**TITLE PAGE**

*Original Article*

**Influence of rurality deprivation and distance-from-clinic on the uptake by men of abdominal aortic aneurysm screening**

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***Abstract***

**Background:** Effective abdominal aortic aneurysm (AAA) screening requires high uptake, but information concerning factors associated with uptake by men is limited. The aim was to assess the independent association of screening uptake with rurality, social deprivation, clinic-type, distance-to-clinic and season.

**Methods:** Screening across Grampian was undertaken by trained nurses in six community and three hospital clinics. Men aged 65 were invited for screening by post (with two further reminders for non-responders). AAA-screening data is stored on a national ‘call re-call database’. The Scottish ‘postcode directory’ was used to allocate all invited men a deprivation index (Scottish Index of Multiple Deprivation, SIMD), Scottish Urban-Rurality Category (SURC6) and distance-to-clinic. Multivariable analysis was undertaken using IBM-SPSS-Statistics (version 22).

**Results:** The cohort included 5,645 men invited for screening over 12-months (October 2012- October 2013); 42% lived in ‘urban’ areas, 40% ‘rural’ areas and 18% ‘small towns’ (uptake 87%, 89%, 91% respectively). Overall uptake was 89% with 76 new AAA’s detected (15 per 1,000 men screened; 95%CI 12 to 19). Aberdeen city (‘large urban’ area) had the lowest uptake (86%). Uptake declined with increasing deprivation with the steepest decline in ‘urban’ areas. On multivariable analysis a 1-point increase in deprivation-deciles was associated with a 0.08 (95%CI 0.06 to 0.11; p<0.0001) reduction in the odds of being screened. Clinic-type (community versus hospital), distance-to-clinic and season were not independently associated with uptake.

**Conclusions:** Both urban-residence and social deprivation were independently associated with uptake among men. Despite high-uptake the overall effectiveness of AAA-screening may be restricted by a lower than anticipated detection rate.

**Key words**

Abdominal aortic aneurysm

Mass screening

Patient acceptance of healthcare

Health Services Accessibility

Rural health services

Socioeconomic factors

Regression analysis

**Introduction**

A major challenge for population-based screening programmes is ensuring high uptake 1. Evidence relating to those factors which influence uptake predominantly relate to the screening of women for cervical cancer and breast cancer 1-3. Women living in socially deprived areas have generally been found to have a lower uptake of cervical and breast cancer screening, but little previous research has been undertaken on the independent influence of rurality on uptake 3. The majority of evidence relating to the uptake of screening derives from North America (82% of published research in a previous review) 2. and its applicability to other countries such as the UK which have very different healthcare systems is uncertain 2,3. Although information is available concerning some of the factors which influence women’s participation in cancer screening programmes, research relating to the participation of men in population-based screening programmes is currently very limited 1,2.

Screening for abdominal aortic aneurysms (AAA) in men aged 65 years, using portable ultrasound on a single occasion, is a new screening programme that has recently been launched in Scotland and elsewhere in the UK. AAA-screening is targeted solely at men. 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, but without any impact on overall mortality 4-7. Uptake among invited men in these four clinical trials ranged from 70% to 80% 6. AAA-screening inthe Grampian region of northeast Scotland was launched in October 2012 as part of a national population-based screening programme.

A particular advantage of studying the relative influence of deprivation, rurality and geographical remoteness in Scotland is the availability of postcode linked small-area statistics created specifically for the evaluation of deprivation, rurality and geographical remoteness 8;9. The Grampian region (population 555 k) includes 11% of the Scottish population and has a higher proportion of rural settlements compared to the rest of Scotland and the UK. Within Grampian 40% of the population live in the city of Aberdeen. The rest of the population live in the neighbouring rural administrative areas of Aberdeenshire (45%) and Moray (15%).

Concerns about uptake of screening in rural and remote areas have been a persistent concern for the delivery of health services around the world 10-12. A particular problem has been to disentangle the interlinked influences of social deprivation, rurality and geographical remoteness 13,14. The aim of this study is to assess the independent influence of rurality, social deprivation, clinic-type (hospital versus community), distance to the screening clinic and season on the uptake of AAA-screening by men aged 65 years.

**Methods**

Screening for AAA in men aged 65 years using portable ultrasound began in Grampian on the 25th October 2012, with an initial allocation of 3,853 men aged 65 years at inception. The programme can provide men with up to three postal invitations for screening (initial appointment letter, reminder letter and final reminder letter) before categorising them as having ‘defaulted’. Screening is undertaken at nine clinics across Grampian (**Fig 1**) and is delivered by trained nurses (working in pairs) using portable ultrasound machines which link electronically with the national Scottish AAA-screening database (‘Call Re-Call Management System’). The screening sites in Grampian include six community clinics (based in community/cottage hospitals) and three clinics based in three major hospitals: ‘Woodend Hospital’ and ‘Royal Infirmary’ (both in Aberdeen city; population 220 k), along with ‘Dr Grays Hospital’ (in the town of Elgin; population 21 k) in Moray.

***Scottish AAA-screening database***

For this study we extracted the details for all men resident in Grampian who were invited for screening (between 25 October 2012 and 31 October 2013) from the Scottish AAA-screening database**.** The cohort included an initial allocation of 3,853 men aged 65 years in October 2012, plus Grampian men who subsequently ‘turned 65’ during subsequent months. Men over the age of 65 years who self-referred themselves for screening were excluded.

The data extracted from the Scottish AAA-screening database for Grampian men included their: unique community health index (CHI) number, date of birth, home postcode, date of first screening appointment and subsequent invitations, screening clinic location, date of screening assessment and aortic measurements recorded. We defined ‘not been screened’ as defaulting on three screening appointments, or contacting the Grampian AAA-screening office to ‘opt-out’ of the programme.

We used the ‘Postcode Directory’ from the National Records of Scotland (NRS) to allocate ‘Scottish urban/rural categories’ (SURC6) and ‘Scottish Index of Multiple Deprivation’ (SIMD) rankings to all Grampian men aged 65 years invited for screening 8,9. The NRS ‘Postcode Directory’ was also used to assign map co-ordinates to postcodes and Pythagoras' Theorem used to calculate the straight line distance between two points (home addresses and clinic location).

***Scottish Urban/Rural Classification (SURC6)***

We used the current version of the ‘Scottish Urban/Rural Classification’ (SURC6, August 2012) to distinguish between urban, rural and remote areas in Grampian (**Table 1**). SURC6 is produced by the National Records of Scotland (NRS) based on ‘small area population estimates’ combined with the national ‘postcode address file’8. The approach adopted identifies areas of high/low density contiguous postcodes with a population of 500 (or more) that make up a ‘settlement’. SURC6 classifies settlements of less than 3000 people as ‘rural’. Settlements more than 30 minutes estimated drive-time from a larger settlement (10,000 or more) are classified as ‘remote’ (drive-times are based on a raster grid of the transport network in Scotland with each road type classified by an average speed) 8. The only ‘large urban’ area in Grampian is Aberdeen city (population 220 k). There are six ‘other urban’ areas (populations ranging from 10 to 21 k) and sixteen ‘smaller towns’ across Grampian (populations ranging from 3 to 9 k).

***Scottish Index of Multiple Deprivation (SIMD)***

Deprivation was measured using the current version of the Scottish Index of Multiple Deprivation (SIMD, 2012) which numerically ranks ‘datazones’ (small areas of around 800 people) relative to each other across the whole of Scotland. Datazones are ranked numerically from 1 (the most affluent) to 6,505 (the most deprived) in Scotland. A higher index indicates a higher level of multiple social deprivation. SIMD is an area-based measure of relative deprivation that includes multiple dimensions of deprivation across seven domains. SIMD assesses deprivation based on 38 items which contribute to these seven domains. SIMD conceptualises deprivation in relative terms and assigns the largest weightings to income and employment. The SIMD domains (and weights) are: income (28%), employment (28%), education (14%), health (14%), access (9%), crime (5%) and housing (2%). The seven weighted domains are combined to produce an overall deprivation score for each datazone, which are then ranked across Scotland.

***Data analysis***

The relationship of AAA-screening uptake with five factors (SIMD, SURC6, distance-to-clinic, season and clinic-type (community versus hospital-based) was investigated using logistic regression. SIMD was ranked from the ‘least deprived’ to the ‘most deprived’ for the Grampian men invited for screening and converted to deciles (1=least deprived ; 10=most deprived). Age at first invitation to screening was not included in the multivariable analysis as screened and non-screened men were of a similar age. Distance-to-clinic and multiple-deprivation (SIMD) were not normally distributed and are summarised as medians (inter-quartile range, IQR). Because distance-to-clinic appeared to have a curvilinear relationship with uptake ‘distance-squared’ was included in the multivariable model. Goodness to fit of the model was assessed using the Wald statistic, Hosmer-Lemenshew test and the omnibus test of model coefficients chi-square. Screening status (yes/no) was cross-checked against the availability of aortic measurements. All p-values are 2-sided and statistical significance was assumed at the 0.05 level. All data analysis was undertaken in IBM-SPSS Statistics (version 22). The quality of the data extracted from the ‘call re-call database’ was exceptionally high with only eight duplicate records. There was minimal missing data and 98% (5,537/5,645) of invited men were included in the fully adjusted analysis.

The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki. The study involved the analysis of data routinely collected as part of the national AAA-screening programme in Scotland, undertaken by the NHS team responsible for screening in Grampian. All men provided informed verbal consent before being screened. The analysis was undertaken as part of the quality assurance process for the delivery of the AAA-screening in Grampian. For this type of study formal consent is not required. The study adheres to the NHS Scotland ‘Caldicott Guardians: Principles into Practice’ (November 2010) and the NHS Scotland ‘Code of Practice on Protecting Patient Confidentiality’ (July 2003). The initial dataset included patient identifiers (such as postcode), but these were removed from the study-dataset once the relevant variables (SIMD, SURC6, distance-to-clinic) had been derived.

**Results**

A cohort of 5,692 male Grampian residents on the national Scottish AAA-screening ‘call re-call database' who had been invited for screening between 25th October 2012 and 31st October 2013 was identified; with 5,645 (99.2%) of these men included in the analysis. Some 47 (0.8%) men were excluded for the following reasons: 6 had died (none of the deaths were AAA-related), 4 were medically unfit for screening, 2 were unable to provide informed verbal consent, and 10 were no longer resident in Grampian. A further 5 men were already under the care of a vascular surgeon for AAA. Also excluded were 20 men who had defaulted on their first screening appointment, but had not had the opportunity to respond to further screening invitations (19 of these 20 men were subsequently screened after the 31st October 2013).

Among the 5,645 men invited for screening 5,002 (88.6%) underwent ultrasound screening and 643 men (11.4%) ‘defaulted’ on screening (by not responding to 3 postal invitations, or formally ‘opting-out’ of the programme). Men could receive up to three invitations (initial appointment letter, reminder letter and final reminder letter); the ‘cumulative uptake’ of AAA screening was 79.7% after 1st invitation, 88.0% after 2nd invitation and 88.6% after the 3rd and final invitation. Across the AAA-screening sites in Grampian included uptake ranged from between 86% to 92%. The characteristics of the 5,645 invited men are shown in **Table 2.** The median distance-to-clinic was 6 (IQR 2 to 13) miles and only 15 men (0.2%) had a distance-to-clinic of more than 30 miles. Non-screened men lived closer to the screening clinics (4 versus 6 miles) and had a higher level of SIMD-deprivation (13 versus 11).

Mean aortic diameter among the 5,002 screened men was 1.76 (SD 0.35) cms. Screening identified 76 new AAA’s (AA diameter >= 3.0 cms); a detection rate of 15.2 (95%CI 11.8 to 18.6) per 1,000 men screened. The 12-month period prevalence for AAA among men aged 65 years in Grampian (including the 5 men already under the care of a vascular surgeon for AAA) was 16.2 (95%CI 12.7 to 19.7) per 1,000 men.

***Urban and rural settlements***

Among the 5,645 men invited for screening 42% resided in ‘urban’ areas, 40% in ‘rural’ settlements, and 18% in ‘small towns’ (with screening uptakes of 87%, 89% and 91% respectively). Screening took place at nine clinic sites across Grampian with 3,374 men (60%) screened at six community-based clinics and 2,271 (40%) screened at three hospital-based clinics. The relationship between screening uptake with rurality, multiple-deprivation and distance-to-clinic are shown in **Table 3**. The majority of men (99.8%) lived within 30 miles of their allocated screening clinic. Multiple-deprivation was lowest in ‘other urban’ areas and ‘accessible small towns’; and highest in ‘remote small towns’. The shortest median distance-to-clinic was in Aberdeen (the only ‘large urban’ in Grampian) and ‘other urban’ areas (2 and 5 miles respectively); and around 10 miles for all the other ‘non-urban’ areas. The lowest uptake of AAA-screening was among men in the ‘large urban area’ of Aberdeen (86%). The highest uptake of AAA-screening was in ‘accessible small towns’, ‘remote small towns’ and ‘remote rural areas’ (91% in all three settlement types).

***Remoteness and rurality***

The pattern of screening uptake by multiple-deprivation in relation to remoteness and rurality of residence is shown in **Figure 2.** The general trend of declining uptake with increasing levels of deprivation beyond the second SIMD quintile is shown as the finely dotted line for ‘all men’ in **Figure 2a**. High levels of uptake of around 91%were generally sustained in the two most affluent SIMD quintiles. In ‘urban’ and ‘accessible’ areas uptake declined with increasing deprivation (from the third to fifth quintile). Uptake was lowest (82%) among men living in the ‘most deprived urban’ areas (**Figure 2a**). In ‘remote’ areas a high level of uptake was maintained irrespective of increasing deprivation and uptake was actually highest (93%) in the most deprived remote areas (**Figure 2a**). The pattern in relation to ‘rurality’ was similar although somewhat more variable (**Figure 2b**). Uptake again declined with increasing deprivation beyond the second SIMD-quintile. The decline in uptake was steepest for men living in ‘urban’ areas; it was less marked for men in ‘small towns’ and ‘rural’ areas. In the most deprived SIMD-quintile uptake in ‘small towns’ and ‘rural’ areas was between 87%-89%, compared with 82% in ‘urban’ areas.

***Distance from screening clinic***

As shown in **Figure 3** uptake had a ‘U-shaped’ relationship with distance-to-clinic irrespective of residential location (urban, rural, or small town). Uptake was relatively high among men living within one mile of the clinic, declined between 1.0 to 4.9 miles, before rising again beyond 5 miles with a higher level of uptake sustained beyond 10 to 15 miles. Uptake was consistently lower at ‘all distances’ from the clinic in ‘urban’ areas compared with ‘small towns’ and ‘rural’ areas.

***Unadjusted and adjusted analyses***

The crude and adjusted analyses of factors potentially associated with AAA-screening uptake are shown in **Table 3**. Unadjusted and adjusted odds ratios (OR) were very similar, the main exception being the higher uptake associated with community clinics (versus hospital clinics) on unadjusted analysis (OR 1.22, 95%CI 1.04 to 1.44, p=0.02) which disappeared on multivariable adjustment (OR 1.00, 95%CI 0.71 to 1.34, p=0.99). There was minimal missing data and 99.4% (5,612/5,645) of invited men were included in the fully adjusted multivariable regression model.

Multiple-deprivation was strongly and independently associated with a lower uptake of screening. A 1-point increase in SIMD-decile was associated with an adjusted 0.08 (95%CI 0.06 to 0.11; p<0.0001)reduction in the relative odds of being screened. Compared to men living in the ‘large urban’ area of Aberdeen city, the uptake of screening was higher in all the other urban/rural categories. The largest relative differences (with statistically significant adjusted OR greater than 1.50) were observed for men living in ‘accessible small towns’, ‘remote small towns’ and ‘remote rural’ areas. Uptake was also higher in ‘other urban’ and ‘accessible rural’ areas, although these differences did not reach statistical significance. Summer was associated with a higher uptake than winter (OR 1.22, 95%CI 0.95 to 1.56, p=0.13), but this difference was not statistically significant. Distance to the clinic was not associated with uptake on multivariable analysis.

**Discussion**

A very high uptake of AAA-screening among a large cohort men aged 65 years was achieved during the first year of screening in northeast Scotland. On multivariable analysis only social deprivation and urban/rural residence were independently associated with the uptake of screening. Distance to the screening clinic and season were not independently associated with uptake. Being invited for screening at a ‘community-based’ clinic was associated with a higher uptake on crude analysis, but this association disappeared on fully adjusted analysis.

This study has several important strengths.AAA-screening in Grampian is undertaken as part of national population-based programme that employs a bespoke ‘call and re-call’ electronic database that is integrated with both administrative and clinical software. The quality of the data extracted from the ‘call re-call database’ was exceptionally high and 98% of invited men were included in the fully adjusted analysis. Because of the large number of participants available from the initial 12-months of screening in Grampian it was possible to undertake a robust multivariable analysis. Age was not include in the multivariable model because the programme invites men aged 65 years to participate in AAA-screening and the average age of screened and unscreened men were almost identical. The median age of invited men was close to 66 years (65.9 years) due to the ‘backlog’ of 3,853 men who were already ‘aged 65 years’ at the inception of screening in Grampian in October 2012.

This study has some important limitations.The analysis is limited to five factors which are available from the AAA-screening database. Other factors such as marital status, that may be associated with uptake, were not assessed 15. Anecdotally we perceived an important influence of both wives and supportive social networks (such as golfing-buddies and retirement groups) on uptake. Area-based measures were used to ascribe a level of multiple social deprivation to individual men. This is prone to the ‘ecological fallacy’ of assuming that all those living in an area all share the same level of a characteristic such as social deprivation 16.This is mitigated somewhat by Scottish index (SIMD) being based on small-area ‘datazones’ of around 800 people, rather than larger areas such as wards or local government administrative areas. Scotland has a much higher prevalence of smaller rural settlements than the rest of the UK and the SIMD was specifically developed to accurately identify areas of deprivation in both rural and urban locations. As a consequence Scottish datazones are half the size of their English and Welsh counterparts. It was striking and rather surprising that uptake in Grampian was highest (93%) in the most remote areas (which also had the highest levels of deprivation). The reasons for this are unclear, but we would speculate that deprived rural communities highly value services provided by their local ‘community hospitals’ (with close links to general practice) and are prepared to travel greater distances to use such services than urban men. The North Sea oil industry has brought considerable affluence to the Grampian region and the high uptake of AAA-screening (‘a simple scan to detect a mechanical failure which can be repaired’) may partly be attributable to the ‘engineering oriented’ culture of northeast Scotland. The influence of ethnicity on uptake was not explored as northeast Scotland lacks ethnic diversity; based on the 2011 National Census the majority of the population are of white ethnicity (Aberdeen 92%, Aberdeenshire 99% and Moray 99%).

The development SIMD and SURC make Scotland a useful environment in which

to investigate the inter-relationship between deprivation and rurality in relation to the uptake of AAA-screening 8,9. The definition and measurement of rurality and deprivation are intertwined and complex; neither concept has a clear and unambiguous definition 14. A predominantly urban perspective can misrepresent deprivation in rural areas, where car ownership and seasonal employment are of particular importance. The relationship of rurality and deprivation is also complicated by the movement of affluent individuals from urban areas to accessible rural areas 14. Deprivation tends to be more ‘geographically dispersed’ in rural areas compared with urban areas 9. The ‘Scottish Index of Multiple Deprivation’ (SIMD-2012) was specifically created to be an appropriate measure of deprivation in rural areas and SIMD indicators were selected to reflect relative deprivation irrespective of where people live 9,14.

Uptake of AAA-screening in Grampian is higher than that observed among men (aged between 65 to 74 years) in both the Viborg and MASS (‘Multicentre Aneurysm Screening Study’) trials (76% and 80% respectively) 15,17. In the Danish ‘Viborg trial’ lower uptake was associated with lower social class and travel distance > 12.5 miles. Higher uptake was also associated with being married 15. In the UK-based MASS trial, increasing deprivation was associated with lower uptake. Neither trial found season to be associated with uptake 15,17.

Both the ‘Viborg’ and ‘MASS’ trialists employed multivariable methods to assess the independent influence of several factors on uptake. We can identify only one additional research group who have also utilised multivariable methods 18. AAA-screening was launched in Grampian in October 2012 as part of the roll-out of a national screening programme in Scotland, but AAA-screening has been undertaken in the neighbouring Highland region among men aged 65-74 years since 2001 18,19. After two invitations overall uptake was 90% across 51 sites (mainly general practice surgeries and a single city hospital) over 10-years 18. A higher uptake in rural areas (based on SURC6) was also observed, but the association disappeared after adjusting for multiple-deprivation (using the earlier 2009 version of the SIMD) 18. A limitation of the Highland data were ‘missing postcodes’ for 9% of men and their analysis did not include distance-to-clinic, season, or clinic-type. The high uptake achieved in both Highland and Grampian may relate to AAA-screening being predominantly offered in community based settings. Both regions include remote-rural communities, although Highland has a higher proportion of remote-rural communities than Grampian. No additional strategies, such as ‘local media promotion’ or telephoning eligible men, were employed to enhance screening uptake in Grampian.

A recent Swedish study (overall uptake 80%) found low socioeconomic status to be associated with a lower uptake of AAA-screening among men aged 65 years, but reported only a Spearman correlation coefficients for the relationship of uptake of AAA-screening with ‘municipality-level’ welfare support (-0.70; p=0.004) and distance-to-clinic of (-0.26; p=0.33) 20. In Northern Ireland (NI) men aged 65 to 75 years in 23 local GP practices were invited for AAA-screening at a single city hospital in Belfast 21. Uptake was disappointingly low (only 45%) and decreased (from 54% to 29%) with increasing quintiles of deprivation (from Q1 to Q5 based on the NI index of multiple deprivation) 21. Neither study adjusted for other factors 20,21.

The effectiveness of AAA-screening depends not only upon high uptake, but also on the prevalence of AAA in the target population. The high uptake rate of 89% in the first year of screening in Grampian means that the data provides a robust estimate of the 12-month period prevalence of AAA among men aged 65 years. The observed prevalence of 16 (95%CI 13 to 20) per 1,000 men is comparable with that observed recently among men in Sweden (17 per 1,000 men) 22. But this is substantially lower than the anticipated prevalence of between 35 to 45 per 1,000 men based on the four controlled clinical trials that established the impact of AAA-screening 22. Recent evidence from Gloucestershire in the UK indicates that the prevalence of AAA in men aged 65 has declined from 47 to 11 per 1,000 between the years 1990 to 2009 23.The reason for this is unknown, but it may be as a result of reduced male smoking levels and improved control of blood pressure and hyperlipidaemia 22,23.

Having achieved an initially high level of uptake in the first year of screening in Grampian, a major challenge is to sustain this level of uptake and also increase uptake among the smaller percentage of men who default on screening. Since uptake was lowest among men living in the city, a further screening site based in a newly established ‘urban community hospital’ (Aberdeen Community Health and Care Village) has been added. The ‘health village’ is located in the city centre with easier access from the more deprived areas of the city centre by bus.

In conclusion the high uptake of 89% in Grampian is encouraging and superior to that achieved in the major randomised trials of AAA-screening. This suggests that the provision of screening clinics within reasonable distance of rural/remote communities is sufficient to ensure a high uptake of AAA-screening among men. Uptake appears to be more problematic in urban areas where the impact of multiple social deprivation on uptake is more substantial and some men appear to be reluctant to travel even relatively short distances for screening.

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**Figure Legends**

**Fig 1**:

Location of AAA screening clinics in Grampian

**Fig 2**:

Screening uptake and social deprivation:

(a): Uptake of AAA-screening in relation to social deprivation and remoteness.

(b): Uptake of AAA-screening in relation to social deprivation and rurality.

**Fig 3**:

Uptake of AAA-screening in relation to distance-to-clinic and rurality.

**Table Legends**

**Table 1**:

Scottish Urban/Rural Classification (SURC6)

**Table 2**:

Men aged 65 years invited for AAA-screening over 12-months

**Table 3**:

Screening for AAA in men aged 65 years by urban/rural area of residence

**Table 4**:

Unadjusted and adjusted analysis of men’s uptake of AAA-screening by urban/rural residence, deprivation index, distance-to-clinic, clinic-type and season