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

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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.

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. 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). 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. 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 and breast screening programmes have become more aware of the need for promoting informed choice. Attendance at breast screening is not uniform among the eligible population. Ross et al 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 22 November 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 (e.g., 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 (e.g., 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 size18 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...
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. 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). 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.1,8 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, 85%. 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 F values of around 99%, meaning that there was a high level of heterogeneity, except for the analysis of homeowners versus tenants, where the F 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:
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).

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 et al.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 difference.

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 vs 50−59)‡ | Observational studies 5065779 (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) 271641 (3) 74 vs 74 | 0.93 to 1.05 | 0.99 (0.93 to 1.06) |
| Education level | 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) | 223293 (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 | 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 | 1 293 753 (7) 80 vs 69 | 1.38 to 2.36 | 1.86 (1.58 to 2.19) |
| (Married/cohabiting vs unmarried/non-cohabiting) | Residence (rural vs urban) 65641(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).
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                               | 144181      | Jensen 2012b     | 61 vs 82                               | 0.33 (0.32 to 0.34) |
|                                                   | 37059       | 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                      | 885979      | Le 2019          | 69 vs 76                               | 0.70 (0.70 to 0.71) |
| First invitation to screening                      | 742786      | Renshaw 2010     | 40 vs 76                               | 0.22 (0.21 to 0.22) |
| Spoken/preferred language not English              | 18851       | Blanchard 2004   | 62 vs 83                               | 0.33 (0.28 to 0.39) |
|                                                   | 43819       | Tatla 2003       | 60 vs 78                               | 0.43 (0.41 to 0.46) |
| Long-term limiting illness                         | 37059       | O'Reilly 2012    | 71 vs 77                               | 0.71 (0.68 to 0.75) |
| Smoking (current)                                  | 144264      | Jensen 2015b     | 71 vs 80                               | 0.64 (0.61 to 0.66) |
| Living in crowded housing conditions               | 31948       | Zackrisson 2004  | 37 vs 66                               | 0.29 (0.24 to 0.36) |
| **Employment status**                              |             |                  |                                        |            |
| Outside workforce vs employed/self-employed        | 640843      | Le 2019          | 63 vs 77                               | 0.51 (0.50 to 0.51) |
|                                                   | 119269      | Jensen 2012b     | 77 vs 83                               | 0.66 (0.64 to 0.68) |
| Unemployed vs employed/self-employed               | 481911      | Le 2019          | 61 vs 77                               | 0.47 (0.45 to 0.49) |
|                                                   | 102178      | Jensen 2012b     | 67 vs 83                               | 0.41 (0.40 to 0.43) |
| Number of childbirths                              | 46041       | 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                            | 119502      | O'Byrne 2000     | 85 vs 86                               | 0.90 (0.86 to 0.94) |
| Type of clinic (mobile vs fixed)                   | 119502      | O'Byrne 2000     | 84 vs 85                               | 0.93 (0.88 to 0.98) |
| Schizophrenia                                      | 110240      | Chochinov 2009   | 45 vs 58                               | 0.58 (0.52 to 0.64) |
| **More likely to attend**                          |             |                  |                                        |            |
| No comorbidities                                   | 76520       | Larsen 2018      | 82 vs 75                               | 1.53 (1.46 to 1.60) |
| 60+ primary care visits during 6-year study period | 43968       | Katz 2018        | 91 vs 79                               | 2.70 (2.55 to 2.86) |
| Depression                                         | 38823       | Katz 2018        | 86 vs 85                               | 1.12 (1.02 to 1.23) |
| Good general health                                | 37059       | 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                         | 885979      | Le 2019          | 76 vs 62                               | 1.94 (1.91 to 1.97) |
| Previous attender                                  | 11664       | Taylor-Phillips 2013 | 73 vs 45 | 3.32 (3.05 to 3.61) |
| Citizen of country                                 | 885979      | Le 2019          | 75 vs 51                               | 2.88 (2.82 to 2.94) |
| Member of majority racial/ethnic group             | 17997       | Blanchard 2004   | 85 vs 75                               | 1.70 (1.52 to 1.89) |
| Religion                                           |             |                  |                                        |            |
| Catholic vs none                                   | 37140       | 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                                      | 119502      | O'Byrne 2000     | 16 vs 14                               | 1.13 (1.09 to 1.17) |
| Referral by health professional                    | 56420       | Tatla 2003       | 77 vs 76                               | 1.05 (1.00 to 1.10) |
| No difference in attendance or mixed results       |             |                  |                                        |            |
| BMI                                                | 19168       | Katz 2018        | 87 vs 87                               | 0.95 (0.87 to 1.04) |
| >0 GPs per 100 000 inhabitants                     | 4865        | Pornt 2010       | 55 vs 56                               | 0.96 (0.85 to 1.08) |
| >0 radiologists per 100 000 inhabitants            | 4865        | Pornt 2010       | 52 vs 56                               | 0.87 (0.72 to 1.05) |

Continued
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.

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.

Association 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

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**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)                       |
|                                   | 504288 | Chan 2014      | 60 vs 66 0.79 (0.78 to 0.80)                       |
| Distance to screening centre      | 137419 | Jensen 2012b   | 77 vs 80 0.86 (0.84 to 0.88)                       |
|                                   | 833856 | St-Jacques 2013 | 53 vs 52 1.02 (1.01 to 1.03)                       |
|                                   | 13260 | Ouédraogo 2014 | 54 vs 50 0.85 (0.79 to 0.91)                       |
| Physician years since graduation  | 105575 | 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.
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...
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. To points of 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 group educated 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: 2.05 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.

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, perhaps related to the informed-choice agenda. 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, 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. 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.\(^\text{94}\)

**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\(^\text{18}\) 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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Supplemental material
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