BMJ Open

Factors associated with attendance at screening for breast cancer: a systematic review and meta-analysis

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To cite: Mottram R, Knerr WL, Gallacher D, *et al*. Factors associated with attendance at screening for breast cancer: a systematic review and meta-analysis. *BMJ Open* 2021;**11**:e046660. doi:10.1136/bmjopen-2020-046660

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-046660).

Received 05 November 2020
Accepted 17 September 2021

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ABSTRACT

Objective Attendance at population-based breast cancer (mammographic) screening varies. This comprehensive systematic review and meta-analysis assesses all identified patient-level factors associated with routine population breast screening attendance.

Design CINAHL, Cochrane Library, Embase, Medline, OVID, PsycINFO and Web of Science were searched for studies of any design, published January 1987–June 2019, and reporting attendance in relation to at least one patient-level factor.

Data synthesis Independent reviewers performed screening, data extraction and quality appraisal. OR and 95% CIs were calculated for attendance for each factor and random-effects meta-analysis was undertaken where possible.

Results Of 19 776 studies, 335 were assessed at full text and 66 studies (n=22 150 922) were included. Risk of bias was generally low. In meta-analysis, increased attendance was associated with higher socioeconomic status (SES) (n=11 studies; OR 1.45, 95% CI: 1.20 to 1.75); higher income (n=5 studies; OR 1.96, 95% CI: 1.68 to 2.29); home ownership (n=3 studies; OR 2.16, 95% CI: 2.08 to 2.23); being non-immigrant (n=7 studies; OR 2.23, 95% CI: 2.00 to 2.48); being married/cohabiting (n=7 studies; OR 1.86, 95% CI: 1.58 to 2.19) and medium (vs low) level of education (n=6 studies; OR 1.24, 95% CI: 1.09 to 1.41). Women with previous false-positive results were less likely to reattend (n=6 studies; OR 0.77, 95% CI: 0.68 to 0.88). There were no differences by age group or by rural versus urban residence.

Conclusions Attendance was lower in women with lower SES, those who were immigrants, non-homeowners and those with previous false-positive results. Variations in service delivery, screening programmes and study populations may influence findings. Our findings are of univariable associations. Underlying causes of lower uptake such as practical, physical, psychological or financial barriers should be investigated.

Trial registration number CRD42016051597.

Strengths and limitations of this study

- Comprehensive systematic review of all identified patient-level factors associated with attendance at routine population-based breast cancer (mammographic) screening.
- Two reviewers independently conducted all study selection, data extraction and quality appraisal using Quality in Prognosis Studies.
- Both observational and experimental designs were included, using control arms of quasi-experimental or randomised designs and ORs were independently recalculated using each study's raw data.
- Heterogeneity is high partly due to the large size of studies. Studies were separately meta-analysed by study design, and sensitivity analysis was conducted for one study with an extreme effect size.
- Reporting of potential confounders and effect modifiers was highly variable in studies; this was partially mitigated by recategorising variables, such as education levels, to harmonise variables across studies where possible.

INTRODUCTION

Breast cancer was the most commonly diagnosed cancer worldwide in 2020, with 2.3 million cases, and the most common cause of cancer death in women.[1] Breast cancer incidence is higher in more developed countries (Europe, Australia, New Zealand and North America; 55.9 cases per 100 000 population) than in less developed countries (29.7 per 100 000), while the reverse is true of death rates (12.4 vs 15.0 per 100 000, respectively).[1] In the EU, mortality rates decreased 18.7% between the period 2005–2009 and 2019 from 16.44 to (predicted) 13.36 per 100 000.[2]

Population-based mammographic screening aims to reduce breast cancer mortality. However, there has been controversy about the balance of benefits and harms of breast screening[3] and breast screening programmes have become more aware of the need for promoting informed choice.[4 5]

Attendance at breast screening is not uniform among the eligible population.[6] Ross *et al*[7] described attendance at screening

as an individual decision (behavioural) which is affected by accessibility of services (structural) and by a woman's immediate surroundings (societal). Characteristics that have been associated with screening attendance can be grouped into a number of categories related to sociodemographic factors; health status; health behaviours; accessibility and logistics; beliefs, attitudes and knowledge; simple intention to attend and societal factors including health systems financing and organisation.[8–11]

Most reviews of factors associated with breast screening attendance have focused on individual factors.[12–14] We aimed to provide a comprehensive systematic review of all identified patient-level characteristics associated with the uptake of population-based mammographic screening, to inform screening programmes of the available evidence about who does and does not attend.

METHODS

Protocol and registration

The review was conducted in accordance with prespecified methods documented in the protocol registered on the 22November 2016 in the PROSPERO International Prospective Register of Systematic Reviews database (online supplemental file A).[15]

Search and information sources

The Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Library, Embase, Medline, PsycINFO and Web of Science were searched for studies published between 1 January 1987 and 26 June 2019. The search was developed in Medline using a combination of MeSH headings and free-text terms and adapted for use in the other databases (the search strategy is available in online supplemental file B).

Reference lists of relevant reviews were searched for potentially relevant studies. Experienced researchers with prior studies in the field were contacted to identify other potentially relevant studies that had not been identified in the searches.

Eligibility criteria

Primary studies of any design were included if they reported attendance data from routine population-based mammography screening programmes in relation to at least one patient-level factor, and were written in English between January 1987 and June 2019. Studies were excluded if they involved self-reported mammography uptake, opportunistic screening programmes, data for only a subgroup of the eligible population (eg, only women in a narrow age range, only immigrants or only rural women) or uptake data by number of invitations sent rather than number of women. Reviews, commentaries, opinions, letters, and non-empirical and qualitative studies were excluded.

Study selection and data extraction process

Pairs of reviewers screened titles and abstracts independently to identify potentially relevant studies with third reviewer cross-check. Two reviewers independently assessed full-text studies for formal inclusion/exclusion assessment against predefined eligibility criteria with third reviewer cross-check. Disagreements were resolved by a consensus between the two reviewers or by help of a third reviewer.

Data from included studies were extracted and then cross-checked by two reviewers independently. The data included the number of women who attended mammographic screening and the number invited, and data on patient characteristics, including: sociodemographic factors, such as age, marital status, educational level, race/ethnicity, immigration status and socioeconomic status (SES, which was measured in two ways, (a) with various composite indices of deprivation that included factors such as housing density, employment, education, social support, car ownership and crime prevalence, and (b) based on household income); beliefs, attitudes and socioemotional factors; health history and behaviours; logistic and accessibility factors (eg, distance from screening centre).

Risk of bias of included studies

Risk of bias (RoB) of all included studies was appraised by two independent reviewers using the Quality in Prognosis Studies (QUIPS) tool.[16] The QUIPS tool covers six RoB domains (participation, attrition, prognostic factor, confounding factors, outcome measurement and analysis and reporting), each of which includes multiple items that are judged separately. A conclusive judgement for each RoB domain is reached and expressed on a three-grade scale (high, moderate or low RoB).

Synthesis of data

We used raw attendance data to calculate unadjusted ORs for each factor. A random-effects model-based meta-analysis was conducted for an association between a factor of interest (dichotomous or more categories) and the dichotomous outcome (screening attendance) to generate Mantel-Haenszel ORs with 95% CIs, when possible.[17] Random-effects models were used to allow for heterogeneity in the effects of the factors considered to vary across the different studies.

In addition to the main meta-analyses, we conducted separate meta-analyses for (a) observational studies whose samples were made up only of women who had previously attended screening (hereafter referred to as rescreening studies) and (b) intervention studies (quasi-experimental and randomised controlled trials) that reported characteristics separately for intervention and control arms, recording only data for the control group, as their attendance would not be influenced by exposure to an intervention. We also conducted a sensitivity analysis to determine the impact of a study with an extreme effect size[18] on the meta-analysis of SES.

We summarised results narratively if there were inadequate quantitative data for meta-analysis, if variables were reported in fewer than three studies,[17] or if the data from

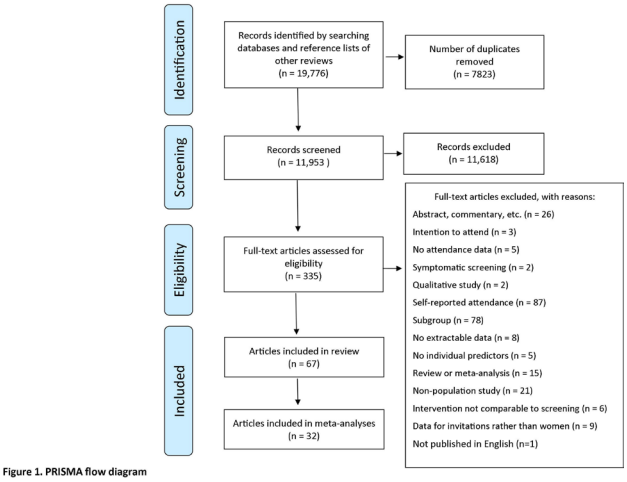


Figure 1 PRISMA flow diagram, showing the process of study flow and reasons for exclusion. The searches of electronic databases identified 11 953 unique publications (after deduplication), published between January 1987 and June 2019, of which 11 618 were excluded at the level of abstract/title screening, leaving 335 records for full-text review. Of the 335 full texts, 66 unique studies reported in 67 publications were included. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

multiple studies were highly variable and therefore could not be meaningfully pooled.

This review is reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (online supplemental file C).[19] All analyses were conducted in Stata V.16.

Patient and public involvement

Public contributors were involved in design and informed of ongoing progress and findings as part of the West Midlands Centres for Leadership in Applied Health Research. Results were reported back to the contributors as part of the wider dissemination activities of the relevant theme in the Centres for Leadership in Applied Health Research.

RESULTS

Literature search

The process of study flow and reasons for exclusion are provided in figure 1. In brief, the searches of electronic databases identified 11 953 unique publications (after deduplication), published between January 1987 and June 2019, of which 11 618 were excluded at the level of abstract/title screening, leaving 335 records for full-text review. Of the 335 full texts, 66 unique studies reported in 67 publications were included.[18 20–87]

Study characteristics

Characteristics of all included studies are listed in online supplemental file D. Of the 66 studies, 49 were observational (45 retrospective cohort, 2 cross-sectional and 2 case–control designs); and 17 were intervention studies (16 randomised controlled trials and 1 quasi-experimental). Sample sizes ranged from 82 to 4.8 million.

The studies were conducted in Europe (n=40), North America (n=18), Asia-Pacific (n=5) and the Middle East (n=3). The UK had the most studies (n=16) followed by the USA (n=11).

We were able to pool data from 31 observational studies (reported in 32 publications) on the attendance at screening in relation to nine factors (age, education, home ownership, immigration status, marital status, results of previous mammogram, rural/urban residence, SES and income) (table 1). We were only able to pool data from three intervention studies, and only for one factor (age).

Adequate data for meta-analysis was not provided for 35 studies; although six of these studies provided adequate data to calculate ORs and CIs, and are narratively reported in table 2. The remaining 29 studies reported data that could not be analysed. (Reasons are detailed in online supplemental file E.) In brief, 14 of the 29 studies were intervention trials, where data were not in the right format for us to use. The other 15 studies could not be analysed because uptake data were reported by health-provider characteristics rather than patient characteristics; because the paper reported percentage uptake but not sample sizes per category; or because data for different factors were not reported separately.

Risk of bias

RoB across studies was generally low on all domains (figure 2). For study participation, 71% of studies were considered at low RoB; for attrition, 91%; for outcome measurement, 97% and for statistical analysis and reporting, 83%. For measurement of variables associated with attendance (prognostic factors), more than half (61%) of studies had a low RoB, while 23% had a high RoB, mostly due to SES being measured at the area level (eg, neighbourhood) rather than at the individual level. More than half of studies (53%) had a low RoB with regard to measuring potential confounders, with around one-quarter (27%) having a moderate risk and just over one-fifth (21%) having a high risk.

Quantitative data analysis (meta-analyses)

Table 1 presents unadjusted OR estimates with their 95% CIs of attendance at breast screening for factors that were reported in three or more studies. The analyses gave I^2 values of around 99%, meaning that there was a high level of heterogeneity, except for the analysis of homeowners versus tenants, where the I^2 value was 38.9% (table 1).

We compared the odds of attending mammographic screening by the age bands most commonly eligible for national screening programmes (60—69 and 50—59). There was no significant difference by age group in meta-analyses of observational studies (n=16; OR 0.97, 95% CI:

Table 1 Results of meta-analyses*

Variables	Number of women (number of studies included)†	% uptake	OR of attendance (unadjusted): range | overall (95% CI)
Age (60—69 vs 50—59)‡			
Observational studies	5 065 779 (16)	56 vs 55	0.65 to 1.42 | 0.97 (0.88 to 1.08)
Intervention studies	2343 (3)	52 vs 57	0.24 to 1.16 | 0.78 (0.47 to 1.31)
Rescreening studies (age at initial screen)	271 641 (3)	74 vs 74	0.93 to 1.05 | 0.99 (0.93 to 1.06)
Education level	550 646 (6)		
Medium vs low		83 vs 77	1.05 to 1.45 | 1.24 (1.09 to 1.41)
High vs low		81 vs 77	0.76 to 1.31 | 1.10 (0.97 to 1.26)
High vs medium		81 vs 83	0.61 to 1.10 | 0.89 (0.78 to 1.02)
Housing tenure (homeowner vs tenant/non-owner)	223 293 (3)	84 vs 70	2.06 to 2.20 | 2.16 (2.08 to 2.23)
Country of origin (non-immigrants vs immigrants)	2 409 902 (7)	81 vs 60	1.75 to 2.81 | 2.23 (2.00 to 2.48)
Income	1 193 238 (5)		
Intermediate vs low		77 vs 66	1.78 to 2.09 | 1.96 (1.68 to 2.29)
High vs low		80 vs 66	1.61 to 2.87 | 2.18 (1.86 to 2.56)
High vs intermediate		80 vs 77	0.81 to 1.37 | 1.11 (0.95 to 1.30)
Marital status (Married/cohabiting vs unmarried/non-cohabiting)	1 293 753 (7)	80 vs 69	1.38 to 2.36 | 1.86 (1.58 to 2.19)
Residence (rural vs urban)	65 641(3)	74 vs 65	0.80 to 1.59 | 1.12 (0.76 to 1.66)
Previous result of mammogram (rescreening studies only: false positive vs normal)	3 540 953 (6)	60 vs 68	0.49 to 0.89 | 0.77 (0.68 to 0.88)
Socioeconomic status (SES)	6 600 283 (11)		
Medium vs low		56 vs 48	1.08 to 2.35 | 1.45 (1.20 to 1.75)
High vs low		54 vs 48	0.75 to 3.59 | 1.69 (1.40 to 2.05)§
High vs medium		54 vs 56	0.69 to 1.53 | 1.17 (0.96 to 1.41)

*All results in this table are for observational studies except the data for age, which includes results for the separate meta-analysis of intervention studies.
†References for studies pooled for meta-analyses of observational studies are provided in forest plots in figures 3 and 4.
‡We focused on the age bands most commonly eligible in population-based programmes and did not analyse odds for those younger than age 50 or older than 69.
§The ORs and CIs for SES include all relevant observational studies. We also performed a sensitivity analysis by removing the large study from France by DeBorde *et al*,[18] which found that women with high or medium SES were both more likely to attend compared with women of lower SES (OR 1.84, 95% CI: 1.55 to 2.17, p<0.001; and OR 1.49, 95% CI: 1.27 to 1.76, p<0.001, respectively).

0.88 to 1.08, p=0.631, figure 3) or intervention trials (n=3; OR 0.78, 95% CI: 0.47 to 1.31, p=0.354).

We grouped education data from six studies to approximate the United Nations Educational, Scientific and Cultural Organisation (UNESCO) three-level classification: low (≤10 years), middle (11–15 years) and high (>15 years). Compared with women with a low level of education, women with a medium level were more likely to attend (OR 1.24, 95% CI: 1.09 to 1.41, p<0.001). Results from comparisons of women with a high level of education versus low or medium levels were not statistically significant (figure 4A).

The odds of attending mammographic screening were higher for homeowners than for tenants or non-owners (n=3; OR 2.16, 95% CI: 2.08 to 2.23, p<0.001, figure 3).

Meta-analysis of participants' country of origin showed that people born in the study country (non-immigrants) were more likely to attend than immigrants (n=7; OR 2.23, 95% CI: 2.00 to 2.48, p<0.001, figure 3).

We meta-analysed attendance using two measures of SES. Data for overall SES from 11 studies were grouped into low, medium and high categories. Women with medium or high SES were more likely to attend than those with a low SES (medium vs low SES OR 1.45, 95% CI: 1.20 to 1.75, p<0.001; high vs low SES OR 1.69, 95% CI: 1.40 to 2.05, p<0.001, figure 4B). One study from France (DeBorde)[18] (n=4.8 million) reported that women with a higher SES were less likely to attend than those with either a low or intermediate SES. We conducted a sensitivity analysis excluding that study, but it made very little

Table 2 Likelihood of attending screening by factors not suitable for meta-analysis in observational studies

Variable	N*	Included studies	% uptake: variable vs reference category	OR (95% CI)
Less likely to attend				
No access to vehicle	144 181	Jensen 2012b	61 vs 82	0.33 (0.32 to 0.34)
	37 059	O'Reilly 2012	60 vs 78	0.43 (0.41 to 0.46)
Negative attitude about breast screening	497	Kee 1993	53 vs 60	0.44 (0.35 to 0.55)
Receiving disability benefits	885 979	Le 2019	69 vs 76	0.70 (0.70 to 0.71)
First invitation to screening	742 786	Renshaw 2010	40 vs 76	0.22 (0.21 to 0.22)
Spoken/preferred language not English	18 851	Blanchard 2004	62 vs 83	0.33 (0.28 to 0.39)
	43 819	Tatla 2003	60 vs 78	0.43 (0.41 to 0.46)
Long-term limiting illness	37 059	O'Reilly 2012	71 vs 77	0.71 (0.68 to 0.75)
	144 264	Jensen 2015b	71 vs 80	0.64 (0.61 to 0.66)
Smoking (current)	28 874	Katz 2018	84 vs 88	0.72 (0.65 to 0.79)
Living in crowded housing conditions	31 948	Zackrisson 2004	37 vs 66	0.29 (0.24 to 0.36)
Employment status				
Outside workforce vs employed/self-employed	640 843	Le 2019	63 vs 77	0.51 (0.50 to 0.51)
	119 269	Jensen 2012b	77 vs 83	0.66 (0.64 to 0.68)
Unemployed vs employed/self-employed	481 911	Le 2019	61 vs 77	0.47 (0.45 to 0.49)
	102 178	Jensen 2012b	67 vs 83	0.41 (0.40 to 0.43)
Number of childbirths	46 041	Lagerlund 2002		
0 vs 1–2			82 vs 91	0.44 (0.40 to 0.48)
3+vs 1–2			90 vs 91	0.81 (0.75 to 0.87)
No family history of BC	119 502	O'Byrne 2000	85 vs 86	0.90 (0.86 to 0.94)
Type of clinic (mobile vs fixed)	119 502	O'Byrne 2000	84 vs 85	0.93 (0.88 to 0.98)
Schizophrenia	110 240	Chochinov 2009	45 vs 58	0.58 (0.52 to 0.64)
More likely to attend				
No comorbidities	76 520	Larsen 2018	82 vs 75	1.53 (1.46 to 1.60)
60+ primary care visits during 6-year study period (vs<60)	43 968	Katz 2018	91 vs 79	2.70 (2.55 to 2.86)
Depression	38 823	Katz 2018	86 vs 85	1.12 (1.02 to 1.23)
Good general health	37 059	O'Reilly 2012	77 vs 68	1.55 (1.46 to 1.64)
Heart disease	6501	Katz 2018	90 vs 85	1.75 (1.61 to 1.91)
Not living in capital city	885 979	Le 2019	76 vs 62	1.94 (1.91 to 1.97)
Previous attender	11 664	Taylor-Phillips 2013	73 vs 45	3.32 (3.05 to 3.61)
Citizen of country	885 979	Le 2019	75 vs 51	2.88 (2.82 to 2.94)
Member of majority racial/ethnic group	17 997	Blanchard 2004	85 vs 75	1.70 (1.52 to 1.89)
Religion				
Catholic vs none	37 140	O'Reilly 2012	74 vs 68	1.40 (1.25 to 1.47)
Protestant vs none		O'Reilly 2012	77 vs 68	1.57 (1.46 to 1.70)
Never HRT use	119 502	O'Byrne 2000	16 vs 14	1.13 (1.09 to 1.17)
Referral by health professional	56 420	Tatla 2003	77 vs 76	1.05 (1.00 to 1.10)
No difference in attendance or mixed results				
BMI	19 168	Katz 2018	87 vs 87	0.95 (0.87 to 1.04)
>0 GPs per 100 000 inhabitants	4865	Pornet 2010	55 vs 56	0.96 (0.85 to 1.08)
>0 radiologists per 100 000 inhabitants	4865	Pornet 2010	52 vs 56	0.87 (0.72 to 1.05)

Continued

Table 2 Continued

Variable	N*	Included studies	% uptake: variable vs reference category	OR (95% CI)
Diabetes	9849	Katz 2018	87 vs 84	1.25 (1.17 to 1.33)
	504 288	Chan 2014	60 vs 66	0.79 (0.78 to 0.80)
Distance to screening centre	137 419	Jensen 2012b	77 vs 80	0.86 (0.84 to 0.88)
	833 856	St-Jacques 2013	53 vs 52	1.02 (1.01 to 1.03)
	13 260	Ouédraogo 2014	54 vs 50	0.85 (0.79 to 0.91)
Physician years since graduation	105 575	Makedonov 2015	74 vs 75	1.03 (0.99 to 1.06)

*Reflects the number of participants analysed for each factor, which can differ for different factors in the same study depending on data availability.
BMI, body mass index; GPs, general practitioners; HRT, hormone replacement therapy.

difference to the odds of attending: women with high or medium SES were both more likely to attend compared with women of lower SES (OR 1.84, 95% CI: 1.55 to 2.17, p<0.001, and OR 1.49, 95% CI: 1.27 to 1.76, p<0.001, respectively).

Data on income from five studies were grouped into low, intermediate and high categories. Women with an intermediate or high income were more likely to attend than those with low income (intermediate vs low income OR 1.96, 95% CI: 1.68 to 2.29, p<0.001; high vs low OR 2.18, 95% CI: 1.86 to 2.56, p<0.001; high vs intermediate OR 1.11, 95% CI: 0.95 to 1.30, p=0.20, figure 4C). For both income and SES, there was no significant difference between women at intermediate and high levels, indicating that there was no statistically significant dose response effect for higher SES or income.

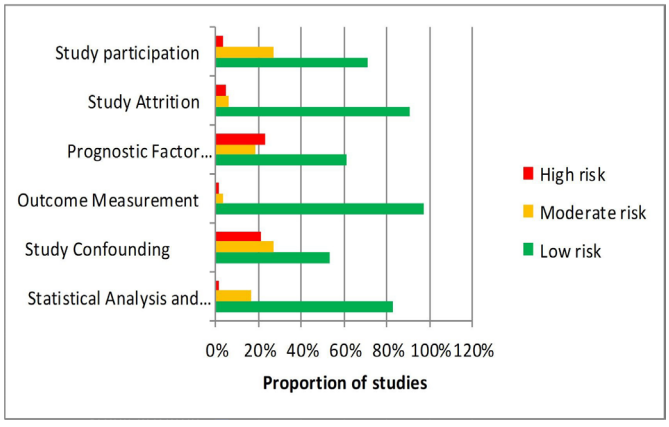


Figure 2 Overall summary of QUIPS risk of bias scores: risk of bias (RoB) of all included studies was appraised by two independent reviewers using the Quality in Prognosis Studies (QUIPS) tool. The QUIPS tool covers six RoB domains (participation, attrition, prognostic factor, confounding factors, outcome measurement and analysis and reporting), each of which includes multiple items that are judged separately. A conclusive judgement for each RoB domain is reached and expressed on a three-grade scale (high, moderate or low RoB). RoB across studies was generally low on all domains.

Women who were married or cohabiting were more likely to attend than their unmarried or non-cohabiting counterparts (n=7; OR 1.86, 95% CI: 1.58 to 2.19, p<0.001, figure 3).

We analysed data separately for studies with samples made up only of women who had previously attended mammographic screening (ie, rescreening studies). Six of these studies reported data on attendance based on the results of a previous mammogram. Women who had previously received a false-positive result were less likely to attend than those with a normal result (OR 0.78, 95% CI: 0.68 to 0.88, p<0.001, figure 3).

There was no statistically significant difference in attendance among women living in rural compared with urban areas (n=3; OR 1.12, 95% CI: 0.76 to 1.66, p=0.557).

Narrative synthesis

Factors that could not be meta-analysed (because they were reported in fewer than three studies or could not be pooled) are reported in table 2 with ORs.

These studies include a variety of factors associated with reduced attendance clustered around sociodemographic, accessibility and logistics (living in crowded housing and being unemployed, receiving disability benefits, lack of access to a vehicle), and spoken language not English.

Associations with women's health status, behaviours, attitudes and knowledge showed a mixed picture. There was some evidence that good general health, lack of comorbidity and not taking hormone replacement therapy (HRT) were all associated with higher attendance, but studies also reported higher attendance among women with a higher numbers of previous clinic visits, depression and heart disease. A previous negative attitude to breast screening, limiting long-term illness, schizophrenia, non-work-related stress and current smoking were associated with lower attendance.

Factors that did not show any statistical difference included body mass index and service provision factors. No difference in women's attendance was found according to availability of general practitioners or radiologists or physician years since graduation, and there were

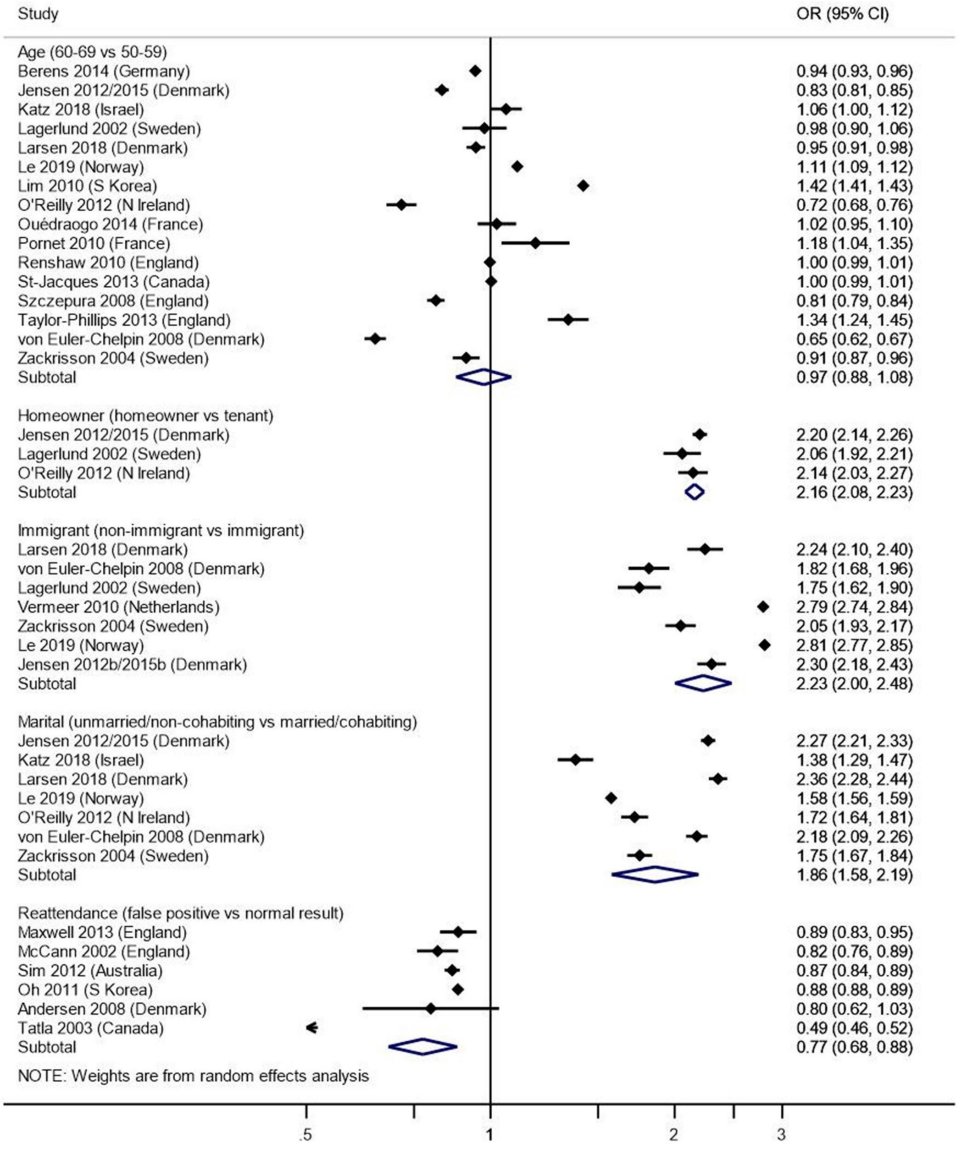


Figure 3 Meta-analyses. This figure shows comparisons of the odds of attending mammographic screening, using random-effects analysis, in observational studies by the following variables. Points to the left of the centre line (<1) suggest a lower likelihood of attending screening, while points to the right of the centre line (>1) indicate a higher likelihood of attending. Age bands: we compared the age bands most commonly eligible for national screening programmes (60—69 and 50—59); there was no significant difference by age group (n=16; OR 0.97, 95% CI: 0.88 to 1.08, p=0.631); Home ownership: we compared people who own their homes to those who are tenants or do not own their homes; the odds of attending were higher for homeowners than for tenants or non-owners (n=3; OR 2.16, 95% CI: 2.08 to 2.23, p<0.001); Immigrant status: we compared screening attendance of people born in the country in which the study took place (non-immigrants) to those born in another country (immigrants); non-immigrants were more likely to attend than immigrants (n=7; OR 2.23, 95% CI: 2.00 to 2.48, p<0.001). Marital status: we compared women who were married or cohabiting to those who were unmarried or not cohabiting: women where were married/cohabiting were more likely to attend than their unmarried/non-cohabiting counterparts (n=7; OR 1.86, 95% CI: 1.58 to 2.19, p<0.001). Reattendance; using data from studies with samples made up only of women who had previously attended mammographic screening, we compared women who had previously received a false-positive to those who had had a normal result; those with a previous false-positive result were less likely to reattend (OR 0.78, 95% CI: 0.68 to 0.88, p<0.001).

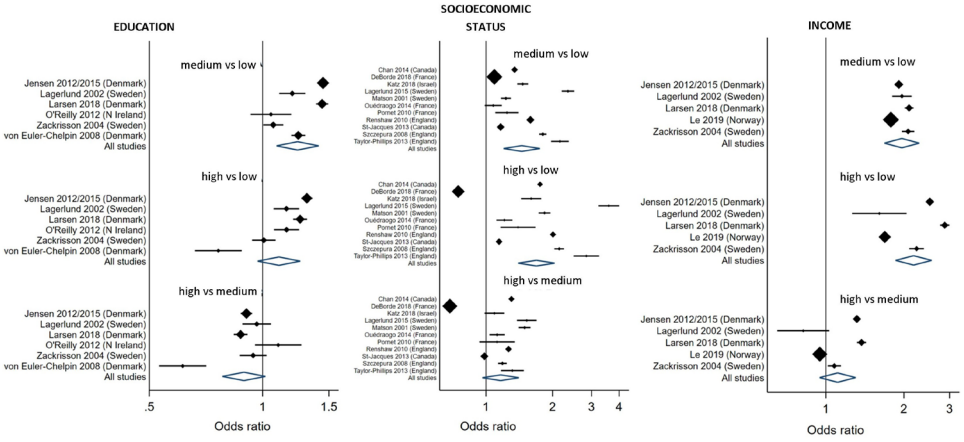
mixed results according to distance to screening centre and diabetes.

DISCUSSION

We undertook a comprehensive review of the current evidence on patient-level factors associated with breast cancer (mammographic) screening attendance. Where appropriate, meta-analyses were performed to determine the strength of association.

Main findings

In line with other systematic reviews, we found that in general higher SES status, higher income,[14] being born in the country of residence (ie, non-immigrant)[12] and home ownership (compared with renting) predicted



4A. Meta-analysis of attendance by educational level
Medium vs low level: OR 1.24, 95%CI: 1.09-1.41, p < 0.001
High vs low level: OR 1.10, 95% CI: 0.97-1.26, p = 0.133
High vs medium level: OR 0.89, 95% CI: 0.78-1.02, p = 0.12

4B. Meta-analysis of attendance by socioeconomic status (SES)
Medium vs low level: OR 1.45, 95% CI: 1.20-1.75, p < 0.001
High vs low level: OR 1.69, 95% CI: 1.40-2.05, p < 0.001
High vs medium level: OR 1.17, 95% CI: 0.96-1.41, p = 0.12

4C. Meta-analysis of attendance by income
Medium vs low level: OR 1.96, 95%CI: 1.68 -2.29, p < 0.001
High vs low level: OR 2.18, 95% CI: 1.86-2.56, p < 0.001
High vs medium level: OR 1.11, 95% CI: 0.95-1.30, p = 0.20

Figure 4 Meta-analyses of attendance by educational level, socioeconomic status (SES) and income. These figures show random-effects meta-analyses of screening attendance by educational level and socioeconomic status in observational studies. Points to the left of the centre line (<1) suggest a lower likelihood of attending screening, while points to the right of the centre line (>1) indicate a higher likelihood of attending. Figure 4A shows the effects of different levels of education on screening attendance. We grouped education data to approximate the United Nations Educational, Scientific and Cultural Organization (UNESCO) three-level classification: low (≤10 years), middle (11–15 years) and high (>15 years). Compared with women with a low level of education, women with a medium level were more likely to attend (OR 1.24, 95% CI: 1.09 to 1.41, p<0.001). Results from comparisons of women with a high level of education versus low or medium levels were not statistically significant (figure 4A). Figure 4B shows the meta-analysis of attendance by overall SES. Studies were grouped into low, medium and high categories. Women with medium or high SES were more likely to attend than those with a low SES (medium vs low SES OR 1.45, 95% CI: 1.20 to 1.75, p<0.001; high vs low SES OR 1.69, 95% CI: 1.40 to 2.05, p<0.001, figure 4B). Figure 4C shows the meta-analysis of screening attendance by income. Studies were grouped into low, intermediate and high categories. Women with an intermediate or high income were more likely to attend than those with low income (intermediate vs low income OR 1.96, 95% CI: 1.68 to 2.29, p<0.001; high vs low OR 2.18, 95% CI: 1.86 to 2.56, p<0.001; high vs intermediate OR 1.11, 95% CI: 0.95 to 1.30, p=0.20, figure 4C). For both income and SES, there was no significant difference between women at intermediate and high levels, indicating that there was no statistically significant dose response effect for higher SES or income.

mammographic screening attendance. However, it appears that women with a higher SES or income were not more likely to attend than those with an intermediate level. We hypothesise that women with a higher SES may be more likely to use alternative screening services (ie, opportunistic or privately funded screening) compared with women with a low or intermediate SES, thus their attendance would not be apparent in studies using data from national screening programmes. This was suggested as a limitation by many of the included studies in this review, most notably the large study from France[18] (n=4.8 million), which was the only study to find that women with a higher SES were less likely to attend than those with either a low or intermediate SES. The authors of that study note the high levels of opportunistic screening available to women with a high SES in France. We conducted a sensitivity analysis excluding that study, but it made very little difference to the ORs for attendance.

A medium level of education was also associated with screening attendance when compared with a low level, but a higher level of education was not associated with increased attendance compared with either medium or lower levels. As with the analyses of SES, it is possible that women with the highest levels of education are more likely to use alternative screening services not reflected in data from public screening programmes.

We hypothesised that some variation in relation to education or SES might be due to changes in women's attitudes to breast screening as a result of concerns about its overall benefits,[65 88] perhaps related to the informed-choice agenda.[4] However, we found no population screening studies investigating this.

Our results also support previous research indicating that marital status is associated with attendance at mammography,[65 88–91] with women who were married or cohabiting more likely to attend than their unmarried or non-cohabiting counterparts. Previous literature indicates lower uptake among women from minority-ethnic backgrounds.[92 93] While our data were not sufficient to meta-analyse ethnicity, we did find that immigrant women were less likely to attend screening than non-immigrants.

We did not find a significant effect of age. There was very high heterogeneity here, with individual large studies finding highly statistically significant results in both directions. We hypothesised that attendance may be higher among older women because they have been invited

to breast screening for at least two decades, and attendance may have become more routine in this cohort, and possibly less likely to be affected by recent debates around the risks and benefits of screening. To explore this, we did a post-hoc analysis of the effect of age on attendance by the year of study completion. We found that older women were more likely to attend compared with younger women in more recent studies (ie, those completed since 2010), but that the opposite was true in older studies, particularly those published before 2005.

Women who received a false-positive result at a previous screening were less likely to attend than those with a normal result, confirming previous findings.[94]

Strengths and limitations

This review has many strengths. The large number of studies included (n=66), involving more than 22 million women, represents a comprehensive overview of available evidence. Studies included in the meta-analysis were judged to have a low RoB on most domains and included large numbers of women. At least two reviewers were involved at all stages to reduce the risk of errors and bias. This study was undertaken from the perspective of population-based breast cancer screening programmes and we were strict in our eligibility criteria in including only those studies. Studies where the sampling frame was restricted to population subgroups (and not based on population-based screening programmes) were excluded. We also excluded studies that relied on self-reported attendance (though it is important to note that self-report is essential for some factors, such as ethnicity and attitudes to screening).

A limitation is that most studies reported cross-sectional attendance data, which included mixed groups of those who were attending for the first time and some who had previously attended. Also, we inevitably had to make choices of categories for meta-analysis which may affect meta-analytic results; where possible we used independent sources to select appropriate categorisations.

The main limitation of this review is significant between-study heterogeneity. Although we used random-effect models throughout, our results should be considered in light of this. We chose random-effects models as almost all of our analyses contained heterogeneity and it is also expected that there would be differences in attendance across the different study populations. Studies with larger sample sizes are assumed to contain the least uncertainty and are given higher weightings than smaller studies. For analyses of small numbers of studies, the random-effects analysis may struggle to correctly estimate uncertainty, but any meta-analysis performed on few studies would have its limitations, and the use of random-effects analysis maintained consistency with the other analyses.

Heterogeneity may in part be due to differences between health systems and the organisation of mammographic screening, as well as differences in the culture and attitudes of the populations served. We conducted sensitivity analysis to determine the impact of a very large study with an extreme effect size[18] on the meta-analysis of SES. For some outcomes (such as age), the heterogeneity encompasses studies with highly significant results in both directions, and here the results of the meta-analysis should be interpreted with great caution. For other variables (such as reattendance after false-positive results), the high I^2 simply reflects that there were very large studies with very small CIs, which all had point estimates of different magnitude in the same direction. Here the meta-analysis results show a consistent effect, with some disagreement between studies on the exact size of effect.

Another limitation is that we extracted univariable associations with uptake. In practice, many of the variables investigated will be highly correlated, and there will be complex interactions and confounding which we have not been able to account for. While some studies did report multivariable models, these were varied in structure, methods and variables included, so would have been difficult to combine in any meaningful way. We were therefore unable to undertake multivariable meta-regression analysis, examining the effects of individual attendance factors on overall attendance.

For the studies included in the narrative analysis, large numbers of women were also often involved, but these studies should be treated with caution as they are potentially subject to bias. The risk of confounding was found to be high in these studies using the QUIPs tool. However, confounding is inherent in the design of population-based observational and especially ecological designs.

To investigate the risk of reporting bias, we conducted funnel plots (online supplemental file F), which demonstrated the high level of heterogeneity present between the studies in our analyses. Age was the only analysis where the studies disagree over the direction of attendance, however the disagreement is among larger studies, suggesting this is unlikely to be associated with biased reporting and instead down to the study heterogeneity. All other analyses, while having studies which disagree on the point estimate, have agreement as to which group is more or less likely to attend mammographic screening. Overall, we are not concerned about reporting bias.

Finally, we have not included health insurance (or lack of health insurance) as a factor in the narrative analysis because of the problems of comparison between countries.

CONCLUSIONS

A wide variety of factors affect a woman's decision to attend breast screening. Our main findings are that attendance was lower in women with lower SES, those who were immigrants, non-homeowners and those with previous false-positive results. Based on our current findings, if screening programmes wish to improve equity of access to breast screening services, they should concentrate on women facing access (practical, physical, psychological and financial) barriers.

Future research in this area would also need to systematically assess the effects of interventions to reduce the impact of access barriers to screening attendance.

Deviations from study protocol

To assess RoB, the QUIPS tool was used rather than the Quality Assessment Tool; and for data synthesis, despite significant heterogeneity, meta-analysis was possible for some predictors. In addition, we clarified our inclusion criteria to include only studies with data from routine population-based mammography screening programmes in order to ensure generalisability.

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Acknowledgements The authors would like to thank Magdalena Skrybant, Patient and Public Involvement and Engagement Lead, Applied Research Centre West Midlands (formerly Centres for Leadership in Applied Health and Care, West Midlands) for her support in coordinating public engagement in this project.

Contributors RM conceived the study as part of her PhD Dissertation, and it was further refined in collaboration with AC and ST-P. AC, CS and WLK further developed the inclusion and exclusion criteria. SJ undertook database searches and AC, HF, RM, LA-K, SW and WLK reviewed titles and abstracts. Each study retained for full-text review was reviewed by RM and WLK. Discrepancies regarding inclusion and exclusion were resolved by AC and CS. RM and WLK did data extraction, and data were checked by OAU and CN. Studies were critically appraised by AA, AT, CS and WLK. Meta-analyses were conducted by DG. Thematic synthesis was done by AC, ST-P and WLK. All authors contributed to the manuscript and approved the final version. AC is the guarantor for this paper.

Funding This research was funded by the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care West Midlands (NIHR CLAHRC WM), now recommissioned as NIHR Applied Research Collaboration West Midlands (NIHR ARC WM). RM, L A-K, ST-P, SW, HF, CS and AC were all supported by the NIHR CLAHRC WM and WLK, AA, AC and L-AK are all partly supported by the NIHR ARC WM. OAU is supported by the NIHR using Official Development Assistance (ODA) funding. ST-P is supported by an NIHR Career Development Fellowship (CDF-2016-09-018). The views expressed in this publication are those of the author(s) and not necessarily those of the UK National Health Service (NHS), the NIHR or the Department of Health and Social Care.

Competing interests RM reports personal fees from the National Institute for Health Research (NIHR) Centre for Leadership in Applied Research and Health Care (CLARHC) West Midlands during the conduct of the study. LA-K reports grants from the NIHR during the conduct of the study. ST-P reports grants from NIHR outside the submitted work. AC reports grants from the NIHR for the NIHR Applied Research Centre (ARC) West Midlands and previously from the NIHR CLARHC West Midlands, which supported her and researchers working on this project. AC also received grants from Public Health England (PHE) outside the submitted work.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available.

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International prospective register of systematic reviews

A systematic review to identify the worldwide predictors of breast screening uptake

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Citation

Rebecca Crosby, Sian Williamson, Chris Stinton, Aileen Clarke, Sian Taylor-Phillips. A systematic review to identify the worldwide predictors of breast screening uptake. PROSPERO 2016 CRD42016051597 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42016051597

Review question

What are the predictors of breast cancer screening uptake worldwide?

Searches

The electronic databases that will be searched to identify published studies are:
EMBASE (via Ovid), MEDLINE (via Ovid), CINAHL (The Cumulative Index to Nursing and Allied Health Literature), PsycINFO, Cochrane Library (Wiley) including the Cochrane Database of Systematic Reviews and Thomson Reuters Web of Science (all databases including Science Citation Index, Conference Proceedings and Science Citation Index Expanded and Social Sciences Index).
Reference lists of included papers and relevant reviews will be searched for papers that were not identified by the electronic search.
Experts in the field will be contacted to identify further significant papers.

Types of study to be included

Included:Any quantitative study type that mentions uptake rates of breast screening;Study must include at least one predictor of uptake to be included.Excluded:Case studies, editorials, letters and commentaries.

Condition or domain being studied

Breast screening. Predictors of uptake.

Participants/population

Inclusion:
Women of screening age (variable worldwide).
Exclusion:
Women with previously diagnosed breast cancer;
Women attending diagnostic screening;
Non-human studies.

Intervention(s), exposure(s)

Any intervention related to uptake of breast screening will be included in the review. Studies will be included where they mention uptake rates of breast screening - either current, previous or changes. The study must mention at least one predictor variable of uptake.

Comparator(s)/control

Not applicable.

Main outcome(s)

Worldwide predictors of uptake of breast screening.

* Measures of effect

The outcomes will be measured in terms of uptake, i.e. rate or percentages.

Additional outcome(s)

None.

* Measures of effect

Not applicable.

Data extraction (selection and coding)

A two-step process will be used to identify relevant studies at abstract and title stage and then at full text stage using pre-defined screening criteria. Two researchers will screening the titles and abstracts against inclusion and inclusion criteria independently using the results from the search. if a decision cannot be made on the title and abstract a full text review will be performed.
Where there are disagreements between the two researchers, a third reviewer will be contacted until a consensus is reached.
The full texts of the included studies will be obtained and undergo a second screen by two researchers and again any discrepancies resolved by the third reviewer.
Reasons for inclusion and exclusion will be stated where appropriate. The PRISMA flow diagram will be provided in the review.
Data extraction will take place after the full text review and will include:
General - authors, year, publication journal, study title, article type, stated aims, period of study;
Study characteristics - country, setting, screening programme style in this country;
Study design - cohort, case-control, prospective, retrospective, randomised controlled trial, etc.;
Participants - population;
Outcomes - primary and secondary outcomes definitions, validity of measures used, data collection method;
Predictors - number of predictors, type of predictors, definition of predictors;
overall results;
Overview - strengths and limitations of the study, Was the study blinded?; source(s) of research funding, potential conflicts of interest.
The domains involved in data extraction are broad and comprehensive due to the variability of the potential studies to be included within this review. A piloted data extraction form will be used by the two researchers to test. Any discrepancies will be discussed and a third reviewer will be involved where necessary to reach a consensus.

Risk of bias (quality) assessment

Extracted data will be stored in tabular format on Microsoft Access spreadsheet to complete the methodological quality assessment/risk of bias scoring.
Quality assessment of the included studies will be completed using the quality assessment tool.

Strategy for data synthesis

Descriptive analysis will be presented in tabular format to describe the included studies. Significant hetergeneity is expected to be found amongst the included papers considering the differences between screening programmes internationally. Therefore pooling data in a meta-regression would not be appropriate. Instead, a narrative synthesis will be adopted to explain and summarise results by predictor. This narrative synthesis will analyse the population characteristics, predictor variables and their effects on uptake rate.

Analysis of subgroups or subsets

None planned.

Contact details for further information

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Organisational affiliation of the review

University of Warwick

Review team members and their organisational affiliations

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PROSPERO
International prospective register of systematic reviews

Dr Sian Taylor-Phillips. University of Warwick

Type and method of review
Systematic review

Anticipated or actual start date
21 November 2016

Anticipated completion date
31 July 2017

Funding sources/sponsors
This systematic review presents independent research funded by the NIHR Collaboration for Leadership in Applied Health Research and Care West Midlands (CLAHRC-WM) initiative. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

Conflicts of interest
None known

Language
English

Country
England

Stage of review
Review Ongoing

Subject index terms status
Subject indexing assigned by CRD

Subject index terms
Breast Neoplasms; Developed Countries; Developing Countries; Early Detection of Cancer; Early Diagnosis; Healthcare Disparities; Humans; Mass Screening; Patient Acceptance of Health Care; Socioeconomic Factors

Date of registration in PROSPERO
17 November 2016

Date of first submission

Stage of review at time of this submission

Stage	Started	Completed
Preliminary searches	No	No
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

Revision note
Updated the prospero registration to be more accurate. Updated inclusion criteria to only include quantitative studies due to the number of results found after sifting.

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PROSPERO
International prospective register of systematic reviews

The record owner confirms that the information they have supplied for this submission is accurate and complete and they understand that deliberate provision of inaccurate information or omission of data may be construed as scientific misconduct.

The record owner confirms that they will update the status of the review when it is completed and will add publication details in due course.

Versions

17 November 2016
23 June 2017

Supplementary file B: Search strategy

Database: Ovid MEDLINE(R) <1946 onwards>

Search Strategy:

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1 exp Breast/ or breast*.mp.

2 (screen* or early detection or mammogra* or mass screening or screening program* or mammogra* screen* or direct to consumer or health screen*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

3 (uptake or adheren* or complian* or patient acceptance of healthcare or patient acceptance or patient access or attend*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

4 1 and 2 and 3

5 limit 4 to humans

6 limit 5 to english language

Database: Ovid MEDLINE(R) Daily Update, Ovid MEDLINE(R) Epub Ahead of Print and In-Process, In-Data-Review & Other Non-Indexed Citations

Search Strategy:

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1 exp Breast/ or breast*.mp.

2 (screen* or early detection or mammogra* or mass screening or screening program* or mammogra* screen* or direct to consumer or health screen*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

3 (uptake or adheren* or complian* or patient acceptance of healthcare or patient acceptance or patient access or attend*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept

word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]

4 1 and 2 and 3

Database: Embase Classic+Embase <1947 onwards>

Search Strategy:

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1 exp Breast/ or breast*.mp.

2 (screen* or early detection or mammogra* or mass screening or screening program* or mammogra* screen* or direct to consumer or health screen*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]

3 (uptake or adheren* or complian* or patient acceptance of healthcare or patient acceptance or patient access or attend*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]

4 1 and 2 and 3

5 limit 4 to humans

6 limit 5 to english language

Database: APA PsycInfo <1806 onwards>

Search Strategy:

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1 breast.mp. or exp Breast/

2 (screen* or early detection or mammogra* or mass screening or screening program* or mammogra* screen* or direct to consumer or health screen*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh] (132904)

3 (uptake or adheren* or complian* or "patient acceptance of healthcare" or "patient acceptance" or attend*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]

4 1 and 2 and 3

5 limit 4 to yr="2017 -Current"

6 limit 5 to human

7 limit 6 to english language

Database: Web of Science, 1900 onwards

TOPIC: (breast*) *AND* **TOPIC:** (screen* or "early detection" or mammogra* or "mass screening" or "screening program*" or "mammogra* screen*" or "direct to consumer" or "health screen") *AND* **TOPIC:** (uptake or adheren* or complian* or "patient acceptance of healthcare" or "patient acceptance" or "patient access" or attend*)

Database: CINAHL (Limiters - Publication Year: 1987-June 2019)

S1. TX breast'

S2. TX screen' OR early detection OR TX mammogra' Or TX mass screening OR TX screening program' OR TX mammogra' screen' OR TX direct to consumer OR TX health screen'

S3. TX uptake OR TX adheren' OR TX complian' OR TX patient acceptance of health care OR TX patient acceptance OR TX patient access OR TX health screen'

S4. S1 AND S2 AND S3

Database: Cochrane Library

S1. TX breast'

S2. TX screen' OR early detection OR TX mammogra' Or TX mass screening OR TX screening program' OR TX mammogra' screen' OR TX direct to consumer OR TX health screen'

S3. TX uptake OR TX adheren' OR TX complian' OR TX patient acceptance of health care OR TX patient acceptance OR TX patient access OR TX health screen'

S4. S1 AND S2 AND S3

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4-5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Supplementary file B
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5–6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5–6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	6

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	6
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	6
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	7, Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Supplementary file D
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8, Figure 2
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table 1, Figures 3 & 4, Table 2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Table 1
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	10, 14
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	14–15
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	16–17
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	17–18
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	18–19

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

Breast cancer screening attendance factors: Systematic review

Supplementary file D: Characteristics of included studies

*indicates studies that could be included in meta-analysis or narrative analysis

Author	Publication year	Study country	N in analysis	Study start	Study end	Study design	Factors analysed	Odds ratio (95%CI)
Allgood	2016	UK	22828	unclear	unclear	RCT	NA	NA
Andersen*	2008	Denmark	22653	1999	2001	retrospective cohort	Previous result of mammogram	0.80 (0.62–1.03)
Barlow	2019	USA	305568	2012	2013	cohort	Age	NA
Berens*	2014	Germany	423649	2010	2011	cohort	Age	0.94 (0.93–0.96)
Blanchard*	2004	USA	18851	1985	2002	retrospective cohort	Non-English language spoken	0.33 (0.28–0.39)
							Member of majority racial/ethnic group	1.70 (1.52–1.89)
Bourmaud	2016	France	15844	2009	2009	RCT	NA	NA
Chan*	2014	Canada	504288	1999	2010	retrospective cohort	SES:	
							Medium vs low	1.35 (1.33–1.37)
							High vs low	1.76 (1.72–1.79)
							Medium vs high	1.30 (1.28–1.32)
							Diabetes	0.79 (0.78–0.80)
Chiarelli*	2003	Canada	125250	1990	1995	retrospective cohort	Age at initial screen	0.99 (0.96–1.02)
Chochinov*	2009	Canada	110240	2002	2004	retrospective cohort	Schizophrenia	0.58 (0.52–0.64)
DeBorde*	2018	France	4805390	2013	2014	cohort	SES:	
							Medium vs low	1.09 (1.09–1.10)
							High vs low	0.75 (0.74–0.75)
							Medium vs high	0.69 (0.68–0.69)
Douglas	2016	UK	NA	2012	2012	cohort	NA	NA

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Finney Rutten	2014	USA	62754	2004	2005	cohort	NA	NA
Gatrell	1998	UK	24000	1988	1995	cohort	NA	NA
Goldzahl	2018	France	26495	2015	2015	RCT	NA	NA
Hyndman	2000	Australia	5968	1991	1996	retrospective cohort	NA	NA
Jensen*	2012b/2015b	Denmark	144264	2008	2009	cohort	Education:	
							Medium vs low	1.45 (1.41–1.49)
							High vs low	1.31 (1.27–1.36)
							Medium vs high	0.91 (0.88–0.94)
							Housing tenure (homeowner vs non)	2.20 (2.14–2.26)
							Marital status (non-married/non-cohabiting vs married/cohabiting)	2.27 (2.21–2.33)
							Income:	
							Intermediate vs low	1.91 (1.85–1.97)
							High vs low	2.52 (2.44–2.60)
							Intermediate vs high	1.32 (1.27–1.36)
							Access to vehicle	0.33 (0.32– to 0.34)
							Employment status:	
							Outside workforce vs employed/self-employed	0.66 (0.64– to 0.68)
							Unemployed vs employed/self-employed	0.41 (0.40– to 0.43)
							Distance to screening centre	0.86 (0.84– to 0.88)

Breast cancer screening attendance factors: Systematic review

Katz*	2018	Israel	44318	2008	2014	cohort	Age	1.06 (1.00–1.12)
							Current smoker	0.72 (0.65–0.79)
							Limiting long-term illness	0.64 (0.61– to 0.66)
							60+ primary care visits during 6-year study period (vs <60)	2.70 (2.55–2.86)
							Depression	1.12 (1.02–1.23)
							Diabetes	1.25 (1.17–1.33)
							Heart disease	1.75 (1.61–1.91)
							BMI	0.95 (0.87–1.04)
Kee*	1993	Northern Ireland	600	1991	1991	cross-sectional	Negative attitude about breast screening	0.44 (0.35–0.55)
Lagerlund*	2002	Sweden	46041	1988	1997	cohort	Age	0.98 (0.90–1.06)
							Country of origin (immigrant vs non)	1.75 (1.62–1.90)
							Education:	
							Medium vs low	1.20 (1.11–1.30)
							High vs low	1.16 (1.07–1.25)
							Medium vs high	0.96 (0.88–1.05)
							Housing tenure (homeowner vs non)	2.06 (1.92–2.21)

Breast cancer screening attendance factors: Systematic review

							Income:	
							Intermediate vs low	1.96 (1.80–2.14)
							High vs low	1.61 (1.26–2.05)
							Intermediate vs high	0.82 (0.65–1.03)
							Number of childbirths:	
							0 vs 1–2	0.44 (0.40–0.48)
							3+ vs 1–2	0.81 (0.75–0.87)
Lagerlund*	2015	Sweden	46041	2005	2009	cohort	SES:	
							Medium vs low	2.35 (2.20–2.51)
							High vs low	3.59 (3.22–4.00)
							Medium vs high	1.53 (1.38–1.69)
Larsen*	2018	Denmark	91517	2008	2009	cohort	Age	0.95 (0.91–0.98)
							Country of origin (immigrant vs non)	2.24 (2.10–2.40)
							Education:	
							Medium vs low	1.44 (1.39–1.49)
							High vs low	1.26 (1.21–1.31)
							Medium vs high	0.87 (0.84–0.91)
							Income:	
							Intermediate vs low	2.09 (2.01–2.18)
							High vs low	2.87 (2.76–2.99)
							Intermediate vs high	1.37 (1.32–1.43)
							No comorbidities	1.53 (1.46–1.60)
Le*	2019	Norway	885979	1996	2015	cohort	Age	1.11 (1.09–1.12)
							Country of origin (immigrant vs non)	2.81 2.77–2.85)

Breast cancer screening attendance factors: Systematic review

							Marital status (non-married/non-cohabiting vs married/cohabiting)	1.58 (1.56–1.59)
							Income:	
							Intermediate vs low	1.78 (1.76–1.81)
							High vs low	1.69 (1.65–1.72)
							Intermediate vs high	0.95 (0.93–0.96)
							Receiving disability benefits	0.70 (0.70–0.71)
							Employment status (vs employed/self-employed):	
							Outside workforce	0.51 (0.50–0.51)
							Unemployed	0.47 (0.45–0.49)
							Not living in capital city	1.94 (1.91–1.97)
							Citizen of country	2.88 (2.82–2.94)
Leung*	2015	UK	27416	2008	20101	cohort	Residence (rural vs urban)	1.11 (1.04–1.19)
Lim*	2010	South Korea	3705246	2008	2008	cohort	Age	1.42 (1.41–1.43)
Luckman	2019	USA	10063	2010	2014	RCT	NA	NA
Makedonov*	2015	Canada	105665	2005	2011	case-control	Age at initial screen	1.05 (1.02–1.08)
							Physician years since graduation	1.03 (0.99–1.06)
Matson*	2001	Sweden	32605	1990	1994	cohort	SES:	
							Medium vs low	1.23 (1.17–1.30)
							High vs low	1.84 (1.73–1.96)
							Medium vs high	1.49 (1.41–1.59)
Maxwell*	2013	UK	253017	2005	2008	retrospective cohort	Previous result of mammogram	0.89 (0.83–0.95)

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Mayer	2000	USA	1562	1995	1998	RCT	NA	NA
McCann*	2002	UK	113409	1989	1991	retrospective cohort	Previous result of mammogram	0.82 (0.76–0.89)
Meldrum	1994	UK	3083	1992	1993	RCT	NA	NA
Merrick	2015	USA	4427	2010	2012	RCT	NA	NA
Moss	2001	UK	210939	1996	unclear	retrospective cohort	NA	NA
O'Byrne*	2000	Australia	119502	1995	1996	retrospective cohort	No family history of breast cancer	0.90 (0.86–0.94)
							Type of clinic (mobile vs fixed)	0.93 (0.88–0.98)
							Never HRT use	1.13 (1.09–1.17)
Offman	2013	UK	12929	2010	2011	RCT	NA	NA
Oh*	2011	South Korea	2511976	2005	2008	retrospective cohort	Previous result of mammogram	0.88 (0.88–0.89)
Ore*	1997	Israel	736	1994	1994	RCT	Age	1.16 (0.83–1.62)
O'Reilly*	2012	Northern Ireland	37059	2001	2004	cohort	Age	0.72 (0.68–0.76)
							Education:	
							Medium vs low	1.05 (0.93–1.19)
							High vs low	1.16 (1.07–1.25)
							Medium vs high	1.10 (0.95–1.27)
							Housing tenure (homeowner vs non)	2.14 (2.03–2.27)
							Marital status (non-married/non-cohabiting vs married/cohabiting)	1.72 (1.64–1.81)

Breast cancer screening attendance factors: Systematic review

							Residence (rural vs urban)	1.59 (1.50–1.68)
							No access to vehicle	0.43 (0.41–0.46)
							Long-term limiting illness	0.71 (0.68–0.75)
							Good general health	1.55 (1.46–1.64)
							Religion:	
							Catholic vs none	1.40 (1.25–1.47)
							Protestant vs none	1.57 (1.46–1.70)
Ouédraogo*	2014	France	13565	2010	2011	cohort	Age	1.02 (0.95–1.10)
							Residence (rural vs urban)	0.80 (0.75–0.86)
							SES:	
							Medium vs low	1.08 (0.99–1.18)
							High vs low	1.21 (1.11–1.32)
							Medium vs high	1.12 (1.04–1.22)
							Distance to screening centre	0.85 (0.79–0.91)
Peeters*	1994	Netherlands	1863	1992	1992	RCT	Age	0.69 (0.57–0.84)
Pelfrene	1998	Belgium	40713	1992	1992	cohort	NA	NA
Pinckney	2003	USA	41844	1996	1997	retrospective cohort	NA	NA
Pornet*	2010	France	4865	2004	2006	cohort	Age	1.18 (1.04–1.35)
							SES:	
							Medium vs low	1.24 (1.10–1.40)
							High vs low	1.40 (1.16–1.67)
							Medium vs high	1.12 (0.93–1.35)

Breast cancer screening attendance factors: Systematic review

							>0 GPs per 100,000 inhabitants	0.96 (0.85–1.08)
							>0 radiologists per 100,000 inhabitants	0.87 (0.72–1.05)
Renshaw*	2010	UK	742786	2004	2007	cohort	Age	1.00 (0.99–1.01)
							SES:	
							Medium vs low	1.59 (1.57–1.61)
							High vs low	2.01 (1.98–2.04)
							Medium vs high	1.26 (1.25–1.28)
							First invitation to screening	0.22 (0.21–0.22)
Richards	2001	UK	5732	1997	1998	RCT	NA	NA
Rodriguez	1995	Spain	1859	1989	1989	cohort	NA	NA
Scaf-Klomp	1995	Netherlands	6898	1975	1990	cohort	NA	NA
Segnan	1998	Italy	8069	1993	1993	RCT	NA	NA
Sim*	2012	Australia	582729	1995	2007	retrospective cohort	Previous result of mammogram	0.87 (0.84–0.89)
Simon	2001	USA	1718	1992	1993	RCT	NA	NA
St-Jacques*	2013	Canada	833856	2006	2008	cohort	Age	1.00 (0.99–1.01)
							SES:	
							Medium vs low	1.16 (1.15–1.18)
							High vs low	1.15 (1.13–1.16)
							Medium vs high	0.98 (0.97–0.99)
							Distance to screening centre	1.02 (1.01–1.03)
Sutradhar	2016	Canada	2389889	2001	2010	retrospective cohort	NA	NA

Breast cancer screening attendance factors: Systematic review

Szczepura*	2008	UK	86211	2001	2004	cohort	Age	0.81 (0.79–0.84)
							SES:	
							Medium vs low	1.81 (1.74–1.88)
							High vs low	2.14 (2.04–2.25)
							Medium vs high	1.19 (1.13–1.24)
Taplin	1994	USA	1322	unclear	unclear	RCT	NA	NA
Tatla*	2003	Canada	57201	1995	2005	retrospective cohort	Age at initial screen	0.93 (0.90–0.97)
							Previous result of mammogram	0.49 (0.46–0.52)
							Non-English language preferred	0.43 (0.41– to 0.46)
							Referral by health professional	1.05 (1.00– to 1.10)
Taylor*	1999	USA	82	1995	1996	RCT	Age	0.24 (0.05–1.13)
Taylor-Phillips*	2013	UK	11664	2012	2012	cohort	Age	1.34 (1.24–1.45)
							SES:	
							Medium vs low	2.16 (1.97–2.37)
							High vs low	2.84 (2.49–3.25)
							Medium vs high	1.32 (1.17–1.48)
							Previous attender	3.32 (3.05–3.61)
Vermeer*	2010	Netherlands	1279982	2007	2008	cohort	Country of origin (immigrant vs non)	2.79 (2.74–2.84)
Vidal	2014	Spain	12475	2011	2011	quasi-experimental	NA	NA
Visser	2005	Netherlands	825523	1995	2002	retrospective cohort	NA	NA

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von Euler-Chelpin*	2008	Denmark	73416	1991	1999	cohort	Age	0.65 (0.62–0.67)
							Country of origin (immigrant vs non)	1.82 (1.68–1.96)
							Education:	
							Medium vs low	1.24 (1.19–1.30)
							High vs low	0.76 (0.66–0.88)
							Medium vs high	0.61 (0.53–0.71)
							Marital status (non-married/non-cohabiting vs married/cohabiting)	2.18 (2.09–2.27)
Wilf-Miron	2011	Israel	157928	2008	2008	retrospective cohort	NA	NA
Williams	1989	UK	392	unclear	unclear	RCT	NA	NA
Yarnall	1993	USA	unclear	1985	1988	case-control	NA	NA
Zackrisson*	2004	Sweden	33627	1990	1993	cohort	Age	0.91 (0.88–1.08)
							Country of origin (immigrant vs non)	2.05 (1.93–2.17)
							Education:	
							Medium vs low	1.07 (1.00–1.14)
							High vs low	1.01 (0.94–1.08)
							Medium vs high	0.94 (0.87–1.02)
							Marital status (non-married/non-cohabiting vs married/cohabiting)	1.75 (1.67–1.84)
							Income:	
							Intermediate vs low	2.08 (1.96–2.19)

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							High vs low Intermediate vs high Living in crowded housing conditions	2.24 (2.10–2.39) 1.08 (1.02–1.14) 0.29 (0.24– to 0.36)
Zidar	2015	Sweden	52541	2011	2012	cross-sectional	NA	NA

SES: socioeconomic status/deprivation

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Supplementary file E: Studies included in review but not in meta-analyses or narrative synthesis

Author	Publication year	N in analysis	Study design	Analysis status	Explanation
Allgood	2016	22828	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Barlow	2019	305568	cohort	No useable data	Age categories could not be pooled
Bourmaud	2016	15844	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Douglas	2016	NA	cohort	No useable data	Percentages reported, but not Ns per category
Finney Rutten	2014	62754	cohort	No useable factors	Age categories could not be pooled
Gatrell	1998	24000	cohort	No useable factor	Reports uptake by health provider characteristic(s)*
Goldzahl	2018	26495	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Hyndman	2000	5316	cohort	No useable data	Could not isolate data for different factors
Luckman	2019	10063	RCT	Intervention was confounder	Control-group data for age was reported, but categories could not be pooled
Mayer	2000	1562	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Meldrum	1994	3083	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Merrick	2015	4427	RCT	Intervention was	Control-group-only data not

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				confounder	calculable for other factors
Moss	2001	210939	Cohort	No useable data	Age categories could not be pooled
Offman	2013	12929	RCT	Intervention was confounder	Control-group data for age was reported, but categories could not be pooled
Pelfrene	1998	40713	cohort	No useable data	Percentages reported, but not Ns per category
Pinckney	2003	41844	cohort	No useable data	Age data could not be pooled; attendance data by other factors could not be calculated
Richards	2001	5732	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Rodriguez	1995	1859	cohort	No useable data	Inadequate data reported
Scaf-Klomp	1995	6898	cohort	No useable data	Risk of double-counting participants; time-series data
Segnan	1998	8069	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Simon	2001	1718	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Sutradhar	2016	2389889	cohort	No useable data	Does not report data adequate for calculating ORs
Taplin	1994	1322	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Vidal	2014	12475	quasi-experimental	Intervention was confounder	Control-group-only data not calculable for other factors
Visser	2005	825523	Cohort	No useable	Country of origin

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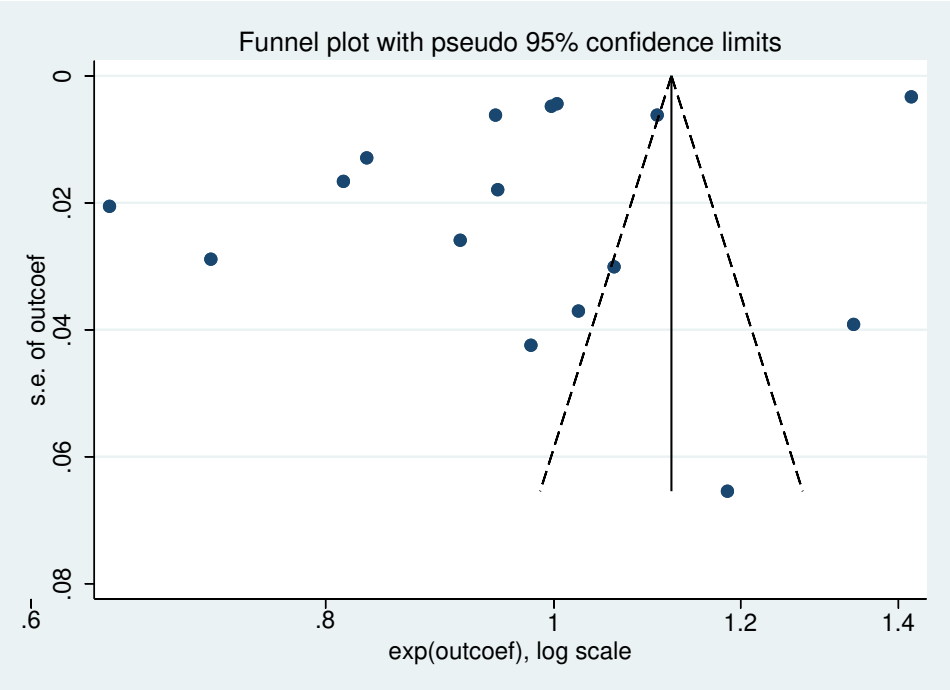
				factors	data could not be pooled
Wilf-Miron	2011	157928	cohort	No useable data	Ns and % attendance not reported
Williams	1989	392	RCT	Intervention was confounder	Control-group-only data not calculable for other factors
Yarnall	1993	unclear	case-control	No useable factor	Reports uptake by health provider characteristic(s)*
Zidar	2015	52541	cross-sectional	No useable data	Reports % non-attendance by age group, but no N per category

*Attendance was measured based on a characteristic or behaviour of the medical provider or facility, not a characteristic of the patient, for example, physician's gender, health centre's use of a special assessment form, or the social deprivation status of the health centre (rather than the patient).

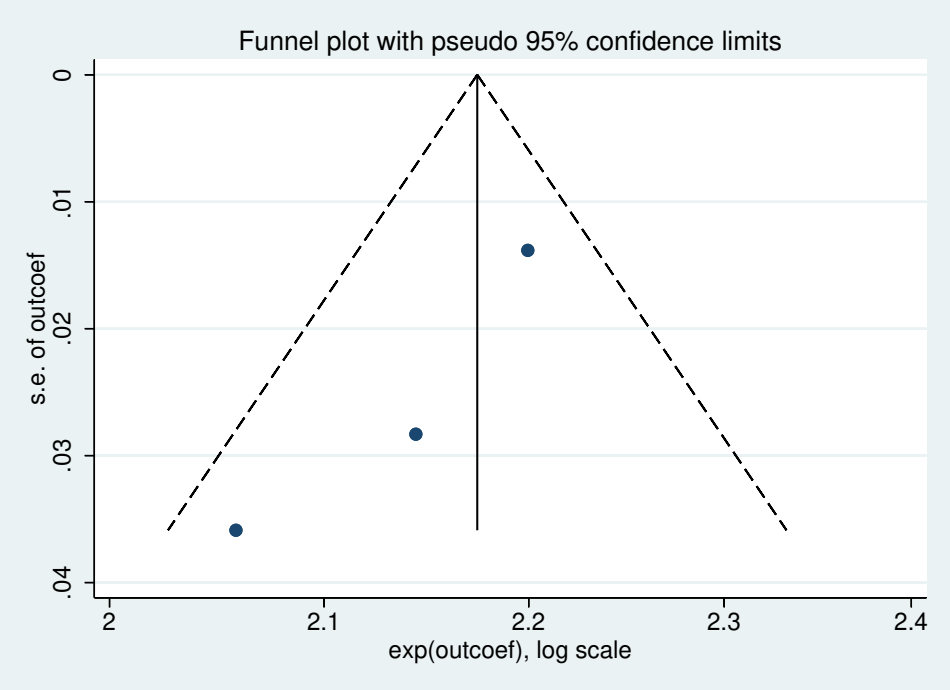
Supplementary file E: Funnel plots

Funnel Plots (note the central estimates come from fixed effects analyses, as these are the only way to assess bias, but means they will not match with the random effects estimates in the main paper)

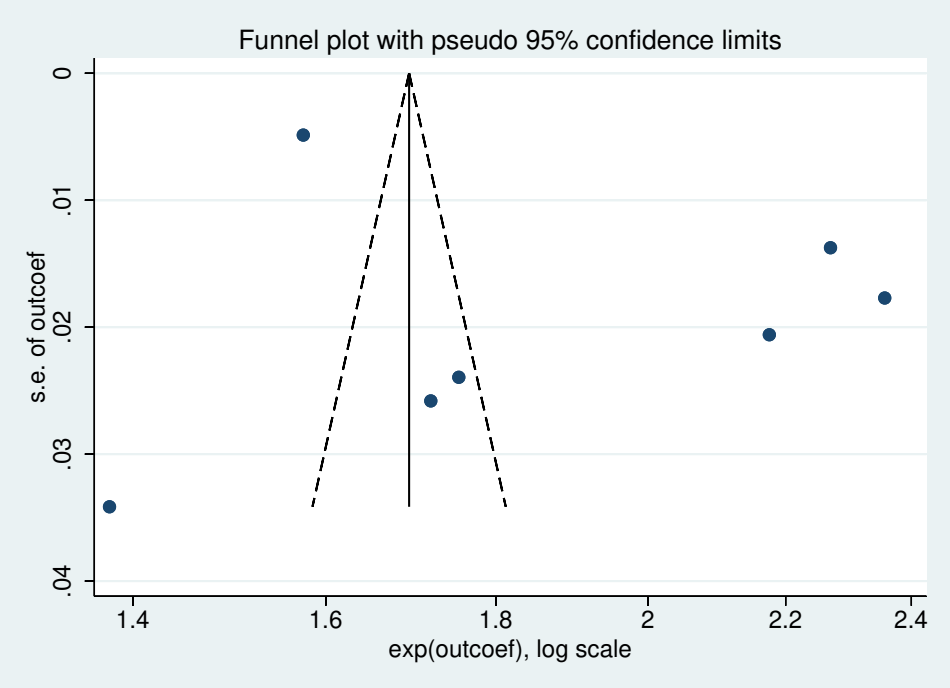
Age



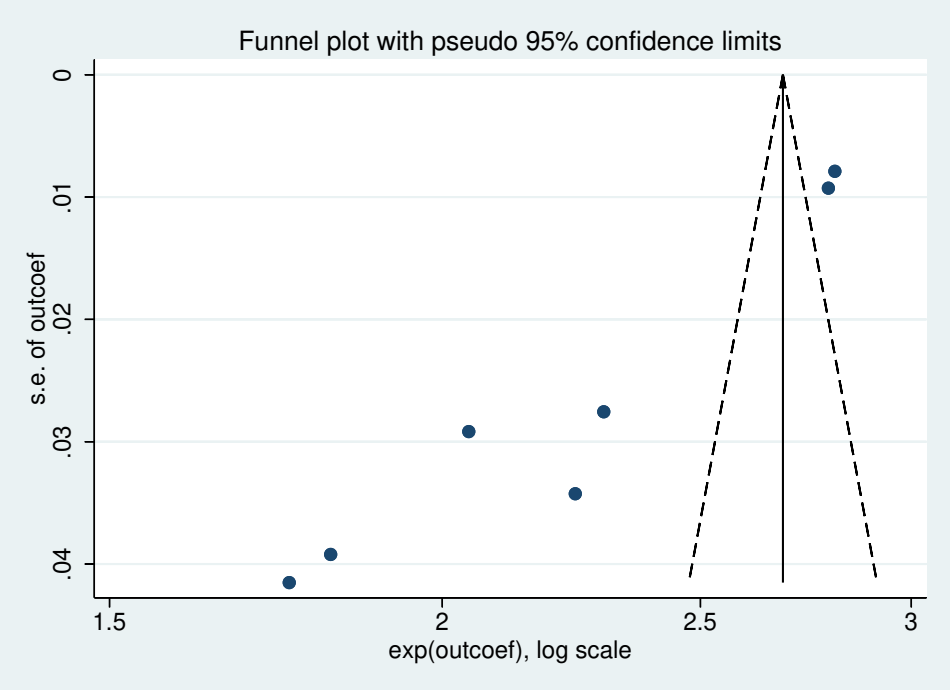
Homeowner



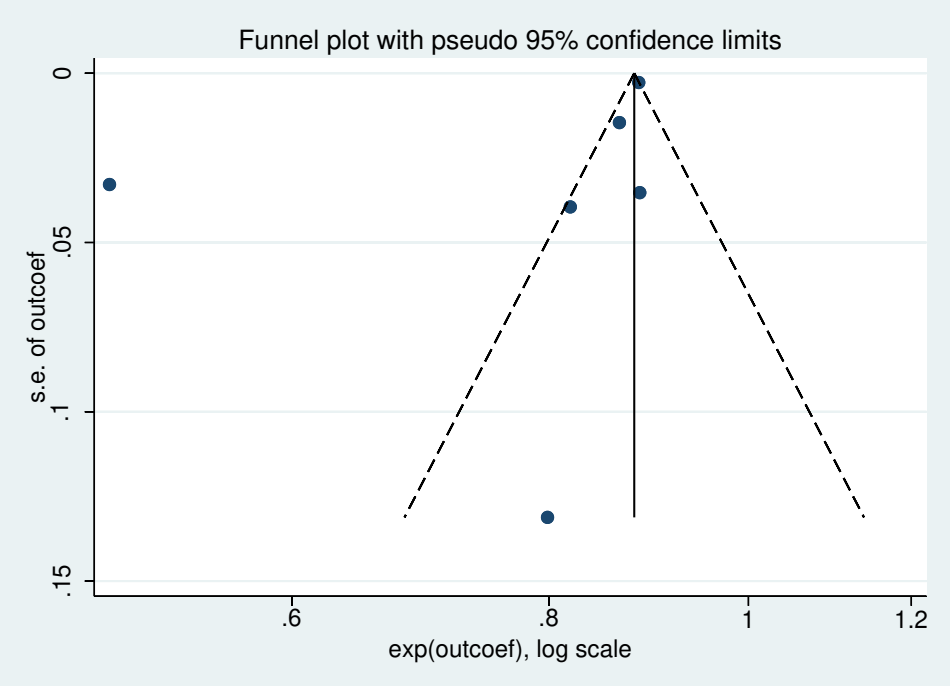
Marital status



Immigrant status



Reattendance



These graphs demonstrate the high level of heterogeneity present between the studies in these analyses.

Age is the only analysis where the studies disagree over the direction of attendance, however the disagreement is among larger studies, suggesting this is unlikely to be associated with biased reporting and instead down to the study heterogeneity. All other analyses, whilst having studies which disagree on the point estimate, have agreement as to which group is more or less likely to attend breast cancer screening.

Overall, we are not concerned about reporting bias.