Annals of Internal Medicine | Review

Systematic Review: The Long-Term Effects of False-Positive Mammograms

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Background: Although abnormal screening mammograms deleteriously affect the psychological well-being of women during the time immediately surrounding the tests, their long-term effects are poorly understood.

Purpose: To characterize the long-term effects of false-positive screening mammograms on the behavior and well-being of women 40 years of age or older.

Data Sources: English-language studies from the MEDLINE, Web of Science, EMBASE, CINAHL, PsycINFO, and ERIC databases through August 2006.

Study Selection: Studies were identified that examined the effects of false-positive results of routine screening mammography on women's behavior, well-being, or beliefs.

Data Extraction: Two investigators independently coded study characteristics, quality, and effect sizes.

Data Synthesis: 23 eligible studies (n = 313 967) were identified. A random-effects meta-analysis showed that U.S. women who received false-positive results on screening mammography were more likely to return for routine screening than those who received normal results (risk ratio, 1.07 [95% CI, 1.02 to 1.12]). The effect was not statistically significant among European women (risk ratio, 0.97 [CI, 0.93 to 1.01]), and Canadian women were less likely to return for routine screening because of false-positive results (risk ratio, 0.63 [CI, 0.50 to 0.80]). Women who received false-positive results conducted more frequent breast self-examinations and had higher, but not apparently pathologically elevated, levels of distress and anxiety and thought more about breast cancer than did those with normal results.

Limitations: Correlational study designs, a small number of studies, a lack of clinical validation for many measures, and possible heterogeneity.

Conclusions: Some women with false-positive results on mammography may have differences in whether they return for mammography, occurrence of breast self-examinations, and levels of anxiety compared with women with normal results. Future research should examine how false-positive results on mammography affect other outcomes, such as trust and health care use.

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Regular mammography has become part of routine health care in the developed world for women 40 years of age or older. Routine mammography is important because it reduces death due to breast cancer by detecting tumors early (1–3). Unfortunately, many women receive false-positive results on screening tests. In the United States, approximately 11% of screening mammograms lead to false-positive results, which can cause women to incur substantial personal and financial costs related to follow-up testing (4, 5). One study (6) estimated that increased medical care use related to false-positive results on mammography costs $100 million per year in the United States. Researchers have shown that false-positive results negatively influence women's psychological well-being during the period immediately surrounding tests (7). Although researchers have performed several studies (7–9) on the effect of false-positive mammograms on women, the long-term effect is poorly understood.

Women who receive false-positive mammograms may be discouraged from further routine screening mammographies (10). Testing errors could undermine women's confidence in the benefit of mammography and in the medical system's ability to provide adequate care, making them less likely to return for routine mammography. The costly and time-consuming follow-up procedures prompted by false-positive results may be an additional disincentive for return.

Alternatively, false-positive mammograms may not have a negative effect on subsequent screening mammographies. Only one half of women with abnormal mammograms are aware of having received false-positive results (11). A recent survey in the United States found that of the adults who recall having received false-positive results on screenings for cancer (including mammographies), 98% were still glad that they had had the tests performed (12, 13). Women are concerned about receiving overdiagnosis and overtreatment but not about receiving false-positive results per se (14). A final and less commonly argued alternative is that false-positive results might actually increase routine screening because they increase anxiety, worry, and perceived risk (7, 15–20). Anxiety, in turn, may cause women who receive false-positive results to be more vigilant about early detection than women who receive normal results. Although extreme anxiety caused by screening

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seems to be rare, abnormal mammograms apparently prompted 2 British women to commit suicide (21).

Many studies have addressed the long-term consequences for women who receive false-positive mammograms, but these studies have yielded contradictory results, with different studies supporting each of the 3 possibilities described. Other reviews (7, 9, 18, 22–25) emphasized short-term psychological consequences, largely ignored health behaviors, were typically not systematic reviews, and did not screen studies for minimum quality criteria. Because mixed findings among diverse outcomes have thwarted the understanding of the presence and extent of the long-term effects of false-positive screening mammograms, we conducted a systematic review of the relevant literature. We aimed to characterize the long-term effects of false-positive screening mammograms on the behavior and well-being of women 40 years of age or older.

Context

Do false-positive mammograms affect women's well-being and behavior?

Contribution

This systematic review summarizes data from 23 observational studies that compared outcomes after false-positive results or normal results on screening mammograms. Women who received false-positive results had slightly higher levels of distress and more thoughts about cancer several months after screening than women who received normal results. They also performed breast self-examinations more frequently and, in the United States, were slightly more likely to return for repeated routine screening examinations (risk ratio, 1.07 [95% CI, 1.02 to 1.12]).

Implication

False-positive mammograms may have persistent small effects on some women's psychological well-being and behavior.

—The Editors

METHODS

Data Sources and Searches

We conducted the review by using the following protocol. Two reviewers independently searched the MEDLINE, Web of Science, EMBASE, CINAHL, PsycINFO, and ERIC databases for studies published through September 2006 whose title, abstract, or keywords included reference to both false-positive results and screening mammography. The search terms were (*false positive* OR *abnormal* OR *benign*) AND (*breast cancer* OR *mammog**). We also manually searched the reference sections of relevant papers and circulated requests for unpublished studies among colleagues and the authors of the articles we identified. We limited the searches to English-language studies.

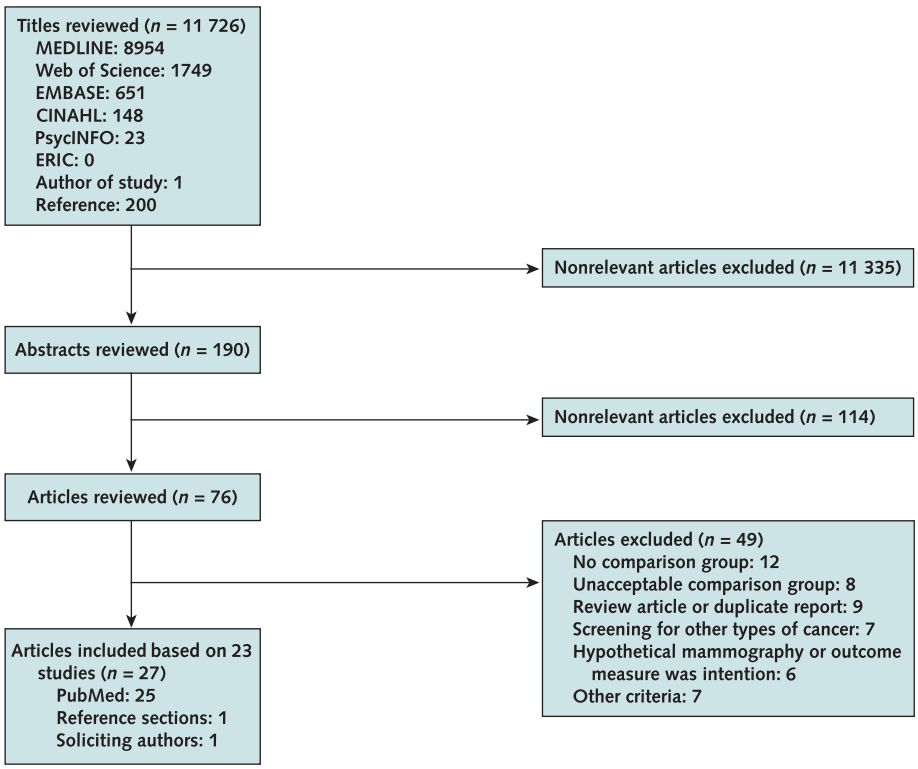
Study Selection

Two reviewers independently screened the titles, then abstracts, and then text of articles that seemed pertinent. We identified studies that examined the effects of false-positive mammograms on the behavior, well-being, or beliefs of women 40 years of age or older by using selection criteria that we specified before the review began, except as noted. We excluded studies that did not meet the following quality criteria. We required that initial mammography screening results (abnormal or normal) be obtained from routine mammography because mammographies conducted for reasons other than screening take place in a very different context. We excluded studies of mammography prompted by symptoms or initial screening by clinical breast examination. We required that women receiving false-positive results be compared with women from the same sample who received normal results. Unacceptable comparison groups included unscreened women and women screened at other times or in different settings. We defined false-positive results on mammograms as abnormal results that did not lead to a cancer diagnosis after follow-up mammography, ultrasonography, magnetic resonance imaging, fine-needle aspiration, or biopsy. While reviewing the studies, we decided to include 2 studies (26, 27) that did not report the resolution of abnormal screening results because very few abnormal results indicate cancer (28). The inclusion of these studies did not change our findings. We required that initial screening be real (not imagined in a hypothetical vignette) and that results be assessed from medical records or by patient self-report.

Studies had to include the outcome of return for routine screening within the interval recommended in the country or health system in which the study was conducted; we did not consider mammographies that were follow-ups of abnormal results or were part of a clinical trial as routine, initial mammographies. We required that women who returned for screening be assessed from medical or registry records or by patient self-report; however, we did not include intention to be screened as an acceptable measure. Additional outcomes included behavior, well-being, and beliefs, such as self-report of conducting breast self-examinations, anxiety, worry, perceived risk, and depression. We required that these outcome measures be assessed at least 1 month after cancer was ruled out so that the data reflected long-term consequences of false-positive screening results and not immediate distress in the period between receiving an abnormal test result and the subsequent negative result for cancer. Although breast self-examination has not been shown to reduce death due to breast cancer (29), we included it in our analysis as an additional demonstration of the effect of false-positive results on women's behavior.

We required that studies reported bivariate statistical analyses of original, quantitative data or reported data that could be reanalyzed, although we accepted studies that reported null effects without indicating their size or direction. In practice, we did not exclude studies that reported

Figure 1. **Study flow diagram.**



results only after adjustment for covariates, although we excluded several studies that reported complex analyses that did not allow us to determine the relevant main effect.

Data Extraction and Quality Assessment

Two investigators independently used a standardized data extraction form to code the studies on characteristics that could alter the effect of receiving a false-positive result. In addition, we coded variables that reflect study quality, such as study design and use of self-report. During our review process, we refined our coding criteria to exclude study results for women whose follow-up for an abnormal mammogram was not further testing but was instead early recall for their next screening mammography. We could not exclude data for these women in 2 studies included in the review because data on women placed on early recall were combined with data on women receiving diagnostic follow-up in the study analyses (30, 31). Two investigators independently calculated a risk ratio for each study of return for the next routine mammogram.

Data Synthesis and Analysis

For studies assessing whether women returned for mammography, we pooled risk ratios (1 per study) by using a random-effects meta-analysis (32). For the 1 study (33) that reported data about reattendance at several time intervals after the initial mammogram, we chose data from month 18 of the study because that was the next period after the recommended screening interval of 12 months. Our analysis weighted risk ratios according to the sample size in each study while taking into account the variability among studies. We created a funnel plot to assess possible publication bias. We conducted the analyses by using the metan procedure in Stata (Stata Corp., College Station, Texas). We used 2-tailed statistical tests (critical $\alpha = 0.05$).

Role of the Funding Sources

The study was funded by grants from the University of North Carolina Lineberger Comprehensive Cancer Center and the American Cancer Society. The funding sources had no role in conducting the review or in preparing and submitting the manuscript.

RESULTS

As shown in **Figure 1**, we reviewed 11 726 titles, 190 abstracts, and 76 articles for inclusion in the review. We identified 27 articles on 23 unique studies ($n = 313\,967$) that examined the long-term effects of false-positive screening mammograms (**Appendix Table 1**, available at www.annals.org [15, 27, 30, 31, 33–55]). Thirteen studies were conducted in Europe, 7 in the United States, 2 in Canada, and 1 in Australia. Thirteen studies did not include women

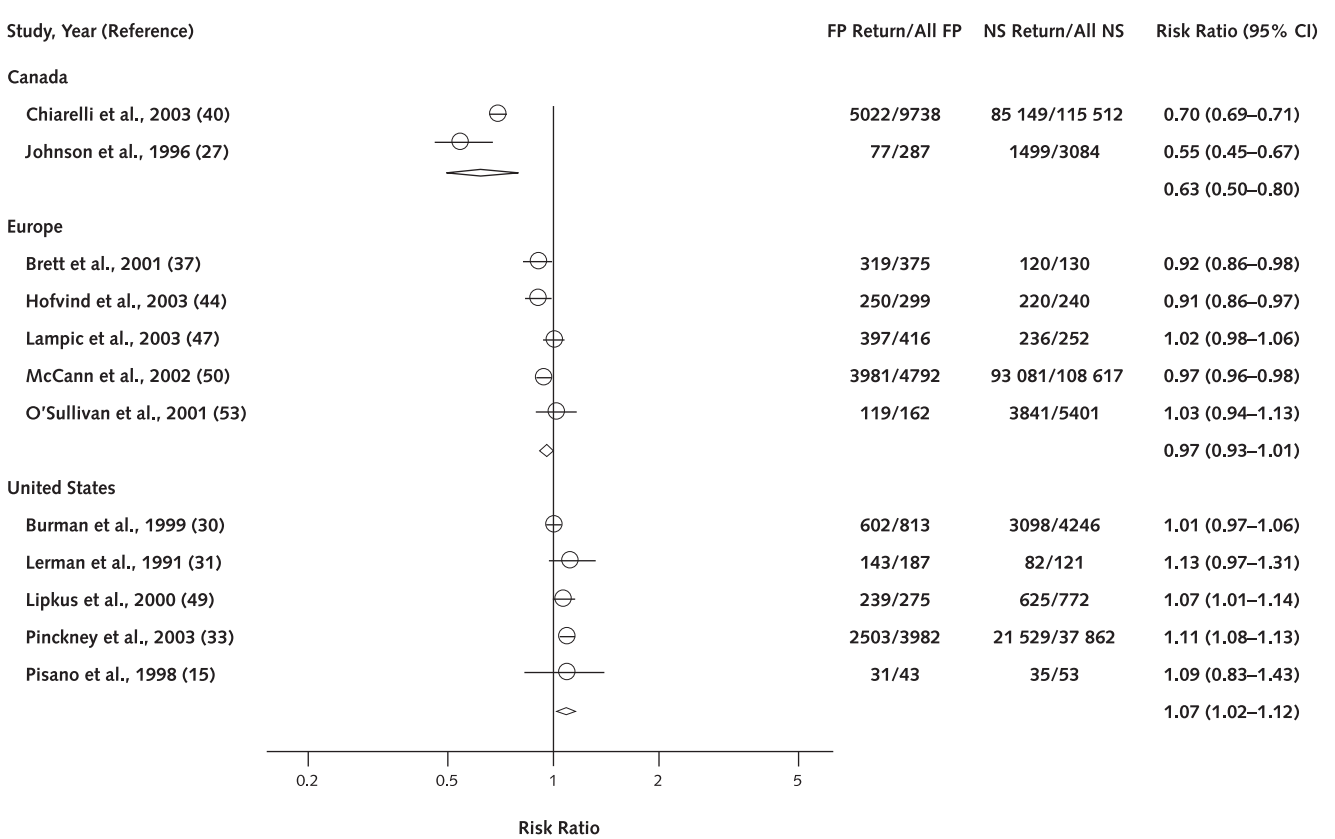
between 40 and 49 years of age. Information on race, insurance status, and education of the women was reported in too few studies to allow meaningful summary of these characteristics. Women were typically studied in clinical settings, such as physicians' offices and screening clinics, although some studies used data from breast cancer registries or national health surveys.

Tests used to rule out cancer were clinical breast examination, a second mammogram, ultrasonography, fine-needle aspiration, and biopsy, although some studies did not report specific tests. Return for the next routine mammogram was assessed 15 to 48 months after the initial screening. Because some studies examined the effects of false-positive mammograms from any time in the women's medical histories (31, 45), the longest time since initial screening for these studies is not specified and may exceed the range previously stated. Mammography reattendance was assessed from medical records in 9 studies and by self-report in 3. For other outcomes, time since initial screening ranged from 1 to 35 months and all were assessed by self-report. All but 1 study (49) of return for mammography used longitudinal cohort designs (that is, prospective or retrospective); the studies of other outcomes typically used the same designs, but 2 (45, 49) used cross-sectional designs. Only 2 studies (40, 53) explicitly addressed whether women who received abnormal mammograms may have been further treated through another medical system, and neither stated whether this had occurred. The time between the abnormal mammogram and negative result for cancer was reported in too few studies to provide a meaningful summary.

Meta-analysis: Return for Next Routine Screening

Twelve studies examined the effect of false-positive screening mammograms on whether women returned for their next routine mammogram (**Figure 2**). We stratified the meta-analysis of these studies by geographic region because of potentially important regional differences in mammography screening practices. For example, return for mammography was generally measured over a shorter time in the United States than in Europe because of shorter recommended screening intervals. Also, the systems for following mammography are national in scope in most European countries and in Canada, whereas in the United

Figure 2. **Meta-analysis of the relationship between receiving a false-positive mammogram and return for routine mammography.**



Circles indicate point estimates for risk ratios of individual studies, and bars indicate their 95% CIs. Diamonds indicate the summary risk ratios and 95% CIs pooling across studies in each geographical region. For each study, the proportion of women returning for routine mammography who received false-positive results (*FP*) and those who received normal screening results (*NS*) is shown.

States, a patchwork of private and public providers (56) handle mammography.

Women in the United States were more likely to return for their next routine mammogram if they had received false-positive rather than normal mammograms (5 studies) (risk ratio, 1.07 [95% CI, 1.02 to 1.12]; $Q = 11$ [$P = 0.026$]). European women who received false-positive mammograms were less likely to return for routine screening, but the finding was not statistically reliable (5 studies) (risk ratio, 0.97 [CI, 0.93 to 1.01]; $Q = 14$ [$P = 0.007$]). The 2 studies of Canadian women seemed to be outliers, with Canadian women who received false-positive results being much less likely to return for mammography (risk ratio, 0.63 [CI, 0.50 to 0.80]; $Q = 6$ [$P = 0.017$]).

Although the stratified effect sizes from the 3 geographic regions yielded heterogeneity statistics that were statistically significant, we believe that this is an artifact of the several studies with very large sample sizes. Indeed, a visual inspection of the forest plot (**Figure 2**) shows little variability in the U.S. and European studies. We note that Johnson and colleagues' study (27) reported an unusually low percentage of women returning for screening that was perhaps due to its retrospective use of existing medical records. Pinckney and colleagues' well-conducted, population-based study (33) of mammography in Vermont from 1996 to 1997 contributed the most to the pooled risk ratio for the United States, and it had one of the highest rates of nonreturn overall. McCann and colleagues' large study (50) that contributed the most to the pooled risk ratio for Europe examined the effect of the introduction of comprehensive screening mammography into East Anglia, United Kingdom, between 1992 and 1998 and thus may have differed somewhat from other studies of ongoing programs. A visual examination of funnel plots for the meta-analysis (data not shown) revealed no apparent publication bias, but this conclusion should be viewed as tentative given the small number of studies analyzed and the limitations of funnel plots for assessing such bias.

Systematic Review

We report the remainder of the findings in the form of a narrative review because relatively few studies assessed the outcomes of interest and because the studies' wide variety of assessment methods is not appropriate for meta-analysis (9) (**Appendix Table 2**, available at www.annals.org [15, 31, 34, 35, 37, 39, 41–49, 51, 52, 54, 55, 57–69]).

Frequency of Breast Self-Examination and Attitudes toward Breast Screening

Six studies examined the effect of false-positive results on frequency of conducting breast self-examinations. Compared with those who received normal results, women who received false-positive results reported conducting statistically significantly more frequent breast self-examinations in 3 studies. Two studies showed no effect, and 1 study had mixed findings. Too few studies examined attitudes toward breast self-examination and mammography to allow us to characterize trends in the findings.

Health Care Use and Symptoms

Eight studies examined topics related to health care use and symptoms. Compared with women who received normal results, women who received false-positive results reported similar physician use (1 study), higher use of mental health professionals (1 study), similar numbers of subsequent clinical breast examinations (1 study), and similar health habits (1 study). False-positive results were associated with statistically significantly more physical symptoms in 1 study, whereas 2 studies found no difference and 1 study had mixed findings. False-positive results were also associated with some negative effects from symptoms (1 study), greater impairment in daily activities (1 study), perceiving breasts as less healthy (1 study), equivalent bodily preoccupation (1 study), and equivalent well-being (1 study).

Psychological Distress

Nine studies assessed psychological distress. False-positive mammograms were associated with statistically significantly more symptoms of distress in 4 studies, whereas 3 studies reported no statistically significant differences and 2 studies had mixed findings. Of the 4 studies that measured distress by using the Psychological Consequences Questionnaire (63), a scale developed specifically to assess the immediate psychological effect of breast screening, 3 found statistically significantly more symptoms of distress among women who received false-positive results.

Anxiety

Eleven studies assessed anxiety. Four of these studies used ad hoc measures of anxiety about breast cancer or further screening, and all but 1 of the remaining studies used validated measures of generalized symptoms of anxiety. Statistically significantly higher levels of anxiety were found among women who received false-positive results than among women who received normal results in 4 studies, whereas 4 studies found no effect and 3 studies had mixed findings. The 4 ad hoc measures that were specific to breast cancer showed statistically significantly higher levels of anxiety, although the normed measures of generalized symptoms of anxiety showed no apparent pattern. This finding suggests that false-positive mammograms increase an anxious mood that is specific to breast cancer or mammography but do not increase clinically diagnosable psychological harm or generalized anxiety.

Worry, Intrusive Thoughts, Fear, and Perceived Risk

Researchers assessed worry in 6 studies. The studies used ad hoc measures (or used nonstandard scoring for a previously published measure) of worry about further screening, breast cancer, illness, and death, suggesting spe-

cific concerns that were not generalized or pathologic in extent. Women who received false-positive mammograms reported statistically significantly higher levels of worry in 4 studies, whereas 1 study showed no difference and 1 study showed mixed results. Two studies showed that women had statistically significantly more intrusive thoughts and increased concerns about breast cancer. Of the 3 studies examining fear of breast cancer, cancer, illness, or death, 2 found statistically significantly greater fear and 1 found no difference. Three studies found that women who had received false-positive results on mammography had statistically significantly higher perceived likelihood or risk for receiving positive results for breast cancer in the future, and 1 study found no effect. Two studies found no effect on perceived severity of breast cancer. All studies of perceived risk used ad hoc measures whose quality could not be assessed (70, 71). These findings, combined with those for anxiety, suggest that women who receive false-positive results on screening mammograms have a general increase in thoughts and apprehension about breast cancer and breast cancer–related topics.

Depression

Researchers assessed depression in 9 studies. Eight of the studies used standardized measures of generalized symptoms of depression, many of which are acceptable screening tools for clinical depression. One study found lower levels of depression, 7 reported no effect, and 1 reported mixed findings. The pattern of results suggests no long-term symptoms of depression in women who receive false-positive mammograms.

Discussion

We reviewed the long-term effects of false-positive mammography results on subsequent mammography screening behavior, breast self-examination, well-being, and beliefs of women 40 years of age or older. Our meta-analysis found no statistically significant relationship between false-positive screening mammograms and return for routine mammography screening among women in Europe. Women in the United States who received false-positive results were more likely to return for screening, and Canadian women who received false-positive results were less likely to return for routine screening. Although many studies we reviewed had large sample sizes, we suggest caution in interpreting our findings because of the small number of studies, especially Canadian studies. Women who received false-positive results were generally more likely to conduct breast self-examinations than were those who did not receive these results. False-positive results were associated with generally more thoughts about breast cancer (including greater distress, anxiety, and worry and a greater perceived likelihood of receiving positive results for breast cancer in the future), but they had no consistent relationship to generalized anxiety or depression.

Before offering our theoretical interpretation of the findings, we consider the anomalous finding that Canadian women were substantially less likely to return for mammography after receiving false-positive results. In some Canadian provinces, women who receive false-positive mammograms continue their routine screening in a separate surveillance system (56). The registries surveyed in the 2 Canadian studies may not have adequately captured the women's routine screening behavior in this separate surveillance system (72). One Canadian research group (40) offered a similar speculation about their findings. We cannot rule out this explanation for the Canadian finding because inadequate information was reported in the published studies (27, 40). In addition, although the Canadian studies had a large combined sample size, we should be tentative in drawing conclusions from only 2 studies.

Our findings suggest that women who receive false-positive mammograms often have higher anxiety about breast cancer, but we speculate that they may also have less trust in the accuracy and benefit of mammography. Previous research on false-positive results shows that false-positive chemical warfare alarms decrease trust in those tests (73; Brewer T, Hallman WK. Somatic consequences of failing to unbelieve a false test: chemical warfare alerts and exposure. In preparation). One implication is that anxiety and trust could offset each other in affecting return for mammography. The false-positive results would increase breast cancer anxiety, and higher levels of anxiety and worry have been shown to increase mammography use (74, 75). At the same time, receiving false-positive results may decrease trust in mammography, which in turn could decrease interest in future mammography. Increased interest in mammography because of an increase in anxiety could offset the trust-related decrease, yielding a null effect of false-positive results on return for screening. Our review supports 2 predictions of this model—an increase in anxiety and a minimal or null effect on return for mammography. Other research (74, 75) supports the effect of anxiety on screening.

The 2 effects we posit would not offset each other in their effect on the frequency of breast self-examinations. False-positive results increase breast cancer anxiety (an assertion supported by our findings), and higher anxiety has been shown to increase the frequency of breast self-examination (76). On the other hand, the false-positive results may also decrease trust in mammography, which could have no effect on the frequency of breast self-examinations or could increase the frequency in a compensatory way.

The regional differences in our finding that women from the United States are more likely than women in Europe to return for routine screening mammography after false-positive results may be because of differences in mammography procedures in the 2 regions. First, the United States has a shorter routine screening interval than many countries in Europe. Second, European screening systems

place a much higher premium on accuracy by using double reading and other procedures that result in abnormal mammogram rates that are 3 to 5 times lower than those in the United States (28, 77, 78). Third, most European countries have screening programs that automatically invite all women for their next routine mammogram. This type of system, in which women must "opt out" of routine screening if they do not attend, yields much higher participation than "opt-in" systems, such as those in the United States (79). Lastly, European countries typically have national mammography programs, unlike the more fragmented and often private systems in the United States. These regional differences may affect women's levels of anxiety and trust in mammography, or they may have independent effects on mammography reattendance.

Our review has several limitations. We reviewed only correlational studies because the existing experimental studies were of insufficient quality (for example, an experiment using hypothetical scenarios with behavioral intention as the outcome measure [80]) and because experiments of acceptable quality would probably be unethical to conduct. Although most studies in our meta-analysis used longitudinal designs, we had limited ability to infer a causal relationship between false-positive results and our outcome measures because of potentially unidentified or unmeasured variables. To address this concern, we examined possible predictors of receiving a false-positive result across the included studies, such as age, history of false-positive mammograms, and breast density, but no clear pattern emerged. The studies we reviewed did not provide adequate information on many important issues, including the time between an abnormal result and the negative result for breast cancer and whether the tests ruling out cancer indicated benign breast disease or no physiologic finding. These are 2 important variables that could affect the findings of the studies and our review. Although assessment of return for mammography screening in most studies relied on medical records, some studies used self-report rather than clinical records. Although we based our return for mammography meta-analysis on data from more than 300 000 women, we based the qualitative review on data from between a few hundred and a few thousand women. The finding of increased thoughts and anxiety about breast cancer relied on ad hoc measures. Because few standardized measures exist, we could not fully interpret the clinical significance of these outcomes. Although additional empirical studies are needed in this area, our meta-analysis and review advances our ability to organize and interpret this literature. The studies were somewhat heterogeneous, but we believe that this was primarily because of the oversensitivity of the heterogeneity statistic of the few very large studies. For this reason, although we reported heterogeneity statistics, we derive more confidence from the visual inspection of the forest plot. In our examination of the funnel plot for the meta-analysis, we found no apparent publication bias, but the limitations inherent to funnel plots in identifying such bias, especially given the number of small studies analyzed, prevented us from rendering a judgment about the absence of publication bias with confidence. The published studies that we reviewed may represent a biased subset of studies conducted, or they may have had selective reporting of outcomes.

Our review highlights some long-term consequences for women who receive false-positive mammograms and shows areas that need further study. To our knowledge, no study has used accepted statistical procedures to establish whether anxiety mediates the effects of false-positive results on women's return for routine screening or on breast self-examination (81, 82). Few studies included in our analysis examined the effect of false-positive mammograms on trust, functional status, quality of life, and health care use (43, 83), and no studies examined whether breast self-examination was a replacement for routine screening among women who had anxiety after receiving false-positive mammograms. Finally, the literature on false-positive results has focused almost exclusively on breast cancer screening. Few studies have examined the effects of false-positive results on screening for cervical cancer, prostate cancer, or colon cancer (84–87). Given our findings that false-positive mammograms have long-term effects on the behavior and well-being of the women who receive them, these effects may also be results of testing for other types of cancer, diseases, and health threats.

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Note: Portions of this paper were presented at the 2006 meetings of the American Society for Preventive Oncology, Bethesda, Maryland, 26–28 February 2006; the Society for Behavioral Medicine, San Francisco, California, 22–25 March 2006; and the Society of Judgment and Decision Making, Houston, Texas, 17–20 November 2006.

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Appendix Table 1. Characteristics of Reviewed Studies*

Author, Year (Reference)	Study Country	Study Design and Objective†	Included Women Age 40–49 Years	Dropout Rate from Screening to Outcome Assessment, %	Initial Screening Mammogram Assessment	Time from Abnormal Result to Negative Result for Cancer	Tests Used to Rule Out Cancer	Return for Mammography, *n*‡	Timing and Method of Assessment of Return Mammography	Other Outcomes, *n*‡
Aro et al., 2000 (34)	Finland	Prospective cohort study of psychological distress after false-positive mammogram	No	5 (at 2 mo); 20 (at 12 mo)	Medical records	2–27 d to follow-up test; time to negative result NR	NR	–	–	781–881
Barton et al., 2004 (35)	United States	Prospective cohort study (data are from nonintervention groups of a controlled trial to reduce anxiety after abnormal mammogram)	Yes	15	Medical records	72% of women with abnormal mammogram received negative result at 3 wk	Mammography, ultrasonography, biopsy	–	–	588
Brett et al., 1998 (36)	United Kingdom	Prospective cohort study of adverse psychological consequences of false-positive mammogram	No	24 (from those invited from previous study [38])	Medical records	NR	Mammography, clinical examination, ultrasonography, fine-needle aspiration, biopsy	–	–	279
Brett and Austoker, 2001 (37) (same study sample as reference 36)	United Kingdom	Prospective cohort study of adverse psychological consequences of false-positive mammogram	No	23 (reported by authors but denominator is unclear)	Medical records	NR	Mammography, clinical examination, ultrasonography, fine-needle aspiration, biopsy	505	35 mo since initial screening; assessed from medical records	167
Ong et al., 1997 (38) (same study sample as reference 36)	United Kingdom	Prospective cohort study of the effects of early recall relative to false-positive and normal mammograms	No	25	Medical records	NR	Mammography, clinical examination, ultrasonography, fine-needle aspiration, biopsy	–	–	394
Bull and Campbell, 1991 (39)	United Kingdom	Prospective cohort study of psychological effect of routine breast screening program	No	19	Medical records	NR	Mammography, ultrasonography, fine-needle aspiration, biopsy	–	–	573–584
Burman et al., 1999 (30)	United States	Prospective cohort study of effect of false-positive mammogram on routine mammography	Yes	27	Medical records	NR	Mammography, ultrasonography, early recall for mammography, biopsy	5059	Time since initial screening varied (18–42 mo) and the assessment of return was 6 mo past the recommended interval); assessed from medical records	–
Chiarelli et al., 2003 (40)	Canada	Retrospective cohort study of the effect of false-positive mammogram on reattendance for routine mammography screening	No	28	Medical records	NR	NR	125 250	36 mo since initial screening; assessed from medical records	–
Cockburn et al., 1994 (41)	Australia	Prospective cohort study of psychological consequences of mammography screening	No	19	Medical records	NR (results of initial mammograms sent 7 d later)	Mammography, clinical examination, ultrasonography	–	–	200
Ellman et al., 1989 (42)	United Kingdom	Prospective cohort study of psychiatric morbidity associated with screening for breast cancer	Yes (included women age 45–49 y)	2	Medical records	NR	NR	–	–	553
Gram et al., 1990 (43)	Norway	Prospective cohort study of quality of life after receiving a false-positive mammogram	Yes	14 (at 6 mo); 35 (at 18 mo)	Medical records	NR	Mammography, biopsy	–	–	287–357

Appendix Table 1—Continued

Author, Year (Reference)	Study Country	Study Design and Objective†	Included Women Age 40–49 Years	Dropout Rate from Screening to Outcome Assessment, %	Initial Screening Mammogram Assessment	Time from Abnormal Result to Negative Result for Cancer	Tests Used to Rule Out Cancer	Return for Mammography, *n*‡	Timing and Method of Assessment of Return Mammography	Other Outcomes, *n*‡
Hofvind et al., 2003 (44)	Norway	Prospective cohort study of reattendance for routine mammography related to previous screening experiences and attitudes	No	13	Medical records	NR	NR	539	24 mo since initial screening; assessed from medical records	–
Jatoi et al., 2006 (45)	United States	Cross-sectional study of psychological distress related to false-positive mammograms	Yes	NA (nonparticipation rate, 28%)	Self-report	NR	NR	–	–	9571–9598
Johnson et al., 1996 (27)	Canada	Retrospective cohort study of adherence to screening mammography program	No (no data on false-positive results in younger cohort)	47	Medical records	NR	NR	3371	18 mo since initial screening; assessed from medical records	–
Lampic et al., 2001 (46)	Sweden	Prospective, age-matched cohort study of short- and long-term anxiety and depression in women routinely screened for breast cancer	Yes	9 (at 3 mo); 17 (at 12 mo)	Medical records	Within 2–8 wk	Clinical examination, mammography, ultrasonography, fine-needle aspiration, biopsy	–	–	619–684
Lampic et al., 2003 (47) (same study sample as reference 46)	Sweden	Prospective, age-matched cohort study of short- and long-term anxiety and depression in women routinely screened for breast cancer	Yes	21 (at 24 mo)	Medical records	Within 2–8 wk	Clinical examination, mammography, ultrasonography, fine-needle aspiration, biopsy	668	30 mo since initial screening; assessed from medical records	556–601
Lerman et al., 1991 (31)	United States	Prospective cohort study of psychological and behavioral consequences of false-positive mammograms	No	15	Medical records	Within 1–2 mo	Ultrasonography, biopsy, may include some early recall	308	15 mo since initial screening; assessed by self-report	305
Lerman et al., 1991 (48) (same study sample as reference 31)	United States	Prospective cohort study of psychological side effects of false-positive mammograms	No	15 (at 3 mo); 20 (at 15 mo)	Medical records	Within 1–2 mo	Ultrasonography, biopsy, may include some early recall	–	–	299
Lipkus et al., 2000 (49)	United States	Cross-sectional study of the effect of false-positive screening mammograms on subsequent screening and psychosocial outcomes	Yes	NA (nonparticipation rate, 24%)	Self-report	NR	NR (some had biopsy)	1047	15 mo (patient age ≥51 y) or 27 mo (patient age 40–50 y) since initial screening; assessed by self-report	1047
McCann et al., 2002 (50)	United Kingdom	Retrospective cohort study of the effect of false-positive mammograms on return for routine mammography and risk for cancer	Yes (included women age 49 y)	14	Medical records	NR	Ultrasonography, fine-needle aspiration, biopsy	113 409	42 mo since initial screening; assessed from medical records	–
Meystre-Agustoni et al., 2001 (51)	Switzerland	Prospective cohort study of effects of mammography screening on anxiety	No	3	Medical records	NR	NR	–	–	859
Olsson et al., 1999 (52)	Sweden	Prospective cohort study of ways that women cope with false-positive mammograms	Yes	10 (includes those who declined a 2-wk survey)	Medical records	NR (1 wk on average for follow-up testing)	Mammography, clinical examination, ultrasonography, fine-needle aspiration, biopsy	–	–	1222

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Appendix Table 1—Continued

Author, Year (Reference)	Study Country	Study Design and Objective†	Included Women Age 40–49 Years	Dropout Rate from Screening to Outcome Assessment, %	Initial Screening Mammogram Assessment	Time from Abnormal Result to Negative Result for Cancer	Tests Used to Rule Out Cancer	Return for Mammography, *n*‡	Timing and Method of Assessment of Return Mammography	Other Outcomes, *n*‡
O'Sullivan et al., 2001 (53)	United Kingdom	Retrospective cohort study of false-positive mammograms on routine mammography screening	No	29	Medical records	NR	NR	5649	36 mo since initial screening (some women were asked to return earlier); assessed from medical records	–
Pinckney et al., 2003 (33)	United States	Retrospective cohort study of effect of false-positive mammograms on routine mammography screening	Yes	43 (at 18 mo); 31 (at 24 mo); 17 (at 30 mo)	Medical records	NR	Mammography, "other diagnostic testing"	41 844	18 mo since initial screening; assessed from medical records	–
Pisano et al., 1998 (15)	United States	Prospective cohort study of effect of false-positive mammograms on routine mammography screening	No	21	Medical records	NR (within 6 mo)	Biopsy only	96	24–48 mo since initial screening (adherence defined as having had 3 mammographies within 3 y); assessed from medical records	90
Sandin et al., 2002 (54)	Spain	Prospective cohort study of the psychological effects of false-positive mammograms	Yes (included women age 45–49 y)	0	Medical records	NR	NR	–	–	1195
Scaf-Klomp et al., 1997 (55)	The Netherlands	Prospective cohort study of psychological side effects of breast cancer screening; cohorts matched for age and municipality	No	35 (at 8–10 wk); 41 (at 6 mo)	Medical records	Less than 8–10 wk	NR	–	–	164–185

* Dashes mean that the outcome was not assessed. NA = not available; NR = not reported.
† "Prospective cohort study" refers to studies in which the outcome of screening mammography was known before a later survey or assessment of return for mammography. Study objectives are those stated by the authors.
‡ Sample sizes refer to usable data abstracted for this review and may be smaller than the total number reported by the authors for their studies.

Appendix Table 2. **Qualitative Review of the Long-Term Effects of False-Positive Mammograms on Outcomes Other than Return for Screening***

Outcome	Study, Year (Reference)	Timing of Assessment after Screening	Finding and Statistical Significance†	Outcome Assessment
Frequency of BSE and attitudes toward BSE and mammography				
Frequency of BSE	Aro et al., 2000 (34)	2 mo 12 mo	FP significantly more FP significantly more	Ad hoc (1 item)
Frequency of BSE	Bull and Campbell, 1991 (39)	6 wk	FP significantly more	Ad hoc (1 item)
Frequency of BSE	Gram et al., 1990 (43)	18 mo	No effect (direction of null effect NR)	NR
Frequency of BSE	Lampic et al., 2001 (46); Lampic et al., 2003 (47)	12 mo	FP significantly more	Ad hoc (1 item)
Frequency of BSE	Lerman et al., 1991 (31); Lerman et al., 1991 (48)	3 mo	No effect	Ad hoc (1 item)
Frequency of BSE	Scaf-Klomp et al., 1997 (55)	8–10 wk	FP more, not significant	Ad hoc (1 item)
Confidence in BSE	Aro et al., 2000 (34)	8 mo 2 mo 12 mo	FP significantly more FP less, not significant FP significantly less	Ad hoc (1 item)
Perceived importance of BSE	Aro et al., 2000 (34)	2 mo	FP more, not significant	Ad hoc (1 item)
Confidence in breast cancer prevention	Aro et al., 2000 (34)	12 mo 2 mo 12 mo	FP more, not significant FP less, not significant FP less, not significant	Ad hoc (1 item)
Perceived sensitivity of mammography	Bull and Campbell, 1991 (39)	6 wk	FP significantly more	Ad hoc (1 item)
Perceived benefits of mammography	Gram et al., 1990 (43)	18 mo	FP more, not significant	NR
Perceived benefits of screening	Lipkus et al., 2000 (49)	Varied	FP significantly more	Rakowski pros and cons scale (reference 57) (20 items)
Ambivalence about future mammograms	Lipkus et al., 2000 (49)	Varied	FP significantly more	Ad hoc (1 item)
Perceived benefits of mammography	Pisano et al., 1998 (15)	Varied	FP significantly more	NR
Perceived barriers to mammography	Pisano et al., 1998 (15)	Varied	FP less, not significant	NR
Perceived negative effect of mammography screening	Pisano et al., 1998 (15)	Varied	FP less, not significant	NR
Belief that annual mammography is necessary	Pisano et al., 1998 (15)	Varied	FP more, not significant	NR
Health care use and symptoms				
Frequency of outpatient care	Gram et al., 1990 (43)	18 mo	FP more, not significant	NR
Frequency of physiotherapy	Gram et al., 1990 (43)	18 mo	FP less, not significant	NR
Frequency of visits to general practitioner	Gram et al., 1990 (43)	18 mo	FP no effect	NR
Mental health professional use	Jatoi et al., 2006 (45)	Varied	FP significantly more	Ad hoc (1 item)
Clinical breast examination in past 12 mo	Lipkus et al., 2000 (49)	Varied	FP no effect	Ad hoc (1 item)
Good health habits	Aro et al., 2000 (34)	2 mo 12 mo	FP less, not significant FP no effect	Illness attitude scale (reference 58), subscale (2 items)
Symptoms in breasts	Aro et al., 2000 (34)	2 mo	FP significantly more	Ad hoc (1 item)
Symptom reports	Ellman et al., 1989 (42)	12 mo 3 mo	FP significantly more FP less, not significant	General Health Questionnaire (reference 59) (28 items), subscale
Symptom reports	Sandin et al., 2002 (54)	2 mo	FP more, not significant	SCL-90-R (reference 60), subscale
Symptom reports	Scaf-Klomp et al., 1997 (55)	8–10 wk 8 mo	FP more, not significant FP significantly more	SCL-90 (reference 61), somatization subscale
Effects of symptoms	Aro et al., 2000 (34)	2 mo 12 mo	FP less, not significant FP significantly less	Illness attitude scale (reference 58), subscale (3 items)
Impairment in daily activities because of worrying	Lerman et al., 1991 (31); Lerman et al., 1991 (48)	3 mo	FP significantly more	Ad hoc (1 item)
Believe breasts are healthy	Aro et al., 2000 (34)	2 mo	FP significantly less	Ad hoc (1 item)
Bodily preoccupation	Aro et al., 2000 (34)	12 mo 2 mo 12 mo	FP significantly less FP less, not significant FP less, not significant	Illness attitude scale (reference 58), subscale (4 items)
Well-being	Gram et al., 1990 (43)	18 mo	No effect (direction of null effect NR)	Ad hoc

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Appendix Table 2—**Continued**

Outcome	Study, Year (Reference)	Timing of Assessment after Screening	Finding and Statistical Significance†	Outcome Assessment
Psychological distress				
Generalized symptoms of distress related to past mammogram	Barton et al., 2004 (35)	3 mo	FP significantly more	Impact of Events Scale (reference 62)
Distress about breast cancer	Cockburn et al., 1994 (41)	8 mo	FP more on 3 subscales, not significant	Psychological Consequences Questionnaire (reference 63)
Symptoms of distress, summary score	Ellman et al., 1989 (42)	3 mo	FP less, not significant	General Health Questionnaire (reference 59) (28 items)
Symptoms of social dysfunction	Ellman et al., 1989 (42)	3 mo	FP less, not significant	General Health Questionnaire (reference 59) (28 items), subscale
Stress	Gram et al., 1990 (43)	18 mo	No effect (direction of null effect NR)	NR
Taking sleeping pills	Gram et al., 1990 (43)	18 mo	No effect (direction of null effect NR)	NR
Sleeplessness	Gram et al., 1990 (43)	18 mo	No effect (direction of null effect NR)	NR
Symptoms of distress about breast cancer	Olsson et al., 1999 (52)	6 mo	FP significantly more	Psychological Consequences Questionnaire (reference 64)
Generalized symptoms of distress	Ong et al., 1997 (38); Brett et al., 1998 (36); Brett and Austoker, 2001 (37)	1 mo 5 mo 3 y	FP significantly more FP significantly more FP significantly more	Psychological Consequences Questionnaire (reference 65)
Symptoms of distress about breast cancer	Meystre-Agustoni et al., 2001 (51)	8 wk after screening or negative result	FP significantly more	Psychological Consequences Questionnaire (reference 66)
Symptoms of global distress	Sandin et al., 2002 (54)	2 mo	FP less, not significant	SCL-90-R (reference 60)
Symptoms of obsessive–compulsion	Sandin et al., 2002 (54)	2 mo	FP significantly less	SCL-90-R (reference 60), subscale
Symptoms of anger	Sandin et al., 2002 (54)	2 mo	FP significantly less	SCL-90-R (reference 60), subscale
Symptoms of psychoticism	Sandin et al., 2002 (54)	2 mo	FP significantly more	SCL-90-R (reference 60), subscale
Symptoms of paranoia	Sandin et al., 2002 (54)	2 mo	FP more, not significant	SCL-90-R (reference 60), subscale
Symptoms of interpersonal sensitivity	Sandin et al., 2002 (54)	2 mo	FP less, not significant	SCL-90-R (reference 60), subscale
Symptoms of distress	Scaf-Klomp et al., 1997 (55)	8–10 wk 8 mo	FP less, not significant FP significantly less	General Health Questionnaire (reference 59)
Loss of appetite	Scaf-Klomp et al., 1997 (55)	8–10 wk	FP significantly more	Ad hoc (1 item)
Sleep disturbances	Scaf-Klomp et al., 1997 (55)	8 mo 8-10 wk 8 mo	FP more, not significant FP significantly more FP more, not significant	Ad hoc (1 item)
Anxiety				
Generalized symptoms of anxiety	Aro et al., 2000 (34)	2 mo 12 mo	FP more, not significant FP significantly less	State Trait Anxiety Inventory (67) (20 items)
Generalized symptoms of anxiety	Barton et al., 2004 (35)	3 mo	FP more, not significant	HSCL (reference 68), subscale
Generalized symptoms of anxiety	Bull and Campbell, 1991 (39)	6 wk	FP less, not significant	Hospital Anxiety and Depression Scale (reference 69), subscale (7 items)
Generalized symptoms of anxiety	Ellman et al., 1989 (42)	3 mo	FP more, not significant	General Health Questionnaire (reference 59) (28 items)
Anxiety about breast cancer	Gram et al., 1990 (43)	6 mo 18 mo	FP significantly more FP significantly more	NR
Generalized feelings of nervousness, restlessness	Jatoi et al., 2006 (45)	Varied	FP significantly more	K6 Questionnaire (reference 70) (2 of 6 items)
Generalized symptoms of anxiety	Lampic et al., 2001 (46); Lampic et al., 2003 (47)	3 mo 12 mo	FP less, not significant FP less, not significant	Hospital Anxiety and Depression Scale (reference 69), subscale
Anxiety about future mammograms	Lampic et al., 2001 (46); Lampic et al., 2003 (47)	24 mo	FP significantly more	Ad hoc (11 item)
Anxiety about future mammograms	Lerman et al., 1991 (31); Lerman et al., 1991 (48)	3 mo	FP significantly more	Ad hoc (1 item)
Anxiety about breast cancer	Meystre-Augustoni et al., 2001 (51)	8 wk	FP significantly more	Ad hoc (1 item)
Generalized symptoms of anxiety	Sandin et al., 2002 (54)	2 mo	FP more, not significant	SCL-90-R (reference 60), subscale
Phobic anxiety	Sandin et al., 2002 (54)	2 mo	FP less, not significant	SCL-90-R (reference 60), subscale
Generalized symptoms of anxiety	Scaf-Klomp et al., 1997 (55)	8–10 wk 8 mo	FP significantly more FP more, not significant	Hospital Anxiety and Depression Scale (reference 69), subscale

Appendix Table 2—**Continued**

Outcome	Study, Year (Reference)	Timing of Assessment after Screening	Finding and Statistical Significance†	Outcome Assessment
Worry, intrusive thoughts, fear, and perceived risk				
Worry about illness	Aro et al., 2000 (34)	2 mo 12 mo	FP more, not significant FP more, not significant	Illness Attitudes Scale (reference 58), subscale (4 items)
Worry about breast cancer	Aro et al., 2000 (34)	2 mo 12 mo	FP significantly more FP significantly more	Ad hoc (1 item)
Worry	Gram et al., 1990 (43)	18 mo	No effect (direction of null effect NR)	NR
Worry about breast cancer	Lerman et al., 1991 (31); Lerman et al., 1991 (48)	3 mo	FP significantly more	Ad hoc (1 item)
Worry about breast cancer	Lipkus et al., 2000 (49)	Varied	FP significantly more	Ad hoc (2 items)
Worry about breast cancer	Sandin et al., 2002 (54)	2 mo	FP significantly more	Ad hoc (1 item)
Worry about breast cancer	Scaf-Klomp et al., 1997 (55)	8–10 wk 8 mo	FP significantly more FP significantly more	Ad hoc (1 item)
Intrusive thoughts	Aro et al., 2000 (34)	2 mo 12 mo	FP significantly more FP significantly more	Ad hoc (1 item)
Increased concerns about breast cancer	Lerman et al., 1991 (31); Lerman et al., 1991 (48)	3 mo	FP significantly more	Ad hoc (1 item)
Fear of breast cancer	Sandin et al., 2002 (54)	2 mo	FP significantly more	Ad hoc (1 item)
Fear of cancer	Scaf-Klomp et al., 1997 (55)	8–10 wk 8 mo	FP significantly more FP significantly more	Ad hoc (8 item)
Fear of death	Aro et al., 2000 (34)	2 mo 12 mo	FP less, not significant FP less, not significant	Illness attitude scale (reference 58), subscale (3 items)
Fear of illness	Aro et al., 2000 (34)	2 mo 12 mo	FP more, not significant FP more, not significant	Illness attitude scale (reference 58), subscale (6 items)
Perceived risk for breast cancer	Aro et al., 2000 (34)	12 mo	FP significantly more	Ad hoc (1 item)
Perceived likelihood of breast cancer	Aro et al., 2000 (34)	12 mo	FP significantly more	Ad hoc (5 items)
Perceived likelihood of breast cancer	Lipkus et al., 2000 (49)	Varied	FP significantly more	Ad hoc (2 items)
Perceived likelihood of breast cancer	Pisano et al., 1998 (15)	Varied	FP significantly more	NR
Perceived likelihood of breast cancer	Sandin et al., 2002 (54)	2 mo	FP more, not significant	Ad hoc (1 item)
Perceived severity of breast cancer	Aro et al., 2000 (34)	12 mo	FP less, not significant	Ad hoc (6 items)
Perceived severity of breast cancer	Pisano et al., 1998 (15)	Varied	FP less, not significant	NR
Depression				
Generalized symptoms of depression	Aro et al., 2000 (34)	2 mo 12 mo	FP more, not significant FP more, not significant	Beck Depression Inventory (reference 71) (21 items)
Generalized symptoms of depression	Barton et al., 2004 (35)	3 mo	FP more, not significant	HSCL (reference 68), subscale
Generalized symptoms of depression	Bull and Campbell, 1991 (39)	6 wk	FP more, not significant	Hospital Anxiety and Depression Scale (reference 69), subscale (7 items)
Generalized symptoms of depression	Ellman et al., 1989 (42)	3 mo	No effect	General Health Questionnaire (reference 59) (28 items), subscale
Generalized feelings of sadness, worthlessness, everything being an effort	Jatoi et al., 2006 (45)	Varied	FP significantly more	K6 Questionnaire (reference 70) (3 of 6 items)
Generalized feelings of hopelessness	Jatoi et al., 2006 (45)	Varied	FP more, not significant	K6 Questionnaire (reference 70) (1 of 6 items)
Generalized symptoms of depression	Lampic et al., 2001 (46); Lampic et al., 2003 (47)	3 mo 12 mo	FP significantly less FP significantly less	Hospital Anxiety and Depression Scale (reference 69), subscale
Generalized symptoms of depression	Lipkus et al., 2000 (49)	Varied	No effect (direction of effect NR)	Center for Epidemiologic Studies Depression Scale, short form (reference 72)
Generalized symptoms of depression	Sandin et al., 2002 (54)	2 mo	FP less, not significant	SCL-90-R (reference 60), subscale
Generalized symptoms of depression	Scaf-Klomp et al., 1997 (55)	8–10 wk 8 mo	FP more, not significant FP more, not significant	Hospital Anxiety and Depression Scale (reference 69), subscale

* All variables assessed by self-report. BSE = breast self-examination; FP = false-positive mammogram; HSCL = Hopkins Symptoms Checklist; K6 = Kessler 6; SCL-90 = Symptoms Checklist-90; SCL-90-R = Symptoms Checklist-90-Revised.
† The term "significant" refers to statistical significance ($P < 0.05$, 2-tailed test) of the bivariate relationship of receiving a false-positive mammogram to the outcome. Although we report the direction of results that do not reach statistical significance to allow the possibility of detecting trends in the data, the text of the paper summarizes the studies as finding an increase or decrease only when the effects are statistically significant.