | Adequate             | Adequate            | Adequate    | NR†      | NR            |
| Fontaine et al. 1998 | NR           | Adequate             | Adequate            | Adequate    | 87%      | NR            |
| Fontaine et al. 2001 | <10%         | Adequate             | Adequate            | Adequate    | NR†      | NR            |
| Gorin et al. 2001    | None         | Adequate             | Adequate            | Fair        | Referred to other reference for details of Harlem Survey used |
| Ostbye et al. 2005   | NR           | Adequate             | Adequate            | Adequate    | NR§      | 87%           |
| Rosenberg et al. 2005| NR           | Adequate             | Adequate            | Adequate    | NR       | 61.7%         |
| Satia et al. 2007    | NR           | Adequate             | Adequate            | Adequate    | NR       | 94% for NHIS overall;
|                      |              |                      |              |            | N/A       | 88% for supplement† |
| Wee et al. 2004      | <10%         | Adequate             | Adequate            | Adequate    | NR†      | 90% for NHIS overall;
|                      |              |                      |              |            | NR         | 73% for Family Core and supplement¶ |
| Winkleby et al. 2003 | None         | Adequate             | Adequate            | Fair        |          | 87%           |
| Zhu et al. 2006      | 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 additional questionnaires 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

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**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/m², class I obesity 30–34.9 kg/m², class II obesity 35–39.9 kg/m², class III obesity ≥40 kg/m². *Data from analysis of white women. †Data from analysis of black women. BMI, body mass index; OR, odds ratio; CI, confidence interval.
### 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\(^\text{40}\), and the other was a Harlem survey among mostly non-Hispanic blacks\(^\text{42}\). 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\(^\text{41}\) included women <40 years of age. These results may be confounded by age since younger women are more likely to have a lower BMI\(^\text{44}\) 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\(^\text{35}\) because of poor self-esteem and body image, embarrassment\(^\text{30,33,35}\), a perceived lack of respect from health-care providers, or to avoid unwanted weight loss advice\(^\text{28}\). Obesity may be a marker for sub-optimal health behavior in general, of which lack of mammography is simply one facet\(^\text{30,33}\). Also, beliefs regarding cancer screening may vary by BMI\(^\text{35}\). 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\(^\text{57,58}\). Finally, obesity is associated with lower socioeconomic status\(^\text{99}\), 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\(^\text{41,60,61}\). In addition, providers have reported difficulty and inadequate resources and education in providing care for obese women\(^\text{28}\). Finally, physicians may have biases against obese women, resulting in less screening\(^\text{52-64}\).

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\(^\text{65-67}\). 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\(^\text{32}\). Black women may have a similar risk of developing breast cancer\(^\text{68,69}\), but higher breast cancer mortality\(^\text{21,68-71}\). They tend to present with a higher stage of breast cancer\(^\text{69,71}\), which has been linked to (1) less follow-up for abnormal exams\(^\text{72}\), (2) higher rates of obesity\(^\text{72-75}\), (3) socioeconomic factors\(^\text{76}\), (4) cultural beliefs (e.g., belief in herbal treatments)\(^\text{76}\), and possibly, lower likelihood of screening\(^\text{77}\). Although this is controversial\(^\text{68,80-82}\), 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\textsuperscript{83}, but may also overestimate obesity, especially in blacks\textsuperscript{85}. Self-report of height and weight may differ by survey type (telephone versus in-person), age, and BMI\textsuperscript{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%\textsuperscript{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\textsuperscript{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\textsuperscript{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\textsuperscript{6–12}, obesity increases postmenopausal breast cancer risk\textsuperscript{10,11,13–15} and mortality\textsuperscript{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.

Acknowledgments: We thank the following individuals for contributions to the study and/or providing access to their data: Elnseo Guillar, MD, DrPH (Johns Hopkins University, Baltimore, MD); Nancy K. Amy, PhD (University of California, Berkeley, CA); Jeanne Ferrante, MD (University of Medicine and Dentistry of New Jersey Robert Wood Johnson Medical School and New Jersey Medical School, Newark, NJ); Marilyn Winkleby, PhD (Stanford School of Medicine, Stanford, CA); Lynn Rosenberg, ScD (Slone Epidemiology Center at Boston University, Boston, MA). No compensation was given to those acknowledged.

Funding: There was no project-specific support. Dr. Maruthur was supported by a training grant (5 T32 HL007024–31) from the National Heart, Lung, and Blood Institute, National Institutes of Health (NIH). Dr. Brancati was supported by a mid-career investigator award (5 K24 DK062222–05) from the National Institute of Diabetes and Digestive and Kidney Diseases, NIH.

Conflicts of Interest: Dr. Brancati declares the following conflicts: Healthways (disease management), Kinko’s (venture capital), Ringer Advanced Aesthetics (cosmetics), and law firms (Burg Simpson Law Firm; Garrettson Law Firm; Richardson, Patrick, Westbrook & Brickman, LLC)—Zyprexa litigation. He donates all fees to Johns Hopkins University. Drs. Bolen and Clark had unrestricted grants from Pfizer, Glaxo-Smith-Kline, and Johnson & Johnson for analyses from several large Blue Cross Blue Shield Plans. Dr. Bolen received an honorarium from Laboratories Paltreix in February 2007 to give a talk to health care providers in the Dominican Republic on the comparative effectiveness of oral diabetes medications. Dr. Maruthur has no conflicts to disclose.

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APPENDIX

Table 5. Electronic Database Search Terms*

| PubMed | MeSH terms |
|--------|------------|
| **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); breast; mammary carcinoma(s); human; carcinoma(s); human mammary carcinoma(s); malignant neoplasm(s); neoplasm(s); mammmary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); malignant neoplasm(s); human mammary mammary neoplasm(s); mammography; mammographies; screening mammography; screening for breast cancer 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 Cancer screening Mammography Body weights and measures | **CINAHL** |
| **CINAHL** | **CINAHL headings** |
| Breast cancer, breast neoplasms | Mammography |
| Breast cancer screening, mammography, mammogram | BMI, body mass index, obesity, Quetelet index |
| Cancer screening Cancer screening | Body weights and measures |

*Our overall search strategy addressed a broader question regarding the association between obesity and screening for breast cancer, 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)

22. Were sources of funding identified?
   _ adequate (source of funding or no funding specified)
   _ poor (funding not described)

Other comments on study quality:

CONFLICTS OF INTEREST

Maruthur et al.: Obesity and Mammography

JGIM