Decision-analytical model with lifetime estimation of costs and health outcomes for one-time screening for abdominal aortic aneurysm in 65-year-old men

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Record Status
This is a critical abstract of an economic evaluation that meets the criteria for inclusion on NHS EED. Each abstract contains a brief summary of the methods, the results and conclusions followed by a detailed critical assessment on the reliability of the study and the conclusions drawn.

Health technology
The present study compared a strategy of ultrasonographic screening for abdominal aortic aneurysm (AAA) in 65-year-old men with a no screening strategy (current clinical practice).

Type of intervention
Screening.

Economic study type
Cost-utility analysis.

Study population
The hypothetical population comprised a cohort of 65-year-old men.

Setting
The setting was primary care (screening strategy) and tertiary care (surgical intervention). The economic study was carried out in Linkoping, Sweden.

Dates to which data relate
The studies used for effectiveness evidence were from the period 1987 to 2005. For cost data, the date range was 1997 to 2003. The price year was 2003.

Source of effectiveness data
The evidence was derived from a review or synthesis of completed studies and estimates based on authors’ assumptions.

Modelling
A computer-simulation, state-transition, probabilistic, Markov model was employed to describe disease progression and the use of resources for both strategies during a lifetime horizon. In each year, each person was assumed to transit among the following health states:

the "no-AAA" state (individuals without an aneurysm);

three AAA states, each representing different sizes of aneurysm;

a "postoperative" health state representing the survival prognosis after surgery; and

the "dead" state.
Outcomes assessed in the review
The outcomes in the baseline model included:

- the prevalence of AAA in 65-year-old men;
- conditional probabilities of the proportion of AAA in each size group;
- mortality after an elective operation;
- mortality after an emergency operation;
- the probability of reaching surgery after rupture;
- the yearly probability of rupture;
- the yearly probability of AAA growth;
- the proportion of men complying with an invitation;
- the proportion having elective surgery when diagnosed with a large AAA;
- the yearly probability of opportunistic detection of AAA; and
- the sensitivity and specificity of ultrasonography.

A more detailed description of the data incorporated in the model, as well as the model structure itself, was given in a technical report (Henriksson et al. 2005, see 'Other Publications of Related Interest' below for bibliographic details).

Study designs and other criteria for inclusion in the review
The study designs used were screening studies and other published literature (Henriksson et al. 2005).

Sources searched to identify primary studies
To collect data, different searches were performed on MEDLINE (searched to July 2004) for several of the parameters. Different combinations of the terms "abdominal aortic aneurysm", "natural history", "risk of rupture", "growth rate" and other variables were used (Henriksson et al. 2005).

Criteria used to ensure the validity of primary studies
Not reported.

Methods used to judge relevance and validity, and for extracting data
Not reported.

Number of primary studies included
The authors reported that at least 50 primary studies were included in the review for different purposes (e.g. prevalence rates, mortality after an elective operation, mortality after an emergency operation, rupture probability, probability of AAA growth, proportion of men complying with an invitation).

Methods of combining primary studies
Where possible, random-effects meta-analyses of the identified studies were performed to estimate the log-odds of the variables (Henriksson et al. 2005).
Investigation of differences between primary studies
The authors investigated differences between the primary studies and provided an explanation for the differences, as well as the results of statistical tests they performed.

Results of the review
The point estimates of the parameters used in the model were:

- 0.051 for mortality after an elective operation;
- 0.215 for mortality after an emergency operation;
- 0.361 for reaching surgery after rupture;
- 0.005, 0.015, 0.156 for the yearly probabilities of rupture of small, medium and large AAA, respectively;
- 0.115 for the yearly probability of AAA growth from small to medium;
- 0.159 for the yearly probability of AAA growth from medium to large;
- 0.773 for the proportion complying with an invitation;
- 0.84 for the proportion having elective surgery when diagnosed with large AAA; and
- 0.051 for the yearly probability of opportunistic detection of AAA.

Methods used to derive estimates of effectiveness
This analysis was based on published data and authors’ assumptions.

Estimates of effectiveness and key assumptions
The assumptions used in the model were as follows:

- an individual with no AAA at the age of 65 years would not develop an aneurysm later in life;
- the sensitivity and specificity of ultrasonography were both 100%;
- when diagnosed, individuals were kept under surveillance with regular ultrasonography,
- 100% compliance with surveillance; and
- the long-term prognosis after surgery reflected the general health status of the AAA population, as their probability of having further problems related to the operated aneurysm was small.

Measure of benefits used in the economic analysis
The authors used both life-years and QALYs as the measures of benefit. The QALY weights used in the model for males in the normal population were 0.83 for individuals aged 65 to 69 years, 0.81 for individuals aged 70 to 79 years, and 0.74 for individuals aged more than 80 years. No long-term effects on quality of life after a diagnosis of AAA have been demonstrated, so this was not incorporated into the base-case analysis.

The utility data were based on a Swedish population study of health-related quality of life using Euroqol (EQ-5D) (Burstrom et al. 2005, see ‘Other Publications of Related Interest’ below for bibliographic details). For the probabilistic assessment, a gamma distribution was defined for this parameter. Individuals diagnosed with an AAA were assigned a
decrement in quality of life of 0.071, while individuals in the postoperative state were assigned a utility decrement of 0.1. Discounting was performed at a rate of 3%.

Direct costs
The direct health care costs included were the variable and fixed costs of acute and elective operations, the costs for the invitation to and for the administration of the screening programme, the costs of initial ultrasonography and subsequent investigations, and patient costs of ultrasound investigation. Non-health care costs included private travel costs incurred when attending for ultrasonography. The costs were in 2003 prices and were adjusted using the Consumer Price Index. Discounting was performed at a rate of 3%. The estimations of the quantities and total costs were derived using modelling. The resource quantities and a full report of detailed costs were presented in the technical report (Henriksson et al. 2005).

Statistical analysis of costs
The treatment of the costs depended on the nature of the cost. The costs of the invitation, ultrasound investigation and surveillance were treated deterministically. Costs treated stochastically included acute and elective operations, bed days and blood products, and added life-years. Gamma distributions were defined for these parameters and incorporated for the probabilistic analysis.

Indirect Costs
Since all hypothetical individuals in the model were 65 years of age, it was assumed that everyone had retired. Hence, the loss of production due to absence from work was not included. The cost related to added life-years as the net of future consumption and production was considered in a sensitivity analysis employing previous estimates of these costs. Full details of the cost calculations and the incorporation of uncertainty were presented in the technical report (Henriksson et al. 2005).

Currency
Euros (EUR). The conversion rates were EUR 1 = 9 Swedish kronor and EUR 1 = 0.71 UK pounds sterling.

Sensitivity analysis
Sensitivity analyses were carried out for all of the parameters included in the model and the authors’ assumptions. In particular, the discount rate costs and health outcomes, decrement in quality of life after surgery, decrement in quality of life after diagnosis, standard rather than estimated mortality for non-AAA-related death in individuals with AAA, sensitivity of ultrasonography, and the inclusion of costs of added life-years. The ranges were derived from confidence intervals and published literature.

For the probabilistic analyses, several types of distributions were assumed (normal, beta, etc.), employing the standard errors from the meta-analyses. For each parameter, pooled estimates were calculated and their 95% confidence intervals reported. A second-order Monte Carlo simulation was repeated 1,000 times, generating 1,000 estimates of the mean costs and mean effects in a cohort for both screening and no-screening strategies.

Estimated benefits used in the economic analysis
In the base-case analysis, the incremental life-years were 0.025 and the incremental gain in QALYs for the screening programme was 0.020.

Cost results
In the base-case analysis, the incremental costs of the screening programme were EUR 194. The total costs of each strategy were not stated either in the text or in the technical report.
Synthesis of costs and benefits
In the base-case analysis, the incremental cost-effectiveness ratio (ICER) was EUR 7,760 per life-year and EUR 9,700 per QALY. Cost-effectiveness acceptability curves were presented. These showed that if a decision-maker was willing to pay EUR 30,000 for an additional QALY, the probability of screening being cost-effective would be more than 95%.

The results of the sensitivity analyses showed that with a 3% discount rate for costs and 0% for health outcomes, the ICER was EUR 5,550 per life-year and EUR 7,065 per QALY. When varying the discount rates to 6% for costs and 1.5% for health outcomes, the ICERs were EUR 6,490 and EUR 8,230, respectively. The ICER was EUR 13,800 per QALY when considering a 0.1 decrement in quality of life after surgery and EUR 16,710 per QALY for a 0.071 decrement in quality of life after diagnosis. The ICER was EUR 13,800 per QALY when considering a 0.1 decrement in quality of life after surgery and EUR 16,710 per QALY for a 0.071 decrement in quality of life after diagnosis. Using the standard rather than the estimated mortality for non-AAA-related death in individuals with AAA, the ICER was EUR 14,250 per life-year and EUR 18,000 per QALY. If the sensitivity of ultrasonography was 80% instead of 100%, the ICER would be EUR 9,620 per life-year and EUR 12,170 per QALY. Finally, when considering the inclusion of costs of added life-years, the ICER was EUR 29,800 per life-year and EUR 37,800 per QALY.

Authors' conclusions
This study has shown that the screening programme is cost-effective in comparison with the current clinical practice of no screening. Considering that the cost per gained life-year or quality-adjusted life-year (QALY) was lower than a willingness to pay value of EUR 10,000, the investigated strategy should, in principle, be recommended for provision.

CRD COMMENTARY - Selection of comparators
The choice of the screening strategy was justified, mainly because long-term data on costs and health outcomes were not readily available from randomised trials, the cost-effectiveness results were ambiguous, and the often practical option of inviting only individuals of a particular age for screening had been poorly evaluated. In addition, whilst the feasibility of running such a screening programme had been documented based on published literature, the long-term cost effectiveness had not been clearly established. You should judge whether this screening programme is relevant in your own setting, or whether other comparators could have been relevant as well.

Validity of estimate of measure of effectiveness
The authors conducted a review of the literature but, as they acknowledged, it was not systematic. They also acknowledged that this could be a potential limitation of the study. However, the possibility of missing information that would actually affect the conclusions of the study was considered to be low. The authors derived estimates of effectiveness from published literature and assumptions, and they provided justification for their choice of assumptions. The estimates were investigated in a sensitivity analysis, and the authors justified the ranges they used. All input parameters of the model were reported extensively in a technical report.

Validity of estimate of measure of benefit
The authors used QALYs as a measure of benefits. The estimation of quality-adjusted utility weights was taken from the literature, and details were provided in a technical report. The estimation of benefits was modelled through a state transition Markov model to simulate the natural history and progression of AAA. The model outputs were also compared for external validity with randomised screening trials that reported cost-effectiveness calculations.

Validity of estimate of costs
Although the authors reported that the study was carried out from a societal perspective, the loss of production due to absence from work was not included since all hypothetical individuals in the model were 65 years of age and it was assumed that all would have already retired. However, they did include the yearly costs of added life and production in their sensitivity analyses, which strengthens the validity of the analysis. The costs and the quantities were reported separately in a technical report, and this would simplify the task of reworking the analysis for other settings. Discounting was appropriately carried out, as the time horizon of the model was longer than 2 years, and sensitivity analyses of the discount rates for costs and health outcomes were performed. Revaluation of the costs was carried out...
and the price year was reported, which will aid any future reflation exercises.

**Other issues**
The authors compared their findings with those from other studies which, in general, showed their findings to be concordant. The authors addressed the issue of generalisability of the results to other settings. The authors’ conclusions reflected the scope of the analysis. The authors acknowledged a potential limitation to their study in that the literature searches carried out did not entirely fulfil the criteria for a systematic review. However, they stated that they believed that this would not actually affect the conclusions of the study.

**Implications of the study**
Although further research is needed, the screening programme for AAA, in which men are invited for ultrasonography in the year in which they turn 65, appears to be financially and practically feasible.

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