Randomised controlled trial of mammographic screening from age 40 (‘Age’ trial): patterns of screening attendance

LE Johns¹, SM Moss¹, for the Trial Management Group²

¹Cancer Screening Evaluation Unit, Institute of Cancer Research, Sir Richard Doll Building, Cotswold Road, Sutton, Surrey, SM2 5NG, UK

Correspondence: LE Johns, E-mail: louise.johns@icr.ac.uk

²Trial Management Group: Professor H Cuckle (Chair), Dr L Bobrow, Dr A Evans, Dr E Kutt, Dr SM Moss, Dr C Record, Dr BA Thomas
ABSTRACT

Background
The Age trial was a randomised controlled trial to study the effect on breast cancer mortality of invitation to annual mammography from age 40-41. Uptake of invitation to screening mammography in UK women aged below 50 is of interest, particularly in the light of the recent announcement that the national breast screening programme will begin inviting women from age 47.

Methods
The trial took place in 23 NHS breast screening units in England, Wales and Scotland between 1991 and 2004. Data on invitation and attendance during 13 years of trial fieldwork were analysed. The participants were 53,884 women in the intervention arm of the Age trial who were randomised to receive annual invitation to mammography from age 40 or 41 up to age 48. The trial is registered as an International Standard Randomised Controlled Trial, number ISRCTN24647151.

Results
Uptake of invitation to routine screening was 68% at first round and 69% at subsequent rounds. A total of 43,709 women in the intervention arm (81.1%) attended at least one routine screen and 23,262 (43.2%) attended at least seven screens; 31,392 women attended 75% or more of all routine invitations they were offered. Previous trial attendance was a predictor of subsequent uptake; attendance was inversely related to Townsend deprivation score.
Conclusion

Uptake in this trial was comparable with that in the UK screening programme for women aged over 50. There was an inverse relationship between deprivation level and the number of screens attended.

**Keywords:** breast, screening, attendance, age, trial
INTRODUCTION

The effectiveness of mammographic screening among women aged 50-69 in reducing mortality from breast cancer is widely accepted \(^1\). However, debate continues in relation to the risks and benefits of mammographic screening in women in their forties. A number of countries, such as Australia, Iceland, Japan and Sweden, include women below age 50 in organised breast screening \(^2\), \(^3\), \(^4\), \(^5\).

High uptake is necessary if screening and subsequent treatment are to be effective in reducing breast cancer mortality in the target population; the screening attendance patterns of women in their forties offered annual mammographic screening in the UK have not previously been reported in detail. The UK Trial of Early Detection of Breast Cancer found comparable or marginally higher uptake rates in the youngest women, aged 45-49, compared with other age groups in the study \(^6\). The Swedish Two County randomised trial also reported higher uptake amongst women aged under 50 years \(^7\).

The UK National Health Service Breast Screening Programme (NHSBSP) plans to lower the minimum invitation age for its three-yearly screening from 50 to 47 by 2012. The Age trial invited women up to age 48 and therefore information on uptake in the trial has relevance for the NHSBSP.

In 2006, we published mortality results from the trial after 10 years of follow-up \(^8\). The present paper reports information on invitation and attendance among women in the intervention arm of the Age trial during 13 years of fieldwork and investigates the impact of social deprivation on uptake. The influence of false-positive experience on re-attendance is discussed in a separate paper.
This study is registered as an International Standard Randomised Controlled Trial, number ISRCTN24647151.
MATERIALS AND METHODS

The trial

The Age trial was designed to investigate the effect of annual invitation to mammography starting at age 40. The design of the study has been described in detail elsewhere ⁹. Briefly, 160,921 women aged 39-41 years were randomised between 1991 and 1997 to an intervention arm and a control arm, in the ratio 1:2. A total of 53,884 intervention arm women were available for analysis. The trial was conducted in 23 NHS breast screening units in England, Wales and Scotland. The average age of women at randomisation in the control and intervention arms was 40.39 and 40.38 years respectively. Women in the intervention arm were offered annual screening by mammography up to and including the calendar year of their 48th birthday; those in the control arm received usual medical care. All women in the intervention arm, including previous non-responders, were re-invited annually unless they requested not to be invited again. As in the NHSBSP, invitations included a specific date to attend for screening, but women were able to contact the screening centre to re-arrange the appointment date if required. Women moving out of the catchment area of their trial screening centre could, if they wished, return to their original centre or to their nearest participating screening unit to continue screening within the trial. All women in the trial become eligible for invitation by the national programme from age 50.

The analysis included trial screening occurring between date of entry to the trial and 31st December 2004. All screening in the trial had been completed by this date.
Invitation and attendance

Individual-level data on screening invitation and attendance were downloaded from the national breast screening computer system at participating screening units using extraction software written specifically for the trial. A woman’s first trial invitation within six months of entry into the study was defined as round one. After the first invitation, a screening round was defined as the offer of a routine trial screen in a 10-14 month period following the previous screen (or invitation to screen). Three centres (Cumbria, Epping and Hull) whose NHSBSP commitment meant they were unable to invite Age trial women for a limited period of time or permanently, have been included in these analyses, contributing data for the period during which they were participating in the trial.

In this paper, ‘ever attenders’ are defined as women who attended at least one routine screen.

Uptake

In later rounds the number of women invited will be less than the total number in the intervention arm as women moving away from a participating centre will no longer be routinely invited. A measure of participation was calculated using the number of women randomised to the intervention arm as denominator. Uptake was calculated as the proportion screened of those who were invited.

Socio-economic status and rural-urban categorisation

Socio-economic status was measured by the Townsend index of social and material deprivation; a summary score calculated using unemployment, car ownership, owner
occupation, and overcrowding variables derived from census data. Pre-calculated Townsend values by enumeration district (available from the Census Dissemination Unit website [http://cdu.mimas.ac.uk/related/deprivation.htm](http://cdu.mimas.ac.uk/related/deprivation.htm)) were mapped to each woman’s postcode of residence at the time she entered the trial. Values calculated from the 1991 census data were used as they were most current for the period of trial entry which took place between 1991 and 1996. Townsend quintiles used in analyses were defined according to the distribution of values in the whole of England and Wales. For the comparison of deprivation in trial areas with England and Wales, the mean Townsend score of enumeration districts where women in the intervention arm had their postcode of residence was compared with the mean of all enumeration districts in England and Wales.

The UK National Statistics Rural/Urban Definition at ward level [http://www.statistics.gov.uk/geography/rudn.asp](http://www.statistics.gov.uk/geography/rudn.asp) was used to derive an approximate rural-urban category for the catchment area of each participating screening centre.

### Statistical tests

Chi-squared tests were used for comparison of attendance between groups and to test for trend. Linear regression was used to investigate factors associated with variation in screening uptake between mammography centres. All tests were performed using the statistical program STATA (version 10.09.2, Stata Corporation, TX, USA).
RESULTS

Invitation

A total of 83 women were never invited due to post-randomisation updates to their health care information which made them ineligible for invitation (for example, they were under care for cancer of the breast or had moved away).

For routine trial invitations, 53.8% of appointments were offered at 12 month intervals (+/- 2 weeks) and 95.4% were offered between 10 to 14 months after the previous invitation.

Uptake rates & patterns of attendance

Ninety-six percent of screens attended took place at an interval of 10 to 14 months.

Figure 1 shows that uptake of invitation to screening ranged from 68.1% to 69.9% in the first eight rounds. Participation, affected by the loss of women to invitation, was lower than uptake at successive screening rounds. At round five for example, uptake was 69.0%, but only 84.5% of women randomised to the intervention arm were invited (n=45,522), resulting in a participation rate of 58.8%.

Table 1 shows attendance and re-attendance as a proportion of the number of invitations offered. Uptake of first invitation to prevalent screen was 68.1% and uptake of re-invitation to prevalent screen non-attenders was 12%. In women who attended the prevalent screen, uptake of invitation to a second routine screen was 72.4% in the group who had attended their first screen straight away, compared with 44.9% in the group who had declined at least one prevalent screen invitation. Uptake of invitation to a third screen rose to 77% and increased at each subsequent routine screen such that uptake of invitation to a seventh screen among women who had already attended six
times was 91.3%. The data show a highly statistically significant trend for increased uptake of invitation with increasing number of previous screen attendances (P<0.0001).

Of the 15,490 women who were re-invited after failing to attend their first invitation, 45.8% did eventually attend for a prevalent screen and having attended once, 81.1% of this group attended a second screen when invited. Of those who had attended a prevalent screen in response to their first invitation, 95.7% attended a second routine screen. After attending two trial screens, the proportion of women re-attending remained at over 95% for each additional screen they were offered.

As a proportion of all women in the intervention arm of the trial, 81.1% (43,709 women) attended at least one routine screen ('ever attenders'), 18.7% (10,092 women) never attended and 0.2% (83 women) were not invited. Overall, 69.6% (37,507 women) attended at least three screens, 57.0% (30,690 women) attended at least five screens and 43.2% (23,262 women) attended at least seven routine screens.

Overall, 31,392 women (58.3% of the intervention arm, 71.8% of ever attenders) accepted 75% or more of their screening appointments and 21,435 women (39.8% of the intervention arm, 49.0% of ever attenders) accepted all their invitations to routine screening. On average, women in the intervention arm of the trial accepted 64.8% of the invitations they were offered for routine screening. This average varied by screening centre (range 46.6% to 76.0%), but only 17% of the variation was explained by the mean of the individual-level deprivation scores at each centre and a broad rural-urban categorisation.

**Uptake, attendance and measures of socio-economic status**

For England and Wales, individual enumeration district Townsend scores derived from the 1991 census data ranged from -7.55 (least deprived) to 11.8 (most deprived) with a mean of 0.0006. Townsend scores for the enumeration districts of women in the
intervention arm of the trial ranged from -7.04 to 10.81 and had a mean score of -0.3566, suggesting a slightly lower mean level of deprivation compared with the whole of England and Wales ($P<0.0001$). There was no difference in the distribution of Townsend scores between the intervention and control arms of the trial.

Table 2 shows uptake of first routine invitation by socio-economic status. In the least deprived group (Townsend quintile 1), the first invitation to routine trial screening was accepted by 10,152 women (75.1%) and a further 1,474 (10.9%) refused their first offer of screening but accepted a later invitation. In the most deprived group (quintile 5), 4,190 women (55.5%) attended in response to the first invitation and 1,331 (17.6%) accepted subsequently. The difference in proportions accepting the first invitation in the least and most deprived groups is highly statistically significant ($P<0.0001$). A total of 1,867 women (13.8%) declined all invitations to routine screening in the least deprived group, compared with 2,019 women (26.7%) in the most deprived group ($P<0.0001$).

Table 3 shows categories of trial screening attendance, among women who attended at least once, by Townsend deprivation quintile. In the least deprived group, 6,538 (56.2%) women attended all offers of routine screening, compared with 2,025 (36.7%) in the most deprived group ($P<0.0001$). There was an inverse relationship between the number of screens attended and the degree of deprivation. The mean number of attendances was 6.3 (median 7) in the least deprived group and 5.3 (median 6) in the most deprived group ($P<0.0001$).
DISCUSSION

There had been concerns that screening uptake might be low in the trial, but uptake has remained at just under 70% across all rounds, with 50% of intervention arm women attending six or more routine screens. Whilst studies of breast screening attendance in the US have reported low compliance with the American Cancer Society’s recommendation of annual mammography from age 40 years \(^{11}\), little information on uptake among women under 50 in organised screening programmes has been published. In the Age trial, 81.1% of women attended at least one screen and having attended once, 93.4% of these women attended again, with the highest uptake of second screen among women who had attended their prevalent screen the first time they were offered an invitation. The likelihood of an invitation to screening being accepted increased markedly the more times a women had previously attended, such that 91.3% of invitations to a seventh routine screen were accepted. Age trial attendance and re-attendance figures are comparable with NHSBSP uptake between 2000 and 2005 in women aged 50 and above of 74-75% at first screen and 88-89% in previous attenders \(^{12}\).

In the Age trial, 18.7% of the intervention arm (10,092 women) failed to attend any of the routine annual screening invitations they were offered. A study by Wallis et al, covering a cohort of women invited by the NHSBSP over a similar time period, but looking at four three-yearly screening rounds, found 10% of women failed to attend any screens \(^{13}\). The same study reported that 62% of women attended all four screens and 77% attended three of the four offered screens. These findings compare with 40% of Age trial women accepting all annual screening invitations and 58% accepting three-quarters of offered invitations.
Participation in routine Age trial screening was found to be inversely related to deprivation as measured by the Townsend index, based on postcode of residence. Re-analysis using deprivation values derived from 2001 census data had little effect on individual deprivation scores or the relationship observed between Townsend score and attendance in the trial.

Internationally, lower uptake of breast screening has long been associated with social deprivation, although there is some suggestion that this association may be less pronounced in younger women. Whilst some early British studies found no such relationship between uptake and deprivation, more recent UK studies show an inverse association between socio-economic status and breast screening uptake. Resulting inequalities continue to be of concern and although initiatives targeting sections of the population with low uptake have had limited success to date, ways to improve attendance continue to be investigated and have been made a priority by the UK government Cancer Reform Strategy.

Components of social deprivation that may play a role in screening participation include economic and personal factors, such as the financial resources to reach a screening facility and a woman’s knowledge of breast cancer risk. The majority of studies have found no significant association between education and uptake of breast screening. Attendance for breast screening in the UK has been positively associated with indicators of wealth, such as owner-occupied housing, but has not been associated with education, occupation, region or ethnicity. In the UK, whilst car ownership is unrelated to uptake of cervical screening, it is positively associated with breast screening uptake. This may be due to the fact that reaching mammography units usually involves some travel whilst, cervical screening is generally provided more locally.
Other factors believed to influence uptake of breast screening, in addition to social deprivation, include the mobility and ethnic mix of the target population. Population mobility affects the accuracy of information used for invitation purposes. Patients may remain on GP registers in error despite having died, emigrated or moved to another area. Urban areas tend to be particularly affected by this. In the UK, ethnicity is associated with uptake of cervical screening, but not necessarily with breast screening uptake, a finding which is at odds with results from some countries, but is consistent with the conclusions of a review by Jepson et al.

No specific or individual-level information on reasons for non-attendance was available for the trial and the Townsend score was used to reflect an area-based summary measure of social deprivation. The Townsend score combines measures of unemployment, car ownership, owner occupation, and overcrowding. It does not directly measure education or ethnicity. It may therefore be more reflective of issues which are important in relation to uptake of breast screening than some other summary measures of socio-economic status.

Only 17% of the variation in attendance between trial screening centres was explained by differences in the mean deprivation of women invited by each centre and a rural-urban categorisation of each centre’s catchment area. This suggests that other, unmeasured factors were responsible for the variation in screening uptake between the centres. Distance to mammography facilities may have caused some variation, over and above the car ownership component measured by the Townsend deprivation score. A study of breast screening attendance in Derbyshire, UK, found a small negative effect of distance on attendance after adjustment for deprivation. We were not able to investigate this factor since, although the postcode of residence of trial women and the location of static screening centres was known, the actual location of...
the facility to which women were invited, which would have included mobile units, was not known.

To allow for women moving out of the study area, uptake was calculated on the basis of attendance following invitation, rather than attendance as a proportion of women randomised to be invited. However, as discussed above, geographical mobility of the trial population may have led to the re-invitation of women who were no longer resident and resulted in an underestimation of uptake. Whilst every effort was made to track movement of the Age trial population using information on the screening system and Primary Care Trust patient registers, this situation will inevitably have arisen.

Trial screening ceased in 2004 and routinely collected NHSBSP data suggest that uptake rates have fallen slightly since 2004, including among the youngest age-group invited by the national programme (women aged 50-54)\(^{30, 31, 32, 33, 34}\). However, in order to avoid increasing demand for screening in the control arm, no health promotion was associated with the trial and it is likely therefore that these results may slightly underestimate the uptake achievable in a service setting with its associated publicity. When the minimum age for NHSBSP invitation is lowered to 47, there is no reason to expect lower uptake rates than those observed in this study, but the inequalities in uptake identified in this trial are likely persist.

Uptake of the first invitation to NHSBSP screening by women in both arms of the trial will be reported in a separate paper.

Our results suggest that uptake of routine invitation to breast screening in the Age trial was comparable with that in the NHSBSP, and re-attendance was particularly high
among women who had previously attended two or more trial screens. There was an inverse relationship between deprivation and the number of screens attended, a finding that is consistent with other published studies. The fact that the trial was set completely within the NHSBSP framework should ensure the applicability of the results to the UK programme.
Figure 1  Age trial mammographic screening uptake and participation, by round

* Uptake: Number of women screened expressed as a proportion of those invited

# Participation: Number of women screened expressed as a proportion of the number randomised to the intervention arm who were still alive and still resident in the United Kingdom at each round
### Table 1  Attendance and re-attendance for routine Age trial mammographic screening

<table>
<thead>
<tr>
<th></th>
<th>No. invitations offered</th>
<th>No. invitations accepted</th>
<th>Uptake %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prevalent screens</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First invitation *</td>
<td>53,801</td>
<td>36,622</td>
<td>68.1</td>
</tr>
<tr>
<td>Invitations to previous never attenders **</td>
<td>59,026</td>
<td>7,087</td>
<td>12.0</td>
</tr>
<tr>
<td><strong>Incident screens</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second routine screen***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– women who attended their first invitation to prevalent screen</td>
<td>47,976</td>
<td>34,753</td>
<td>72.4</td>
</tr>
<tr>
<td>– women who were invited more than once before they attended their prevalent screen</td>
<td>12,097</td>
<td>5,430</td>
<td>44.9</td>
</tr>
<tr>
<td>Third routine screen</td>
<td>48,453</td>
<td>37,507</td>
<td>77.4</td>
</tr>
<tr>
<td>Fourth routine screen</td>
<td>41,835</td>
<td>34,592</td>
<td>82.7</td>
</tr>
<tr>
<td>Fifth routine screen</td>
<td>35,845</td>
<td>30,690</td>
<td>85.6</td>
</tr>
<tr>
<td>Sixth routine screen</td>
<td>30,368</td>
<td>26,937</td>
<td>88.7</td>
</tr>
<tr>
<td>Seventh routine screen</td>
<td>25,482</td>
<td>23,262</td>
<td>91.3</td>
</tr>
<tr>
<td>Subsequent routine re-screens ****</td>
<td>25,659</td>
<td>23,758</td>
<td>92.6</td>
</tr>
</tbody>
</table>

* First invitations issued in screening round 1 plus first invitations issued more than 6 months after entry to the trial

** Invitations to routine screen sent to women who failed to attend in response to any previous routine invitations

*** Invitations to routine screen sent to women who have previously attended once within the trial (screening rounds 2 and above).

**** Invitations to routine screen sent to women who have previously attended at least seven times within the trial (screening rounds 8 and above)
Table 2  Uptake of first Age trial routine invitation, by socio-economic status*

*Townsend 1991 deprivation quintile, based on postcode of residence

<table>
<thead>
<tr>
<th>Townsend quintile</th>
<th>1 (least deprived)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (most deprived)</th>
<th>n/k</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Attended 1st invitation</td>
<td>10,152</td>
<td>75.1</td>
<td>7,963</td>
<td>72.6</td>
<td>6,707</td>
<td>68.6</td>
<td>5,825</td>
</tr>
<tr>
<td>Failed to attend 1st invitation, attended later</td>
<td>1,474</td>
<td>10.9</td>
<td>1,327</td>
<td>12.1</td>
<td>1,261</td>
<td>12.9</td>
<td>1,318</td>
</tr>
<tr>
<td>Failed to attend all invitations</td>
<td>1,867</td>
<td>13.8</td>
<td>1,661</td>
<td>15.1</td>
<td>1,803</td>
<td>18.4</td>
<td>1,899</td>
</tr>
<tr>
<td>Not invited</td>
<td>18</td>
<td>0.1</td>
<td>22</td>
<td>0.2</td>
<td>13</td>
<td>0.1</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>13,511</td>
<td>100.0</td>
<td>10,973</td>
<td>100.0</td>
<td>9,784</td>
<td>100.0</td>
<td>9,059</td>
</tr>
</tbody>
</table>
Table 3  Age trial mammographic screening attendance patterns by socio-economic status* among women who attended at least once

*Townsend 1991 deprivation quintile, based on postcode of residence

<table>
<thead>
<tr>
<th>Townsend quintile</th>
<th>1 (least deprived)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (most deprived)</th>
<th>n/k</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>Attended all invitations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6,538</td>
<td>56.2</td>
<td>5,491</td>
<td>53.3</td>
<td>3,940</td>
<td>49.4</td>
<td>3,100</td>
<td>43.4</td>
</tr>
<tr>
<td>Attended at least 1 invitation, but less than 50% of those offered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,215</td>
<td>10.5</td>
<td>1,200</td>
<td>12.9</td>
<td>1,106</td>
<td>13.9</td>
<td>1,335</td>
<td>18.7</td>
</tr>
<tr>
<td>Failed to attend at least one invitation, but attended 50% or more of those offered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3,873</td>
<td>33.3</td>
<td>3,139</td>
<td>33.8</td>
<td>2,922</td>
<td>36.7</td>
<td>2,708</td>
<td>37.9</td>
</tr>
<tr>
<td>Total</td>
<td>11,626</td>
<td>100.0</td>
<td>9,290</td>
<td>100.0</td>
<td>7,968</td>
<td>100.0</td>
<td>7,143</td>
</tr>
</tbody>
</table>
Acknowledgements

The trial is supported by grants from the Medical Research Council and Cancer Research UK, and has also received funding from the Department of Health. Additional funding has been received from the US National Cancer Research Institute.

The authors would like to acknowledge that the collection of the large volumes of information required for this trial is made possible by the enthusiasm and dedication of screening office managers, clerical, secretarial and computing staff working at participating trial centres* and administrative staff at relevant Primary Care Trusts. Contributions from Derek Coleman and Nicola Kingston for data processing and analysis at the Trial Co-ordinating centre are gratefully acknowledged.


The authors are grateful to the Census Dissemination Unit at the University of Manchester for the provision of pre-calculated enumeration-level Townsend scores based on 1991 census area statistics.
Reference List


