Four population-based trials of screening for abdominal aortic aneurysm (AAA) have been conducted and summarised in a Cochrane review and a systematic review. These reviews are broadly in favour of screening being offered for men aged 65 years and more, since screening clearly reduces aneurysm-related mortality. There is weak evidence from one trial to suggest that screening also may have late benefits (7–10 years) on all-cause mortality. However, there is no good evidence to support screening in older women. The success of regional or national screening programmes depends on the prevalence of aneurysms, the uptake of screening, local operative mortality rates for aneurysm repair and other factors. For this reason, it is reasonable to conduct a pilot phase of screening before offering screening more widely. There is no robust evidence about optimal rescreening surveillance for those in whom small aneurysms are detected.

Introduction
The population of Europe and the Western world is ageing – a contributing factor underlying the continuing increase in prevalence for AAA. Abdominal aortic aneurysm, the most common form of aortic aneurysm, has a prevalence in men over 60 years of age of approximately 5% (the prevalence in women of the same age is much less at only 1–2%); however, some variation in prevalence across Europe has been reported (Figure 1). Although the prevalence of AAA has been increasing for the past two decades, it is uncertain if this high prevalence will be sustained. Smoking – the principal risk factor for AAA – has been in decline for some years, particularly in men. This may be mirrored with a future reduction in AAA prevalence. Amongst women, however, declines in smoking rates have been more modest, which in combination with an ageing population may result in a continued increase in AAA rates. Population prevalence is

Fig. 1
Some reported percentage population prevalences for abdominal aortic aneurysm in older men across Europe.
A critical factor for the success and cost-effectiveness of any screening programme. Effective screening uptake rates and disease intervention are also important to the success of screening programmes.

Abdominal aortic aneurysms are extremely dangerous. This is because they are usually asymptomatic until rupture – a catastrophic event in more than 80% of cases. Small aneurysms have a very low risk of rupture, but this risk escalates as the aneurysm enlarges which is the natural progression of an AAA. Open surgical or endovascular repair of the aneurysm prevents the risk of future rupture in nearly all cases, but repair itself carries a significant 30-day mortality rate. This initial risk seems to be three times higher for conventional surgical repair compared with open surgical repair, but beyond 1–2 years post-repair mortality rates are similar. These discrepancies have been addressed in a number of randomised clinical trials, which support management of AAA by vascular surgeons and population screening for AAA in order to improve patient outcomes.

Aneurysm screening is performed using ultrasonography

Ultrasonography is highly specific and sensitive for the detection of AAA, which is commonly defined as a maximum infra-renal aortic diameter of ≥ 3 cm. This diameter may be measured in both anterior-posterior and transverse orientations, although reproducibility is better for the anterior-posterior approach, with measurement variability of ± 2 mm being attainable by a well-trained operator. It also is possible to train any healthcare worker to undertake aortic ultrasonography and specialist ultrasonographers or radiologists are only essential for maintaining quality control.

Not surprisingly, all the population-based randomised trials of AAA screening have been based on measurement of anterior-posterior diameters by ultrasonography. These trials have been conducted in the UK, Australia and Denmark, with participant follow-up extending to 10 years, and although there are differences between the trials, they have been summarised in both a Cochrane review and a review for the US Preventive Services Task Force. The evidence in favour of screening in men

The four randomised trials of population screening are the Chichester trial in the UK, the Viborg trial in Denmark, the Western Australia trial and the MASS trial in the UK. In each trial, participants were randomised to receive either; an offer of aneurysm screening or no offer of screening. In each trial, screening was shown to reduce aneurysm-related mortality for men. In the Cochrane Review the odds ratio in favour of screening for men was 0.60 [95% CI 0.47–0.78]. The systematic review reported a similar benefit for screening in men, odds ratio 0.53 [95% CI 0.42–0.68], despite a small late benefit has been reported from the MASS trial. The individual characteristics of the trials, including the percentage uptake of screening (68–80%) are summarised in Table 1. This table also serves to illustrate some of the differences between the trials. Of note, there is one broad similarity between the trials, not listed in Table 1, in that all trials were conducted in relatively advanced socioeconomic areas where a semi-rural hinterland is dotted with medium or small size towns. None of the screening trials were conducted, except in a small part, in very deprived large city districts.

Update on the screening trials

After a seven-year follow-up, the MASS trial reported an all-cause mortality benefit in favour of screening at the limits of statistical significance. Very recently the MASS trial published 10-year results. These showed that aneurysm-related deaths were halved in the group invited for screening at a cost of £100
per person screened. Overall there were 552 elective aneurysm repairs in the screened group (with an operative mortality of 4%) versus 226 in the control group (with an operative mortality of 6%). However, after 8 years there was a noticeable increase in ruptures in the screened group. Although studies have reported that a single screen at age 65 years is sufficient, this may require re-evaluation, given the current and continuing trend for longevity.

The evidence for screening in women

The population prevalence of AAA is three times higher in men than women. Therefore, not surprisingly, there is limited evidence to support aneurysm screening in older women. The only screening trial conducted in women was in Chichester, UK and is reported as part of the Chichester trial in Table 1.

Can screening cause harm?

There are three potential dangers that may be caused by screening. Firstly, there is the anxiety and subsequent impact on quality of life associated with being told that you have a serious, potentially fatal, condition. Both the MASS and Viborg trials reported that subjects diagnosed with an aneurysm on screening experienced anxiety and a decreased quality of life for a short period afterwards. Such effects were most marked in those with poor quality of life at baseline but the effects resolved within a few months of screening. Secondly, and perhaps more importantly, there is the mortality risk associated with intervention. If screening is to be conducted safely, the vascular surgical referral centres for patients must have an audited low mortality for both open and endovascular aneurysm repair (EVAR) – for elective open repair, the

### Table 1

Summary of the population based randomised screening trials

<table>
<thead>
<tr>
<th>Trial characteristics</th>
<th>Chichester UK&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Viborg Denmark&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Western Australia&lt;sup&gt;1&lt;/sup&gt;</th>
<th>MASS UK&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>15,775</td>
<td>12,639</td>
<td>41,000</td>
<td>67,800</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>Men &amp; women 65–80</td>
<td>Men 65–73</td>
<td>Men 65–79&lt;sup&gt;**&lt;/sup&gt;</td>
<td>Men 65–74</td>
</tr>
<tr>
<td><strong>Date published</strong></td>
<td>1995</td>
<td>2005</td>
<td>2004</td>
<td>2002</td>
</tr>
<tr>
<td><strong>% accepting screening</strong></td>
<td>68</td>
<td>77</td>
<td>70&lt;sup&gt;‡&lt;/sup&gt;</td>
<td>80</td>
</tr>
<tr>
<td><strong>Aneurysm prevalence</strong></td>
<td>4.0% (7.6% in men)</td>
<td>4.0%</td>
<td>7.2%</td>
<td>4.9%</td>
</tr>
<tr>
<td><strong>Place of screening</strong></td>
<td>Hospital</td>
<td>Hospital</td>
<td>Community</td>
<td>Community</td>
</tr>
<tr>
<td><strong>Intervention policy</strong></td>
<td>At 6.0 cm</td>
<td>At 5.0 cm</td>
<td>none</td>
<td>At 5.5 cm</td>
</tr>
<tr>
<td><strong>Mean follow-up (months)</strong></td>
<td>30.5</td>
<td>52.0</td>
<td>43.0</td>
<td>49.0</td>
</tr>
<tr>
<td><strong>AAA mortality, odds ratio. Screened vs. not (95% CI)</strong></td>
<td>0.59 men only (0.27–1.29)</td>
<td>0.33 (0.16–0.71)</td>
<td>0.72 (0.39–1.32)</td>
<td>0.58 (0.42–0.78)</td>
</tr>
<tr>
<td><strong>All-cause mortality, odds ratio. Screened vs. not (95% CI)</strong></td>
<td>1.07 men only (0.93–1.22)</td>
<td>0.92 (0.84–1.00)</td>
<td>0.98 (0.91–1.04)</td>
<td>0.97 (0.93–1.02)</td>
</tr>
<tr>
<td><strong>Other outcomes reported</strong></td>
<td>No aneurysm-related mortality benefits in women</td>
<td>Hospital deaths Costs Quality of life Total mortality Number of operations and indications for operations Number of ruptured aneurysms</td>
<td>N/A</td>
<td>Quality of life Costs Workload</td>
</tr>
<tr>
<td><strong>Extended follow-up available</strong></td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes&lt;sup&gt;†&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup>Reported odds ratio taken from Cochrane review. <sup>2</sup>Pooled odds ratio over all four trials strongly in favour of screening: odds ratio 0.57 (0.45–0.74); together with a halving of the incidence of aneurysm rupture in screened populations. <sup>3</sup>Reported odds ratio taken from Cochrane review. <sup>4</sup>Pooled odds ratio trend in favour of screening: odds ratio 0.98 (0.95–1.02).<sup>5</sup>Because of the method of recording age in the electoral roll, some men were older than the target age range by the time they were invited for screening and, as a result, 725 (5.9%) of those who attended were aged 80–83 years. As a percentage of those alive when invitation for screening was sent, randomisation predated this invitation by several months in a large sector of subjects.<sup>6</sup>The MASS trial recently published 10-year follow-up, demonstrating the cost-effectiveness of screening and a significant all-cause mortality benefit but a rising incidence of AAA rupture in the screened group.
operative mortality must be less than 5% and
for EVAR less than 2%. Recent work clearly
shows that most patients have a preference
for aneurysm repair by EVAR rather than by
open repair, although some patients still
prefer open repair since it avoids the need
for long-term post-operative surveillance.18,11
Thirdly, screening may cause an unacceptable
burden on local vascular surgical services.
The MASS trial has shown that the rate of
elective repairs doubled with the advent
of screening, although the burden of
out-of-hours ruptures is reduced.

Current status of aneurysm screening
Given the results of these trials, a decision has
been made in the UK to roll out a national
aneurysm screening programme during
2009–2015. The programme will be
community-based and target men in the year
they reach 65 years. Time will tell if the
ambitious national screening programme in
the UK will be successful. In the US a more
cautious approach has been adopted, with
recommendations to screen male smokers in
the 65–75 year age range. Implementation of
these recommendations, however, appears to
be poor. The potential benefits of screening
are under debate in the Netherlands and
other European countries. In addition, a pilot
study of 10,000 men is to be undertaken in
Italy. Local aneurysm screening programmes
exist in Sweden and some other countries. In
Sweden it has been argued that screening
might be cost-effective for women too.

What has changed since the
screening trials were conducted?
The recruitment phase for the screening trials
mentioned above occurred more than 10
years ago. Since then the prevalence of
smoking has declined, national legislation to
ban smoking in public places has come into
force across much of Europe and there has
been a rise in the use of statins for
cardiovascular risk prevention. Weak evidence
suggests statins reduce both aneurysm
growth and rupture rates.12,13 Does this mean
that AAA will become less dangerous?
Preliminary evidence from two London-based
screening districts suggests that the
prevalence of AAA in 65-year old men is now
closer to 1% than to 5% and that in inner city
areas the acceptance of screening is much
lower than the 80% of the MASS trial.6
Therefore, the cost effectiveness of screening
in such communities may be compromised.

What has not changed since these
screening trials were conducted?
The threshold for surgery in men remains at
5.5 cm, as originally set by the UK Small
Aneurysm and Aneurysm Detection and
Management trials.13 These trials compared
surveillance with early open surgical repair of
the AAA and showed surveillance was safe
and cost less. Specifically, in men the
aneurysm rupture rates were very low (<1%
per annum), but higher in women. We now
know that the operative mortality from open
repair is three times higher than for EVAR. New
trials,14,15 have compared surveillance of small
aneurysms with early EVAR; however, there is
still no survival or cost benefit associated with
early intervention to exclude small AAAs.

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Management</th>
</tr>
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<tbody>
<tr>
<td>3 cm</td>
<td>Community surveillance (annual) and comorbidity management</td>
</tr>
<tr>
<td>4 cm</td>
<td>Community surveillance (6 monthly) and comorbidity management</td>
</tr>
<tr>
<td>5 cm</td>
<td>Community surveillance (3 monthly) and comorbidity management</td>
</tr>
<tr>
<td>5.2 cm</td>
<td>FEMALES only, grey area, refer to vascular surgeon and consider repair</td>
</tr>
<tr>
<td>5.5 cm</td>
<td>ALL LARGE ANEURYSMS, rapid referral to vascular surgeon, assess fitness and aneurysm morphology</td>
</tr>
</tbody>
</table>

ANEURYSM REPAIR
An algorithm for the current management of small aneurysms is shown in Figure 2.

Missing evidence

Currently, there are no robust data to support any particular frequency of small aneurysm surveillance according to aneurysm diameter, although a modeling exercise has suggested the frequencies shown in Figure 2. The National Institute of Health Research in the UK has commissioned analysis to establish the cost-effective rescreening intervals. This project will use data from the four screening trials as well as other large cohort studies from Spain, Sweden and the UK. There is no evidence as to whether screening in the community is more effective than screening in hospital, although community screening is likely to be cheaper.

We have yet to find a robust therapy to reduce small aneurysm growth rates, although it is possibly too late to establish the benefit of statins in a randomised trial. It has been suggested that use of angiotensin-converting enzyme (ACE) inhibitors may diminish the risk of aneurysm rupture, which raises the potential for all patients with small aneurysms to be prescribed these drugs for control of hypertension. The optimal cardiovascular risk prevention strategy for patients with small aneurysms remains to be established and implemented, although many consider AAA to be a coronary heart disease equivalent. Similarly, the potential benefits of rescreening men after 75 years or screening women at age 70 years has yet to be evaluated. It should be considered that the age-dependent increase in AAA prevalence may be offset by the rising mortality from elective repair, particularly by EVAR, in women and the elderly.

Summary

Although both a Cochrane review and a systematic review suggest a benefit for population aneurysm screening for older men, the effectiveness of screening for AAA has not been definitively established. If the prevalence in older men falls below 3% and the uptake of screening falls below 70%, population screening may no longer be cost-effective and a change from population screening to targeting those at highest risk (smokers) may be appropriate. It is also possible that indirectly, screening may do harm rather than benefit if local operative mortality rates for aneurysm repair are high. Much will be learned from the UK National Aneurysm Screening programme and regular publically available updates from this programme will be essential. In other countries and geographical areas it would be prudent to initiate pilot studies of aneurysm screening before the decision is taken to implement population screening.