Factors influencing attendance at Abdominal Aortic Aneurysm (AAA) Screening and interventions to reduce inequalities

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Background

An abdominal aortic aneurysm (AAA) is a swelling of the aorta which can ultimately rupture and lead to death. Risk factors include being male, older age, smoking and high blood pressure. Men aged 65 years in the UK are invited to attend a one off ultrasound scan as part of the national population based screening programme. Screening is intended to reduce the number of deaths due to AAA through the early detection, monitoring and surgical repair of AAAs. The effectiveness of AAA-screening in men is supported by evidence from four randomised controlled trials which have demonstrated that screening reduces AAA-related deaths (Guirguis-Blake 2014). These results are based on uptake rates of over 80 per 100 men invited and AAA detection rates of around 5 per 100 men screened.

Eligible men receive a postal invitation to attend for screening. Typically men who fail to attend after one or two further reminders are removed from the programme and not followed up. Given the national coverage of the programme, the absolute number of non-responders is substantial and will continue to grow. The human right to health includes universal physical and economic access to healthcare and appropriate accessible information (WHO 2015). Knowing the reasons for non-attendance would allow programme managers to evaluate whether men are making an informed decision or whether there are barriers to uptake which could be addressed. Further to this, those from more deprived backgrounds are more likely to have an AAA (Kim 2004). It is important for these men to attend for screening to allow them to benefit from early detection and to ensure the cost-effectiveness of the programme. Lack of attendance by this group of men may inadvertently increase health inequalities. In fact, if any one group of men is less likely to attend than another, this could lead to differences in health status between the different population groups. It is in the interest of all to avoid this and the responsibility of those leading the screening programme to ensure the implementation of interventions to minimise inequalities in attendance.

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The aims of this systematic review are to assess what factors influence attendance at AAA screening and what interventions are effective at reducing inequalities in attendance.

Methods

Criteria for considering studies for this review

Types of studies

Systematic reviews, randomised controlled trials, observational studies, analysis of routinely collected data

Types of participants

Adult men or men and women invited for AAA screening

Types of screening programme and intervention

AAA screening

Any intervention to reduce inequalities in attendance

Types of outcome measures

Factors associated with attendance excluding sex and age, since these cannot influence attendance in the National AAA Screening Programme.

Effectiveness of the intervention in reducing inequalities

Search methods for identification of studies

Ovid Medline (1946-2017), Embase (1974-2017), and Proquest Public Health (1963-2017) databases were searched on 30th June 2017. The search strategy was deliberately broad. Medline and Embase were searched using exp(Abdominal aortic aneurysm) AND exp(Mass screening) AND (uptake or non-respon* or barriers or facilitat* or non-particip* or disadvantage* or depriv* or socioeconomic* or inequality*or factors).ti,ab. Proquest Public Health database was searched using (SU.exact(Aortic aneurysm abdominal) and SU.exact(Mass screening)) OR ((disadvantage* or depriv* or socioeconomic* or inequalit* or uptake or non-respon* or barriers or facilitate* or non-particip*) and SU.exact(Aortic aneurysm abdominal)) OR (ti(abdominal aortic aneurysm or AAA) and ab(screening) and (disadvantage* or depriv* or socioeconomic* or inequalit* or uptake or non-respon* or barriers

or facilitate* or non-particip*). The Cochrane Database of Systematic Reviews was searched. Google Scholar was used to look for grey literature as well as the following sources: National Institute for Health Research (NIHR), Agency for Healthcare Research and Quality (AHRQ), Canada Agency for Drugs and Technologies in Health (CADTH). No language or date restrictions were used.

Additional search

An initial scope of results suggested that there is some evidence available for factors influencing attendance but very little on interventions. Based on the lack of papers looking at interventions specifically for AAA screening, it was decided that an additional search would be helpful.

Types of studies
Systematic reviews

Types of participants
Adult men or women

Types of screening programme and intervention
Breast, bowel or cervical screening
Any intervention to reduce inequalities in attendance excluding:

    i)   interventions that simplify or change the test
    ii)   interventions that reduce or eliminate the fee for screening

Comparator
Standard invitation alone

Types of outcome measures
Effectiveness of the intervention in increasing uptake
Effectiveness of the intervention in reducing inequalities

We searched for systematic reviews assessing interventions to reduce inequalities in uptake of bowel, breast and cervical screening using the Cochrane Database of Systematic Reviews, Ovid Medline, Embase and Proquest Public Health databases on 31st July 2017. Medline and Embase were searched with the following strategy: exp(Mass screening) AND (uptake or non-respon* or barriers or facilitat*

or non-particip* or disadvantage* or depriv* or socioeconomic* or inequalit* or rates).ti,ab. AND systematic review.ti AND interven*.mp. Proquest Public Health was searched using SU.exact(Mass screening) AND ti(systematic review) AND interven*.

Data collection and analysis

Selection of studies

For the main search, two researchers (PM and ED) independently undertook an initial selection of studies based on titles and abstracts. One of these researchers (ED) than read the full text papers of the selected studies and decided if they met the inclusion criteria. For the additional search, one researcher (ED) did both the initial and final selections. The decision to include or reject full text papers was checked by a further researcher (MC). Those excluded at this stage are listed in Appendix A.

Data extraction and management

One researcher (ED) extracted the data using a predesigned data extraction form (Appendix B). For the main search, information collected included country of origin, setting and duration of study, details of the screening programme, 'did not attend' definition, inclusion and exclusion criteria, total (and percentage) who attended screening and author recommendations for reducing inequalities. Factors investigated for possible influence on attendance were also extracted and the associated reported outcomes. For the additional search, information collected included inclusion and exclusion criteria for the review, type of intervention, comparator and reported effectiveness of the intervention.

Assessment of quality in included studies

The CASP (Critical Appraisal Skills Programme) tools were used to generate a basic framework for quality assessment, which was incorporated into the data extraction forms. In the main search, the following were considered: missing data, other possible data inaccuracies, risk of bias, potential confounders and role of chance. The risk of selection, detection, performance and attrition bias were assessed, as recommended by the Cochrane Collaboration and using their risk of bias tool.   In the additional search, quality assessment of the systematic reviews was achieved through critique of the

selection and quality appraisal processes and assessment of the overall risk of bias. The results are presented alongside the list of included studies in Appendix C.

Measures of effect

Percentage attendance and/or adjusted odds ratios with 95% confidence intervals (main search)

Absolute percentage change in overall uptake/uptake between subgroups and/or adjusted odds ratios with 95% confidence intervals (additional search)

Results

Description of studies

See Appendices A and C.

Results of the main search (see Figure 1)

The search produced 217 papers. Of these, 191 were excluded after reading titles and abstracts, leaving 26 papers which were retrieved in full text form. Out of the 26, 9 met the inclusion criteria and were used in the narrative synthesis.

Figure 1: Study flow diagram

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┌─────────────────────┐   ┌─────────────────────┐
│ 214 papers          │   │ 3 papers identified │
│ identified from     │   │ from other sources  │
│ database searching  │   │                     │
└─────────────────────┘   └─────────────────────┘
            │                       │
            └───────────┬───────────┘
                        ▼
            ┌─────────────────────┐        ┌─────────────────────┐
            │ Titles and          │        │ 191 excluded as     │
            │ abstracts read      │───────▶│ not relevant        │
            │ =217 papers         │        │                     │
            └─────────────────────┘        └─────────────────────┘
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                        ▼
            ┌─────────────────────┐        ┌─────────────────────┐
            │ Full text read =    │        │ 17 excluded:        │
            │ 26 papers           │───────▶│                     │
            │                     │        │ 9 duplicates        │
            └─────────────────────┘        │                     │
                        │                  │ 8 did not meet      │
                        ▼                  │ inclusion criteria  │
            ┌─────────────────────┐        └─────────────────────┘
            │ 9 included in       │
            │ narrative           │
            │ synthesis           │
            └─────────────────────┘
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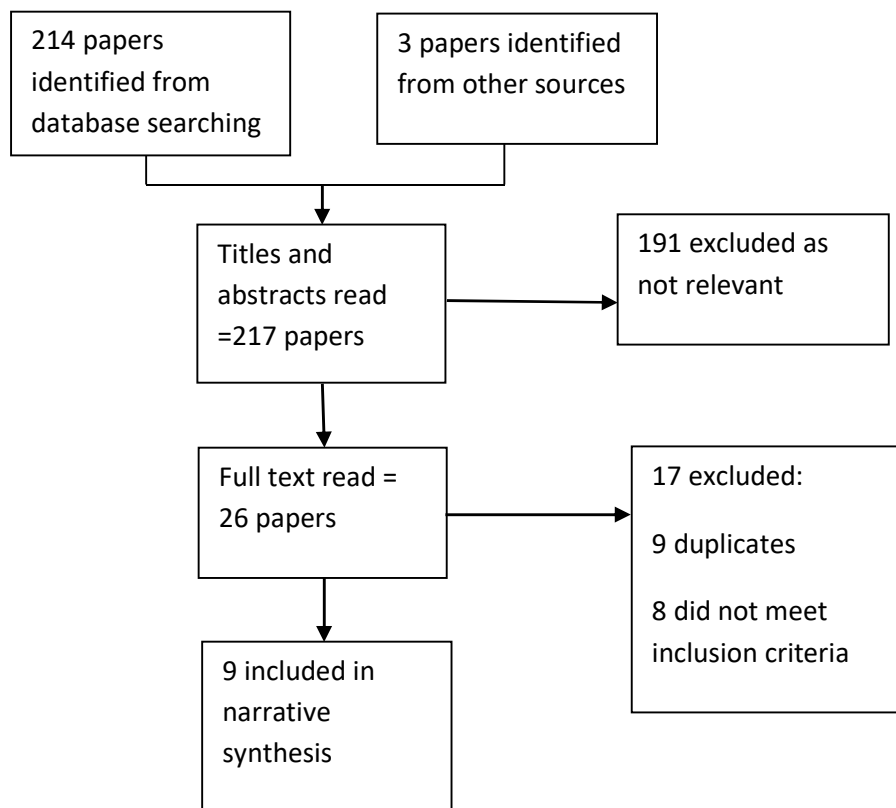
Included studies

All included studies were published in English. Five were analyses of routinely collected data, three were observational studies (case-control) and one was a retrospective analysis of interventional group data collected as part of a randomised controlled trial. Six were from the UK (three Scottish, two English and one from Northern Ireland), two from Sweden and one from the USA. Four used data from 2010 onwards, three between 2000 to 2009 and one prior to 2000.

Participants

The nine studies included 724,654 participants. The number in each studied varied from 3652 to 593,032. Eight studies had included only men and one included men and women. Four had invited only those aged 65 years, three had invited 65 to 74 year olds and one had invited a random selection of individuals aged 65 years and older. The final study had altered the age criteria half way through so that initially 65 to 74 year olds had been invited and then this changed to only 65 year olds.

Participants		Study IDs	Number of studies
Sex	Men only	Badger 2008; Crilly 2015; Jacomelli 2017; Kim 2004; Lindsay 2006; Linne 2014; Ross 2013; Zarrouk 2013	8
	Men and women	Schermerhorn 2008	1
Age	65 years	Crilly 2015; Jacomelli 2017; Linne 2014; Zarrouk 2013	4
	65-74 years	Badger 2008; Kim 2004; Lindsay 2006	3
	65-74 years (50%) 65 years (50%)	Ross 2013	1
	65 years +	Schermerhorn 2008	1

Screening programme

The methods of invitation and screening were similar in all studies; they invited participants by postal letters and screening was by ultrasound scan. Four were part of a national programme, three were prior to a national programme being implemented and recruitment was through GP practices, one was a mix of these two options and one invited a selection of Medicare beneficiaries. In seven studies the screening was free, in one there was a fee and in the final one the fee was scrapped three-quarters of the way through the study. Seven of the studies used the same 'did not attend' definition which was no attendance after an invitation and one reminder or formally opted out if part of a national screening programme. One study used a similar definition which was no attendance after an invitation and two reminders or formally opted out. The final study analysed those who opted out separately and those who did not attend were only those who were not present for their appointment after an invitation and two reminders.

Screening programme		Study IDs	Number of studies
Method of invitation	Postal letter	Badger 2008; Crilly 2015; Jacomelli 2017; Kim 2004; Lindsay 2006; Linne 2014; Ross 2013; Schermerhorn 2008; Zarrouk 2013	9
Method of screening	Ultrasound scan	Badger 2008; Crilly 2015; Jacomelli 2017; Kim 2004; Lindsay 2006; Linne 2014; Ross 2013; Schermerhorn 2008; Zarrouk 2013	9
Recruitment	National screening programme	Crilly 2015; Jacomelli 2017; Linne 2014; Zarrouk 2013	4
	GP practices	Badger 2008; Kim 2004; Lindsay 2006	3
	GP practices then national programme once implemented	Ross 2013	1
	Random selection of Medicare beneficiaries	Schermerhorn 2008	1
Cost	Free	Badger 2008; Crilly 2015; Jacomelli 2017; Kim 2004; Lindsay 2006; Ross 2013; Schermerhorn 2008	7
	Fee	Zarrouk 2013	1
	Fee then free	Linne 2014	1
Did not attend definition	After one invitation and one reminder or opted out	Badger 2008; Kim 2004; Lindsay 2006; Linne 2014; Ross 2013; Schermerhorn 2008; Zarrouk 2013	7
	After one invitation and two reminders or opted out	Crilly 2015	1
	After one invitation and two reminders	Jacomelli 2017	1

Intervention to reduce inequalities in attendance

There were no studies which looked at interventions to reduce inequalities in attendance at AAA screening.

Outcomes

We extracted data on the following outcomes: total number and percentage attended; number and percentage attendance by deprivation score; median deprivation score and interquartile range for those who attended and did not attend; percentage uptake and median private cost in pounds sterling by rural classification; percentage who attended and did not attend who had more than two hospital admissions in the last ten years, more than two outpatient visits, ischaemic heart disease, chronic obstructive pulmonary disease, diabetes, stroke, renal failure and malignancy; coefficient for correlation between attendance and mean income, unemployment levels, percentage of subjects on welfare support, distance to clinic, proportion of immigrants and smoking rates; adjusted odds ratios and 95% confidence intervals for attendance by deprivation score, rural classification, clinic type, distance to clinic and season, income quintile, education level, marital status and immigration status.

Excluded studies

There were eight papers excluded (see Appendix A). The primary reason for exclusion was that there was no reporting of the outcomes of interest (six papers). The other reason for exclusion was that there was not sufficient evidence provided to determine effectiveness of interventions implemented aiming to reduce inequalities in attendance (two papers).

Risk of bias in included studies

As described in Appendix C, each study was assessed for the likelihood of selection, performance, detection and attrition biases. Figure 2 summarises the findings. All studies had low risk of performance and detection biases. Only one study had a high risk of any type of bias (selection). Despite this, only one study had a low risk of any bias. This was largely due to a lack of reporting of how participants were identified, specific reasons for excluding participants and how this was achieved, characteristics of those who declined to participate and how missing data was dealt with. This meant that the risk of selection and attrition biases had to be categorised as 'uncertain' in 67% and 44% of studies, respectively.

Figure 2: Risk of bias graph
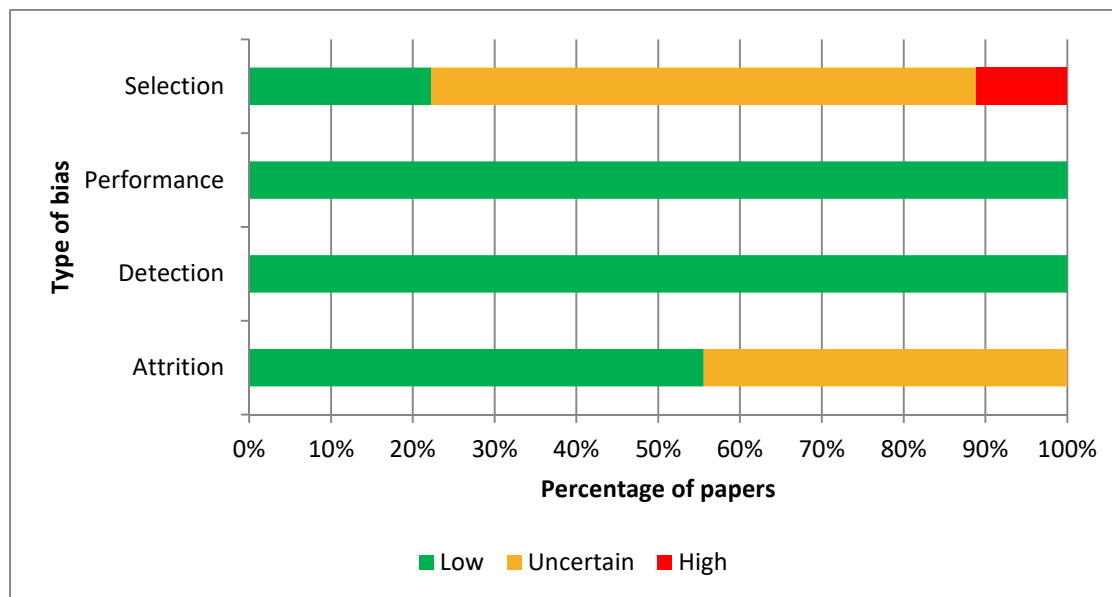
Factors influencing AAA screening attendance

See Appendix D: Data used in review

Socioeconomic status

Six studies assessed how socioeconomic status influenced AAA screening attendance by using an index of multiple deprivation. For all five studies (Badger 2008; Crilly 2015; Jacomelli 2017; Kim 2004; Ross 2013) which broke deprivation score into categories, as deprivation level increased, the less likely it was for men to attend. Linne (2014) produced similar results for income level and education level (as decrease, less likely to attend). Lindsay (2006) compared median Scottish Index of Multiple Deprivation (SIMD) score between those who attended and did not attend. A higher value indicated higher deprivation. The results were a score of 17.27 for those who attended and 19.83 for those who did not. This was statistically significant (p<0.001). Zarrouk (2013) looked at correlations between attendance and mean income, unemployment rates and percentage of subjects on welfare support at datazone level. There was no adjustment for age or sex and no ability to match data on a smaller or more specific level. Areas with higher mean income had higher uptake rates. However, the correlation between lower unemployment and higher uptake was only found in the city and the correlation between lower percentage on welfare support and higher uptake was only found in the suburbs.

Ethnicity and immigration status

There were no studies which were able to look at how ethnicity influenced screening attendance. Two studies used immigration status as a form of by proxy measure. These were both Swedish studies and the information obtained from the Statistics Sweden database (Linne 2014; Zarrouk 2013). Zarrouk (2013) identified a correlation between proportion of immigrants and attendance; the larger the proportion the lower the uptake (r -0.685, p=0.005). Linne (2014) demonstrated that immigrants were less likely to attend than native Swedish. They also observed that the more time an immigrant had lived in the country, the more likely it was that they would attend. However, those living in the country for over 20 years were still less likely to attend than native Swedish. The adjusted OR (95% CI) for non-attendance in immigrants living in Sweden for >20 years compared with native Swedish was 1.31 (1.20, 1.31) and the adjusted OR (95% CI) for immigrants living in Sweden for <5 years was 3.25 (1.94, 5.47).

Rurality

Three studies assessed how rurality influenced AAA screening attendance (Crilly 2015; Lindsay 2006; Ross 2013.) Of these, two used the Scottish Urban Rural Classification and one used the Scottish Household Survey classification of settlements. Percentage attendance was high for all settlement types across the three studies (i.e.>85%). With regards to the results looking at how rurality influenced attendance, there was a range of findings. Crilly (2015) found that those from all other settlement types were more likely to attend than those from large urban settlements. However, only the differences with those from small towns (accessible or rural) and remote rural settlements were statistically significant. From lowest to highest uptake the order was: large urban, accessible rural, other urban, accessible small town, remote small town and remote rural. Lindsay (2006) also observed a statistically significant difference in uptake according to settlement type (only reported as p<0.05), although no adjustment for confounding was conducted. Their classification system was slightly different to Crilly (2015) which makes it difficult to compare the two. From lowest to highest, uptake was as follows: remote small town, accessible small town, very remote small town, very remote rural area, urban, remote rural area, accessible rural area. Ross (2013) did not find any difference in attendance by settlement type but no large urban settlements were included in their analysis.

Lindsay (2006) also looked at methods of travel and travel time according to settlement type. They found that the majority of men used the car to drive to the screening clinic. As expected, those from very remote rural areas spent more time travelling. Arguably more surprising however, was the

observation that men in urban areas also spent more time travelling than those coming from other areas. This could, at least partially, be explained by greater traffic congestion and the greater use of public transport (particularly the bus) by urban men compared with those coming from non-urban areas.

Distance to clinic

Four studies assessed how distance to clinic affected attendance at AAA screening (Crilly 2015; Linne 2014; Schermerhorn 2007; Zarrouk 2013). Crilly (2015) observed no difference in the odds of attending per extra mile to travel; adjusted OR 1.0 (0.98, 1.03). Linne (2014) found no difference in the odds of attending until men were expected to travel over 32km. These men were 23% (10%-37%) more likely not to attend. In contrast to this, Zarrouk (2013) demonstrated that a correlation between distance to clinic and attendance only existed for those resident in the city (r 0.760 p=0.011). However, when measuring distance to clinic, the authors assumed that everyone in that particular zone lived in the largest town. It is therefore unclear how distances in the ten city zones were calculated and the level of accuracy. Schermerhorn (2007) did not report their figures but stated that the clinics were on average closer to those who attended than those who did not attend (p<0.05).

Clinic type

One study (Crilly 2015) assessed if the clinic being in a hospital or community environment influenced attendance. They observed no difference between the two; adjusted OR (95% CI) 1.0 (0.74, 1.34).

Season

Two studies looked at whether the time of year when the invite was sent altered the likelihood of attendance (Crilly 2015; Kim 2004). Both demonstrated no statistically significant difference in attendance when time of invitation was split into winter, spring, summer and autumn.

Cost

Lindsay (2006) reported percentage uptake and median private cost to attend screening by Scottish Household Survey classification of settlement. Private costs included the direct cost of travel, wages

lost and activity foregone for the participant and any accompanying companion or carer. Private costs were approximately £4.00 for those living in urban areas, small towns and accessible rural areas. This increased to £4.59 for those in remote rural areas and £7.29 for those in very remote rural areas. However, there remained high uptake rates in these areas and higher private cost did not correlate with lower attendance.

Marital status

Linne (2014) demonstrated a statistical difference in the odds of men not attending AAA screening according to marital status. The odds of non-attendance were greatest if the man was single or divorced (adjusted OR 2.23 95% CI 2.08, 2.39) then widowed (adjusted OR 1.66 95% CI 1.35, 2.04) and lowest if married (used as reference OR 1.0).

Hospital use

Linne (2014) observed that men who did not attend AAA screening were more likely to have had more than two hospital admissions in the last ten years (32.9% *versus* 29.1%; p<0.001) and less likely to have attended more than two outpatient appointments in the last ten years (76.3% *versus* 85.1%; p<0.001).

Comorbidities

Linne (2014) showed that men who did not attend AAA screening had a higher prevalence of COPD (2.9% *versus* 1.3%; p<0.001), diabetes (9.7% *versus* 8.0%; p<0.001), stroke (4.5% *versus* 2.8%; p<0.001) and renal failure (1.6% *versus* 1.1%; p=0.009). In contrast, men who did not attend had a lower prevalence of malignancy (ten year period prevalence) than those who attended (8.7% *versus* 11.0%; p<0.001). There was no difference observed in the prevalence of ischaemic heart disease between attendees and non-attendees (7.4% *versus* 7.4%; p=0.10).

Smoking status

The higher prevalence of COPD in those who did not attend AAA screening, as demonstrated by Linne (2014), may indicate higher levels of smoking in this group. Zarrouk (2013) did not find a correlation between uptake of screening and smoking rates at zone level. However, using non-adjusted averages at community level is going to be less accurate than individual matching of data.

Recommendations for reducing inequalities

Since no papers were found analysing the effectiveness of interventions at reducing inequalities in attendance for AAA screening, any recommendations produced by the study authors were also extracted. Four themes were reflected in the comments; to increase awareness, increase accessibility, promote local tailoring of the programme and the need for further research.

Recommendation		Justification	Study IDs	Study number
i.Increase awareness	Of the benefits of screening	Apathy towards prophylactic interventions	Badger (2008); Schermerhorn (2007)	4
	Of AAA/ AAA screening	Lack of public awareness	Badger (2008); Kim (2004); Ross (2013)	
ii.Increase accessibility	For deprived men	Deprived men less likely to attend	Crilly (2015); Linne (2014)	3
	For immigrants	Immigrants less likely to attend	Linne (2014)	
	Of information	May be educational or language barriers	Jacomelli (2017); Linne (2014)	
iii.Local tailoring of programme	National programme to monitor and provide regular feedback to screening teams based on equality and diversity data to allow local changes to be made	Variation in uptake rate by geographical location	Jacomelli (2017)	2
	Identify modifiable factors and focus on them	No point trying to influence factors if they are non-modifiable	Linne (2014)	
iv.Further research	Local screening teams to have a responsibility to evaluate any new interventions	No research available	Jacomelli (2017)	2
	Understand better the factors influencing participation/ non-participation for more socially deprived men	Research limited	Kim (2004)	

Results for the additional search

10 papers were retrieved and read in full text form; 6 met the inclusion criteria. Papers from the same authors reporting on the same review process were pooled together. One review (Jepson 2000) had since been updated by different authors (Camilloni 2013 and Ferroni 2012). The methodology used in the updated version, and the accuracy in reporting the initial review, were checked. It was decided that there was no additional benefit in including the initial review in the results as it had been adequately updated. This left 3 distinct reviews to be used in the narrative synthesis.

Included studies

All included studies were systematic reviews and published in English.

Outcomes

We extracted data on the following outcomes: type of intervention, comparator and effectiveness of intervention in increasing overall uptake and uptake between subgroups for breast, cervical and bowel screening.

Excluded studies

There were six papers excluded (see Appendix A).

Interventions to reduce inequalities in attendance at breast, bowel and cervical screening

See Appendix D: Data used in this review

Invitation letter

The majority of studies (10/11) comparing a standard written invitation with an alternative form of written invitation have demonstrated no difference in overall uptake. It is unlikely that a different form of invitation letter than the ones currently used could reduce inequalities in attendance. There appears to be no difference in overall uptake whether invitations are sent out by the GP practice or a

central call/recall centre. In contrast, the individual's own GP signing the invitation letter appears to increase overall uptake.

Reminders

Postal reminders are effective at increasing overall uptake but the effect on inequalities in attendance is unknown. In addition, telephone reminders are likely to be effective at increasing overall uptake. The current evidence is suggestive that telephone reminders plus support for low income groups and ethnic minorities could be effective at reducing inequalities in attendance but more studies are required. Allen (2005) targeted African Americans and women from Latin America through telephone reminders and support in Spanish or English. They found a 8% absolute increase in attendance at breast screening in the intervention group compared to controls, but this was not statistically significant (p=0.121). There are potentially logistical issues with applying the intervention used in this study to a UK setting since it requires a suitably experienced person to call who is fluent in the native language.

The available evidence is suggestive that face-to-face reminders may be effective at increasing overall uptake. However, there are a number of issues with this method including participant acceptability and the large time and resources required. There were no studies found assessing the use of text or email reminders.

Appointment type

 Scheduled appointments are more effective at increasing overall uptake than open appointments. The effect on uptake in subgroups with typically lower attendance rates is unknown.

Reducing logistical barriers

Studies looking solely at the impact of reducing logistical barriers focussed on reducing or eliminating the fee for screening. These were excluded in this review since screening is already free (at point of use) in the UK. Other studies looked at reducing logistical barriers in combination with education provision.

Education – individual

Most interventions also included a motivational and logistical support component in addition to the educational element so it is not possible to conclude the effectiveness of education alone. These suggest that education and appropriate support could be effective at increasing overall uptake and uptake in subgroups with typically lower rates of attendance. However, further studies are required.

There is weak evidence that personalised risk communication increases uptake of screening. Uptake appears to be higher if the risk communication is less detailed and numerical-based. The authors (Edwards 2013) acknowledge that there are only a small number of studies and that the results are dominated by findings related to breast cancer screening. They discuss the issue of feasibility in calculating accurate individual risk scores.

Education –community and population level

Despite the frequency and popularity of mass media campaigns, there is not enough evidence to conclude how mass media and community education affects uptake. However, it is generally recognised that interventions aimed at the whole population are not useful at addressing inequalities (Naidoo 2016).

Discussion

Summary of main results

No studies were identified assessing the effectiveness of interventions at reducing inequalities in attendance for AAA screening. Nine studies were found looking at factors which influence attendance. Understanding which factors affect attendance should help to direct interventions seeking to address barriers and promote facilitators. Socioeconomic status, immigration status and marital status have been shown to influence attendance. In contrast, there is no evidence to suggest that uptake is affected by clinic type or season and there is not sufficient evidence to conclude any difference according to rurality.

There have been conflicting findings on the role of distance to the clinic. For those studies demonstrating no difference, this may be explained by the fact that screening is already offered in various locations and so the vast majority of participants are required to travel relatively short distances that are viewed as acceptable. Logically then, only once the requested distance to clinic becomes viewed as unacceptable would this affect attendance. Time to the clinic may be a more important factor than the distance. For example, Lindsay (2006) found that men living in urban areas (and thus we assume a short distance from a clinic) were on average taking longer to reach the clinic than those from all other settlement types except very remote rural areas. Reasons for this would most likely include greater traffic congestion and greater use of public transport. Higher private costs did not correlate with lower attendance at the level of Scottish Household Survey settlement. However, it would also be useful to look at whether private costs influence attendance according to socioeconomic status and ethnicity.

Findings by Linne (2014) suggest that men who do not attend are less likely to use outpatient services in general and more likely to require hospital admissions. Therefore, encouraging informed attendance at AAA screening for this group of eligible men is likely part of a wider issue – that in fact they do not attend a range of preventative healthcare services and only seek help once symptoms arise. This is in the context of higher comorbidities (e.g. COPD, diabetes, stroke and renal failure) which are also suggestive of higher smoking rates.

The additional search found that there is good evidence to support the use of scheduled appointments and either a letter or telephone reminder for breast, cervical and bowel screening. Edwards (2013) conclude that a reference to personalised risk may be a useful addition in invitation letters to increase informed uptake. However, it is not known how this would affect inequalities in attendance. The authors recommend that any discussion on personalised risk in the letter should be kept short and simple. Camilloni (2013) also recommend avoiding long detailed letters as these may discourage certain groups from attending and thus increase inequalities.

The GP's signature on the invitation letter appears to increase overall uptake rates. It is anticipated that there may be logistical issues with rolling this out nationally for AAA screening and the effect on inequalities in attendance remains unknown. Extra support and education for subgroups known to have lower attendance rates may be effective although more studies are required.

Strengths and limitations

We used a sensitive search strategy and a range of databases to ensure that as many relevant papers as possible were identified. There were no restrictions imposed on language of publication and the grey literature was also searched so as to avoid publication bias. However, quality assessment was limited by a lack of reporting in the papers particularly around selection and recruitment and how missing data was dealt with. Due to time constraints, it was not possible to go back to the authors to clarify these points.

We are not aware of any other systematic review looking at the factors which influence attendance at AAA screening and the interventions to reduce inequalities. The results of this review, therefore, are important in providing direction as to how programmes move forward in tackling these inequalities.

Conclusions

Implications for practice

It is recommended that extra investment in terms of time and resources are directed towards groups less likely to access AAA screening in order to reduce inequalities in attendance. This includes men from more deprived backgrounds, ethnic minorities and single men. When appointments are being allocated and clinic sites reviewed, there should be increased consideration for the time it will take these men to reach the clinic. In addition to distance to clinic, ease of access using public transport and likelihood of traffic problems should be taken into account, especially in urban areas.

Men who do not attend AAA screening appear to be less likely to use preventative services in general. There is therefore an opportunity to work more broadly with colleagues who share the same interest in improving these men's engagement with healthcare. For instance, this group may overlap with men who do not undergo bowel screening. It may be possible to use the times when the men do attend health or social care services (e.g. their GP or acute hospital services) more opportunistically to discuss screening.

Once men have been invited, it may be useful to provide extra support and personal reminders to men less likely to attend. This could come from the local AAA screening office, a specific screening inequalities coordinator or trained peer supporters. There is not enough evidence to conclude how best this support be offered but potentially could be by telephone call, through text if a mobile number is available, or a combination of both. Further information on AAA and AAA screening could be provided alongside discussions on any logistical barriers and how these could be addressed.

Implications for research

Studies assessing the influence of factors on AAA attendance have relied on routine data which cannot provide explanation as to the underlying reasons. Further studies should now look at why factors such as socioeconomic status, ethnicity and marital status affect attendance. The role of smoking status needs to be determined; its potential impact as a confounder, how it independently affects attendance and the reasons for this (for example, smokers may be less likely to attend because

smoking is a known risk factor). More evidence is required to determine if private costs affect attendance and if this association is modified by socioeconomic status.

Although interventions to reduce inequalities in AAA screening attendance are being implemented in the UK and further afield, there are no published studies evaluating their effectiveness. It is extremely important for interventions to be evaluated and the results widely disseminated so that effective interventions can be implemented elsewhere and ineffective ones can be stopped. More broadly speaking, increase in overall uptake has remained the primary outcome of most studies to date assessing interventions implemented in screening programmes. There is a general lack of reporting on how they affect inequalities in screening attendance, which should be included in any further study.

References

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Appendix A –Excluded studies

Main search

1. Benson (2016)
2. Clinton (2016)
3. Duncan (2005)
4. Gilchrist (2016)
5. Hobbs (2004)
6. Jacomelli (2016)
7. Lindholt (2000)
8. Lindholt (1998)

Additional search

1. Barron (2008)a
2. Barron (2008)b
3. Edwards (2003)
4. Jepson (2001)
5. Jepson (2000)
6. Sabatino (2008)

Appendix B – Data extraction form

Main search

Administration details			
Study ID (last name of first author and publication date)			
Publication status			
Funding			
Aim of the study			
Study details			
Author			
Year			
Country			
Language			
Methods			
Design			
Setting of the study			
Duration of the study			
Details of screening programme			
Did not attend definition			
Missing data			
Other possible (random) data errors			
Bias (selection, performance, detection, attrition)			
Potential confounders			
Eligibility criteria for the study			
Inclusion			
Exclusion			
Participants – baseline characteristics			
Total number			
Age			
Sex			
Ethnicity			
Location of residence (rural, city)			
Outcomes			
	Attended	Did not attend	Opted out
Total n(%)			
Factors identified:			
Socioeconomic status			
Chance			
Recommendations for reducing inequalities			

Additional search

Administration details			
Study ID (last name of first author and publication date)			
Publication status			
Funding			
Aim of the study			
Study details			
Author			
Year			
Language			
Methods			
Design	Systematic review		
Selection process			
Quality assessment process			
Bias			
Eligibility criteria for the review			
Inclusion	Study type		
	Date published		
	Language		
	Participants		
	Intervention		
	Comparator		
Exclusion			
Outcomes			
Type of intervention	Comparator	Effectiveness	
Recommendations for reducing inequalities			

Appendix C- Included studies

Main search

<u>Badger 2008</u>

Study details		
Design	Case-control study	
Setting	Belfast, Lisburn and Saintfield, Northern Ireland	
Duration	August 2004 – February 2006	
Participants	Included (n)	Men aged 65 – 75 years registered at one of the participating GP practices (n=**3652**)
	Excluded	Terminal illness, known AAA, deemed unfit for AAA surgery
Screening programme (intervention)	This was done prior to the National population-based screening programme being introduced. Men were identified through GP practices and invited by postal letter. Screening method was by ultrasound scan.	
Did not attend definition	Did not attend after one reminder or opted out	
Outcome(s)	Total number and percentage attended. Percentage attendance by Northern Ireland Multiple Deprivation Measures quintile.	
Quality assessment		
Possible (random) data inaccuracies	GPs may have missed some eligible men. Deprivation assigned at small community level not at individual level, using Northern Ireland Multiple Deprivation Measures.	
Potential confounders	Adjusting for confounding was not done. Potential confounders therefore include smoking status, alcohol, comorbidities, ethnicity, marital/relationship status, rurality, distance to clinic.	
Role of chance	The difference between deprivation quintiles was statistically significant.	
Risk of bias	Authors' judgement	Support for judgement
Selection	Low	GP practices that agreed to participate may be different to practices that declined but authors state they were a 'wide representative sample'. Men not registered with GP are not invited but proportion of eligible men not invited is likely to be small.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Unclear risk	Not reported

Crilly 2015

Study details		
Design		Analysis of routinely collected data
Setting		Grampian, Scotland, UK
Duration		October 2012 – October 2013
Participants	Included (n)	Men aged 65-66 years invited for AAA screening in Grampian (n=**5692**)
	Excluded	Self referring men, deceased, those medically unfit to be screened or unable to provide consent, not Grampian resident, already known to have AAA
Screening programme (intervention)		The AAA screening programmes in Scotland, England, Wales and N Ireland are similar
Did not attend definition		Did not attend despite three letters or opted out
Outcome(s)		Total number and percentage attended. Adjusted odds ratios and 95% confidence intervals for attendance by deprivation index decile, Scottish Urban Rural Classification, clinic type, distance to clinic and season
Quality assessment		
Possible (random) data inaccuracies		Deprivation assigned at small community level (500 – 1000 people) not at individual level, using Scottish Index of Multiple Deprivation (SIMD).
Potential confounders		Smoking status, alcohol intake, comorbidities, ethnicity, marital/relationship status Logistic regression undertaken adjusting for rurality, deprivation, distance to clinic, clinic type and season.
Role of chance		Attendance associated with lower deprivation statistically significant. Those from any area other than Aberdeen more likely to attend. However, only those from small towns and remote rural statistically significant. Odds of men attending higher in Summer than Winter but this was not statistically significant.
Risk of bias	*Authors' judgement*	*Support for judgement*
Selection	Low	Excluded self-referring men. Yet possible that not all self-referring men were excluded or some invited men were excluded but numbers likely small. Men not registered with GP are not invited but proportion of eligible men not invited is likely to be small.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding. Straight line distance between home address and clinic location used (i.e. shortest possible distance). This would affect results of those travelling longer distances more than those nearby but unlikely to have affected overall results.
Attrition	Low	The men invited will be recorded on the AAA screening database.

		98.1% of invited men were included in the adjusted analysis.

Jacomelli 2017

Study details		
Design		Analysis of routinely collected data
Setting		England-wide data
Duration		April 2013 – April 2015
Participants	Included (n)	Men aged 65-66 invited for AAA screening in England (n=**593,032**)
	Excluded	Self-referring men
Screening programme (intervention)		The AAA screening programmes in Scotland, England, Wales and N Ireland are similar
Did not attend definition		Did not attend after one reminder (men who opted out were analysed separately)
Outcome(s)		Total number and percentage attended, number and percentage attended split by deprivation decile
Quality assessment		
Possible (random) data inaccuracies		Deprivation assigned at small community level (1,000-3,000 people) not at individual level, using Index of Multiple Deprivation (IMD) adjusted for lower super output area boundaries. Self-referring men – not made clear how these were identified
Potential confounders		Smoking status, alcohol, comorbidities, ethnicity, marital/relationship status, rurality, distance to clinic
Role of chance		Association with deprivation is statistically significant
Risk of bias	Authors' judgement	Support for judgement
Selection	Unclear risk	Men not registered with GP are not invited but proportion of eligible men not invited is likely to be small. Excluded self-referring men but not clear how. Paper states that the database was still being implemented in some areas and so their data assumingly is not included although this is not specifically stated. Not clear if any attempt made to ensure deceased individuals/ those already known to have AAA were not included.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post.
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Low	The men invited will be recorded on the database. All men were assigned an IMD decile.

Kim 2004

Study details		
Design		Retrospective analysis of intervention group data collected as part of RCT
Setting		Portsmouth, Winchester, Oxford and Southampton, England
Duration		January 1997 – May 1999
Participants	Included (n)	Men aged 65-74 years in Portsmouth, Winchester, Oxford and Southampton (n=**67,800 men randomised; 33,839 invited**)
	Excluded	Unfit to be screened
Screening programme (intervention)		This was done prior to the National population-based screening programme being introduced. Men were identified through GP practices and invited by postal letter. Screening method was by ultrasound scan.
Did not attend definition		Did not attend after one reminder or opted out
Outcome(s)		Total number and percentage attended. Adjusted OR and 95% confidence intervals for attendance by social deprivation quartile and season invited
Quality assessment		
Possible (random) data inaccuracies		GPs may have missed some eligible men. Deprivation assigned at small community level not at individual level.
Potential confounders		Smoking status, alcohol, comorbidities, ethnicity, marital/relationship status, rurality, distance to clinic
Role of chance		Association with socioeconomic quartile was statistically significant. There was no difference observed in attendance between those invited in different seasons.
Risk of bias	*Authors' judgement*	*Support for judgement*
Selection	Unclear risk	Not reported if some GP practices declined to participate and if the men at those practices were systematically different to those who were included. Not clear how GPs decided if men should be included or excluded. Men not registered with GP are not invited.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Low	95% of men had social deprivation scores and 'season invited' information available

Lindsay 2006

Study details		
Design		Case control (with elements of cost-effectiveness analysis)
Setting		Highlands and Western Isles, Scotland
Duration		February 2001 – January 2004
Participants	Included (n)	Men between 65 and 74 years in Highland and Western Isles (n=**9323**)
	Excluded	Deceased, had moved away, screening would be 'inappropriate' e.g. due to comorbidity, known AAA.
Screening programme (intervention)		Eligible 65- 74 year old men identified by GPs. Invitations sent out by post. Rescheduling could be done over the phone. Method of screening was by ultrasound scan.
Did not attend definition		Did not attend after one reminder or opted out
Outcome(s)		Total number and percentage attended. Median Scottish Index of Multiple Deprivation (SIMD) score and interquartile range for those who attended and did not attend. Percentage uptake and median private cost in pounds sterling by Scottish Household Survey remoteness classification.
Quality assessment		
Possible (random) data inaccuracies		Questionnaire used to work out private costs; asked men duration of journey and how many miles they had travelled – these are likely to be the men's estimates. Other estimates used: cost of car travel per mile, wages lost, cost of activities foregone. Deprivation assigned at small community level (500 – 1000 people) not at individual level, using SIMD.
Potential confounders		No logistic regression analysis performed. Potential confounders were therefore age, deprivation, smoking status, alcohol intake, comorbidities, ethnicity, marital/relationship status, distance to clinic and rurality (depending on which factor was under investigation).
Role of chance		Difference in median SIMD score was statistically significant. Difference in proportion attending by rurality category and private cost incurred were statistically significant (only reported as $p<0.05$).

Risk of bias	Authors' judgement	Support for judgement
Selection	Unclear risk	Exclusion by GPs appears subjective; not made clear the specific reasons for GPs decision not to include men and breakdown of numbers. Possible that excluded men who they thought would be unlikely to attend. Not made clear if every GP practice in this health board participated. Men not registered with GP were not invited.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Unclear risk	8% of men's postcodes could not be used to assign SIMD score or rurality category. According to the authors, the missing data was 'equally distributed across all settlement types' but not able to report if SIMD scores were systematically different to the included men's.

Linne 2014

Study details		
Design	Analysis of routinely collected data	
Setting	Stockholm County, Sweden	
Duration	July 2010 – July 2012	
Participants	Included (n)	Men aged 65 invited for AAA screening in Stockholm County (n=**24 319)**
	Excluded	Deceased within 4 weeks of invitation
Screening programme (intervention)	Similar to UK programmes; became free of charge January 2012. One reminder given to those who do not attend with another prescheduled appointment on it. Rescheduling can be done online or over the phone.	
Did not attend definition	Did not attend after one reminder or opted out	
Outcome(s)	Percentage attended, adjusted odds ratios and 95% confidence intervals for attendance by income quintile, education level, marital status, distance to clinic and immigration status. Percentage who attended and did not attend who had >2 hospital admissions in last 10 yrs, >2 outpatient visits, Ischaemic Heart Disease, Chronic Obstructive Pulmonary Disease, diabetes, stroke, renal failure, malignancy.	
Quality assessment		
Possible (random) data inaccuracies	Income was taken as earnings at age 60 to reduce the likelihood of misclassification due to retirement. Domains of deprivation other than income and education not available. Ethnicity not available so used immigration status. Not made clear how accurate and reliable the Statistics Sweden database is (that keeps information on marital status, income, education and immigration status) and how distance to clinic was calculated.	
Potential confounders	Smoking status, alcohol intake, rurality	
Role of chance	Association with income, education level, marital status, travelling >32km to clinic and immigration status all statistically significant. All differences in healthcare use and disease prevalence were statistically significant.	
Risk of bias	Authors' judgement	Support for judgement
Selection	Unclear risk	Not clear how men are identified as being eligible for AAA screening – only Swedish citizens? Invitation posted to home so have to have a formal address. Not clear if men can self-refer and if so, if these men were included in the analysis.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Low	All participants were able to be matched across the 3 databases (National Board of Health and Welfare database, Statistics Sweden and the AAA screening database)

Ross 2013

Study details		
Design		Analysis of routinely collected data
Setting		Highland, Scotland, UK
Duration		Feb 2001 – Dec 2010
Participants	Included (n)	Men invited for AAA screening in Highland (n=**16 528)** From 2001-2004: 65-74 yr olds From 2004-2010: 65 year olds
	Excluded	Died before appointment, underwent screening elsewhere, deemed unfit for screening, had incomplete or missing postcode on the AAA database or lived in Outer Hebrides
Screening programme (intervention)		The AAA screening programmes in Scotland, England, Wales and N Ireland are similar
Did not attend definition		Did not attend after three letters or opted out
Outcome(s)		Percentage attended, adjusted odds ratio and 95% confidence intervals for attendance by Scottish Index of Multiple Deprivation decile and Scottish Urban Rural Classification.
Quality assessment		
Possible (random) data inaccuracies		A check for duplicate entries was performed. Deprivation assigned at small community level (500 – 1000 people) not at individual level, using SIMD.
Potential confounders		Smoking status, alcohol intake, comorbidities, ethnicity, marital/relationship status, distance to clinic Logistic regression undertaken adjusting for rurality, deprivation and age.
Role of chance		Association with deprivation is statistically significant.
Risk of bias	*Authors' judgement*	*Support for judgement*
Selection	Unclear risk	Not clear whether men can self-refer and if so, if these men were included. Men not registered with GP are not invited but proportion of eligible men not invited is likely to be small.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Unclear risk	Could not assign SIMD (Scottish Index of Multiple Deprivation) decile or SURC (Scottish Urban Rural Classification) to those with an incomplete or missing postcode. These men were excluded from analysis. (Attended = 1401, 8.6% DNA = 202, 10.9%) Not able to report if SIMD scores and SURC were systematically different to the included men's.

Schermerhorn 2008

Study details		
Design		Case-control
Setting		Lebanon (New Hampshire), Philadelphia (Pennsylvania) and Pittsburgh (Pennsylvania), USA
Duration		Not stated
Participants	Included (n)	Medicare beneficiaries aged 65 and over in Lebanon (New Hampshire), Philadelphia (Pennsylvania) and Pittsburgh (Pennsylvania) (n=**30 000**)
	Excluded	Prior aortic surgery, a known AAA, recent abdominal imaging.
Screening programme (intervention)		Medicare beneficiaries over 65 years old randomly selected to be invited for AAA screening by postal letter. Screening method was by ultrasound scan and was free.
Did not attend definition		Did not attend after one reminder or opted out
Outcome(s)		Total number and percentage attended. Distance travelled to clinic split by attended/ did not attend and by clinic location.
Quality assessment		
Possible (random) data inaccuracies		Not clear how distance to clinic was calculated. Medicare database termed as 'questionable' and not up-to-date by authors.
Potential confounders		Adjusting for confounding was not done. Potential confounders therefore include sex, age, smoking status, alcohol, comorbidities, ethnicity, marital/relationship status, rurality.
Role of chance		According to their Figure 1, the association with distance to clinic does not appear to be statistically significant.
Risk of bias	*Authors' judgement*	*Support for judgement*
Selection	High	Very low attendance rate. Included in the men who did not attend were those later confirmed to be deceased, already known to have AAA and those who had recently undergone abdominal imaging, who should have been excluded. Have to be insured by Medicare to be invited.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Unclear risk	Not reported

Zarrouk 2013

Study details		
Design	Analysis of routinely collected data	
Setting	Malmo, Sweden	
Duration	2010 – 2011	
Participants	Included (n)	Men aged 65 invited for AAA screening in Malmo and 15 surrounding areas (n=**8269**)
	Excluded	Nil
Screening programme (intervention)	Eligibility and process is similar to UK programmes but at the time of the study, there was a charge of 130SEK (19USD) for the scan.	
Did not attend definition	Did not attend after one reminder or opted out	
Outcome(s)	Total number and percentage attended. Correlation between attendance and mean income, unemployment levels, percentage of subjects on welfare support, distance to clinic, proportion of immigrants and smoking rates (reported correlation coefficient and p value).	
Quality assessment		
Possible (random) data inaccuracies	Independent variables were based on population averages in Malmo and the surrounding areas (broken down to the level of 25 zones). When calculating distance to clinic, it was assumed that everyone in that zone lived in the largest town. Not made clear how reliable the Statistics Sweden database is.	
Potential confounders	Adjusting for confounding was not done. Potential confounders therefore include smoking status, alcohol, comorbidities, ethnicity, marital/relationship status, rurality, distance to clinic and socioeconomic status depending on which association is under investigation.	
Role of chance	Absolute and relative differences were not reported but p values were provided.	
Risk of bias	Authors' judgement	Support for judgement
Selection	Unclear risk	Only people registered on www.skatteverket.se were sent an invitation. Not clear if men can self-refer and if so, if these men were included in the analysis. Not clear if any attempt made to ensure deceased individuals/ those already known to have AAA were not included.
Performance	Low	Those who attended and did not attend should have received the same invitation letter through the post
Detection	Low	No blinding of outcome assessment but measurement unlikely to be influenced by lack of blinding.
Attrition	Low	The men invited will be recorded on the AAA screening database.

Additional search

1. Camilloni (2013) and Ferroni (2012)
2. Edwards (2013)
3. Porter (2008)

Appendix D – Data used in review

Main search

Socioeconomic status

Study	Measure	Result		Conclusion
Badger (2008)	Northern Ireland Mutiple Deprivation Measures	Least deprived quintile Most deprived quintile	Attended 53.6% 29.0% p<0.001 Dose response relationship	As deprivation level increases, the less likely it is for men to attend
Crilly (2015)	Scottish Index of Multiple Deprivation	Per increase in deprivation by decile	Adj OR (95% CI) 0.92 (0.89, 0.94)	As deprivation level increases, the less likely it is for men to attend
Jacomelli (2017)	Index of Multiple Deprivation	Least deprived decile Most deprived decile	Attended: 55,653 (84.1%) Did not attend: 8,047 (12.2%) Opted out: 2,490 (3.8%) Crude OR for attendance (95% CI) 2.84 (2.76, 2.92) compared with most deprived decile Attended: 29,552 (65.1%) Did not attend: 13,126 (28.9%) Opted out: 2,735 (6.0%) Dose response relationship	As deprivation level increases, the less likely it is for men to attend
Kim (2004)	'Social deprivation score'	Least deprived quartile 2nd 3rd Most deprived quartile	Adj OR (95% CI) Ref 0.87 (0.80, 0.95) 0.67 (0.63, 0.75) 0.44 (0.41, 0.48) p<0.001	As deprivation level increases, the less likely it is for men to attend
Lindsay (2006)	Scottish Index of Multiple Deprivation	SIMD score median (IQR) *Higher values indicate more deprived*	Attended: 17.27 (11.8) Did not attend: 19.83 (11.35) P<0.001	Those that did not attend were on average more deprived than those who attended

Linne (2014)	Disposable income at 60 years	Income quintile 1 (highest)	Attended: 86.5% (used as reference in multivariate analysis)	As income level decreases, the less likely it is for men to attend
		Income quintile 5 (lowest)	Attended: 60.9% Adj OR (95% CI): 2.76 (2.46, 3.10) Dose response relationship	
Linne (2014)	Education level High = University Middle = upper secondary Low = 9 years of compulsory schooling	Education level high	Attended: 81.7% (used as reference in multivariate analysis)	As education level decreases, the less likely it is for men to attend
		Education level low	Attended: 70.6% Adj OR (95% CI): 1.28 (1.16, 1.40) Dose response relationship	
Ross (2013)	Scottish Index of Multiple Deprivation	Most deprived decile	Attended: 79.5% (used as reference in multivariate analysis) Attended: 97.5% Adj OR (95% CI): 10.61 (4.97, 23.48) Dose response relationship	As deprivation level increases, the less likely it is for men to attend
		Least deprived decile		
Zarrouk (2013)	Mean income per zone	Malmo and neighbouring municipalities	R 0.873 p<0.001	Mean income associated with attendance in city and suburbs (zones with higher mean income had higher uptake rates)
		Malmo only	R 0.948 p<0.001	
	Unemployment rate per zone	Malmo and neighbouring municipalities	R -0.247 p=0.375	Unemployment rate only associated with attendance in the city (zones in Malmo with lower unemployment rates had higher uptake rates)
		Malmo only	R -0.796 p=0.006	
	Percentage on welfare support per zone	Malmo and neighbouring municipalities	R -0.698 p=0.004	Percentage of subjects on welfare support only associated with attendance in the suburbs
		Malmo only	R -0.431 p=0.214	

Ethnicity and immigration status

Study	Measure	Result		Conclusion
Linne (2014)	Immigration status	Native Swedish	Attended: 80.0% (used as reference in multivariate analysis)	Immigrants less likely to attend than native Swedish. The more time the immigrant lives in the country, the more likely it is that they will attend but even those living in the country for over 20 years are still less likely to attend than natives.
		Immigrant for >20 yrs	Attended: 70.9% Adj OR (95% CI) for non-attendance: 1.31 (1.20, 1.31)	
		Immigrant for 5-20 yrs	Attended: 66.6% Adj OR (95% CI): 1.48 (1.22, 1.78)	
		Immigrant for <5 yrs	Attended: 51.6% Adj OR (95% CI): 3.25 (1.94, 5.47)	
Zarrouk (2013)	Proportion of immigrants per zone	Malmo and neighbouring municipalities	R -0.685 p=0.005	Associated with attendance in city and suburbs
		Malmo only	R -0.650 p=0.042	

Rurality

Study	Measure	Result		Conclusion
Crilly (2015)	Scottish Urban Rural Classification		Adj OR (95% CI)	Those from all other settlement types are more likely to attend than those from large urban settlements. However, only differences with those from small towns (accessible or rural) and remote rural settlements are statistically significant. In order of uptake (low-high): Large urban Accessible rural Other urban Accessible small town Remote small town Remote rural
		Large urban	Ref	
		Other urban	1.27 (0.89, 1.81)	
		Accessible small town	1.56 (1.05, 2.30)	
		Remote small town	1.64 (1.03, 2.60)	
		Accessible rural	1.18 (0.84, 1.65)	
		Remote rural	1.65 (1.10, 2.49)	

Lindsay (2006)	Scottish Household Survey classification of settlements	Urban Accessible small town Remote small town Very remote small town Accessible rural area Remote rural area Very remote rural area	Percentage attendance 89.6% 87.9% 87.4% 88.7% 92.6% 92% 88.9% P value reported as <0.05	No adjustment for confounding. In order of uptake (low-high): Remote small town Accessible small town Very remote small town Very remote rural area Urban Remote rural area Accessible rural area
Ross (2013)	Scottish Urban Rural Classification	Large urban Other urban Accessible small town Remote small town Accessible rural Remote rural	Percentage attendance - 89.4% 89.0% 89.1% 91.6% 90.5% P=0.02 Results from logistic regression not reported but state no longer any statistical difference observed when take account of deprivation (p=0.06)	No difference in uptake by settlement type but no large urban settlements included

Distance to clinic

Study	Measure	Result		Conclusion
Crilly (2015)	Distance to clinic	Per extra mile	1.0 (0.98, 1.03)	No difference
Linne (2014)	Distance to clinic	0-5km 5-31km 32+km	Attended: 78.7% (used as reference in multivariate analysis) No difference to 0-5km group Attended: 75.7% Adj OR (95% CI): 1.23 (1.10, 1.37)	No difference in attendance until men have to travel 32km or more
Schermerhorn (2007)	Distance to clinic	Percentages not reported but state that the clinics were on average more close to those who attended than those who did not attend (p<0.05)		
Zarrouk (2013)	Distance to clinic	Malmo and neighbouring municipalities Malmo only	R -0.259 p=0.333 R 0.760 p=0.011	Distance to clinic only associated with attendance in the city

Clinic type

Study	Measure	Result		Conclusion
Crilly (2015)	Hospital or community		Adj OR (95% Ci)	No difference
		Hospital	Ref	
		Community	1.0 (0.74, 1.34)	

Season

Study	Measure	Result		Conclusion
Crilly (2015)	Season invited		Adj OR (95% CI)	Overall no difference(summer higher uptake but not statistically significant)
		Winter	Ref	
		Spring	1.07 (0.84, 1.37)	
		Summer	1.22 (0.95, 1.56)	
		Autumn	0.98 (0.79, 1.23)	
Kim (2004)	Season invited		Adj OR (95% CI)	No difference
		Winter	Ref	
		Spring	1.04 (0.95, 1.13)	
		Summer	0.95 (0.88, 1.03)	
		Autumn	1.00 (0.93, 1.08)	
			p=0.370	

Private cost

Study	Measure	Result		Conclusion
Lindsay (2006)	Scottish Household Survey classification of settlements Private costs: direct cost of travel, wages lost, activity foregone for the man and any accompanying companion/ carer		Percentage uptake and median private cost to attend screening	Higher private costs did not correlate with lower attendance
		Urban		
		Accessible small town	89.6% £4.20	
		Remote small town	87.9% £4.00	
		Very remote small town		
		Accessible rural area	87.4% £4.86	
		Remote rural area	88.7% £3.96	
		Very remote rural area		
			92.6% £3.96	
			92% £4.59	
			88.9% £7.29	

Marital status

Study	Measure	Result		Conclusion
Linne (2014)	Marital status	Married	Attended: 84.6% (used as reference in multivariate analysis)	The odds of attending are greater if the man is married, followed by widowed then single/divorced.
		Single/divorced	Attended: 68.4% Adj OR (95% CI): 2.23 (2.08, 2.39)	
		Widowed	Attended: 77.6% Adj OR (95% CI): 1.66 (1.35, 2.04)	

Hospital use

Study	Measure	Result		Conclusion
Linne (2014)	>2 hospital admissions in last 10 yrs	Attended Did not attend	29.1% 32.9% P<0.001	Men who did not attend were more likely to have had >2 hospital admissions in the last 10 years
Linne (2014)	>2 outpatient visits in last 10 years	Attended Did not attend	85.1% 76.3% P<0.001	Men who did not attend were less likely to have attended >2 outpatient appointments in the last 10 years

Comorbidities

Study	Measure	Result		Conclusion
Linne (2014)	IHD period prevalence (10 years)	Attended Did not attend	7.4% 7.4% P=0.10	No difference in prevalence of IHD between those who attended and did not attend
	COPD period prevalence (10 years)	Attended Did not attend	1.3% 2.9% P<0.001	Men who did not attend had a higher prevalence of COPD
	Diabetes period prevalence (10 years)	Attended Did not attend	8.0% 9.7% P<0.001	Men who did not attend had a higher prevalence of diabetes

	Stroke period prevalence (10 years)	Attended Did not attend	2.8% 4.5% P<0.001	Men who did not attend had a higher prevalence of stroke
	Renal failure period prevalence (10 years)	Attended Did not attend	1.1% 1.6% P=0.009	Men who did not attend had a higher prevalence of renal failure
	Malignancy period prevalence (10 years)	Attended Did not attend	11.0% 8.7% P<0.001	Men who attended had a higher prevalence of malignancy

Smoking status

Study	Measure	Result		Conclusion
Zarrouk (2013)	Smoking rates per zone	Malmo and neighbouring municipalities	R -0.132 p=0.625	Not associated with attendance in the city or suburbs
		Malmo only	R -0.565 p=0.089	

Recommendations for reducing inequalities

Study	Recommendation(s)
Badger (2008)	Reasons for non-participation reported as i) apathy towards prophylactic interventions and ii) lack of public awareness of the disease so recommend increasing awareness of benefits of screening and about AAA.
Crilly (2015)	Accessible clinics for deprived urban men
Jacomelli (2017)	Locally directed interventions Men to receive information in an accessible format National programme to monitor and provide regular feedback to screening teams based on their local equality and diversity data Use this data to maximise attendance e.g. by changing venues or increasing awareness in certain groups Local screening teams to evaluate any interventions they use
Kim (2004)	Publicise the screening programme, could consider targeting particular groups. Requires a better understanding of the factors influencing participation for more socially deprived men (lower knowledge? Personal financial costs? Transport difficulties? Difference in health values e.g. greater desire to avoid surgery? This may, therefore, be an informed choice not to attend that should be respected.)
Lindsay (2006)	Majority of men used the car to drive to the screening clinic. More men in urban areas used public transport (particularly the bus) compared with those coming from non-urban areas. Men in urban areas and very remote rural areas spent more time travelling than men coming from other areas.
Linne (2014)	Concentrate on modifiable factors (e.g. marital status is non-modifiable) Target men from areas of high deprivation Target immigrants – increase awareness, provide information in their first language or through pictures Offer screening close to home
Ross (2013)	Increase publicity of the AAA screening programme
Schermerhorn (2007)	Telephoned 120 non-responders: 7% confirmed deceased by relatives or guardians. Interviewed beneficiaries: 28% no recollection of receiving the letter, 24% poor health, 24% lack of interest, 8% known AAA, 4% recent abdominal imaging

Additional search

Type of intervention		Comparator	Effectiveness		Conclusion
Reminders	Postal reminders	Invitation only	Camilloni (2013) – overall uptake	Cervical RR 1.71 (1.60, 1.83) Breast RR 1.37 (1.25, 1.51) Colorectal RR 1.33 (1.17, 1.51) – one study	Postal reminders are effective at increasing overall uptake but effect on inequalities in attendance unknown
	Telephone reminders	Invitation only	Camilloni (2013) – overall uptake	Heterogeneity – unable to perform meta-analysis. 15 studies showed statistically significant improvement in attendance using invitation and tel reminder compared to invitation only, 6 showed no difference.	Telephone reminders are likely to be effective at increasing overall uptake
	Telephone reminder including motivational and logistical support targeting low income groups	Invitation	Porter (2008)	Breast: 1 study increase (12% 6-19%) Dietrich Cervical: 1 study increase (7% 1-12%) Bowel: 1 study no difference, 1 study large increase but not sig, I study increase (13% 7-19%)	Suggestive that telephone reminders plus support for low income groups/ ethnic minorities could be effective at reducing inequalities in attendance but more studies required
	Telephone reminder including	Invitation	Porter (2008)	Allen et al (Latinas and African Americans)	Potentially logistical issues with applying Allen et al's intervention in UK setting since

				8% increase compared to control but not stat sig p=0.121	requires a suitably experienced person to call who is fluent in the native language
	Face to face reminder (going to persons home) – "required many resources and tested on few people"	Invitation and letter reminder	Camilloni (2013) – overall uptake	Heterogeneity – unable to perform meta-analysis. 5 showed statistically significant improvement in attendance, 2 showed no difference.	Suggestive that face-to-face reminders may be effective at increasing overall uptake. However, there are a number of issues with this method including participant acceptability and the large time and resources required (?opportunistic reminders)
Education at individual level	Educational intervention (excluding written information leaflet) aimed at the individual in addition to invitation	Invitation only	Camilloni (2013) – overall uptake	One study each Cervical RR 1.23 (1.04, 1.45) Breast RR 1.24 (1.01, 1.52) Colorectal RR 1.28 (1.00, 1.64)	Suggestive that an educational component delivered to the individual could be effective at increasing overall uptake and uptake in subgroups with typically lower rates of attendance. Most interventions also included a motivational and logistical support component in addition to the educational element so unable to conclude the effectiveness of education alone. Further studies are required.
	One-to-one health education programme and motivational and logistical support, including visits to home, targeting low income	Invitation	Porter (2008)	Paskett et al Cervical: 1.56 (1.29-1.87) Champion et al (African Americans) Breast: 10% absolute increase compared with control – stat analysis not performed Sung et al (African Americans) – lay health advisors	

				Breast: 9.8% absolute increase (2.9-16.7%) Cervical: no difference	
	Personalised risk communication	Standard invitation	Edwards (2013)	Uptake of screening using personalised risk communication compared to standard communication OR 1.13; 95%CI 1.02-1.24	Weak evidence that personalised risk communication increases uptake of screening tests. Uptake appears to be higher if the risk communication is less detailed and numerical-based. The authors acknowledge that there are only a small number of studies and that the results are dominated by findings related to breast cancer screening. They discuss the issue of feasibility in calculating accurate individual risk scores.
Population/ community education	Mass media campaign	Invitation only	Camilloni (2013) – overall uptake	Cervical RR 2.00(1.53, 2.61) – one study – quasi-experimental	Not enough evidence to conclude how mass media and community education affects uptake. Generally recognised that interventions aimed at whole population are not useful at addressing inequalities.
	Community participation	Media campaign	Camilloni (2013) – overall uptake	Clover et al : Breast (two clusters) +29% and +17% p<0.001 in favour of community participation	
	GP involvement intervention	Community participation	Camilloni (2013) – overall uptake	Clover et al: Breast (two clusters) +17% and +10% (p<0.01, p=0.1 respectively) Did not adequately take into account cluster randomisation so significance could be overestimated	

	Media campaign and community education	Invitation only	Camilloni (2013) – overall uptake	Brown et al: Cervical +22% (p<0.001) Did not adequately take into account cluster randomisation so significance could be overestimated	
Type of appointment	Scheduled appointment	Open appointment	Camilloni (2013) – overall uptake	Cervical RR 1.49 (1.27, 1.75) Breast RR 1.26 (1.02, 1.55) Colorectal RR 1.79 (1.65, 1.93) – one study In favour of scheduled appointment	Scheduled appointments are more effective at increasing overall uptake than open appointments. The effect on uptake in subgroups with typically lower attendance rates is unknown.
Who sends out invitation	Invitation sent out by GP practice	Standard invitation letter	Ferroni (2012)	Cervical RR 1.08 (0.99, 1.17) Breast RR 0.99 (0.93, 1.07)	There appears to be no difference in overall uptake whether invitations are sent out by the GP practice or a central call/recall centre.
Variation in invitation letter	Different types of letter	Standard invitation	Camilloni (2013) – overall uptake	1 showed statistically significant improvement in attendance, 8 showed no difference	Unlikely that a different form of invitation letter than the ones currently used could reduce inequalities in attendance
	Personalised letter then further personalised letter/ personalised letter then personalised phone call, targeting African	Standard invitation	Porter (2008)	West et al Breast: No difference between any of the trial arms	

	American women				
	Personalised letter for Vietnamese women (ethnic minority)	Standard invitation	Porter (2008)	Del Mar Cervical: no difference	
	GP signature on letter	Standard invitation	Camilloni (2013) – overall uptake	Cervical RR 1.20 (1.10, 1.30) Breast RR 1.13 (1.11, 1.16) Colorectal RR 1.15 (1.07, 1.24)	GP signature on the invitation letter appears to increase overall uptake. However, there may be logistical issues with rolling this out nationally and the effect on inequalities in attendance remains unknown.

Recommendations for reducing inequalities	
Camilloni (2013) and Ferroni (2012)	Letter or phone reminder Scheduled appointment GP signature Avoid long detailed letters – may increase inequalities by discouraging those with lower educational levels More research measuring effect of mass media campaigns, community based interventions and strategies to reduce logistical barriers Use of routine data to look for trends which may indicate effective strategies
Porter (2008)	Questionnaires regarding inequalities in attendance to any screening programme: 4/40 responses from local boards/PCTs (i.e. 10%) had evaluated their intervention Interventions should be based on existing evidence, introduced for a pilot period, evaluated and results widely disseminated so others can learn. If not effective, should be stopped.