Cost benefit analysis of hearing screening for older people

Final Report for RNID

Prepared by

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About London Economics

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Executive summary

This report sets out the methodology and findings of London Economics's cost-benefit assessment of a proposed nationwide hearing screening programme for older people in the United Kingdom, commissioned by the RNID.

Context and motivation

Hearing loss affects a significant proportion of the UK population, with the majority of people affected aged over 60. It is estimated that approximately 9 million people in the UK (14.5%) are deaf or hard of hearing,[1] with 55% of people over 60 estimated to be somewhat affected by hearing loss.[2] Moreover, as the average age of the UK population continues to rise, the number affected is expected to increase.

Researchers have found that people who are deaf or hard of hearing can experience lower health-related quality of life: higher distress, anxiety, depression, somatisation, social isolation and loneliness with negative implications on emotional, mental, and physical health.

Hearing aids can limit the impacts of hearing loss. The benefits of hearing aid use (significant improvements in emotional, mental, and physical health, as well as general quality of life) are strongly supported by research findings. However, despite being available free-of-charge through the NHS, individuals may delay up to 15 years from the initial onset of hearing loss before seeking to address it.

RNID's proposal

The RNID proposes the implementation of a nationwide hearing screening programme for older people in the hope of reducing the extent of undiagnosed hearing loss, reducing the stigma of hearing loss, increasing the take-up of hearing assistive technology (e.g. hearing aids), enhancing the quality of living of those affected and ultimately reducing the costs of health and social care to the Exchequer.

Cost-Benefit Analysis model

National screening programmes can be expensive. However, the benefits of screening can substantially outweigh the costs, bringing about cost-savings in the longer term, so Cost-Benefit Analysis is required. A Cost-Benefit model was developed in accordance with HM Government guidance and best practice techniques, comprising two age thresholds: screen at 55 years of age; and screen at 65 years of age.

[1] RNID, accessed 22.02.10, available at: http://www.rnid.org.uk/information_resources/factsheets/deaf_awareness/factsheets_leaflets/deaf_and_hard_of_hearing_people.htm

[2] Davis, A, (1995) *Hearing in Adults*, Whurr Publishers, Nottingham.

The information and data used to populate the CBA model was sourced from:

- Review of the economics of hearing screening literature;
- Web-based search for research reports and grey (unpublished) literature;
- Publicly available data sources (e.g. Office for National Statistics, NHS information centre);
- RNID expert opinion (in the absence of reliable data); and
- Expert opinion from other health policy experts.

Estimation of screened and treated populations

The population flows through the screening and NHS audiology system were estimated:

- The number of people to whom a GP screening invitation letter is sent;
- The number of people that that attend their local GP surgery for screening;
- The number of people that undertake a full audiometry assessment under NHS; and
- The number of people that are fitted with a hearing aid under NHS.

The final estimate was adjusted down to remove individuals that would have been treated in any case without the intervention (under the status quo scenario) in order to calculate the estimated *additional* number of people fitted with hearing aids under the NHS per annum due to the screening programme.

It was estimated that an additional 6,688 to 7,398 55 year-olds, or 25,464 to 38,815 65 year-olds, would be fitted with hearing aids under the NHS per annum over the period 2010 to 2019.

Valuation of costs

Present Value (PV) analysis of the costs of the intervention		
Cost item	**Present Value (£m) 55 years-old**	**Present Value (£m) 65 years-old**
Once-off, initial costs	***2.3***	***2.3***
Cost of advertising	1.5	1.5
Cost of providing each GP surgery with a handheld hearing screening device	0.5	0.5
Cost of training nurses to operate the screening using the handheld hearing screening device	0.3	0.3
Ongoing costs (PV)	***83.7***	***253.3***
PV (Cost of ongoing advertising)	6.5	6.5
PV (Cost of invitation letters)	5.1	4.4
PV (Cost of screening)	7.7	7.6
PV (Cost of full hearing assessment)	20.8	36.4
PV (Cost of fitting and provision of hearing aid)	22.1	97.0
PV (Cost of maintenance)	21.4	101.5
PV (Total cost of the intervention)	**86.0**	**255.7**

Note: A discount rate of 3.5% and a time period of 10 years have been used to calculate the PV figures.
Source: London Economics analysis

Valuation of benefits

Present Value (PV) analysis of the benefits of the intervention		
Benefit item	**Present Value (£m) 55 years-old**	**Present Value (£m) 65 years-old**
Once-off, initial benefits	***0.0***	***0.0***
Ongoing benefits (PV)	***699.6***	***2,084.6***
PV (Avoided personal and social costs of living with a HI)	335.6	1,480.9
PV (Employment-related impacts of treating HIs)	339.0	493.6
PV (Avoided costs of Healthcare services)	21.2	92.9
PV (Avoided costs of Health care service efficiency, including missed appointments)	3.9	17.2
PV (Total benefit of the intervention)	**699.6**	**2,084.6**

Net cost/benefit of the policy intervention

The proposed policy intervention, under both age thresholds, is supported by a strong positive Net Benefit and a Benefit:Cost Ratio of more than 8:1.

Table 1: Net Present Value (PV) analysis of the intervention		
Cost item	**Present Value (£m) 55 years-old**	**Present Value (£m) 65 years-old**
PV (Total cost of the intervention)	**86.0**	**255.7**
PV (Total benefit of the intervention)	**699.6**	**2,084.6**
NPV (Net Benefit) of the intervention	**613.6**	**1,829.0**
Benefit:Cost Ratio	**8.1**	**8.2**

Note: A discount rate of 3.5% and a time period of 10 years have been used to calculate the PV figures.
Source: London Economics analysis

1 Introduction and Terms of Reference

London Economics were commissioned by the RNID, the largest charity in the UK tackling hearing loss and making hearing matter, to undertake an independent assessment of the costs and benefits associated with the introduction of hearing screening for older people and the comparison of assessed costs and benefits by way of Cost-Benefit Analysis.

This report sets out the methodology and findings of our cost-benefit assessment of a proposed nationwide hearing screening programme for older people in the United Kingdom.

1.1 Context of health screening in the United Kingdom

The UK government spends billions of pounds annually to maintain the health of the nation. In the case of the fiscal position of the government with respect to the health budget, clearly prevention is better than cure, and as such a significant proportion of this expenditure is concerned with preventative action to prevent death or to reduce expenditure on treatable illnesses later in life. With this in mind, a range of health screening programmes is already offered in the United Kingdom. By way of example, the list of screening programmes in England includes:[3]

- Antenatal
  - NHS Foetal Anomaly Screening Programme
  - NHS Infectious Diseases in Pregnancy Screening Programme
  - NHS Sickle Cell & Thalassaemia Screening Programme
- Newborn
  - NHS Newborn & Infant Physical Examination Screening Programme
  - NHS Newborn Blood Spot Screening Programme
  - NHS Newborn Hearing Screening Programme*
- Young person/adult
  - NHS Abdominal Aortic Aneurysm Screening Programme
  - National Screening Programme for Diabetic Retinopathy
  - NHS Breast Screening Programme
  - NHS Cervical Screening Programme
  - NHS Bowel Cancer Screening Programme

** All babies born in the UK are offered a hearing screen as part of a series of routine health checks in the first few weeks of life.*

National screening programmes can be expensive. In the case of cancer-screening, the NHS spends £157 million on cervical screening, £75 million on breast screening and £76.2 million on bowel screening. However, the benefits of screening can substantially outweigh the costs bringing about cost-savings in the longer term. For example, it is estimated that the National Screening

[3] There are other non-UK NSC-approved systematic population screening programmes, including Prostate Cancer Risk Management, Chlamydia screening and the NHS Health Check for vascular risk. Source: http://www.screening.nhs.uk/england.

Programme for Abdominal Aortic Aneurysms costs £26 million per annum (2008 prices) but yields annual benefits of approximately £267 million (2008 prices), giving a net benefit of approximately £3.9 billion (net present value) over 20 years.[4]

At present there is no national screening programme for hearing loss for adults.

1.2 Rationale for a hearing screening programme for older people

Hearing is one of the traditional five senses and researchers (e.g. Nachtegaal *et al*, 2009, Bridges, 1998, Mulrow *et al*, 1990) have found that "hearing impairment inevitably affects health-related quality of life."[5] People who are deaf or hard of hearing can experience higher distress, anxiety, depression, somatisation, social isolation and loneliness with negative implications on emotional, mental, and physical health.

Hearing loss affects a significant proportion of the UK population; however, the majority of people affected are aged over 60, as the ability to hear declines with age, particularly at high frequencies. It is estimated that approximately 9 million people in the UK (14.5%) are deaf or hard of hearing,[6] with 55% of people over 60 estimated to be somewhat affected by hearing loss.[7] Moreover, as the average age of the UK population continues to increase and as the proportion of individuals over 60 increases, the numbers affected by hearing loss are expected to increase.

Therefore, given the health implications and widespread incidence, hearing loss is an important and pressing issue. Technology can assist in limiting the quality-of-life and health impacts of hearing loss. Once a hearing impairment has been identified, a hearing aid device can be prescribed (available free on the NHS or for purchase from a private retailer), with the resulting benefits of hearing aid use strongly supported by research findings. Numerous studies have found that usage of a hearing aid resulted in significant improvements in emotional, mental, and physical health, as well as general quality of life (Newman *et al*, 1991, Kochkin and Rogin, 2000, Abrams 2002, Bridges, 1998, Mulrow *et al*, 1990, The National Council on the Aging, 1999, Newman *et al*, 1991). For instance, Kochkin and Rogin (2000) found that hearing instrument use was positively related to:[8]

- Reduction in anger and frustration
- Reduction in hearing loss compensation behaviours
- Reduction in the incidence of depression and depressive symptoms

[4] Department of Health (2008) *Impact Assessment of a National Screening Programme for Abdominal Aortic Aneurysms*, Accessed 23.02.08, available from: http://www.ialibrary.berr.gov.uk/uploaded/National%20Screeing%20prog.%20Abdiminal%20Aortic%20Aneurysme.pdf.

[5] Nachtegaal, et al (2009)"The Association Between Hearing Status and Psychosocial Health Before the Age of 70 Years: Results From an Internet-Based National Survey on Hearing", accessed 22.02.10, available from http://journals.lww.com/ear-hearing/pages/articleviewer.aspx?year=2009&issue=06000&article=00002&type=abstract.

[6] RNID, accessed 22.02.10, available at: http://www.rnid.org.uk/information_resources/factsheets/deaf_awareness/factsheets_leaflets/deaf_and_hard_of_hearing_people.htm

[7] Davis, A, (1995) *Hearing in Adults*, Whurr Publishers, Nottingham.

[8] Kochkin S. and Rogin C.M. (2000) "Quantifying the Obvious: The impact of hearing instruments on quality of life", *The Hearing Review*, January 2000. Available at: http://www.betterhearing.org/pdfs/MR40.pdf.

- Enhanced emotional stability
- Reduction in paranoid feelings
- Reduced anxiety symptoms (however, this could be related to lower income and reduced physical health status, which are also correlates of hearing aid usage)
- Improved belief that the subject is in control of their lives (locus of control)
- Reduced self-criticism
- Improved cognitive functioning (primarily severe-to-profound hearing loss)
- Improved health status and less incidence of pain.

However, despite the success of hearing aids in restoring quality of life, many people experiencing hearing loss do not seek medical advice. In fact, Davis, *et al* (2007) found that people may wait up to 15 years from the initial onset of hearing loss until they seek medical advice.[9] The reason for this delay may be the stigma associated with hearing loss, deafness and/or hearing aids, misdiagnosis by GPs and/or attitude to hearing loss even when it is correctly diagnosed, or being unaware of the safety and other serious effects that hearing loss can have, both on the individual and those around to them.

As a result of the tendency to delay in seeking medical advice, an estimated 4 million people in the UK have unmet or unrecognised hearing loss. The majority of these people are likely to be over 60 years old. The RNID estimate that although about two million people in the UK have hearing aids, at least an additional five million others would benefit from having a hearing aid.[10]

With the linkage to other personal health conditions and social problems, such a scale of untreated hearing loss results bears a substantial cost to the NHS health and social care services. There are costs in terms of involuntary unemployment. One estimate puts the loss in earnings due to unaided hearing impairment to the UK economy at £13.5 billion per annum.[11]

1.2.1 RNID's proposal

In order to address this important issue, the RNID proposes the implementation of a nationwide hearing screening programme for older people. It is hoped that such a programme would reduce the number of individuals with undiagnosed hearing loss, reduce the stigma of hearing loss, increase the take-up of hearing assistive technology (e.g. hearing aids), enhance the quality of living of those affected and ultimately reduce the costs of health and social care to the Exchequer.

Given the general tendency to avoid seeking medical advice and the prevalence of hearing loss in those over 55/65 years of age, it is believed that a hearing screening programme targeted at older age cohorts will be cost effective.

[9] Davis, A., Smith, P., Ferguson, M., Stephens, D. and Gianopoulos, I. (2007). "Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models," *Health Technology Assessment*, Vol. 11: No. 42.

[10] RNID, accessed 22.02.10, available at: http://www.rnid.org.uk/information_resources/factsheets/deaf_awareness/factsheets_leaflets/deaf_and_hard_of_hearing_people.htm

[11] Shield, B. (2006). *Evaluation of the Social and Economic Costs of Hearing Impairment*, A Report for Hear-It.

It is the purpose of this research to establish whether such a programme would, in fact, be cost effective to the Exchequer.

1.3 Terms of Reference

The aim of this study is to assess the costs and benefits and produce a cost-benefit analysis of introducing a hearing screening programme for older people in the United Kingdom.

The specific research objectives are:

- To assess the benefits of screening, in terms of avoided costs and potential costs of unaddressed/unrecognised hearing loss;
- To assess the costs of implementing a hearing screening programme;
- To compare the assessed costs and benefits of the proposed policy intervention.
- To conduct sensitivity analysis to identify the key sensitivities of the Cost-Benefit model as the primary cost and benefit drivers to enhance understanding of the impacts, reveal evidence gaps and guide future research;
- Identify any remaining evidence gaps to guide future research.

The remainder of the report outlines how we have met these Terms of Reference, structured as follows: Section 2 outlines the methodology of our cost-benefit modelling, Section 3 sets out the detail of the assumptions, information, data and research that comprise the evidence base for our cost-benefit modelling, and Section 4 presents a discussion of the Cost-Benefit Analysis results and sensitivities.

2 Methodology

2.1 Introduction

The Cost-Benefit Analysis (CBA) of the proposed introduction of a national hearing screening programme for older people in the United Kingdom was undertaken using a bespoke Excel-based CBA model populated using data from publicly available sources and information based on research of existing literature and evidence. In this section we set out the methodology that we have used to analyse the evidence base and build the CBA model that underlies the results presented in Section 4.

2.2 Cost-Benefit Analysis model

We have undertaken this research in accordance with HM Government guidance and best practice techniques of policy evaluation and cost-benefit analysis, as prescribed in HM Treasury's *The Green Book*,[12] HM Government Social Research Service's *The Magenta Book,*[13] and the Department for Business, Innovation and Skills' impact assessment guidance and toolkit.[14]

The 'economic rationale' underpinning any policy is one of the key issues relevant to appraisal and evaluation as listed in The Green Book, which states that "proposals need to be underpinned by sound economic analysis, which should be provided by a cost benefit analysis within an option appraisal."[15] In turn, 'Cost-Benefit analysis' is defined as "[a]nalysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible, including items for which the market does not provide a satisfactory measure of economic value."[16]

2.2.1 Application of the proportionality principle

Any proposed intervention will have a range of impacts in terms of costs and benefits. Some impacts will be obvious, intended, significant and easily quantified and monetised, whereas others will be less so. It is with reference to these latter impacts, i.e. those that are more difficult to quantify and monetise, that the definition of CBA restricts quantification to "as many of the costs and benefits … as feasible".

Accordingly, we have focused our effort in our research and estimation of cost and benefits in proportion to the significance of the costs and benefits. The scale for completeness of analysis is given below - all identified impacts of the proposed national hearing screening programme have been analysed to **level 1** at a minimum, but more effort has been invested to push more significant costs and benefits towards **level 5** of analysis:

[12] Available fromhttp://www.hm-treasury.gov.uk/d/green_book_complete.pdf.

[13] Available from: http://www.civilservice.gov.uk/Assets/complete_Magenta_tcm6-8611.pdf.

[14] Available from: Guidance: http://www.bis.gov.uk/assets/biscore/better-regulation/docs/10-898-impact-assessment-guidance.pdf; and Toolkit: http://www.bis.gov.uk/assets/biscore/better-regulation/docs/10-901-impact-assessment-toolkit.pdf.

[15] HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, p.9.

[16] HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, p.101.

1) Identification of winners and losers;
2) Full description of costs and benefits;
3) Quantification of impacts;
4) Partial valuation of costs and benefits; and
5) Fully monetised costs and benefits.

2.2.2 Application of the principles of Cost-Benefit Analysis

In constructing our CBA model, we have respected the following principles, consistent with HM Government guidance and best practice:

Change from status quo

All policy proposals considered here are evaluated against the 'status quo' scenario, which describes the outcome that would result from the continuation of the current situation, without the policy intervention. All cost and benefit impacts have been defined and measured only to the extent to which they represent deviations from the status quo scenario, with all estimates discounted for status quo where relevant.

Typology of cost and benefit impacts

Impacts are split into 'transition' costs and benefits (incurred or reaped once-off as a direct result in the short-term of the implementation of the proposed policy) and recurring costs and benefits (incurred or reaped on an ongoing basis for the lifetime of the policy and measured annually). Both direct (primary) and indirect (costs and benefits not directly attributable to the intervention) impacts have been considered and have been included in the model where considered relevant.

Forward-looking costs

The identification and measurement of cost impacts has been undertaken based on the idea of forward-looking costs. This perspective means that sunk costs (costs that have already been incurred and are irrevocable) have been ignored and only the cost of implementing the screening programme in the most efficient way possible (given technological, geographical and other practical constraints) have been considered.

Market prices

The monetisation of identified costs and benefits is based on market prices, which best reflect the opportunity cost. Where a market is dominated by a monopoly supplier, or significantly distorted by taxes or subsidies, adjustments may be required, but this has not been the case here.

Constant prices

In order that the valuation of costs or benefits are expressed in 'real terms' to remove the influence of inflation on impacts, we have employed 'constant prices'. All price and value references used in the model, even in future years, are fixed at the price level in the price base year. We have chosen 2010 as the price base year.

Present Value analysis

As a society, we attach a higher value to costs and benefits that occur in the present or near future than those occurring in the more distant future. By way of illustration, £1 million today is worth more than £1 million in ten years because the money could be invested today at an interest rate of, say, 3.5% and be worth £1.36 million in ten years' time. Therefore, to compare the monetised value of costs and benefits that occur at different points in time, we have converted the values of all impacts to a common temporal reference – the present – known as Present Value (PV). This process is called 'discounting'.

The difference between the streams of PV costs and benefits provide the Net Present Value (NPV), the total net cost/benefit of the proposed screening programme in PV terms. As stated in HM Treasury's *The Green Book* "[t]he NPV is the primary criterion for deciding whether government action can be justified."[17]

Discount rate

The (social) discount rate is the rate at which the present value (PV) of each pound of value of a future cost or benefit is assumed to diminish over time. We have used a discount rate of 3.5% for our analysis, as recommended in HM Treasury's *The Green Book*.

Time horizon

As recommended in HM Treasury's *The Green Book*, we have adopted a ten year time horizon (the length in years of the life of the policy for which impacts are measured), as there are insufficient reasons to choose a different period.

[17] HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, p.9.

3 Evidence base

3.1 Introduction

The information and data that was used to populate the CBA model was derived through a desk-based research of published literature and secondary data from a number of sources:

- Review of the economics of hearing screening literature;
- Web-based search for research reports and grey (unpublished) literature;
- Publicly available data sources (e.g. Office for National Statistics, NHS information centre);
- RNID expert opinion (in the absence of reliable data); and
- Expert opinion from other health policy experts.

In this section, we outline every input into the CBA model and describe the basis for the figures that we have used for each element. A detailed source is given for each piece of information.

3.2 Specification of the policy intervention

Given the absence of any existing national hearing screening programme, the RNID proposes that the government should consider introducing a nationwide hearing screening programme for older people. In order to inform the decision as to the chosen age group targeted by the intervention, two versions of the CBA model have been developed:

- 55 years of age; and
- 65 years of age.

Whether targeted at those aged 55 or 65 years of age, the details of the proposed intervention are identical, and are outlined below.

Each member of the general population in the United Kingdom (England, Scotland, Wales and Northern Ireland) will be sent a letter from their GP on the occasion of their 55^{th}/65^{th} birthday inviting them to arrange an appointment to attend their local GP surgery for a free hearing screen.

The screen will be carried out by a Practice Nurse using a handheld screening device. As part of the rollout of the screening programme, each GP surgery in the UK will be equipped with a handheld screening device and the Practice Nurse(s) trained in the operation of the device to perform a hearing screening test.

The screening test will comprise a set of six tones. Individuals who are able to hear four or more tones will be passed and advised to self-refer to their GP should they develop any hearing difficulties in the future. Individuals that hear three or less out of the six tones will not be passed and will be recommended to proceed to a full audiological assessment, offered free of charge under the NHS Audiology Services.

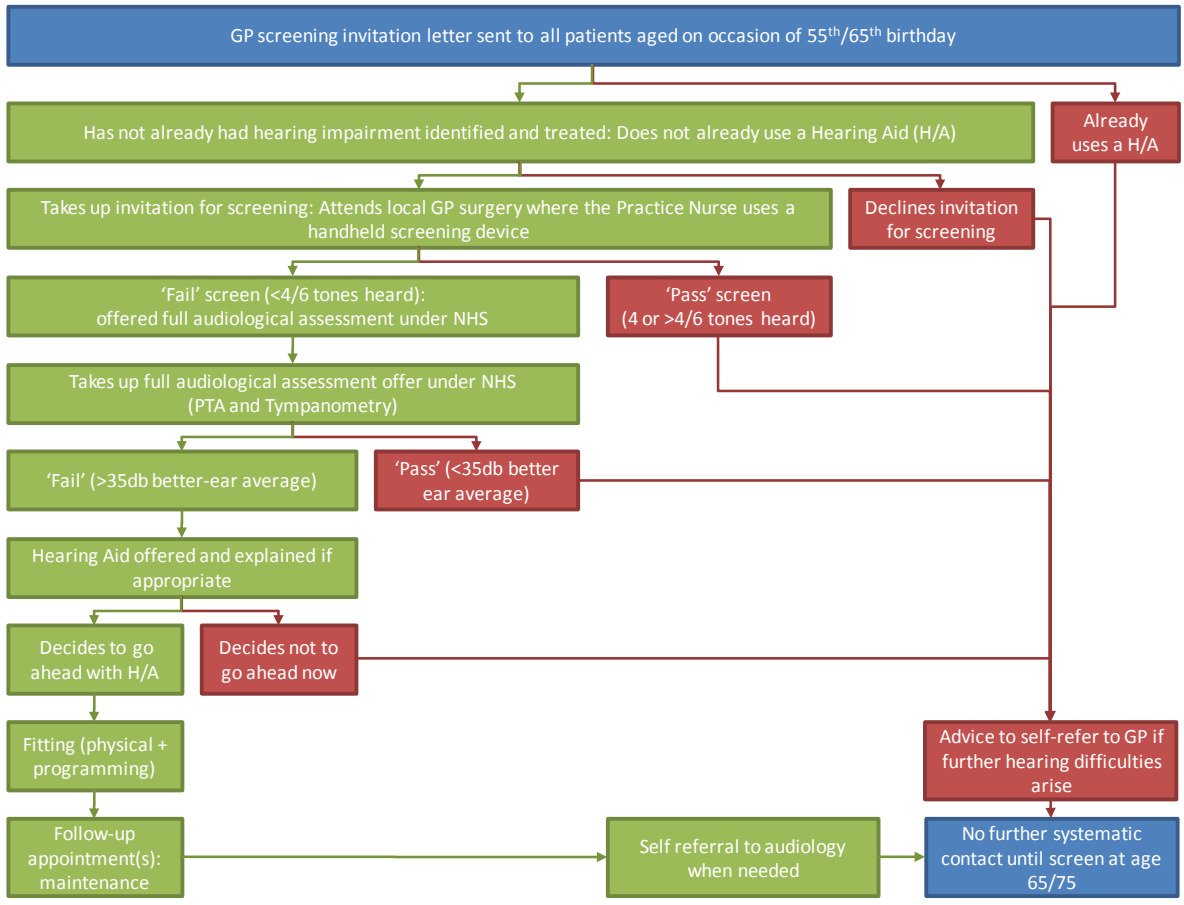
Of those proceeding to a full audiological assessment, individuals with a hearing deficit of less than 35 decibels (<35dB) better-ear average will be passed and advised to self-refer to their GP should they develop any hearing difficulties in the future. Individuals that are assessed as having a hearing deficit of more than 35 decibels (>35dB) better-ear average will not pass. If the audiologist

determines that the individual would benefit from a hearing aid, the individual is fitted and provided with a hearing aid (for one or both ears). Follow-up appointments may be necessary for repair, reprogramming, change of batteries and/or general maintenance.

This process may be re-run ten years later, on the occasion of the cohort turning 65 (for the 55 cohort) and/or 75 years of age.

The process of the intervention is represented in a schematic flowchart in Figure 1, which graphically illustrates the flow of the screened cohort through the system.

Figure 1: Schematic diagram of the hearing screening process



Source: London Economics

In the subsequent pages, we explain the sources of the data, information and assumptions employed in the CBA modelling.

3.3 Estimation the screened, assessed and treated populations

To cost the proposed intervention, we need to know the costs per individual (calculated later) and the number of people concerned at each stage of the process, calculated here. As we do not have any way of measuring the populations directly (as no similar screening system currently exists), we must estimate the population size of the group at each stage.

Returning to consider the flow of the screened cohort through the hearing screening process (Figure 1), we are particularly interested in the population at the four key stages of the process where costs are incurred, specifically:

- The number of people to whom a GP screening invitation letter is sent;
- The number of people that that attend their local GP surgery for screening;
- The number of people that undertake a full audiometry assessment under NHS; and
- The number of people that are fitted with a hearing aid under NHS.

We have estimated each of these group populations sequentially – in that each is a sub-group of the former, defined by the application of a selection filter. The estimation method and data and information sources used are now explained for each of these four key group populations, in sequence.

In each case, the explanation begins with a graphical illustration of the relevant population flow - a 'zoomed-in' section from an augmented version of the Figure 1 flowchart (the key group populations are highlighted). The illustrations are useful in understanding the estimation method as they show the previously estimated upstream population group; the selection processes; and the resulting sub-group population to be estimated in that stage.

3.3.1 Population to whom a GP screening invitation letter is sent

The first task is to calculate the number of GP screening invitation letters that will be sent. Assuming a single mail shot of letters, with no secondary round of reminders, this equates to the number of individuals in the UK population turning 55/65 years-old, so we may use the UK population that are *aged* 55/65 years-old in each year of analysis.

Though the latest UK census took place in 2001, which is quite outdated, the Office for National Statistics (ONS) produces national population *projections* for the UK and constituent countries every two years. We have used the ONS 2008-based National Population Projections (based on estimates of the resident UK population at mid-2008).[18]

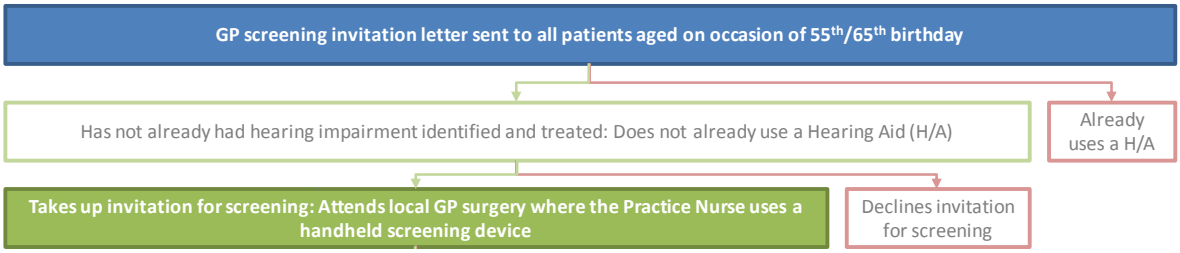
The figures used in the CBA model as estimates of the number of people to whom a GP screening invitation letter is sent are presented in Table 2.

[18] Office for National Statistics (2009). Published on 21 October 2009. Available from: http://www.statistics.gov.uk/downloads/theme_population/NPP2008/NatPopProj2008.pdf.

Table 2: UK population turning 55/65 years-old and receiving a screening invitation letter per annum, 2010-2019		
Year	**55 years-old**	**65 years-old**
2010	723,923	646,073
2011	741,074	658,084
2012	765,985	806,795
2013	793,194	764,343
2014	803,887	709,763
2015	818,582	685,451
2016	850,673	663,866
2017	870,287	657,396
2018	893,088	661,200
2019	907,460	670,345

Source: Office for National Statistics (2009) 2008-based National Population Projections (http://www.statistics.gov.uk/downloads/theme_population/NPP2008/NatPopProj2008.pdf)

3.3.2 Population that attend their local GP surgery for screening



The second stage of the population flow that we are interested in is the number of people that will actually be screened.

As shown in the above 'zoomed-in' graphic, the starting point is the number of individuals that have been invited for screening (estimated above). From this, we must subtract the number of individuals turning 55/65 years of age that have already had a hearing impairment identified and are currently using a hearing aid, as these individuals will not require screening. To do this, we reduced the number of total invitations proportionately based on the research findings by Davis *et al* (2007), who conducted a postal survey of 31,793 individuals in the UK and found that approximately 3% of 55 year olds and 6% of 65 year olds currently use a hearing aid.[19]

Next, we adjusted this number by the proportion that we expect to take-up the invitation by actually attending their local GP surgery for screening. Based on expert advice from RNID, who are experts in the field and very active in helping people identify if they have hearing loss and encouraging them to take action, we estimate that approximately 55% (for 55 year olds) and 65% (for 65 year olds) will take-up the invitation to be screened.

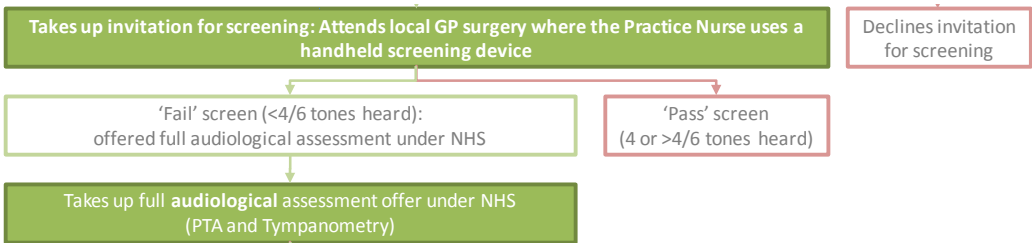
These calculations give the estimated number of people that will be screened in each year, presented in Table 3.

[19] Davis, A., Smith, P., Ferguson, M., Stephens, D. and Gianopoulos, I. (2007). "Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models," *Health Technology Assessment*, Vol. 11: No. 42.

Table 3: Estimated number of people to be screened per annum, 2010-2019		
Year	55 years-old	65 years-old
2010	386,213	394,751
2011	395,363	402,089
2012	408,653	492,952
2013	423,169	467,014
2014	428,874	433,665
2015	436,713	418,811
2016	453,834	405,622
2017	464,298	401,669
2018	476,462	403,993
2019	484,130	409,581

Source: London Economics calculations

3.3.3 Population undertaking a full audiometry assessment under NHS



Of those screened, a certain proportion will pass the screen (defined as being able to hear four or more of the six tones), thus not requiring a hearing aid and will be advised to self-refer to their GP if further hearing difficulties arise. The remainder will 'fail' the screen (hearing three or less of the six tones). UK-based research by Davis *et al* (2007) conducted clinical effectiveness trials with a total of 351 respondents to a previous postal questionnaire and found information on the likelihood of individuals failing an audiometric screen in either ear. Based on their findings, we have estimated that 14% of 55 year olds and 25% of 65 year olds would 'fail' the screen and would be recommended to proceed for a full audiometry assessment.

Again, not all of those referred would be expected to take-up the invitation so, based on expert opinion from RNID, we estimated that 70% of these individuals failing the screen will actually undertake a full audiometry assessment under the NHS.

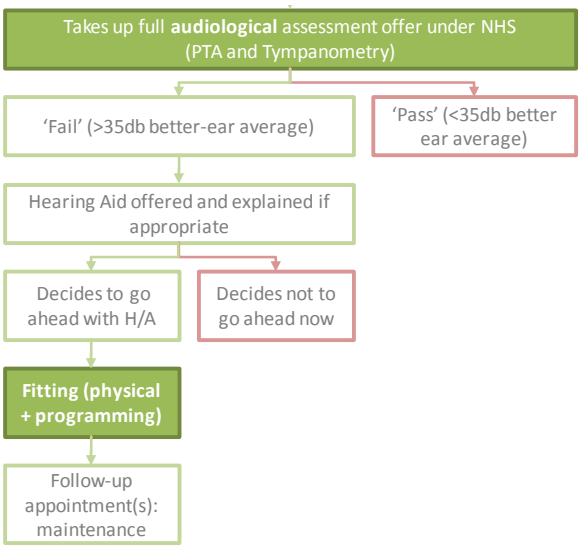
These calculation steps yield the estimated number of people undertaking a full audiometry assessment under the NHS annually, as presented in Table 4.

Table 4: Estimated number of people undertaking a full audiometry assessment under the NHS per annum, 2010-2019		
Year	**55 years-old**	**65 years-old**
2010	37,849	69,081
2011	38,746	70,366
2012	40,048	86,267
2013	41,471	81,727
2014	42,030	75,891
2015	42,798	73,292
2016	44,476	70,984
2017	45,501	70,292
2018	46,693	70,699
2019	47,445	71,677

Source: London Economics calculations

A further consideration may be the fact that not all of this new flow of patients would be able to get an appointment for a full assessment immediately, but may be placed on a waiting list of NHS Audiology Services. For the purposes of this analysis, we have assumed that all of these new patients will be accommodated and actually receive a full assessment under the NHS and have ensured that NHS costs are adjusted accordingly to reflect the additional activity.

3.3.4 Population fitted with a hearing aid under NHS



The final stage of the population flow through the system is the number of people that will need to be fitted with a customised digital hearing aid under the NHS.

Beginning with the number of people undertaking a full audiometry assessment under the NHS annually (estimated above), we apply a proportion representing those that would benefit from a hearing aid. In consultation with RNID, we defined the threshold for benefit from a hearing aid as a hearing impairment of more than 35dB. Based on the prevalence findings of Davis *et al*'s (2007) clinical effectiveness trials, we estimated that 21% of 55 year olds and 56% of 65 year olds would be found to have a hearing impairment of more than 35dB and therefore would be offered a hearing aid.

However, it is likely that a small number of these individuals will reject the offer of a hearing aid for reasons related to stigma, having already become conditioned to 'a quiet world' or general unease using the device. We estimate this proportion to be 15%, based on RNID expert opinion, with 85% accepting the device.

This gives the following population figures (Table 5) for those fitted with a hearing aid as a result of the proposed hearing screening programme.

Table 5: Estimated number of people fitted with hearing aids under the NHS per annum, 2010-2019

Year	55 years-old	65 years-old
2010	6,756	32,883
2011	6,916	33,494
2012	7,149	41,063
2013	7,402	38,902
2014	7,502	36,124
2015	7,639	34,887
2016	7,939	33,788
2017	8,122	33,459
2018	8,335	33,653
2019	8,469	34,118

Source: London Economics calculations

3.3.5 Status quo adjustment

As noted in the methodology section, all policy proposals should be evaluated against the 'status quo' scenario, which describes the outcome that would result from the continuation of the current situation, without the policy intervention. In simple terms, if some people screened under the proposed programme would have gone to get their hearing checked *in any case, without the intervention*, then the costs and benefits of screening these individuals should not be included.

As a further refinement to the status quo, past the case where people simply *may* or *may not* have been screened *at all* over the period of analysis (10 years), we consider the more realistic case that the screening programme may induce individuals to get their hearing checked *earlier* than they would have otherwise done without the intervention. Research has shown that individuals tend to wait up to 15 years to address their hearing difficulties,[20] so the number of people 'brought forward' per annum is likely to be low. Nonetheless, some small proportion of individuals screened would have done so anyway that same year, another small proportion the year after, and so on. Therefore, to reflect this fact, we must adjust our population estimates so that cost and benefit impacts have been defined and measured only to the extent to which they represent deviations from the status quo scenario.

The factors we have used to identify the number of those screened that would have been screened, identified and treated under the current (NHS) system without the new screening programme are presented in Table 6. The first row covers those that would have been

[20] Davis, A., Smith, P., Ferguson, M., Stephens, D. and Gianopoulos, I. (2007). "Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models," *Health Technology Assessment*, Vol. 11: No. 42.

screened/treated in the 'Same year that they were screened by the new screening programme', and removing this proportion from cost and benefit valuations is straightforward. The remaining rows have a more challenging intuition. From a Present Value (PV) valuation perspective, the timing and duration of cost/benefit incidence are important and the model must account for this. Timing is important as the PV of a cost incurred today is higher than the same cost incurred in a later year – so, for example, bringing forward treatment of an individual is more costly than waiting for him/her to self-present. Duration is important as the benefits of hearing aid use continue in the years after treatment, over the lifetime of the unit, but benefits reaped after the point at which an individual would have self-presented should be excluded.

Table 6: Status quo adjustment factors

Year	55 years-old	65 years-old
- Same year that they were screened by the new screening programme	1.0%	2.0%
- 1 year later than they were screened by the new screening programme	1.1%	2.1%
- 2 years later than they were screened by the new screening programme	1.2%	2.2%
- 3 years later than they were screened by the new screening programme	1.3%	2.3%
- 4 years later than they were screened by the new screening programme	1.4%	2.4%
- 5 years later than they were screened by the new screening programme	1.5%	2.5%
- 6 years later than they were screened by the new screening programme	1.6%	2.6%
- 7 years later than they were screened by the new screening programme	1.7%	2.7%
- 8 years later than they were screened by the new screening programme	1.8%	2.8%
- 9 years later than they were screened by the new screening programme	1.9%	2.9%

Source: London Economics assumptions, in consultation with RNID

By adjusting the estimated number of people receiving a hearing aid per annum by these factors, we calculate the estimated *additional* number of people fitted with hearing aids under the NHS per annum, excluding those that would have been treated absent the intervention under status quo scenario. These population figures are presented in Table 7.

Table 7: Estimated additional number of people (excluding those that would have been treated under status quo) fitted with hearing aids under the NHS per annum, 2010-2019

Year	55 years-old	65 years-old
2010	6,688	32,225
2011	6,773	32,134
2012	6,920	38,815
2013	7,079	35,769
2014	7,076	32,122
2015	7,101	30,004
2016	7,277	28,013
2017	7,328	26,763
2018	7,398	25,999
2019	7,380	25,464

Source: London Economics calculations

Having estimated the number of people concerned at each stage of the process, we now turn our attention to the valuation of the unit (per person) and total (all persons) costs and benefits of the intervention.

3.4 Valuation of the costs

For the purposes of valuation, as explained in the methodology section, costs are divided into those that are once-off and those that are ongoing. Each set of costs is valued separately, as explained in the discussion that follows.

3.4.1 Once-off, initial costs

In the first instance, we identify and value costs related directly to the implementation of the proposed policy, including necessary adjustments as part of the transition to the new regime. These costs are incurred immediately in period zero (year 1) and so do not require any Present Value analysis.

We have identified four such costs in respect of the introduction of a new nationwide hearing screening programme – the costs of:

- A public awareness advertising campaign;
- Provision of handheld hearing screening devices to GP surgeries;
- Training for GP Practice Nurses to operate the screening device; and
- Any necessary capacity increase for NHS audiology services to deal with the extra demand.

Any potential cost of setting up a database to facilitate the operation of the screening programme has not been included, as the administration of the invitation letters is assumed to be centralised whilst the local recording of patients will use existing GP surgery patient databases.

Cost of advertising

In order to introduce and inform the general public about the new hearing screening programme, promote the legitimacy of the programme and boost take-up rates, a public awareness advertising campaign would be required. Whilst there is likely to be ongoing annual advertising (valued separately below), the initial wave will be more substantial as its purpose is introductory and informational.

In order to estimate the level of advertising expenditure required to achieve the public awareness objective, we have used previous expenditures on Department of Health advertising campaigns as a guide.

Table 8 shows the Department of Health's advertising expenditure on all specific and identifiable campaigns over the five years between 2004/05 and 2008/09. The overall average expenditure per campaign in 2008/09 (the closest year to our price base year) was £3.53 million. However, this average is biased upwards by large-scale campaigns (e.g. the smoking control campaign, at £23.4 million), so we have taken two restricted averages: all campaigns <£5 million (£1.92 million); and all campaigns <£3 million (£1.34 million).

Based on these restricted averages, as a conservative estimate, we have assumed the once-off cost of advertising for the initial wave of nationwide advertising to be **£1,500,000**.

Table 8: Department of Health advertising spend in £ millions, 2004-2009 (current prices)					
Campaign	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**
Alcohol			0.56	0.61	4.77
Antibiotics		0.38		0.39	1.15
Change4Life					7.69
Drugs	0.91	0.18	1.34	0.67	1.45
Flu (Immunisation)	1.45	1.83	1.11	0.98	1.42
Hepatitis C			0.52	1.34	1.30
HPV Vaccination					2.80
Immunisation			1.66		0.32
NHS including nurse recruitment	5.96	0.22			
NHS Injury Benefits Scheme				0.40	
NHS Choices				0.03	0.55
Patient Choice					0.53
Respiratory and Hand Hygiene				0.32	1.53
Sexual health/teenage pregnancy	1.40		2.88	3.11	2.83
Social care/worker recruitment	1.80	2.42	2.31	2.22	2.03
Smoking - Tobacco Control	20.05	20.80	13.17	10.79	23.38
Stroke					4.52
Tobacco Legislation			0.32	5.38	
Winter (Get the right treatment)	0.54	0.59			
5 a Day	0.06	0.05	0.05		
E111/EHIC	0.24	1.00			0.16
DoH outdoor campaign	0.32				
Average (all campaigns)	*3.27*	*3.05*	*2.39*	*2.19*	*3.53*
Average (campaigns<£5m)					*1.92*
Average (campaigns<£3m)					*1.34*

Source: Lords Hansard, http://www.publications.parliament.uk/pa/ld200809/ldhansrd/text/91005w0012.htm#0909072000373[21]

Cost of providing each GP surgery with a handheld hearing screening device

Based on a familiarity with the handheld scanner devices and experience from the bulk discount negotiated by the NHS for digital hearing aids as part of the modernisation of NHS hearing aid services,[22] RNID provided an indicative expected unit cost for a handheld hearing screening device of £50 as a conservative estimate (i.e. high) if bulk purchased by the NHS.

We have estimated the total number of GP surgeries in the UK at 10,162 based on publicly available data on England, Scotland, Wales and Northern Ireland.[23] Assuming one scanner unit is provided per GP surgery, this gives a total cost of **£508,000**.

[21] Baroness Thornton (2009) *Response to Government Initiatives: Advertising*, Question asked by Baroness Thomas of Winchester: "To ask Her Majesty's Government which initiatives of the Department of Health or its agencies have been advertised in each of the last five years; how much was spent in each case; and which were carried out via the Central Office of Information." [HL5332], 5 Oct 2009 : Column WA439. Available from: http://www.publications.parliament.uk/pa/ld200809/ldhansrd/text/91005w0012.htm#0909072000373

[22] RNID assisted the Department of Health from 2000 to 2005 in the £125m modernisation programme in England.

[23] England, 2009/10: 8,279 http://www.dh.gov.uk/en/Publicationsandstatistics/Statistics/Performancedataandstatistics/PrimaryCare/DH_089459. Wales,

Cost of training nurses to operate the screening using the handheld hearing screening device

As stated in the specification of the policy intervention subsection (3.2), it is envisaged that the screen will be conducted by Practice Nurses in GP surgeries rather than GPs. Thus, in addition to the cost of providing the handheld screening devices, there will be the additional cost of training nurses to operate the screening using the handheld hearing screening device.

We estimate that about one hour of training would be necessary per GP Practice Nurse. Training required is assumed to consist of reading manufacturer guidance, the instruction leaflet and practice with the device. We have not included any cost for the creation and provision of any training materials, which are assumed to be provided by the manufacturer as part of the £50 unit cost (given the bulk order). The only cost is therefore the loss of each GP Practice Nurse's output for the one hour, estimated as the hourly wage for a GP practice nurse.[24] Below we outline the mechanics of the estimation and data used.

With recent data (2009) on the number of GP Practice Nurses only available for England,[25] we have estimated the total number of practice nurses in the UK on a pro-rata basis using the ONS national population estimates for England and the UK in 2008 (most recent year).[26] This method estimates that there are approximately 26,169 GP Practice Nurses in the UK that will require training.

Given national pay deals, the average hourly wage for a GP practice nurse is readily calculable. Based on NHS pay for nurses and midwives, the pay rate for a "Nurse GP practice" from April 1st 2010 (Band 5) is between £21,176 and £27,534.[27] We use the midpoint of this range, £24,355, as the average GP Practice Nurse annual basic salary.

To calculate the average hourly wage, we follow the Royal College of Nursing's recommended methodology: "[t]o calculate your hourly rate, divide your annual basic salary by 52.14 and then by 37.5."[28] The result is an hourly wage for a GP practice nurse of £12.46.

With 26,169 GP Practice Nurses spending one hour of their time on training, at £12.46 per hour, the total cost of training is therefore estimated at **£325,966**.

Cost of increasing NHS audiology capacity

To ensure that the additional patients identified as requiring a full audiometry assessment and treatment as a result of the screening programme are not simply added to an existing waiting list for treatment, it is likely that, potentially substantial, costs will be incurred in order to increase the capacity of NHS audiology services. It is estimated that a 5% to 10% increase in capacity may be

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2010: 497 (http://www.wales.nhs.uk/localservices.cfm?type=gp). Scotland, 2010: 1,023 (http://www.isdscotland.org/isd/6114.html). Northern Ireland, 2010: 363 (http://www.hscni.net/index.php?link=gps).

[24] Following the marginal revenue productivity theory of wages.

[25] NHS Hospital & Community Health Service (HCHS) and General Practice workforce as at 30 September each specified year, available from: http://www.ic.nhs.uk/statistics-and-data-collections/workforce/nhs-staff-numbers/nhs-staff-1999--2009-general-practice.

[26] Office for National Statistics (2009) *2008-based National Population Projections*, available from: http://www.statistics.gov.uk/downloads/theme_population/NPP2008/NatPopProj2008.pdf.

[27] NHS Careers (2010), available from: http://www.nhscareers.nhs.uk/details/Default.aspx?Id=4.

[28] Royal College of Nursing (2009), available from: http://www.rcn.org.uk/support/pay_and_conditions/pay_rates_2009_-_2010.

necessary. Whilst the increased variable costs (for example, labour costs of additional audiologists) will be included in the Payment-by-Results tariffs used as unit costs in our cost valuations, it has not been possible to include or monetise the fixed costs (for example, the capital costs of building accommodations and machinery) owing to a lack of available information. Such costs are included in the results as non-monetised costs. Though not included explicitly in the CBA model, ranges of the fixed costs that might be associated with a capacity increase have been included as a sensitivity test on the results (reported in section 4.4).

3.4.2 Ongoing costs per annum

In the second instance, we identify and value recurrent costs – costs that are incurred on an ongoing basis for the lifetime of the policy. The costs are measured annually over all time periods, so Present Value analysis of the valuations is required.

We have identified five such costs in respect of the introduction of a new nationwide hearing screening programme, including the cost of:

- A continuing public awareness advertising campaign;
- Printing and distributing the screening invitation letters;
- Administering the screening tests;
- Administering the full audiometry assessments; and
- Fitting, programming and providing hearing aids, including annual maintenance.

Cost of advertising

A continuation public awareness advertising campaign will be undertaken on an annual basis, possibly as part of 'Deaf Awareness Week'. Given that the objective of such an annual campaign would be to boost and maintain a general level of public awareness, we assume that a maximum of half of the initial public awareness advertising campaign budget would be an upper-bound of the cost of advertising required. Therefore, we conservatively estimate the recurring cost of ongoing advertising costs to be **£750,000 per annum**.

Cost of invitation letters

If the Department of Health was to undertake a large-scale (650,000 - 900,000 items) mail shot of invitation letters to individuals turning 55/65 years of age, it is likely that they would outsource the task, with Royal Mail a likely candidate. Thus, we have used information from Royal Mail's direct mail marketing services as the source of our unit cost estimates.[29]

Firstly, there is the cost of acquiring record data (target individuals' postal addresses), available from Royal Mail via contact lists sold at a cost of £0.125 per record. Next is the cost of preparation, printing and postage per invitation letter: Royal Mail offer an A4, enveloped, full-colour, single or double sided letter sent via Second Class post for a cost of £0.61, including print, production, postage and VAT. Combined, this gives a unit cost per individual sent a screening invitation letter of £0.735.

[29] Royal Mail (2010), available from: http://www.royalmail.com/portal/rm/content1?mediaId=97700761&catId=72600709.

Combining this unit cost with the estimates from earlier of the number of people to whom a GP screening invitation letter is sent per annum (Table 2), the estimated total costs of the invitation letters per annum from 2010 to 2019 are presented in Table 9.

Table 9: Estimated total cost (£ million) of screening invitation letters per annum, 2010-2019

Year	55 years-old	65 years-old
2010	0.53	0.47
2011	0.54	0.48
2012	0.56	0.59
2013	0.58	0.56
2014	0.59	0.52
2015	0.60	0.50
2016	0.63	0.49
2017	0.64	0.48
2018	0.66	0.49
2019	0.67	0.49

Source: London Economics calculations

Cost of screening

Once the individual attends an appointment for screening with the Practice Nurse, we estimate that administering the 6-tone screen test should take no more than ten minutes, including provision of information about the steps necessary to schedule a full audiometry assessment, if required. At one sixth of an hour, based on our previously estimated average hourly wage for a GP practice nurse of £12.46, this gives a unit cost per individual of £2.08.

Multiplying this unit cost by the estimated number of people that will be screened in each year (from Table 3, earlier) gives the estimated total costs of administering screening tests per annum from 2010 to 2019, as presented in Table 10.

Table 10: Estimated total cost (£ million) of administering screening tests per annum, 2010-2019

Year	55 years-old	65 years-old
2010	0.80	0.82
2011	0.82	0.83
2012	0.85	1.02
2013	0.88	0.97
2014	0.89	0.90
2015	0.91	0.87
2016	0.94	0.84
2017	0.96	0.83
2018	0.99	0.84
2019	1.01	0.85

Source: London Economics calculations

Cost of full hearing assessment

Usefully, the Department of Health issues non-mandatory tariffs (prices worked up based on clinical input) for certain activities as part of the Payment by Results (PbR) initiative, including some adult hearing services. Under the PbR arrangements for 2009-10, the non-mandatory tariff for an audiology hearing aid assessment is £57.[30]

As before, the estimated total costs of audiology hearing aid assessments per annum from 2010 to 2019 (as presented in Table 11) is obtained by multiplying this unit cost by the estimated number of people that will undergo an assessment under the NHS in each year (from Table 4 above).

Table 11: Estimated total cost (£ million) of administering audiology hearing aid assessments per annum, 2010-2019

Year	55 years-old	65 years-old
2010	2.16	3.94
2011	2.21	4.01
2012	2.28	4.92
2013	2.36	4.66
2014	2.40	4.33
2015	2.44	4.18
2016	2.54	4.05
2017	2.59	4.01
2018	2.66	4.03
2019	2.70	4.09

Source: London Economics calculations

Cost of treatment and maintenance

First we consider the cost of treatment (i.e. fitting, programming and provision of hearing aids), before considering the cost of maintenance (i.e. battery replacement, re-programming, repair).

In order to accurately value the cost of treatment, it is essential to know the number of people receiving a single hearing aid and those that are receiving a hearing aid for both ears. As actual information is not available, we estimate these numbers based on RNID expert opinion and experience of current treatment patterns. Having estimated the number of people that would be judged to benefit from a hearing aid (Table 5), we estimate that approximately 70% will be provided with a hearing aid in both ears.

For unit costs, we again draw on the Department of Health's Payment by Results non-mandatory tariffs arrangements for 2009-10, which prescribe the following unit costs:[31]

- Pathway for hearing aid assessment, fitting of one hearing aid device, cost of one device and first follow up: £286.00; and

[30] Department of Health (2009), available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_094091.

[31] Department of Health (2009), available from: http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_094091.

- Pathway for hearing aid assessment, fitting of two hearing aid devices, cost of two devices and first follow up: £396.00.

The product of these unit costs and the estimated number of people that will be fitted with one and two hearing aids, respectively, gives the estimated total annual costs of fitting and providing hearing aids (as presented in Table 12).

Table 12: Estimated total cost (£ million) of fitting and provision of hearing aids per annum, 2010-2019

Year	55 years-old	65 years-old
2010	2.43	11.70
2011	2.46	11.66
2012	2.51	14.09
2013	2.57	12.98
2014	2.57	11.66
2015	2.58	10.89
2016	2.64	10.17
2017	2.66	9.71
2018	2.69	9.44
2019	2.68	9.24

Source: London Economics calculations

In terms of the costs of ongoing average maintenance (including the cost of batteries, repairs, reassessments and replacements as necessary) RNID estimate that the total cost over the ten year period could amount to about £850 per person treated.

At an average cost of £85 per individual in receipt of a hearing aid under the programme per annum, the estimated total annual costs of maintenance per year are presented in Table 13.

Table 13: Estimated total cost (£ million) of hearing aid battery replacement, maintenance and repairs per annum, 2010-2019

Year	55 years-old	65 years-old
2010	-	-
2011	0.57	2.74
2012	1.14	5.47
2013	1.73	8.77
2014	2.33	11.81
2015	2.94	14.54
2016	3.54	17.09
2017	4.16	19.47
2018	4.78	21.75
2019	5.41	23.96

Source: London Economics calculations

3.5 Valuation of the benefits

3.5.1 Once-off, initial benefits

No once-off benefits of implementing the screening programme were identified.

This is not unusual for a policy proposal with a long-term objective, as once-off initial benefits tend only to be of relevance for interventions aimed at solving an urgent issue (e.g. removing an unnecessary restrictive administrative burden).

3.5.2 Ongoing benefits per annum

Rather, the benefits of addressing hearing loss are recurrent in nature, and experienced on an ongoing basis in each year of the lives of those treated.[32] Benefits include the reduced (avoided) costs and potential costs of unrecognised and unaddressed hearing loss to UK society (e.g. enhanced quality of life for individuals) and the economy (e.g. reduced health care expenditure).

Such benefits are supported by the literature. By way of example, Kochkin and Rogin (2000)[33] found that hearing aid use was positively related to: greater earning power, reduced discrimination, reduced communication difficulties, less hearing-loss compensation behaviours, improved feeling of being in control of their lives, less self-criticism and better cognitive functioning.

More specifically for valuation purposes, we identified four ongoing benefits in respect of the introduction of a new nationwide hearing screening programme:

- Avoided personal and social costs of living with a hearing impairment;
- Employment-related impacts of addressing activity-limiting hearing loss;
- Avoided costs of healthcare services (reduced NHS expenditure effects); and
- Increased health care service efficiency, including a reduction in missed appointments.

In addition, there is another potential benefit of addressing hearing loss – reduced demand for, and thus avoided costs of, social care services. Due to information gaps, it has not been possible to quantify the avoided costs for social care expenditure and so they are included as non-monetised benefits (section 4.3.1).

Assessment of the value of these benefits is distinctly more involved than the costs and will draw heavily on existing research literature in the area. Accordingly, the evidence base that follows is based on a review of the literature to inform the scale of undiagnosed hearing loss, the potential

[32] Technically, from a CBA valuation perspective, we only include benefits experienced over the years for which each individual was 'brought-forward' in terms of addressing their hearing loss. As explained with reference to the status quo adjustment (section 3.3.5), some individuals treated under the programme are likely to have self-referred for treatment at some stage during the 10 years *in any case, without the intervention*. Therefore, the benefit of screening and treating these individuals should only be included for the number of years that treatment was 'brought forward'. Notwithstanding this point, a large majority of individuals would never have sought treatment without the screening programme.

[33] Kochkin S. and Rogin C.M. (2000) "Quantifying the Obvious: The impact of hearing instruments on quality of life", *The Hearing Review*, January 2000. Available at: http://www.betterhearing.org/pdfs/MR40.pdf.

improvements to health, well-being and quality of life, as well as the avoided costs to healthcare services.

We outline the valuation methodology for each of these benefits over the subsequent pages. As with ongoing costs (above), the ongoing benefits are measured annually over all time periods, so a present value analysis of the valuations is required.

Avoided personal and social costs of living with a hearing impairment

The most obvious benefit of hearing aids is the improvement in the quality of life that they offer to the individuals themselves. The task of measuring and valuing these benefits is, however, less obvious.

Hearing loss can lead to social isolation, depression, low self esteem, employment difficulties, memory loss and prejudice. As a result, overall quality of life, family and personal relationships, education, general health and social life can be heavily affected. A review of the literature by Ruberg (2007) summarised the improvement impact of hearing aids on quality of life, experienced from the first few weeks after fitting, as:[34]

- Greater self confidence and higher self-esteem;
- Reduced deterioration in psychological functioning;
- Reduction in physical health difficulties;
- Psychosocial improvements;
- Greater satisfaction with life and less depression;
- Benefits in social life, group activities, family relationships;
- Satisfaction higher with greater hearing loss/does not depend on age;
- Better emotional life;
- Better cognitive functioning; and
- Greater overall health status.

Based on best practice approach from the health economics literature, our approach to this challenging exercise follows the cost utility analysis methodology, as outlined below.

To measure the impact of treatment on an individual, it is first necessary to establish a quantifiable link between health status and quality of life, such as a health-related quality of life index. A number of such indices are available, though each is developed with a different focus such that each has strengths and weaknesses.[35] For example, EuroQol's EQ-5D index[36] does not capture hearing related health effects, but instead focuses on mobility, self-care, usual activities,

[34] Ruberg, K. (2007) *Personal, social and economic consequences of hearing loss*, Hear-It AISBL UNSAF. Available from: http://www.unsaf.org/doc/Presentation-Kim-RUBERG-25_03_07.ppt

[35] The Medical Research Council's Institute of Hearing Research (IHR) is currently investigating the limitations of traditional quality of life measures in relation to hearing loss in more details, but no findings have been published yet. For details: http://www.ihr.mrc.ac.uk/research/research_programme.php?strand=3.4&info=lay_details

[36] For more information, please see: http://www.euroqol.org/eq-5d/what-is-eq-5d/eq-5d-nomenclature.html.

pain/discomfort, anxiety/depression. On the other hand, the Health Utility Index (HUI)[37] is calculated along the dimensions of vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain components.

Based on our review of the alternative indices, we selected the widely-used HUI for its relative strength in accounting for sensory issues. Further, the HUI is designed to be appropriate for calculating quality-adjusted life years in cost-benefit type analysis. It is measured along a linear scale from 0.00 (death) to 1.00 (perfect health). As reported by Sorri *et al* (2001)[38], the average HUI score for the UK population under the age of 60 is **0.85**, though it will be lower, on average, for individuals with hearing loss. But the question is: how much lower?

The magnitude of the reduction in quality of life, of course, depends on the severity of an individual's hearing loss: the more profound the loss of hearing, the more substantial the reduction in quality of life. Following Shield (2006) and Sorri *et al* (2001), our estimates of the loss in HUI resulting from mild, moderate, and severe/profound grades of hearing loss are presented in Table 14. Based on the observation that the value of the HUI is approximately 0.85 at the age of 60 and 0.8 at the age of 70, Sorri *et al* (2001) judge it reasonable to associate a HUI value of 0.8 with mild hearing impairment and decreasing linearly with the worsening of the hearing conditions to 0.6 for severe/profound hearing impairment.

Table 14: Health Utility Index values assigned to grades of hearing loss

Grade of hearing impairment	Mild	Moderate	Severe/Profound
Health utility index	0.80	0.70	0.60
Loss in HUI due to hearing impairment (from average: 0.85)	0.05	0.15	0.25

Source: Shield (2006)

As the specification of the policy intervention (section 3.2) assumes that hearing impaired individuals would benefit from the hearing aid in case of hearing loss amounting to more than 35 decibels (mild hearing loss is defined as up to 39 decibels), we focus on moderate and severe/profound hearing loss only. However, whilst hearing aids can help to reduce the loss in HUI for hearing impaired people, they will not be able to fully restore the loss. We make the assumption that 80% of hearing impairment-related loss in HUI (Table 14) is restorable by provision and use of a hearing aid.

In order to value this restored quality of life, or avoided loss in HUI, we use the Quality Adjusted Life Year measure and a monetised value of a 'full quality life year'.

A Quality Adjusted Life Year (QALY) is used in healthcare research to provide an indicative measure of the benefits gained from a medical intervention. The QALY measure combines both the change in quantity of life-years and the change in quality of those life-years resulting from an intervention.[39] As hearing aids do not prolong a user's lifetime (hearing-associated health

[37] For more information, please see: http://www.healthutilities.com/.

[38] Sorri, M., Brorsson, B., David, A., Mair, I., Myhre, K., Parving, A., Roine, R., Rosenhall, U., and Stilven, S. (2001) *Hearing impairment among adults: Report of a joint (Nordic-British) project*. Helsinki: Finnish Office for Health Care Technology Assessment.

[39] The number of QALYs offered by a medical intervention is calculated as the sum product of the number of years of life expectancy added and a measure of the quality of the added life-years. When compared to the expected outcome in QALYs under the 'do nothing' status quo scenario (no intervention), it gives the additional number of QALYs generated by the intervention.

conditions are considered separately later), there are no additional life-years to be considered, but the quality of life-years is improved. The additional QALYs provided by treatment are therefore solely dependent on the (partial) restoration of the hearing-associated loss in HUI (Table 14) per annum of early treatment.

The additional QALYs have been monetised using a value of a life year (VOLY) estimate. We have selected the estimate of Markandya *et al* (2004)[40] of £41,975 per life year in QALY terms, as put forward by the Department for the environment and Rural Affairs (DEFRA)[41], as the best available estimate. A very similar value of £42,000 was used by the Health and Safety Executive (HSE) in the regulatory impact assessment[42] of implementing a new European Commission Directive concerning noise at work in the UK[43]. The HSE value was not selected as it is based on the Department of Transport's road safety estimate of the value of preventing a fatality (VPF) and the application of such an estimate to hearing loss is debatable. Given the similarity of the two figures however, this preference is immaterial.

Finally, the number of individuals treated (Table 7) likely to have a moderate and profound/severe hearing impairment were estimated based on prevalence rates from Shield (2006) at 85% and 15%, respectively.

Following this methodology, our estimated total valuations of the enhanced quality of life benefits resulting from the provision of hearing aids to appropriately screened and assessed individuals under the proposed programme are presented in Table 15. It is clear from the figures that the quality of life impact of hearing aid provision is a substantial benefit to users. Total benefits are inflated for the 65 year old cohort by a higher treated population size and a higher prevalence of more severe hearing impairment.

[40] Markandya, A., Hunt, A., Alberini, A and Ortiz, R. (2004) *The Willingness to pay for Mortality Risk Reductions: an EU 3-Country Survey.* Bath: University of Bath. Mimeo.

[41] Pearce, D. (2004) *Valuation of Health Benefits of Reductions In Air Pollution and Use of Values in UK Appraisal*, Rapporteur's Summary of a DEFRA Workshop, HM Treasury, Horse Guards Road, London, 21 Jun 2004-07-13. Available from: http://www.defra.gov.uk/environment/quality/air/airquality/publications/healthbenefits/pearce.pdf.

[42] Health and Safety Executive (2005) Final Regulatory Impact Assessment of the Draft Control of Noise at Work Regulations 2006. Available from: http://www.hse.gov.uk/ria/noise/noiseria.pdf.

[43] European Commission (2003) "Directive 2003/10/EC of the European Parliament and of the Council of 6 February on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)." *Official Journal of the European Union*, L042, 38-44, 15.

Table 15: Estimated total benefit (£ million) of avoided personal and social costs of living with a hearing impairment, 2010-2019		
Year	55 years-old	65 years-old
2010	36.8	178.5
2011	37.3	178.0
2012	38.1	215.1
2013	39.0	198.2
2014	39.0	178.0
2015	39.1	166.2
2016	40.1	155.2
2017	40.4	148.3
2018	40.7	144.1
2019	40.6	141.1

Source: London Economics calculations

Employment-related impacts of addressing hearing loss

An additional benefit of the programme would come from the reduction in economic inactivity, unemployment and under-employment and the associated boost to the labour force brought about by the reduction in hearing loss-related limiting disabilities for those of working age and post-retirement age workers.

Research from Australia has shown that hearing impaired people may be up to 1.4 times more likely to be unemployed than the general population. Furthermore, they are also more likely to be underemployed – working less hours, receiving lower pay and having lower skilled jobs than people with normal hearing.[44] This is all the more pertinent, as noted by the Hearing Research Review,[45] given the demand for communication skills and higher educational qualifications of today's 'knowledge society'.

Thus, we have sought to estimate two labour market effects of addressing hearing impairment:

- Effect of previously economically inactive (due to hearing impairment) men/women returning to work; and
- Effect of previously employed men/women earning and working more in employment.

The impact of these effects will be to generate new and additional income for the workers concerned, which will be subject to income tax and disposable income spent will incur VAT, leading to increased taxation revenue to the Exchequer.

To measure these effects, we have analysed the UK Quarterly Labour Force Survey to gauge the proportion of people in the covered age cohorts that are (i) classified as being economically inactive and have limiting disability due to hearing loss; and (ii) classified as being employed but

[44] Data from the Australian Bureau of Statistics, cited by: Hear-It (2009) *Hearing impaired people often struggle to stay in labour market*, Hear-It: http://www.hear-it.org/page.dsp?page=6404.

[45] Data from the Australian Bureau of Statistics, cited by: Hear-It (2009) *Hearing impaired people often struggle to stay in labour market*, Hear-It: http://www.hear-it.org/page.dsp?page=6404.

having difficulty in hearing without the use of a hearing aid affects the kind of paid work respondent might have done.

Specifically, we analysed reported hours worked and hourly wages contingent on economic status, employment status and whether the respondent had a limiting disability due to hearing loss.

We have conducted the labour market benefit estimation separately for men and women, reflecting different gender differences in labour market outcomes. In addition, although the Labour Force survey (covering 60,000 households) is one of the largest national surveys carried out in the United Kingdom, we are focusing on very specific sub-groups at a single age point, which causes the problem of small sample sizes. In order to deal with this issue, we have defined +/- 2 year intervals around the various ages of specific interest (55 (53-57) and 65 (63-67)) for use in the analysis.

The results of this analysis in terms of Individual-level income effects are presented in Table 16, which are later applied to the estimated treated population figures from section 3.3.5. In simple English, we firstly found that the rate of employment was higher in the general population cohorts than the population with hearing impairment (HI) cohorts. If provision of hearing aids was able to remove the hearing-related limitation, more of this cohort could gain employment and earn average annual earnings equivalent to the general population (calculated from average hours worked and hourly earnings of the general population).

Secondly, we found that of those in employment, the general population cohorts tended to work longer hours and earn higher wages than the hearing impairment cohorts. Similarly, if provision of hearing aids was able to 'level the field', then this cohort could, on average, be expected to work longer and earn higher annual earnings equivalent to the general population.

Table 16: Individual-level employment (income) impacts of treating hearing impairment (HI) from LFS analysis, 53-57 and 63-67

	53-57		63-67	
	Men	**Women**	**Men**	**Women**
Previously economically inactive returning to work				
% of general population in employment	79.8%	71.3%	35.0%	21.8%
% of population with HI in employment	60.0%	44.1%	22.7%	9.0%
Difference in % employed	19.8 p.p.	27.2 p.p.	12.3 p.p.	12.7 p.p.
Average hours worked per week by general population	40.3	29.3	33.3	20.4
Average hourly earnings of general population	£ 16.18	£ 12.86	£ 13.28	£ 11.17
New average incomes earned by previously economically inactive men/women returning to work, per annum	**£ 33,901**	**£ 19,615**	**£ 22,986**	**£ 11,840**
Previously employed earning and working more				
% of population with HI in employment	60.0%	44.1%	22.7%	9.0%
Average hours worked per week by general population	40.3	29.3	33.3	20.4
Average hourly earnings of general population	£ 16.18	£ 12.86	£ 13.28	£ 11.17
Average annual earnings of general population	£ 33,901	£ 19,615	£ 22,986	£ 11,840
Average hours worked per week by population with HI	-*	25.7	27.9	15.9
Average hourly earnings of population with HI	-*	£ 11.19	£ 14.99	£ 13.62
Average annual earnings of population with HI	-*	£ 14,933	£ 21,737	£ 11,220
Additional income earned by previously employed men/women earning and working more, per annum	**-***	**£ 4,682**	**£ 1,249**	**£ 620**

Note: * In this instance, the average earnings for hearing impaired LFS respondents in employment was statistically insignificantly different from that of the general population.

Source: London Economics analysis of ONS Quarterly Labour Force Survey

When we apply these analysis findings to the estimated treated population figures from section 3.3.5, this yields a substantial total of new and additional income earned as a result of employment-related impacts of treating hearing impairments (Table 17). Once again, the 65 year old cohort figures are inflated by a higher treated population size.

Table 17: Estimated total new and additional income earned as a result of employment-related impacts of treating hearing impairments, 2010-2019		
Year	55 years-old	65 years-old
2010	94.3	150.9
2011	95.5	150.4
2012	97.6	181.7
2013	99.8	167.5
2014	99.8	150.4
2015	100.1	140.5
2016	102.6	131.1
2017	103.3	125.3
2018	104.3	121.7
2019	104.1	119.2

Source: London Economics calculations

These substantial extra incomes will be subject to income tax and National Insurance contributions in the first instance and Value-Added Tax on subsequent spending. We assume a standard combined income and National Insurance rate of 31% (20% basic rate of income tax plus 11% of National Insurance, consistent with 2010-11 tax rates),[46] deducted at source. Of the remaining (disposable) income, we assume that 70 pence out of every pound is spent rather than saved (equivalent to a marginal propensity to consume equal to 0.7) and apply the prevailing standard rate of VAT (17.5%)[47] to calculate indirect taxation revenues.

The total additional tax revenues flowing to the Exchequer resulting from the employment-related impacts of treating hearing impairments under the programme are set out in Table 18.

Table 18: Estimated total benefit (£ million) of the employment-related impacts of treating hearing impairments, 2010-2019		
Year	55 years-old	65 years-old
2010	37.2	59.5
2011	37.7	59.4
2012	38.5	71.7
2013	39.4	66.1
2014	39.4	59.3
2015	39.5	55.4
2016	40.5	51.7
2017	40.8	49.4
2018	41.2	48.0
2019	41.1	47.0

Source: London Economics calculations

Avoided costs of healthcare services

A potentially significant benefit of the screening programme would be the impact that the early identification and treatment of hearing impairment could have on the prevalence of certain

[46] HM Revenue & Customs - Income Tax. Available from: http://www.hmrc.gov.uk/incometax/basics.htm#6.

[47] The standard rate of VAT is currently 17.5% but this will be increased to 20% on 4 January 2011.

hearing-related health conditions amongst those treated. The RNID believe that as hearing instruments improve speech intelligibility, use of hearing aids should lead to improvements in one's social, emotional, psychological and physical functioning and ultimately reduce the negative effects on the individual's psychological well-being and the isolation and social withdrawal that often comes about with more severe hearing loss. These potential avoided costs of healthcare are evaluated in this section.

In order to assess the impact of hearing aid use, it is important to understand as clearly as possible the links between hearing impairment and health issues, for which we look to the research literature. However, whilst there have been some notable research studies undertaken in the UK and internationally, there is a general scarcity of robust research regarding hearing aid and health quality of life issues, as noted by Chisolm *et al* (2007)[48] in their systematic review of the literature. This is a constraint on our ability to assess the beneficial impact on some of the health conditions speculated to be associated to hearing loss.

Notwithstanding this constraint, the existing literature does suggest social, psychological, cognitive and health effects of hearing loss and some positive effects of hearing aid use.

Many studies find negative health effects associated with hearing impairment. In one study, an adverse relationship between hearing loss and psychosocial functioning was found by Nachtegaal *et al* (2009)[49] in research on 1,511 participants between the ages of 18 and 70 years. The researchers found that psychological, social and emotional functioning (including depression, loneliness, stress, anxiety, distress, and somatization) were negatively influenced by hearing loss, more so than mobility or activities of daily living. They did not find any gender differences. Another study comprising a large survey of UK adults by Davis *et al* (2007))[50] suggested that hearing impaired people are more likely to experience tinnitus and balance disorders, which themselves increase the likeliness of injury for a fall or accident.

More positively, however, several studies suggest a positive impact of hearing aid use. Kochkin and Rogin (2000)[51] identified hearing instrument as more likely to report improvements in their physical, emotional, mental and social well-being. Similarly, research on well-being in older adults by Bridges and Bentler (1998)[52] found significantly lower levels of depression in subjects without hearing loss, but that those successfully using hearing aids had significantly lower depression and more life satisfaction than people who used to use a hearing aid but no longer do. In the United

[48] Chisolm T., Johnson C., Danhauer J., Portz L., Abrams H., Lesner S., McCarthy P. and Newman C. (2007) "A Systematic Review of Health-Related Quality of Life and Hearing Aids: Final Report of the American Academy of Audiology Task Force on the Health-Related Quality of Life Benefits of Amplification in Adults"

[49] Nachtegaal, J., Smit, J.H., Smits, C., Bezemer, P.D., van Beek, J.H.M., Festen, J.M., Kramer, S.E. (2009). "The Association Between Hearing Status and Psychosocial Health Before the Age of 70 Years: Results From an Internet-Based National Survey on Hearing", *Ear & Hearing*, June 2009 - Volume 30 - Issue 3 - pp 302-312.

[50] Davis, A., Smith, P., Ferguson, M., Stephens, D. and Gianopoulos, I. (2007) 'Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models', *Health Technology Assessment*, 2007; Vol. 11: No. 42.

[51] Kochkin S. and Rogin C.M. (2000) "Quantifying the Obvious: The impact of hearing instruments on quality of life", *The Hearing Review*, January 2000. Available at: http://www.betterhearing.org/pdfs/MR40.pdf.

[52] Bridges, J.A. and Bentler, R.A. (1998). "Relating hearing aid use to well-being among older adults", Hearing Journal, July 1998 - Volume 51 - Issue 7 - ppg 39,42-44.

States, a study of 192 war veterans by Mulrow *et al* (1992)[53] found that those fitted with hearing aids had reduced levels of depression, which continued after 12 months. Another study of 105 veterans with acquired hearing loss by Abrams *et al* (2002)[54] also found a significant positive impact of hearing aid fitting on a number of quality of life measures. Cacciatore *et al* (1999)[55] found that those with severe hearing loss had significantly lower scores on measures for vitality, emotional wellbeing and mental health, but that those using a hearing aid had lower levels of depression measured on the Geriatric Depression Scale. The National Council on the Aging (2000)[56] found that of the older hearing-impaired people studied, those who did not use hearing aids were more likely to report sadness and depression, worry and anxiety, paranoia, emotional turmoil and insecurity. In summary, a systematic literature review by Chisolm *et al* (2007)[57] concluded that hearing aids improve adults' health-related quality of life by reducing the psychological, social and emotional effects of hearing loss.

A little less positively, Stark *et al* (2004)[58] found that whilst participants fitted with a hearing aid did experience improved hearing-related quality of life, there was no change in their health-related quality of life. A similar ambiguous result was found by Metselaar *et al* (2008)[59], who found that the prevalence of depression unchanged after a hearing aid fitting. Again, Joore *et al* (2002)[60] found that there was not change after hearing aid fitting in four of EuroQol EQ-5D measures, with a significant improvement only experienced in the 'feelings' dimension.

Accordingly, based on the indications of the research findings, we consider health conditions associated as being a common complication of having hearing impairment separately, including:

- Depression;
- Dementia;
- Anxiety;
- Stress; and
- Other health conditions.

[53] Mulrow D, Tuley M, Aguilar C (1992) Sustained Benefits of Hearing Aids, Journal of Speech and Hearing Research, Volume 35, 1402-1405, December 1992.

[54] Abrams, H. Chisolm, T.H. and McArdle, R. (2002) "A cost-utility analysis of adult group audiologic rehabilitation: Are the benefits worth the cost?", Journal of Rehabilitation Research and Development, Vol. 39 No. 5, September/October 2002, pages 549–558. Available at: http://www.rehab.research.va.gov/jour/02/39/5/PDF/Abrams.pdf.

[55] Cacciatore F, Napoli C, Abete P, Marciano E, Triassi M, Rengo F, (1999) Quality of Life Determinants and Hearing Function in an Elderly Population: Osservatorio Geriatrico Campano Study Group, Gerontology 1999; 45: 323-328.

[56] National Council on the Aging, (2000) The Consequences of Untreated Hearing Loss in Older Persons, ORL – Head and Neck Nursing, Winter 2000, volume 18, number 1.

[57] Chisolm T., Johnson C., Danhauer J., Portz L., Abrams H., Lesner S., McCarthy P. and Newman C. (2007) "A Systematic Review of Health-Related Quality of Life and Hearing Aids: Final Report of the American Academy of Audiology Task Force on the Health-Related Quality of Life Benefits of Amplification in Adults"

[58] Stark P, Hickson L. (2004) Outcomes of hearing aid fitting for older people with hearing impairment and their significant others. International Journal of Audiology 2004; 43:390-398.

[59] Metsalaar M, Maat B, Krijnen P, Verschuure J, Dreschler W, Feenstra L. (2008) Self-reported disability and handicap after hearing-aid fitting and benefit of hearing aids: comparison of fitting procedures, degree or hearing loss, experience with hearing aids and uni- and bilateral fittings. Eur Arch Otorhinolaryngol, Oct 2008.

[60] Joore M, Potjewijd J, Timmerman A, Anteunis L. (2002) Response shift in the measurement of quality of life in hearing impaired adults after hearing aid fitting, Quality of Life Research 11: 299-307, 2002.

The valuation methodology for each health condition is identical, requiring two key pieces of information: the number of people that will avoid experiencing the health condition due to hearing aid provision; and the cost of medical treatment for the health condition that will be avoided for each person.

Research has shown the listed health conditions to be associated with hearing impairment, with a higher prevalence rate found in the hard of hearing and deaf population than the rest of the population. As the conditions are not exclusively related to hearing impairment but are also experienced by some proportion of the general public, we can only expect audiological treatment to reduce the higher prevalence rate in the hearing impaired group to the rate that witnessed in the general population. The reduction in the prevalence rate (difference between the rates in the hearing impaired population and the general population) multiplied by the treated population under the screening programme (Table 7) yields an estimate of the number of people that will avoid experiencing the health condition due to hearing aid provision.

The following caveat attaches to the prevalence rates used: whilst every effort has been made to identify research studies that calculate condition prevalence rates in the hearing impaired and the general population for the exact age groups under analysis (55 and 65 years of age), this has not always been possible due to a lack of research evidence. In the absence of precise information by year of age, average prevalence rates across the age band have been used, as noted in the discussion below where relevant.

The second piece of information required is the cost of treatment. Treatment differs for each condition (though usually consisting of GP visits, medication, counselling, or other such treatments) but is valued the same way for each; as the sum, over all types of treatment received, of the product of the frequency of treatment and cost per treatment.

Most of the unit costs used in the analysis are sourced from an annual publication titled "Unit Costs of Health & Social Care"[61] by Curtis (2009) at the Personal Social Services Research Unit (henceforth referred to as PSSRU) at the University of Kent. The publication is the result of an annual programme of work, funded by the Department of Health and now in its eighteenth year, to provide detailed and comprehensive unit cost estimates for all health and social care services.

The information underlying this calculation is now explained for each condition.

Depression

Based on a survey of 2,069 hearing impaired individuals aged 50 and over in the United States, Kochkin and Rogin (2000)[62] found that 28% of the group suffered from depression. In terms of the prevalence of depression in the general population, a survey of 234 participants aged 55 and over in the Netherlands, conducted by Licht-Strunk *et al* (2009),[63] found that 16% suffered from

[61] Curtis, L. (2009) *Unit Costs of Health & Social Care*. Canterbury: Personal Social Services Research Unit, The University of Kent. Available at: http://www.pssru.ac.uk/pdf/uc/uc2009/uc2009.pdf.

[62] Kochkin S. and Rogin C.M. (2000) "Quantifying the Obvious: The impact of hearing instruments on quality of life", *The Hearing Review*, January 2000. Available at: http://www.betterhearing.org/pdfs/MR40.pdf.

[63] Licht-Strunk E, Van Marwijk H, Twisk J, De Haan M, Beekman A (2009) "Outcome of depression in later life in primary care: longitudinal cohort study with three years' follow-up" (http://ukpmc.ac.uk/articlerender.cgi?tool=pubmed&pubmedid=19188214)

depression-related disorders. Thus, we suggest that the prevalence of depression in the hearing impaired population tends to be higher by approximately 12 percentage points.

Based on the finding of the General Practitioner Workload Survey 2006/07[64] that a GP surgery consultation lasts an average of 11.7 minutes, the PSSRU estimates the unit cost of a GP surgery consultation at £35, including training and direct care staff costs.[65] According to the NHS website, 12 GP visits in a year may be expected to treat depression.[66]

NHS National Services Scotland produces data on the prescribing of antidepressant drugs, which estimates the average cost per defined daily dose at 0.22p, equivalent to £80.30 per annum.[67]

With many types of additional non-medication treatment prescribed by doctors according to the particular needs of each patient (including cognitive behavioural therapy, interpersonal therapy, counselling, electroconvulsive therapy), we also include an additional cost of cognitive behavioural therapy, by way of a representative example of such treatment. According to the NHS,[68] 6 sessions of cognitive behavioural therapy are recommended per annum, which are costed by the PSSRU at £59 per session.[69]

Dementia

Research by Herbst and Humphrey (1980)[70] of a sample of 253 people in the UK aged 70 years and over living in their own homes, found that 26% of respondents were both hearing impaired and suffering from dementia, whilst 16% of the non-hearing impaired respondents suffered from dementia. This suggests that the prevalence of dementia in the hearing impaired population is higher by approximately 10 percentage points.

As a representative example of medication-based treatment, we include the cost of antipsychotic drug treatment (Aricept, Exelon and Reminyl). According to the Alzheimer's society[71], these drugs cost the NHS in the range of £800 to £1,000 per patient each year, of which we use the midpoint of £900.

As with depression, many non-medication treatments are available, primarily psychological treatments. Again, we include the additional cost of cognitive behavioural therapy, by way of a representative example of such treatment. Based on the information on treatment under the

[64] The Information Centre (2007) 2006/07 UK General Practice Workload Survey, Primary Care Statistics, The Information Centre, Leeds. Available from: http://www.ic.nhs.uk/webfiles/publications/gp/GP%20Workload%20Report.pdf.

[65] Curtis, L. (2009) *Unit Costs of Health & Social Care*. Canterbury: Personal Social Services Research Unit, The University of Kent. Available at: http://www.pssru.ac.uk/pdf/uc/uc2009/uc2009.pdf. Page 121.

[66] NHS: Treating depression http://www.nhs.uk/Conditions/Depression/Pages/Treatment.aspx.

[67] NHS: National Services Scotland (2009) *Antidepressants*. Available at: http://www.isdscotland.org/isd/information-and-statistics.jsp;jsessionid=E36954F234CF68164B09E2A3E6DB4F97?pContentID=3671&p_applic=CCC&p_service=Content.show&.

[68] NHS: Treating depression http://www.nhs.uk/Conditions/Depression/Pages/Treatment.aspx.

[69] Curtis, L. (2009) *Unit Costs of Health & Social Care*. Canterbury: Personal Social Services Research Unit, The University of Kent. Available at: http://www.pssru.ac.uk/pdf/uc/uc2009/uc2009.pdf. Page 67.

[70] Herbst K G, Humphrey C (1980) "Hearing impairment and mental state in the elderly living at home." Br Med J 1980;281:903-905 (4 October), doi:10.1136

[71] Alzheimer's Society (2010) Drug treatments for Alzheimer's disease. http://www.alzheimers.org.uk/site/scripts/documents_info.php?documentID=147.

NHS,[72] we allow for an average of 12 sessions of cognitive behavioural therapy per annum, costed by the PSSRU at £59 per session.[73]

Anxiety

In their research, Kochkin and Rogin (2000)[74] also considered the impact of hearing impairment on the quality of life in terms of anxiety. In their survey of 2,069 hearing impaired individuals aged 50 and over in the United States, they found that 24% of the group suffered from anxiety. The equivalent prevalence rate for the general population in the U.S. is provided by a review of evidence by the Office of the U.S. Surgeon General[75] which estimates that up to 17% of men and 21% of women aged 55 and over may experience symptoms of anxiety. Taking a mid-point estimate of 19% for the general population suggests that the prevalence rate of anxiety disorders in the hearing impaired population is 5 percentage points higher.

According to the NHS website, one initial GP visit followed by four follow-up appointments as a result of medication would be required to treat anxiety,[76] costed using PSSRU's estimated the unit cost of a GP surgery consultation of £35, including training and direct care staff costs.[77]

According to the NHS, there are two main forms of treatment for generalised anxiety disorder (GAD): psychological therapy (e.g. cognitive behavioural therapy); and medication (e.g. anti-depressants).

One of the medication options available to GPs for anxiety disorders is anti-depressant drugs such as selective serotonin reuptake inhibitors (SSRIs) or venlafaxine. As explained with reference to depression above, the average cost of antidepressant drugs is estimated by NHS National Services Scotland at 0.22p per defined daily dose, equivalent to £80.30 per patient per annum.[78]

According to the NHS,[79] a total of 16-20 hours of cognitive behavioural therapy are recommended over four months. To give an average rate of treatment per patient per year, we assume 12 sessions per annum per patient, costed at the PSSRU's estimate of £59 per session.[80]

[72] NHS: Treating dementia http://www.nhs.uk/Conditions/Dementia/Pages/Treatment.aspx.

[73] Curtis, L. (2009) *Unit Costs of Health & Social Care*. Canterbury: Personal Social Services Research Unit, The University of Kent. Available at: http://www.pssru.ac.uk/pdf/uc/uc2009/uc2009.pdf. Page 67.

[74] Kochkin S. and Rogin C.M. (2000) "Quantifying the Obvious: The impact of hearing instruments on quality of life", *The Hearing Review*, January 2000. Available at: http://www.betterhearing.org/pdfs/MR40.pdf.

[75] NetWellness (2010) "Older Adults and Mental Health: Part 2: Anxiety Disorder" Tuesday, April 13, 2010 (http://www.netwellness.org/healthtopics/aging/anxietydisorder.cfm)

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[79] NHS: Treating anxiety http://www.nhs.uk/Conditions/Anxiety/Pages/Treatment.aspx.

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Stress

De Graaf and Bijl (2002)[81] conducted a study on the mental health of a sample of 523 hearing impaired individuals in the Netherlands, finding that 35% of hearing impaired individuals suffered from stress-related disorders compared with 24% within general population. The prevalence rate among hearing impaired people is therefore approximately 11 percentage points greater than the non-hearing impaired general public.

Once self-help techniques have been found to be unsuccessful, cognitive behavioural therapy can help patients to manage stress. From the NHS's guidance on the treatment of stress,[82] we assume 6 sessions of cognitive behavioural therapy per annum per patient, costed at the PSSRU's estimate of £59 per session.[83]

Other health conditions

Other health conditions, such as balance disorders and tinnitus, have also been suggested to have a higher prevalence in people with a hearing impairment. For example, an extensive survey of individuals in the UK conducted by Davis *et al* (2007)[84] found that of the 3,622 people aged 55-74 with a hearing problem, 21.6% reported balance problems and 18.9% reported suffering from tinnitus. However, due to a lack of clear evidence on the link between the condition, having a hearing impairment and the impact of hearing aid provision, and of the increased prevalence rate vis-à-vis the general population, it has not been possible to value the avoided costs of these conditions.

The estimated annual total benefits, for all health conditions combined, of avoided costs of healthcare services are presented in Table 20.

[81] de Graaf R, Bijl R (2002) "Determinants of mental stress in adults with a severe auditory impairment: Differences between prelingual and postlingual deafness. Psychosomatic Medicine" Psychosomatic Medicine 64:61-70 (2002)

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[84] Davis A , Smith P, Ferguson M, Stephens D and Gianopoulos I (2007) Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models. Health Technology Assessment 2007; Vol. 11: No. 42

Table 19: Estimated total benefit (£ million) of avoided costs of healthcare services, 2010-2019		
Year	55 years-old	65 years-old
2010	2.3	11.2
2011	2.4	11.2
2012	2.4	13.5
2013	2.5	12.4
2014	2.5	11.2
2015	2.5	10.4
2016	2.5	9.7
2017	2.5	9.3
2018	2.6	9.0
2019	2.6	8.9

Source: London Economics calculations

Avoided costs of health care service efficiency, including missed appointments

Another healthcare-related benefit of addressing hearing loss is that fewer appointments will be missed due to miscommunication and the provision of general healthcare to hearing aid patients is facilitated.

A survey of 866 deaf and hard of hearing people undertaken by RNID (2004)[85] into their experiences of the National Health Service found that 24% of all respondents had missed an appointment at their GP surgery because of poor communication. In fact, patients missed an average of 2.89 appointments over the course of ten years, at an estimated cost of £65 per appointment missed. Though this sample is weighted towards the profoundly deaf, it is the only available evidence linking hearing impairment and missed appointments. Applying these figures to our treated population (section 3.3.5) yield the total costs of missed appointments due to poor communication.

Further to reducing missed appointments, addressing hearing impairment will reduce communication barriers, the time required to communicate symptoms and treatment prescribed, but most importantly, dangerous miscommunications regarding treatment (e.g. dosage of medication prescribed) for a whole range of related health conditions. Given total NHS expenditure of £95.4 billion in 2009/10,[86] and 127.9 million NHS patient episodes,[87] the implied average cost per patient episode is £746. Assuming an average of 4 episodes per patient provided with a hearing impairment per annum, and a potential efficiency saving of 2% would yield efficiency savings in the region of £0.4 - £0.5 million (55 year-old cohort) or £1.6 - £2.5 million (65 year-old cohort) per annum.

The combined estimated annual total benefits of increased health care service efficiency, including a reduction in missed appointments are presented in Table 20.

[85] RNID (2004) *A simple cure: A national report into deaf and hard of hearing people's experiences of the National Health Service*. Available from: http://www.rnid.org.uk/VirtualContent/84923/asimplecure.pdf.

[86] NHS Current Expenditure (Consumption of resources) - Hospital and community health services, Plan 2009/10: Figure A.5, p. 219: http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_100819.pdf.

[87] Inpatient, Outpatient & A&E, February 2009 to January 2010: http://www.ic.nhs.uk/pubs/provisionalmonthlyhes.

Table 20: Estimated total benefit (£ million) of increased health care service efficiency, including a reduction in missed appointments, 2010-2019		
Year	55 years-old	65 years-old
2010	0.4	2.1
2011	0.4	2.1
2012	0.4	2.5
2013	0.5	2.3
2014	0.5	2.1
2015	0.5	1.9
2016	0.5	1.8
2017	0.5	1.7
2018	0.5	1.7
2019	0.5	1.6

Source: London Economics calculations

4 Cost-Benefit Analysis results

4.1 Introduction

On the basis of the cost-benefit methodology outlined in section 2 and the evidence base put forward in section 3, we now present the results of our cost-benefits model for both the 55 and 65 year old cohorts.

4.2 Costs of the policy intervention

The Present Value of the total costs of the proposed national screening programme are presented in Table 21, separated into once-off initial costs and ongoing costs. Each is broken down further into the individual costs elements.

Table 21: Present Value (PV) analysis of the costs of the intervention

Cost item	Present Value (£m) 55 years-old	Present Value (£m) 65 years-old
Once-off, initial costs	***2.3***	***2.3***
Cost of advertising	1.5	1.5
Cost of providing each GP surgery with a handheld hearing screening device	0.5	0.5
Cost of training nurses to operate the screening using the handheld hearing screening device	0.3	0.3
Ongoing costs (PV)	***83.7***	***253.3***
PV (Cost of ongoing advertising)	6.5	6.5
PV (Cost of invitation letters)	5.1	4.4
PV (Cost of screening)	7.7	7.6
PV (Cost of full hearing assessment)	20.8	36.4
PV (Cost of fitting and provision of hearing aid)	22.1	97.0
PV (Cost of maintenance)	21.4	101.5
PV (Total cost of the intervention)	**86.0**	**255.7**

Note: A discount rate of 3.5% and a time period of 10 years have been used to calculate the PV figures.
Source: London Economics analysis

4.2.1 Non-monetised costs

It has not been possible to monetise the, potentially substantial, fixed costs of increasing the capacity of NHS audiology services (for example, the capital costs of building accommodations and machinery) owing to a lack of available information. Whilst the increased variable costs (for example, labour costs of additional audiologists) have been included in the Payment-by-Results tariffs used as unit costs in our cost valuations, the capital costs remain as non-monetised costs. However, though not included explicitly in the CBA model, ranges of the fixed costs that might be associated with a capacity increase have been included as a sensitivity test on the results (reported in section 4.4) to assess the impact that such a cost might have on the Benefit:Cost Ratio result.

4.3 Benefits of the policy intervention

The Present Value of the total benefits of the proposed screening programme are presented in Table 22. As explained earlier, no once-off initial benefits were identified, but ongoing benefits are listed, broken down by each benefit element.

Table 22: Present Value (PV) analysis of the benefits of the intervention

Benefit item	Present Value (£m) 55 years-old	Present Value (£m) 65 years-old
Once-off, initial benefits	***0.0***	***0.0***
Ongoing benefits (PV)	***699.6***	***2,084.6***
PV (Avoided personal and social costs of living with a HI)	335.6	1,480.9
PV (Employment-related impacts of treating HIs)	339.0	493.6
PV (Avoided costs of Healthcare services)	21.2	92.9
PV (Avoided costs of Health care service efficiency, including missed appointments)	3.9	17.2
PV (Total benefit of the intervention)	**699.6**	**2,084.6**

Note: A discount rate of 3.5% and a time period of 10 years have been used to calculate the PV figures.
Source: London Economics analysis

4.3.1 Non-monetised benefits

Due to a lack of robust evidence on increased prevalence in people with a hearing impairment vis-à-vis the general population and the impact of hearing aid provision, it has not been possible to value the avoided costs of certain health conditions, such as balance disorders and tinnitus.

In addition, another benefit of addressing hearing loss that has not been included in the model is potentially reduced demand for, and thus avoided costs of, social care services. The link between hearing loss and reduced social function has also been established in the literature, though the evidence is sparse. In one study of 2,688 individuals in the United States, Dayna *et al* (2003)[88] found that those with hearing loss had lower scores (small but significant difference) for social function than those with no hearing loss. In support of the positive impact made by hearing aids, the National Council on Aging (2000) report found that older hearing-impaired people using hearing aids are less likely to report less social activity than those who do not. Similarly, a study of 1,192 people in Italy by Appollonio *et al* (1996)[89] found that people with an uncorrected hearing loss (or visual impairment) had a significant impairment of social relationships compared to those who used some type of sensory aid. However, though the research literature has drawn some links and social isolation, the evidence is weak and there has been no quantification of the link between addressing hearing impairment and the level of required social service provision. Given this weakness, it has not been possible to quantify the potential avoided costs for social care expenditure.

[88] Dayna S, Dalton MS, Cruickshanks K, Klein B, Klein R, Wiley T, Nondahl D, (2003) The Impact of Hearing Loss on Quality of Life in Older Adults, The Gerontologist, vol. 43, no. 5, 661-668.

[89] Appollonio I, Carabellese C, Frattola L, Trabucchi M, (1996) Effects of Sensory Aids on the Quality of Life and Mortality of Elderly People: A Multivariate Analysis, Age and Ageing, 1996:25:89-96.

4.4 Net cost/benefit of the policy intervention

Finally, the litmus test of the proposed intervention, the Net Present Value, is presented in Table 23, which shows a strong positive Net Benefit and Benefit:Cost Ratio for both age cohorts. The proposed policy intervention is therefore supported by economic rationale under the terms of HM Treasury's *The Green Book*.[90]

Table 23: Net Present Value (PV) analysis of the intervention

Cost item	Present Value (£m) 55 years-old	Present Value (£m) 65 years-old
PV (Total cost of the intervention)	**86.0**	**255.7**
PV (Total benefit of the intervention)	**699.6**	**2,084.6**
NPV (Net Benefit) of the intervention	**613.6**	**1,829.0**
Benefit:Cost Ratio	**8.1**	**8.2**

Note: A discount rate of 3.5% and a time period of 10 years have been used to calculate the PV figures.
Source: London Economics analysis

4.4.1 Sensitivity analysis

Each version of the CBA model (55 and 65 year-old thresholds) draws on over one hundred information, data and assumption inputs, and neither was found to be very sensitive to individual inputs.

One key sensitivity of the model that was identified is the fact that the capital costs of increasing NHS audiology services capacity to deal with the increased demand predicted to result from the screening programme were not included in the valuation of costs. Though valuations of the capital costs do not exist, an indicative cost of £100m was included in the model to test sensitivity. The effect was to reduce the Benefit:Cost Ratio to 3.8 : 1 for screening 55 year-olds and 5.9 : 1 for screening 65 year-olds.

Even if a cost of £500m was allowed for the capacity increase costs, the Benefit:Cost Ratio would still be positive, at 1.2 : 1 for screening 55 year-olds and 2.8 : 1 for screening 65 year-olds.

[90] Available fromhttp://www.hm-treasury.gov.uk/d/green_book_complete.pdf.