Interventions Targeted toward Patients to Increase Mammography Use[1]

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Abstract

The objective of this study was to determine the effects of patient-based mammography screening strategies. We performed a meta-analysis and included United States studies that met the following criteria: (*a*) randomized or concurrent control design; (*b*) defined outcomes; and (*c*) data available for reanalysis. Interventions were classified as behavioral, cognitive, or sociological and further categorized by the type of control group (active *versus* usual care), number of interventions, and mode of intervention (interactive *versus* static). Data were combined using DerSimonian and Laird random effects models to yield summary effect sizes. A total of 63 interventions in 43 studies met the inclusion criteria. Behavioral interventions increased screening by 13.2% [95% confidence interval (CI), 4.7–21.2] compared with usual care, and by 13.0% (95% CI, 8.7–17.4) when using multiple strategies and 5.6% (95% CI, 0.6–10.6) when using a single intervention compared to active controls. Cognitive interventions using generic education strategies had little impact on screening, but those that used theory-based education (*e.g.*, health belief model) increased rates by 23.6% (95% CI, 16.4–30.1) compared with usual care. Sociological interventions also increased screening rates. Interventions using a theoretical framework were the most effective in increasing screening rates. The ability of these interventions to increase screening among subgroups and improve rates of ongoing screening, as well as the costs of these strategies, is unknown and is an important area for future research.

Introduction

Despite evidence that regular mammography screening can reduce breast cancer mortality (1–3), many women fail to receive mammography or adhere to recommended guidelines for routine ongoing screening. In the United States, women who do not receive regular mammography are more likely to be elderly (4–10), uninsured or underinsured (10, 11), lack a usual source of care (12–15), have lower levels of education or income (10, 16–19), be non-white, (12, 13, 20–24), be non-native English speakers (25), or have low levels of literacy (12, 26, 27).

When asked why they do not receive screening, women report that breast cancer screening tests are unnecessary in the absence of symptoms (22, 28), that they do not believe themselves to be at risk of cancer (29), or that they are concerned about inconvenience, discomfort, trouble, embarrassment, or pain (27, 30). Culturally mediated concerns about modesty or dignity as well as fatalistic attitudes toward cancer may also prevent women from seeking screening (31, 32). Lower rates of mammography utilization may also result from practical considerations; in rural areas or areas that lack mammography facilities, women are less likely to receive screening (33–35). Although one of the strongest predictors of mammography screening is physician recommendation (12, 28), compliance with such a recommendation may be complicated by distrust of the medical profession in some patient populations (12, 28).

During the past two decades, numerous studies have described interventions developed to address the aforementioned patient barriers to screening (36). However, because of the large number of different interventions, numerous mechanisms of intervention action, variability in study design, and, in some cases, small sample size, it is difficult to develop a cohesive public health approach to improving screening use, particularly in high-risk populations. In this study, we perform a critical review of well-designed patient-targeted interventions designed to increase adherence with mammography. We estimate overall effect sizes for specific types of interventions to determine the most effective strategies.

Materials and Methods

Study Selection. We used the OVID search mechanism with MEDLINE in the years 1980–1998 to identify published English language articles on interventions to increase mammography utilization. The search strategy was as follows: we used the terms "mammography" or "breast neoplasms/prevention and control" ($n = 7{,}074$) to identify the subset of studies focused on mammography screening. We then developed a series of terms to identify settings in which interventions could take place (*e.g.*, "primary health care," "gynecology," and "family physicians") and used the terms "health education," "health behavior," "patient compliance," "patient acceptance of health care," "attitude to health," or "health promotion" ($n = 144{,}660$).

The combination of these searches yielded 600 studies. Study abstracts were reviewed for evidence of prospective follow-up with either randomized assignment to an intervention or control group or a concurrent control group. Pre/post designs without controls and uncontrolled trials were excluded. Increasing rates of mammography use in the general population over

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the past two decades (37) complicate the interpretation of studies without prospective control groups. Any observed increase in mammography use might be attributable to the secular trend rather than the intervention under evaluation. Published abstracts were also excluded because they were judged to have too brief a description of methods for assessment.

Forty-eight patient-targeted studies met these criteria; four of these studies were subsequently eliminated because they lacked concurrent control groups (38–41), and three other studies were eliminated because the intervention was not described in sufficient detail for classification (42–44). This left 41 studies identified from the literature search. Reference lists of the selected studies were also searched to identify other eligible studies, and a hand search of the Journal of General Internal Medicine, Medical Care, Preventive Medicine, Annals of Internal Medicine, Archives of Internal Medicine, and Cancer Epidemiology, Biomarkers and Prevention was conducted for June-August 1998. Ten additional studies were thus identified, yielding a total of 51 studies, 43 of which were performed in the United States. Studies performed outside the United States were excluded because underlying differences in health care systems might limit their generalizability (45–52). Interventions performed in populations of women selected at the receipt of mammography (intervention to increase repeat screening) are included in the data tables (53–55) but were excluded from quantitative analyses.

Data Abstraction. We classified interventions as cognitive, behavioral, or sociological (56). Cognitive strategies provide new information and education, increase existing knowledge, and clarify misperceptions. Behavioral interventions alter cues or stimuli associated with screening behavior; and sociological interventions use social norms or peers to increase screening adherence. Interventions were further classified by the type of control group used, active control and usual care control. Active control groups included a lower level of an intervention, such as generic educational material describing population risk of breast cancer, mailed and telephone reminders, flow sheets in patient charts, and videotaped education. We defined usual care controls as situations in which no intervention associated with mammography utilization was performed. In settings where usual care included routine reminders or flow sheets in patient charts, these interventions were classified as having an active control group.

Within groups of interventions classified by category and type of control group, where a sufficient number of interventions were available, we further classified interventions by the number of strategies (single *versus* multiple) and mode of delivery (*e.g.*, interactive delivery of intervention via telephone or in-person *versus* static delivery of intervention through letters or videotapes).

Data were abstracted from studies using a standardized abstraction format to describe the type of intervention, characteristics of mammography outcome determination (self-report, medical charts, electronic records, or medical claims), the patient population, and intervention effectiveness. Studies with multiple, separate interventions had these data abstracted when possible. Additionally, for studies with multiple assessment points over time, the first assessment was abstracted and used in the combined analysis.

Data Analysis. Effect sizes and 95% CIs[3] were calculated for each intervention. For randomized studies, intervention effectiveness was calculated as the difference in mammography utilization between the intervention and control group at the end of the study. Variance was calculated using the following formula.

$$(P_{\text{screened intervention}} \times P_{\text{unscreened intervention}})/N_{\text{intervention}} + (P_{\text{screened control}} \times P_{\text{unscreened control}})/N_{\text{control}}$$

For concurrently controlled studies, the effect size was calculated as the difference between the rates post- and preintervention for the intervention group and the control group. The variance was calculated using the following formula.

$$(\mathrm{P}_{\text{screened preintervention}} \times P_{\text{unscreened preintervention}})/N_{\text{preintervention}} + (P_{\text{screened postintervention}} \times P_{\text{unscreened postintervention}})/N_{\text{postintervention}} + (P_{\text{screened precontrol}} \times P_{\text{unscreened precontrol}})/N_{\text{precontrol}} + (P_{\text{screened postcontrol}} \times P_{\text{unscreened postcontrol}})/N_{\text{post control}}$$

Among groups of interventions, these effect sizes and 95% CIs were graphed and inspected visually for homogeneity. Formal tests of homogeneity, the DerSimonian and Laird Q-statistic (57), were performed for interventions grouped by mechanism of action (behavioral, cognitive, or sociological), the type of control group, and the mode of intervention delivery. This statistic compares the summary effect measure and the within-study effect measure. It was compared against a χ^2 distribution with a null hypothesis of homogeneity. Meta-Analyst software (58) was used to calculate the combined effect size using random effects models. These models incorporate deviation due to statistical error as well as that due to any underlying differences in study population or other factors specific to individual studies. DerSimonian and Laird random effects summary statistics and 95% CIs (57) are reported separately for different types of interventions. To test the influence of a single intervention on the summarized results, we performed sensitivity analysis by sequentially dropping each intervention and recalculating the summary statistics.

Results

Among the 43 patient-targeted studies in the final study sample, there were 63 distinct interventions to increase mammography utilization: (*a*) 27 behavioral interventions; (*b*) 21 cognitive interventions; and (*c*) 9 sociological interventions; and (*d*) 5 interventions that used both cognitive and behavioral strategies (Table 1; Refs. 53–55 and 59–98). Mammography outcomes were assessed most frequently by self-report (49%), followed by medical chart audit, medical claims or electronic records, and radiology facility reports. The majority of the study populations were composed of white women and women ages 50 years and over. In the studies that reported previous mammography use, the most frequent rates of ever having previous mammography were between 26% and 50%.

Behavioral Interventions. Patient-targeted behavioral interventions are listed in Table 2 (53–55, 59–63, 65–71, 97–98) and include telephone reminders (61, 63) and letters from clinical program directors or primary care clinicians (49, 55, 59, 61, 63, 66, 67). A total of 40% used usual care comparison groups, and 60% had active comparison groups.

Overall, in six interventions with a usual care control (54, 59, 61–63), 13.2% more women received mammography after receiving a behavioral intervention than women getting usual care (95% CI, 4.7–21.2). The high Q-statistic (19.3) and the wide CI indicate that these studies are heterogeneous. Sensi-

[3] The abbreviation used is: CI, confidence interval.

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Table 1 Intervention characteristics

	No.	Percentage (%)	Reference no.
Behavioral intervention	11	17.5	53, 54, 59–63
Usual care			
Active control	16	25.4	54, 55, 64–71, 97
Cognitive intervention			
Generic education	7	11.1	72–77
Theory-based education			
Usual care control	4	63	75, 88
Active control	10	15.9	67, 68, 70, 74, 86, 87, 89, 90, 97
Sociological intervention	9	14.3	77–85, 91
Financial incentives	2	3.2	92 and 93
Behavioral and cognitive intervention	4	6.3	70, 94–97
Total interventions	63	100.0	
No. of intervention modalities			
Single	15	34.9	53, 54, 60, 63, 76, 78, 79, 82, 87, 89, 93, 95; 64, 84, 85
Multiple	28	65.1	46, 55, 59, 61–63, 65–70, 98; 72–75, 77, 80, 83, 86, 88, 90–92, 94, 97; 96
Study design			
Randomized controlled trial	40	93.0	45, 53, 54, 61, 62, 65–70, 74, 95; 75–78, 80, 84, 87, 89, 90, 92, 93 48, 63, 72, 79, 83, 85, 86, 88, 96–98; 55, 59, 64, 94
Concurrently controlled trials	3	7	60, 73, 91
Mammography utilization			
Self-report	21	48.8	53, 67, 70, 73, 75, 76, 86–90, 93, 94, 97
Chart audit	9	20.9	78, 79, 82, 84, 85, 91, 92 53, 60, 61, 65, 72, 83, 84, 93, 95
Claims/eletronic record	8	18.6	52, 55, 62, 63, 66, 69, 74, 77, 80
Mammography facility report/record	4	9.3	46, 50, 51, 54, 59, 68, 80
Mammography appointment	1	2.3	98
Patient age group (yrs)[a]			
<40	5	11.6	55, 71, 73, 75, 79, 88
40–49	20	46.5	53, 55, 60, 62, 63, 72, 75–77, 86–88, 90 71, 79, 82, 84, 85, 89, 91
50–59	31	72.1	53–55, 60, 61, 63, 65–70, 95; 72, 74–77, 86–88, 90 48, 64, 67, 71, 79, 82, 83, 85, 91, 92
>60	26	60.5	52, 53, 55, 59, 60, 63, 65–67, 69, 70, 95, 97 72, 75–77, 79, 80, 83, 85, 88, 90, 91, 93, 94 71
Not stated	1	2.3	98
Patient race[a]			
≥20% Black	9	20.9	62, 64, 65, 77, 79, 82, 83, 93, 97, 98
≥20% Hispanic	2	2.3	85 and 91
≥20% White	22	51.2	59, 61, 63, 64, 67, 72, 73, 75–77, 88, 94, 97 71, 79, 80, 83, 84, 86, 87, 89, 90, 92, 96
≥20% Asian	1	2.3	71
Not stated	14	32.6	53–55, 60, 66, 68, 69, 74, 78, 95 70
Percentage with health insurance[a]			
<50%	3	7.0	68, 85, 91
50–74%	2	4.7	59, 65
75–99%	7	16.3	61, 72, 83, 84, 87, 92, 97
100%	11	25.6	62, 63, 66, 67, 69, 70, 73, 74, 93–95
Not stated	20	46.5	53–55, 60, 75–78, 86, 88–90, 99; 64, 79, 80, 96
Percentage with previous mammography			
0–25%	4	9.3	65, 74, 83, 91
26–50%	12	27.9	50, 60, 66, 72, 73, 82, 84, 85, 87, 88, 93, 94, 96
51–75%	6	14.0	73, 76, 78, 80, 93, 97
76–99%	3	7.0	62, 79
100%	3	7.0	53–55
Not stated	15	34.9	46, 49, 59, 61, 63, 67–70, 75, 90, 95, 98; 64, 71, 77, 86, 89, 92

[a] Values may not add up to 100% because some interventions fall into more than one category.

tivity analyses with sequential removal of each intervention did not change this estimate, indicating that heterogeneity was not associated with a single study.

When the seven behavioral interventions using active controls and a single intervention strategy (64–66, 68, 98) were combined, the null hypothesis of homogeneity was rejected (Q = 33.3). The heterogeneity was associated with a single study (65), and when it was removed, the combined studies were considered homogeneous (Q = 14.3). The overall rate of mammography was 5.5% higher for women receiving behavioral interventions compared with active controls (95% CI, 0.6 to 10.6). Sensitivity analyses with sequential removal of each intervention did little to

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Table 2 Patient-targeted behavioral interventions

	Reference no.	Study setting	Sample size		Percentage of women screened		Effect	95% CI
			Intervention	Control	Intervention	Control		
Usual care controls	59[a]	Community	41	43	6 (15%)	2 (5%)	10	(−2.7–22.7)
	60[a]	University	NE[c]	NE	Pre, 40.9%	Pre, 37.3%	7.5	NE
					Post, 57%	Post, 46%		
	53[b,d]	Community	44	48	32 (72.7%)	17 (35.6%)	37.1	(18.2–56.0)
	53[b,d]	Community	43	48	31 (72.1%)	17 (35.6%)	36.5	(17.4–55.6)
	53[b,d]	Community	43	48	19 (44.2%)	17 (35.6%)	8.6	(−11.5–28.7)
	54[b,d]	Community	32	31	15 (47%)	6 (19%)	28	(5.9–50.1)
	61[b]	Community	38	38	7 (18%)	4 (11%)	7	(−8.8–22.8)
	61[b]	Community	38	38	11 (29%)	4 (11%)	18	(0.5–35.5)
	61[b]	Community	37	38	16 (43%)	4 (11%)	32	(13.2–50.8)
	62[b]	Community	388	381	106 (27.4%)	97 (25.4%)	1.6	(−4.6–7.8)
	63[b]	Community	337	322	88 (26%)	28 (8.7%)	17.3	(11.7–22.9)
Summary	Q = 19.3						13.2	(4.7–21.2)
Active controls, single intervention	98[b]	University	98	130	18 (18%)	25 (19%)	−1	(−11.2–9.2)
	65[b,e]	Community	329	266	56 (21.0%)	73 (27.4%)	−6	(−13.3–0.5)
	55[a,d]	Community	50	50	20 (40%)	17 (34%)	6	(−12.9–24.8)
	55[a]	Community	50	50	27 (54%)	17 (34%)	20	(0.9–39.1)
	66[b]	Community	329	329	150 (45.6%)	154 (46.8%)	−1.2	(−8.8–6.4)
	66[b]	Community	335	329	196 (58.5%)	154 (46.8%)	11.7	(4.5–18.9)
	67[b]	Community	381	364	159 (42%)	100 (28%)	14	(7.9–20.1)
	67[b]	Community	198	198	28 (14%)	23 (12%)	2	(−6.6–8.6)
	68[b]	Community	384	424	306 (79.7%)	316 (74.5%)	5.2	(−.5–11.0)
Summary	Q = 14.3						5.6	(0.6–10.6)
Active controls multiple	71[b]	Community	343	344	250 (73%)	186 (54%)	19	(12.1–26.1)
	66[b]	Community	334	329	206 (61.7%)	154 (46.8%)	14.9	(7.4–22.4)
	54[b,d]	Community	96	91	31 (32%)	33 (36%)	−4	(−17.6–9.6)
	54[b,d]	Community	92	92	44 (48%)	41 (44%)	4	−10.0–18.4)
	69[b]	Community	1171	1171	310 (26.5%)	187 (16.0%)	10.5	(7.2–13.8)
	97[b]	Community	95	122	20 (21%)	16 (13%)	8.0	(−2.1–18.1)
Summary	Q = 5.6						13.0	(8.6–17.4)

[a] Concurrent control group.
[b] Random control group.
[c] NE, not evaluable; Pre, preintervention; Post, postintervention.
[d] Intervention was performed in a population of women enrolled at receipt of mammography (intervention to increase repeat screening) and excluded from quantitative analysis.
[e] Excluded from quantitative analysis.

affect the size of the summary estimate, but did impact the statistical significance.

The combination of six behavioral, multiple-part interventions with active controls was homogeneous (Q = 5.6; Refs. 54, 66, 67, 69, 71, and 97). The combined estimate for increased mammography utilization was 13.0% (95% CI, 8.6–17.4).

Cognitive Interventions. Interventions based on theories of cognitive change typically identify patient attitudes to screening and breast cancer and provide focused educational material directed at increasing compliance with mammography. For example, under the health belief model, a woman is likely to undergo screening mammography if she believes that she is susceptible to breast cancer (perceived susceptibility), that consequences of breast cancer are severe (perceived severity), that mammography has benefits in terms of reducing the impact of breast cancer (perceived benefits), and that barriers associated with receiving a mammography are low (perceived barriers; Ref. 100).

Based on differences in the approach of the cognitive interventions, we further classified cognitive strategies into generic patient education listed in Table 3 (72–77) and theory-based education listed in Table 4 (67, 68, 70, 74, 75, 86–90, 97).

There were seven interventions that compared generic patient education strategies to usual care. These interventions were homogeneous (Q = 7.3), and although several led to an increase in mammography screening (72, 73, 75, 76, 77), overall, this effect was small (1.1%) and was not significant (95% CI, −2.4 to 4.6). Sensitivity analyses did not affect this interpretation.

We divided theory-based cognitive interventions into two groups based on the type of comparison group. Interventions that used usual care controls were homogeneous (Q = 4.1), and compared with usual care, theory-based cognitive interventions appear to be very effective in increasing the rate of mammography utilization: overall, 23.6% more women received mammography (95% CI, 16.4–30.1; Refs. 75, 88).

We divided theory-based cognitive interventions with active controls into those that were static [delivered by letter or videotape (74, 86, 87, 89)], and those that were interactive [delivered by telephone or in person (67, 68, 70, 90, 97)]. The interventions delivered by letter or videotape were homogene-

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Table 3 Patient-targeted cognitive interventions—generic patient education

Intervention used performance score to describe screening.

Reference no.	Study setting	Sample size		Percentage of women screened		Effect	95% CI
		Intervention	Control	Intervention	Control		
72[a]	University	216	216	104 (48.1%)	97 (44.9%)	3	(−6.4–12.4)
73[b]	Worksite	384	379	Pre, 46.9%[c] Post, 62.0%	Pre, 52.8% Post, 63%	4.9	(−4.9–14.7)
74[a]	Community	447	440	110 (24.6%)	121 (27.5%)	−2.9	(−8.7–2.9)
74[a]	Community	595	440	161 (27.1%)	121 (27.5%)	−0.4	(−5.9–5.1)
75[a]	Community	75	78	55 (73%)	48 (62%)	11	(−3.7–0.26)
76[a]	Community	NE	NE	44%	31%	13	NE
77[a]	University	143	144	26 (18%)	31 (21%)	−3	(−12.2–6.2)
Summary	Q = 7.3					1.1	(−2.4–4.6)

[a] Random control group.
[b] Concurrent control group.
[c] Pre, preintervention; Post, postintervention; NE, not evaluable.

Table 4 Patient-targeted cognitive interventions—theory-based patient education

	Reference no.	Study setting	Sample size		Percentage of women screened		Effect	95% CI
			Intervention	Control	Intervention	Control		
Usual care controls	75[a]	Community	74	78	53 (72%)	48 (62%)	10	(−4.9–24.8)
	75[a]	Community	73	78	64 (87%)	48 (62%)	25	(11.8–38.0)
	88[a]	Community	141	122	53 (37.6%)	21 (17.2%)	20.4	(10.0–30.8)
	88[a]	Community	107	122	78 (29.5%)	21 (17.2%)	22.8	(18.7–26.9)
Summary	Q = 4.1						23.6	(16.4–30.1)
Active controls-static intervention	74[a]	Community	594	440	162 (27.3%)	121 (27.5%)	−0.2	(−5.7–5.3)
	86[a]	Community	90	63	59 (65.9%)	35 (55.2%)	10.7	(−15.7–26.4)
	86[a]	Community	44	63	25 (57.1%)	35 (55.2%)	1.9	(−19.1–21.0)
	87[a]	Community	401	401	201 (50%)	225 (56%)	−6	(−12.9–0.9)
	89[a]	Community	68	65	31 (45.3%)	22 (33.8%)	11.5	(−5.0–28.0)
Summary	Q = 6.3						0.4	(−5.4–6.2)
Active controls-interactive intervention	90[a]	Community	870	961	567 (65.2%)	608 (63.3%)	1.9	(−2.5–6.3)
	67[a]	Community	202	198	57 (28%)	23 (12%)	16	(8.3–23.7)
	68[a]	Community	264	424	212 (80.3%)	316 (74.5%)	5.8	(−1.0–12.6)
	70[a]	Community	132	131	37 (28%)	20 (15%)	13	(3.2–22.8)
	97[a]	Community	115	122	21 (18%)	16 (13%)	5.0	(−4.2–14.2)
Summary	Q = 13.0						7.9	(2.3–13.5)

[a] Random control group.

ous (Q = 6.3) but were ineffective, with an estimated increase in mammography utilization of less than 1% (0.4; 95% CI, -5.4 to 6.2). However, theory-based cognitive interventions delivered interactively were effective, with a combined increase in mammography utilization of 7.9% (95% CI, 2.3–13.5). Sensitivity analyses did not change the interpretation of either of these estimates (see Table 4).

Sociological Interventions. We identified nine sociological interventions to increase mammography screening (Refs. 77–80, 82–85, and 91; Table 5). These patient-targeted sociological interventions used community peers (78, 83, 91), friends (80), lay health advisors (82, 84, 85), or media representations (91) of appropriate behavior to influence screening behaviors. The studies that used interactive sociological interventions were relatively homogeneous (Q = 19.8; Refs. 77–80 and 82–85) and improved mammography utilization by 12.6% (95% CI, 7.4–17.9). Sensitivity analyses had little impact on this result.

We found two patient-targeted interventions that used financial incentives to try to increase mammography utilization (92, 93). Both led to increases in mammography utilization, but we could not perform meta-analysis with two interventions.

We also identified five interventions (70, 94–97) that used both behavioral and cognitive strategies to increase mammography utilization. These interventions had variable effectiveness, ranging from little effect (70, 95, 97) to a maximum effect of 33% (94).

Discussion

In our meta-analyses of patient-targeted interventions to increase mammography utilization, we found that most interven-

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Table 5 Patient-targeted sociological interventions

Reference no.	Study setting	Sample size		Percentage of women screened		Effect	95% CI
		Intervention	Control	Intervention	Control		
78[a]	Community	370	242	144 (39%)	73 (30%)	9	(1.4–16.6)
79[a]	Community	289	302	142 (49%)	103 (34%)	15	(7.1–22.7)
80[a]	Community	223	237	85 (38%)	37 (16%)	22	(14.1–29.9)
91[b,d]	Community	Pre, 450[c]	Pre, 473	Pre, 21.4%	Pre, 24.1%	−3.5	(−7.4–0.4)
		Post, 450	Post, 473	Post, 38.1%	Post, 43.3%		
82[a]	Community	80	94	47 (58.7%)	45 (47.9%)	10.9	(−3.9–25.7)
83[a]	Community	165	173	64 (39%)	33 (19%)	20.0	(10.5–29.5)
77[a]	University	151	147	44 (29%)	31 (21%)	8.0	(−1.8–17.8)
84[a]	Community	772	711	295 (37%)	357 (42%)	−5.0	(−9.9–−0.1)
85[a]	Community	56	57	32 (56.4%)	25 (43.6%)	12.8	(−5.5–31.1)
Summary	Q = 19.8					12.6	(7.4–17.9)

[a] Random control group.
[b] Concurrent control group.
[c] Pre, preintervention; Post, postintervention.
[d] Excluded from quantitative analysis.

tions increased rates of screening. Behavioral interventions increased screening by 13.2% (95% CI, 4.7–21.2) compared with usual care, by 13.0% (95% CI, 8.6–17.4) when using multiple strategies, and by 5.6% (95% CI, 0.6–10.6) when using a single intervention compared with active controls. Cognitive interventions using generic education strategies had little impact on screening, but those that used theory-based education (*e.g.,* health belief model) increased screening rates by 23.6% (95% CI, 16.4–30.1) compared with usual care. Sociological interventions also increased screening rates.

The mode of intervention delivery appears to be an important component in increasing rates of mammography utilization. In particular, multiple behavioral interventions (*e.g.,* two reminder letters) led to improved rates of mammography utilization compared with active controls, but a single behavioral intervention had a minimal effect when compared with active controls. Similarly, theory-based cognitive interventions delivered interactively via telephone or in person led to improved rates of mammography screening compared with active controls, whereas theory-based cognitive interventions delivered through letter or videotape had little impact on mammography utilization compared to active controls. The combined sociological interventions, also delivered interactively, were very effective.

These results have important public health implications for the design and delivery of interventions to increase mammography screening. Recent national estimates indicate that 56% of women over the age of 50 years have received a screening mammogram within the past 2 years (10). With the use of theory-based behavioral interventions, this number could be increased to 73–86%, with a resultant down-staging of disease and an improvement in morbidity and mortality.

Similar to our findings, in a recent review of mailed patient reminders, Wagner (100) reported that these interventions led to increased mammography utilization when compared with no intervention or a generic letter.

The results of our meta-analyses were relatively robust. By sequentially removing each study, we could determine the independent impact of a single study on overall results. In no case did the removal of a single study have a large impact on the summarized estimate, and the interpretation of the effect changed only once.

All of the interventions reviewed here included control groups of similar women and were grouped according to mechanism of intervention action. However, there are important differences in the women enrolled in the different types of interventions, which may affect the interpretation and comparison of these results. For example, most of the patients included in the behavioral interventions had health insurance or at least a usual source of care from which a list of potentially eligible patients could be developed (61, 62, 66, 67, 69, 70). Additionally, some studies included populations of women with high rates of previous mammography (62, 79), yet many of the patients included in the sociological interventions did not have health insurance (85, 91) or had low rates of previous mammography (82–84, 91). These health care utilization characteristics, which are associated with mammography utilization in cross-sectional studies (10–13, 15), may also affect patient responsiveness to interventions to increase screening. Thus, comparisons among interventions and adaptation of interventions to dissimilar populations should be approached cautiously. Planning of new interventions should consider existing strategies in the target population, population characteristics, and available resources for intervention delivery.

There are some methodological limitations with the meta-analysis reported here, including heterogeneity among studies that were combined, inconsistencies in the unit of analysis used to calculate intervention effectiveness, reporting of multiple interventions per study with a single control group, and the combination of multiple measures of mammography utilization. We combined data from studies conducted in dissimilar populations or environments in which mammography screening is obtained and attempted to make the groups of interventions as homogeneous as possible, yet in several cases, our measures of homogeneity were high, causing us to reject the null hypothesis that interventions were homogenous. However, sensitivity analyses for these groups indicated that there was no one study that was influencing the results. Overall, combining heterogenous studies will produce a summary estimate that is biased toward no effect.

The majority of studies we identified randomized individual women to receive either the intervention or control condition. However, some studies randomized women by physician or practice group (63, 72, 83, 98) or retirement communities (94, 97). Additionally, related individuals, such as friends of volunteers (79), or women's groups (88) were used as a source

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of subjects, and peer counselors delivered interventions to multiple women (80, 82–85). Yet these data are combined as if randomization occurred individually and all observations are independent. Women treated by the same physician, living in the same retirement community, or who received tailored interventions from the same peer counselor are likely to be more similar in terms of mammography utilization than those recruited from a random sample or those that received a standardized intervention. If analyses were to incorporate the actual unit of analysis (*e.g.,* practice group, retirement community) or correlation among individuals, CIs would be wider, but the estimate of intervention effectiveness would remain unchanged.

The impact of including data from multiple interventions that used a single control group in our summarized estimates is also likely to result in an overstatement of intervention effectiveness via narrower CIs.

The studies included here used several mechanisms to identify mammography utilization: (*a*) self-report; (*b*) chart audit; (*c*) electronic claims; and (*d*) mammography facility records. We considered the validity of these different sources to be equivalent, although this is not necessarily the case. Self-report of mammography has been described as highly correlated with mammography use reported in patient charts or claims, but it is likely to overstate utilization (101, 102), particularly among low-income minority populations (103). However, women in intervention and control groups might be equally likely to overstate mammography utilization, so the relative estimate of mammography utilization (intervention *versus* control) is unlikely to be influenced by the reporting source.

There are some more general limitations that affect the interpretation of the meta-analyses presented here. The studies identified and included were based on a review of the published literature. Studies with negative or null findings might be less likely to be published and thus less likely to be included in this review. This would result in an overstatement of the effectiveness of interventions to improve rates of mammography screening.

Finally, improvements in mammography utilization at a single point in time as described in the studies here do not translate directly into reductions in morbidity and mortality from breast cancer. Even if women do receive regular screening, it is possible that as a result of delays in follow-up after an abnormal test result, incomplete diagnostic work-up, or the lack of adherence to a treatment regimen, a reduction in morbidity and mortality may not be realized. Additionally, there may be adverse effects associated with interventions to increase mammography utilization such as increased rates of false positive exams, which are estimated to be as high as 30% among women receiving regular mammography over a 10-year period (104), and associated psychological distress (105).

Overall, behavioral interventions, theory-based cognitive interventions, and sociological patient-targeted interventions appear to be effective in increasing mammography utilization, particularly when compared with usual care. Multiple behavioral interventions and interactive theory-based cognitive interventions are effective when compared with active controls. The long-term effectiveness of these interventions in increasing rates of regular mammography is only rarely reported (60, 77), and this will be an important area for further research. Additionally, the effectiveness of different types of interventions in patient subpopulations such as elderly, minority, or low-income women and the costs of providing these interventions are critical areas for research in decreasing the morbidity and mortality associated with breast cancer.

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