Uptake of Abdominal Aortic Aneurysm Screening. A Cohort Study

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WHAT THIS PAPER ADDS
This study provides a model for AAA screening in a remote and rural population to reduce associated mortality. We demonstrate the advantages the model has in maintaining high uptake over a decade, independent of rurality and deprivation status in a remote and rural setting.

Background: Abdominal aortic aneurysms (AAA) are responsible for 1.4% of UK deaths. Deprivation is a risk factor for AAA. Screening reduces AAA related mortality and is cost effective if uptake remains high. The Highland aneurysm screening programme (HASP) began in 2001 offering screening to men in a sparsely populated area. The aim was to identify whether uptake varies with deprivation or rurality, in the context of an established programme.

Methods: Retrospective interrogation of HASP records was performed on all men offered screening from 2001 until 2010. Deprivation and rurality status were derived from postcode of residence (SIMD’09 and URC’08) and the relationships with screening uptake were examined.

Results: Mean uptake over the decade was 90.1%. There was a strong association between deprivation and uptake, which ranged from 79.5% in the most deprived population to 97.5% in the least deprived ($p < 0.001$). The odds of men who were least deprived attending was 10.6 times higher than those who were most deprived ($p < 0.001$). Higher uptake was observed in more rural areas ($p = 0.02$). When combined in a logistic regression model, only deprivation remained significant, indicating any apparent effect of rurality was explained by deprivation. No change was observed in the mean aortic diameter of 65-year-old men or the incidence of AAA.

Conclusion: HASP has a high uptake even in the most deprived and rural populations, demonstrating that programme design has overcome any potential rural disadvantage. A gradient of uptake associated with deprivation remains, although even the most deprived have an uptake of almost 80%.

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Article history: Received 17 December 2012, Accepted 21 February 2013, Available online 27 March 2013

MeSH keywords: Aortic aneurysm, Abdominal, Population screening, Rural population, Rural health services, Socioeconomic factors, Public health

INTRODUCTION
Abdominal Aortic Aneurysm (AAA) has a prevalence of around 5% in men who are over 65 years$^{1,2}$ and is responsible for 1.4% of deaths in men in the UK. Screening men over 65 has been shown to reduce aneurysm related mortality$^{3–7}$ and to be cost effective$^{8–11}$ although any screening programme is dependent upon its uptake to be effective.$^{12,13}$

The Highland Abdominal Aortic Aneurysm Screening Programme (HASP) commenced in 2001 and has now offered screening to all men aged between 65 and 85 years of age. This is a well established programme covering a wide geographical area, similar to Wales or Belgium, but with a population of around 210 000. Screening is offered at over 50 sites across the region. The programme has previously reported high uptake$^2$ and the long term follow-up of men who attended for screening has been described.$^{14}$

Socioeconomic status is indicative of deprivation and has been shown to affect the uptake of screening for cancer. Deprivation is a risk factor for AAA and this highlights the importance of targeting high deprivation populations within screening programmes.$^{15,16}$ Screening programmes must have high uptake if they are to be cost effective. National government screening programmes (e.g. breast and cervical cancer) have target uptakes of around 70–80%.$^{17}$ Attendance rates vary significantly between AAA programmes. Northern Ireland reported only 44% uptake$^{11}$ and the St George’s group recently published 66%$^{18}$ uptake in the first year of their national AAA screening programme, with England’s overall programme reporting 75% uptake (2011–12).$^{20}$ The level one evidence for cost effective AAA screening is based on results such as the Multicentre
Aneurysm Screening Study (MASS) which is the largest trial to date, and had an uptake of around 80%.\textsuperscript{4}

We present our results from the well established Highland AAA screening programme (HASP) over the last decade. Our aim was to identify whether uptake into the HASP varied with different levels of deprivation or rurality. A secondary objective was to ascertain if the pattern of uptake has changed over the last 10 years. We also analysed the data to identify any change in incidence of aortic aneurysms over the last 10 years within Highland in those who have attended for AAA screening.

\section*{METHODS}

The methodology associated with this programme has been published previously.\textsuperscript{2} All men aged 65—74 years were offered screening between 2001 and 2004. From 2004 all men aged 65 years have been invited for AAA screening. Men received a letter of invitation and an information sheet explaining aneurysm disease and the risks and benefits of screening. The programme was designed to limit travel to less than 30 miles for a primary screening appointment. In the more remote areas screening was only undertaken in the summer months to avoid winter travel conditions in those areas. A retrospective analysis of the Highland AAA Screening database was performed from February 2001 until the end of December 2010. Patients classified within the ‘did not attend’ (DNA) group had either declined attendance, failed to attend their appointment or did not respond to two attempts at contact in writing over a three month period. All those within the ‘attended’ group were patients who had undergone ultrasound screening within the programme after invitation.

Men who had been offered screening within 3 months of the end date of study and had yet to reply were excluded. We excluded those patients who died prior to their appointment, underwent screening elsewhere, or were deemed too unfit to attend screening appointments. We did not include patients with an incomplete or missing postcode. Within this exclusion group were patients within the Outer Hebrides as the programme utilised to derive deprivation classification has not recognised these postcodes. Due to analytical reasons we choose the 6-fold criteria. This ranges from 1 to 6 informed by population size of a settlement and duration of drive time required to reach a large settlement area (accessibility). These include; large urban areas (settlements >125 000 people), other urban areas (10 000—125 000), accessible small towns (3000—10 000 & within 30 min drive of a 10 000 population settlement), remote small towns (3000—10 000, >30 min 10 000 settlement), accessible rural (<3000, <30 min 10 000) and remote rural (<3000, >30 min 10 000).\textsuperscript{20}

Patient age was defined at the initial screening attendance or the date of offer for those who ‘did not attend’. Aneurysm size was defined as the (inner-to-inner) AP diameter (millimetres) measured at the initial screening USS. Date of screening was also recorded. A thorough check for duplicated patients was performed and those identified removed, retaining only the initial attendance/invite as the defining entry.

Analysis was performed using SPSS version 20. The chi-squared test for trend was first used to investigate the relationship between screening uptake and deprivation/rurality. A logistic regression model including deprivation, rurality and age as independent variables was then used to predict the odds of attending for screening. For those aged 65, ANOVA was used to determine whether the mean aortic diameter differed by year. A statistical significance level of $p < 0.05$ was used.

\section*{RESULTS AND ANALYSIS}

The initial cohort of all men offered screening between 2001 and 2010 was 19 002. Men without postcodes or who resided within the Outer Hebrides, and therefore whose deprivation and rurality classification was unavailable, were excluded. Similar proportions of men in the ‘Attended’ group ($n = 1401, 8.6\%) and the ‘DNA’ group ($n = 202, 10.9\%) were excluded. Analysis was performed on the remaining 16 528 men who met the inclusion criteria (Fig. 1). The statistical significance of deciles 3 and 8 (Table 2).

For definition of rurality status we utilised the \textit{Scottish Government Urban-Rural Classification} (2008) (URC) again derived from postcode of residence. After exclusions the mean uptake of screening over the ten years was 90.1\% (14 892/16 528). In univariate analysis, there was a strong association between deprivation and uptake, which ranged from 79.5\% in the most deprived population decile (Decile 1) to 97.5\% in the least deprived group (Decile 10) (Table 2) (chi-squared test for trend, $p < 0.001$). A statistically significant relationship was also observed between rurality and uptake (Table 1), with higher uptake observed in the more rural areas (chi-squared test for trend, $p = 0.02$).
In the logistic regression model including deprivation, rurality and age as independent variables there was a clear trend of higher uptake with increasing affluence ($p < 0.001$): the odds of participants in decile 3 attending screening was 1.7 times higher than those in the more deprived Decile 1 (OR 1.69; 95% CI: 1.24–2.31) and the odds of patients in Decile 10 attending were 10.6 times higher than those in the most deprived Decile 1 (OR 10.61; 95% CI: 4.79–23.48) (Table 2). A weaker but significant relationship was observed between rurality and uptake (Table 1), with higher uptake observed in the more rural areas (Pearson chi-square, $p = 0.02$). However, when combined in a logistic regression model, the effect of deprivation remained significant but rurality did not, indicating that any apparent effect of rurality was explained by deprivation. Therefore there is no clear evidence, that rurality was associated with uptake ($p = 0.06$).

The initial 4-year programme offered screening to all men over a 10 year age range (65–74). These years had a combined uptake of 90.5%. The latter time period of 2005–2010, offering screening to men of 65 years, had an uptake of 89.7%. Over the last 10 years uptake within HASP remained high with little variation throughout the 10 years.

Table 1. Urban Rural Classification 2008 (6-fold) (URC) demographics of Highland AAA screening programme & associated uptake.

<table>
<thead>
<tr>
<th>Urban Rural Classification 2009 (6-fold)</th>
<th>%</th>
<th>n</th>
<th>Attended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Large urban area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Other urban area</td>
<td>20.3</td>
<td>352</td>
<td>2998</td>
</tr>
<tr>
<td>3 Accessible small towns</td>
<td>2.6</td>
<td>428</td>
<td>428</td>
</tr>
<tr>
<td>4 Remote small towns</td>
<td>20.2</td>
<td>3335</td>
<td>2973</td>
</tr>
<tr>
<td>5 Accessible rural</td>
<td>11.5</td>
<td>1897</td>
<td>1737</td>
</tr>
<tr>
<td>6 Remote rural</td>
<td>45.5</td>
<td>7515</td>
<td>6803</td>
</tr>
</tbody>
</table>

Table 2. Highland AAA screening invited participants by Scottish Index of multiple deprivation 2009 (SIMD). Population and uptake by decile (Decile 1 — most deprived, Decile 10 — least deprived). Likelihood (OR) of those in higher deciles attending in comparison to the least deprived (i.e. Decile 1) (least deprived) (logistic regression analysis controlling for rurality and age, $p < 0.001$).

<table>
<thead>
<tr>
<th>Deprivation decile</th>
<th>n</th>
<th>Attended</th>
<th>Odds ratio compared with decile 1 (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most deprived</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>365</td>
<td>290</td>
<td>79.5</td>
</tr>
<tr>
<td>2</td>
<td>941</td>
<td>779</td>
<td>82.8</td>
</tr>
<tr>
<td>3</td>
<td>1256</td>
<td>1094</td>
<td>87.1</td>
</tr>
<tr>
<td>4</td>
<td>1673</td>
<td>1490</td>
<td>89.1</td>
</tr>
<tr>
<td>5</td>
<td>3169</td>
<td>2838</td>
<td>89.6</td>
</tr>
<tr>
<td>6</td>
<td>3073</td>
<td>2780</td>
<td>90.5</td>
</tr>
<tr>
<td>7</td>
<td>2749</td>
<td>2528</td>
<td>92.0</td>
</tr>
<tr>
<td>8</td>
<td>1825</td>
<td>1692</td>
<td>92.7</td>
</tr>
<tr>
<td>9</td>
<td>1200</td>
<td>1131</td>
<td>94.3</td>
</tr>
<tr>
<td>Least deprived</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>277</td>
<td>270</td>
<td>97.5</td>
</tr>
</tbody>
</table>
even the lowest uptake in 2010 was 88% (Table 3). When considering only men who were age 65 there was high uptake across the decade with a mean of 89.9% (Table 3). Overall the most men offered screening were aged 65 years (n = 3731) and the mean age of all men attending was 67.6 years (SD ± 3.0). The mean age of those who did not attend was 67.7 years (SD ± 3.1).

Abdominal aortic aneurysms were defined as those with an ultrasonic AP diameter of 30 mm and above. There was no evidence of any change in the mean aortic diameter of men aged 65 years over the last 10-year period of screening within the Highlands (ANOVA p = 0.11). The mean diameter of 65-year-old men screened within HASP was 19.6 mm. There has been variability observed through the last 10 years regarding the number of aneurysms detected, ranging from 23 to 41 men. The proportion of 65-year-old men screened who have with an aortic diameter of 30 mm and above has not changed over time, mean 2% (p = 0.39, chi-squared test for trend) (n = 2–10/year).

**DISCUSSION**

The incidence of AAA in men within the Highlands, 5.1%, has been reported previously and correlates with other studies. Prior to the introduction of the Highland Aneurysm Screening Programme (HASP) the annual incidence for ruptured AAA within the Highlands was 12.1 per 100 000. This incidence was higher in the population living beyond 30 miles of the main hospital (15.7 per 100 000). Surgical mortality rate for patients undergoing elective repair nationally is 2.4%, compared to a well documented 80% mortality associated with AAA rupture.

The efficacy of AAA screening has already been established at long-term follow up. The 10 year outcome from the multicentre aneurysm screening study demonstrated a continued mortality benefit with duration of screening. An invitation to AAA screening resulted in a 48% reduction in mortality at 10 years. Importantly this was associated with an uptake rate of 80%. There was also an almost 50% reduction in non-fatal AAA ruptures within the invited group. The majority of the 170 patients who ruptured, despite invitation ‘did not attend’ or failed to comply with the screening protocol. These findings were based on an elective 30-day morality of 4–6%, higher than our own elective results of 1.8% and a national elective AAA repair mortality of 2.4%. A meta-analysis by Flemming supported these findings that screening invitation alone correlated to a reduction of AAA-related mortality, OR 0.57.

Many of the studies published regarding cost-effective analysis are based on estimates of the long-term benefits of AAA screening. The MASS 10-year follow-up estimated an incremental cost-effectiveness ratio of £7600 per life year gained, well within the current NICE guidelines of £20 000 to £30 000 per quality-adjusted life year (QALY). Further studies have suggested AAA screening correlates with gain in life expectancy of 0.02–0.28 life years and gains in QALY of 0.015–0.059. Associated with these gains were incremental cost-effectiveness ratios (ICER) between 1443 and 13 299 Euros per LY or QALY gained. The benefits and cost effectiveness of screening programmes are however dependent on their uptake. Uptake into the HASP is high and has remained so over the last decade. In this study there is a higher uptake in the first 4-year time period than initially published. This reflects the men who were excluded from analysis in this study and those who had incomplete or missing postcodes. The Highland programme meets national guidelines for AAA screening uptake rates, even in the most deprived and rural groups. Our study demonstrates a correlation between deprivation status and failure to attend AAA screening. This is in line with reporting from the MASS trial whereby uptake in the most deprived was 75% in comparison to 85% in the least deprived quartile. Men who are more deprived are ultimately at higher risk of AAA, therefore it is crucial to monitor attendance rates in these men to achieve the maximum benefit from AAA screening and effectively minimise AAA-related mortality.

It is important to acknowledge that one of the domains determining SIMD is geographical access and therefore SIMD derived deprivation status and rurality are inextricably linked. Rurality is determined slightly differently in the URC from SIMD the former using distance to larger settlements and size of settlement as a measure of rurality. The SIMD differs by incorporating ‘access to services’ as one of it’s domains, such as distance to GP or petrol station and public transport times. In our study rurality did not appear to impact upon uptake when deprivation was controlled for. This suggests that our programme design is effective in controlling for this factor by offering local GP based sites across the region, allowing ease of access to a remote and rural population.

Our programme within the Highlands has continuously obtained high rates of attendance as is the case for other Highland population based screening programmes such as breast cancer at 79.8% (2005–9) and cervical cancer, 76.5% within the last 3.5 yrs. Locally GP-based screening sites offer an advantage to those living in a largely remote and rural area. Alternative arguments have been made to support regional hospital based USS screening, notably the Denmark study. Attendance fell in this study in patients who

**Table 3.** Changes related to Highland AAA screening over the last decade in 65-year-old men.

<table>
<thead>
<tr>
<th>Year</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offered (n)</td>
<td>172</td>
<td>164</td>
<td>0</td>
<td>310</td>
<td>273</td>
<td>318</td>
<td>669</td>
<td>817</td>
<td>515</td>
<td>493</td>
<td>—</td>
</tr>
<tr>
<td>Attended (n)</td>
<td>150</td>
<td>147</td>
<td>0</td>
<td>288</td>
<td>241</td>
<td>301</td>
<td>595</td>
<td>717</td>
<td>475</td>
<td>440</td>
<td>—</td>
</tr>
<tr>
<td>Uptake (%)</td>
<td>87.2</td>
<td>89.6</td>
<td>—</td>
<td>92.9</td>
<td>88.3</td>
<td>94.7</td>
<td>88.9</td>
<td>87.8</td>
<td>92.2</td>
<td>89.2</td>
<td>89.9</td>
</tr>
<tr>
<td>Aneurysm (n)</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>21</td>
<td>10</td>
<td>8</td>
<td>—</td>
</tr>
<tr>
<td>Aneurysm (%)</td>
<td>1.3</td>
<td>2.1</td>
<td>—</td>
<td>0.7</td>
<td>2.9</td>
<td>2.4</td>
<td>1.4</td>
<td>3.0</td>
<td>2.1</td>
<td>1.8</td>
<td>2.0</td>
</tr>
</tbody>
</table>
had to travel over 20 km to undergo AAA screening but the author concluded that uptake was not compromised by distance travelled to undergo screening by USS as rates remained high in this group. However, in Denmark\(^2\)\(^7\) the comparisons were categorical ‘within’ and ‘out-with’ 20 km, with no range of the longest distances travelled by some participants. The URC classifies rurality by population size and distance to large population settlements so it is difficult to compare but the drive time for 20 km is likely to be much less than 30 min. Comparison is difficult but it is likely that such participants had to travel a smaller distance on more accessible roads to a regional hospital than is the case in our sparsely populated Highland area. The publicity regarding the screening programme, which has diminished over the last few years, is a possible source of promotion to improve the recent uptake.

In this study we did not show any change in the mean aortic AP diameter over the last decade within 65-year-old men, undergoing screening. This contrasts with the recent publication from Gloucestershire, which describes a reduction in mean aortic diameter from 2.1 cm to 1.7 cm over the last 20 years.\(^2\)\(^8\) However, we started our programme later and had a lower mean diameter than their original. Certainly the reduction in smoking and other lifestyle factors may have a bearing on this reduction and this may not be reflected in the Highlands but it may be worthwhile reviewing this at a national level.

Limitations and bias within this study could have occurred by relying on retrospective data. Date recording bias was minimised with every effort made to include the initial attendance of each patient who did attend screening. Selection bias may have occurred due to a proportion of missing and incomplete postcodes although this effect was minimised as the number of participants was small and this occurred in the attended and the DNA group in similar ratios.

**CONCLUSION**

The Highland AAA screening programme has maintained high uptake, even in remote and rural areas over 10 years. There was evidence that deprivation and rurality affect uptake. In multiple regression analysis the effect of rurality was no longer statistically significant, but a gradient of uptake associated with deprivation remained, although even in the most deprived areas uptake is almost 80%. No change was identified in mean aortic diameter in men aged 65 over this 10-year period.

**ACKNOWLEDGEMENTS**

Thanks to Prof. D. Godden (FRCP), retired from the Centre for Rural Health, University of Aberdeen, for his input into the design of this study.

**CONFLICT OF INTEREST**

None.

**ROLE OF FUNDING SOURCE**

None.

**ETHICAL APPROVAL**

Not required — Audit of Service.

**REFERENCES**


