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The research reported in this monograph was commissioned by the HTA Programme as project number 94/46/01. The contractual start date was in April 1998. The draft report began editorial review in April 2005 and was accepted for publication in February 2007. As the funder, by devising a commissioning brief, the HTA Programme specified the research question and study design. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the referees for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

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Abstract

Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models

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Objectives: To show that hearing loss has such a high prevalence in the older population to justify screening, if effective and acceptable methods are available; and that population take-up and benefit can make a measurable outcome difference in quality of life.
Design: A population study of people aged 55–74 years was undertaken. A clinical effectiveness study of differently organised screening programmes was carried out using a controlled trial to identify those who might benefit from intervention (and the extent of the benefit). A retrospective case–control study examined the very long-term (more than 10 years) compliance of patients in using their hearing aids after early identification and determined the extent to which early-identified hearing-impaired people have better outcomes than equivalent people identified later. An examination of the costs and cost-effectiveness of different potential screening programmes was also undertaken.
Setting: A population study was designed in the UK, with specific stages being conducted in more depth on a sample of people from Nottingham and Southampton. The clinical effectiveness study was conducted in general practices in Nottingham and Bath using a systematic or opportunistic screen. The retrospective case–control study compared a group of early-identified hearing aid users, with control matched for age, gender and occupation, in Cardiff, Glasgow and Manchester.
Participants: In Great Britain responses were obtained for 34,362 individuals from the postal questionnaire as part of a population study, 506 were interviewed, 351 were assessed for benefit from amplification and 87 were fitted with a hearing aid. The clinical effectiveness study received 1461 replies from the first-stage questionnaire screen, with 306 people assessed in the clinic, of whom 156 were fitted with hearing aids. The retrospective case–control study traced 116 previously fitted hearing aid users, who had been identified by a screen, and then conducted a case–control using 50 of these for whom complete data were available, matching with two control groups of 50 people.
Interventions: The major prospective interventions were to introduce amplification through offering people, with minimal hearing impairment, hearing aid(s) in a rehabilitative setting. In the population study, aids were offered as a monaural in-the-ear (ITE) hearing aid and in the clinical effectiveness study people who met the criteria were randomised to be offered two different ITE hearing aids to be fitted bilaterally. The retrospective case–control study used unilateral and bilateral hearing aids.
Main outcome measures: Prevalence of hearing problems and degree to which services meet need in 55–74-year age group. Public acceptability and individual benefits of hearing screening and intervention as a function of demographic and hearing domain-specific characteristics. Improvement in quality of life. Screening costs and cost-effectiveness as a function of proposed programmes.
Results: It was found that 12% of people aged 55–74 years have a hearing problem that causes moderate or severe worry, annoyance or upset, 14% have a bilateral hearing impairment of at least 35 dB hearing level (HL) and only 3% currently receive intervention, through the use of hearing aids. Good amplification was shown to benefit about one in four of this 55–74-year-old population and the degree of hearing loss predicted benefit well. Overall, there was a strong correlation

between benefit from amplification and from using hearing aids. Questionnaires and audiometric screens gave good screening operating characteristics. The systematic screening programme was more acceptable and gave a better response than the opportunistic. About 70% of those who were offered an aid accepted a bilateral fitting. This increased to 95% for those with ⩾35 dB HL (averaged over 0.5, 1, 2 and 4 kHz in the better ear). The retrospective case–control study showed that long-term hearing aid use was low, unless hearing impairment was quite high (e.g. >35 dB HL). Those identified early had greater benefit through additional years of use/better adaptation to use than those of the same age and hearing impairment who were fitted with hearing aids later. Different screening programmes were modelled. The 35 dB HL better ear average hearing impairment level was found to be a good, robust and justifiable target group for screening and here the most efficient and practicable method was to use two questions in primary care concerning hearing problems and a hearing screen using a pure tone at 3 kHz 35 dB HL. The average cost of the screening programme was £13 per person screened or about £100 if treatment costs were included. Making the conservative assumption that identification gives an extra 9 years using hearing aids, the costs of screening and intervention were in the range of £800–1000 per quality-adjusted life-year when using the Health Utilities Index and about £2500 using the Short Form 6 Dimensions metric.

Conclusions: A simple systematic screen, using an audiometric screening instrument, has been shown to be acceptable to people in the age range 55–74 years, is likely to provide substantial benefit and may be cost-effective to those in that target group. Hearing screening appears to meet the National Screening Committee's criteria in most respects, provided screening is targeted at those with at least 35 dB HL better ear average. Based on the research carried out here there is sufficient evidence to support a larger and more definitive study of hearing screening. Further research into who should be referred for and benefit from audiological assessment and provision of hearing aid in a primary care trust setting is needed as is investigation into screening devices and the various aspects of introducing such a programme.

Contents

List of abbreviations

ALDQ	Auditory Lifestyle and Demand Questionnaire
ANOVA	analysis of variance
APHAB	Abbreviated Profile of Hearing Aid Benefit
ASA	Adaptive Speech Algorithm prescription for hearing aid fitting
AV	aversiveness scale (APHAB)
BEA	better ear average (pure tone threshold averaged across 0.5, 1, 2 and 4 kHz)
BEHL	better ear hearing level
BN	background noise scale (APHAB)
BSA	British Society of Audiology
BTE	behind-the-ear (hearing aid)
CHI	Community Health Index
CI	confidence interval
COSI	Client Oriented Scale of Improvement
CV	coefficient of variation
C-V-C-V	consonant–vowel–consonant–vowel
dB pe SPL	decibels, peak equivalent sound pressure level
dB(A)	decibels, A weighted
dB HL	decibels, hearing level
df	degrees of freedom
DFII	Oticon Digifocus II
DigIT	Study of the introduction of digital hearing aids and IT systems in the NHS
DPOAE	distortion product otoacoustic emissions
DSP	digital signal processing
EC	ease of communication scale (APHAB)
ENT	ear, nose and throat
ERS	Emotional Response Scale
FAAF	Four Alternate Auditory Feature speech test
FAR	false alarm rate
GHABP	Glasgow Hearing Aid Benefit Profile
GHSI	Glasgow Health Status Inventory
GLM	generalised linear model
HAT	hearing aid trial
HL	hearing level
HTL	hearing threshold level
HUI	Health Utilities Index
ICRA	International Collegium For Rehabilitative Audiology
IHR	Institute of Hearing Research
IHRCS	Institute of Hearing Research Clinical Section
IQR	interquartile range
ISO	International Standards Organisation
ISVR	Institute of Sound and Vibration Research

continued

List of abbreviations *continued*

IT	information technology
ITE	in-the-ear (hearing aid)
ITT	intention-to-treat
MHAS	Modernising Hearing Aid Services
MLS	maximum length sequence
MRC	Medical Research Council
NA	not applicable
NAL (R)	National Acoustics Laboratory prescription for hearing aid fitting, revised version
NCSR	National Centre for Social Research
NICE	National Institute for Health and Clinical Excellence
NSC	National Screening Committee
NSH	National Study of Hearing
OAE	otoacoustic emission
PAF	Postcode Address File
POEMS	Programmable Otoacoustic Emission Measurement System
PPP	public private partnership
QALY	quality-adjusted life-year
QoFL	Quality of Family Life questionnaire
RCT	randomised controlled trial
REAR	real ear aided response
REIG	real ear insertion gain
REM	real ear measurement
RMSE	root mean square error
RNID	Royal National Institute for Deaf People
ROC	receiver operating characteristic
RUH	Royal United Hospital, Bath
RV	reverberation scale (APHAB)
SD	standard deviation
SE	standard error
SEG	socio-economic group
SF-36	Short Form 36
SF-6D	Short Form 6 Dimensions
SHHI	Social Hearing Handicap Index
SN	speech-weighted noise
SNHL	sensorineural hearing loss
s/n, SNR	signal-to-noise ratio
SPSS	Statistical Package for the Social Sciences
TEOAE	transient evoked otoacoustic emission
WBN	wide-band noise
WEA	worse ear average (pure tone threshold averaged across 0.5, 1, 2 and 4 kHz)
WEHL	worse ear hearing level
WLS	weighted least squares
WN	white noise

All abbreviations that have been used in this report are listed here unless the abbreviation is well known (e.g. NHS), or it has been used only once, or it is a non-standard abbreviation used only in figures/tables/appendices in which case the abbreviation is defined in the figure legend or at the end of the table.

Executive summary

Background

About one in five adults in the UK has a bilateral hearing problem that affects their hearing and communication. The major problems occur in listening to speech in a background of noise (e.g. in social and family settings, shops, cafés or bars, watching television), which makes communication or enjoyment very difficult. Previous estimates have suggested that at least one in ten people might benefit from amplification, but currently only one in six of those who might benefit have and fully use their amplification (hearing aids and assistive listening devices), and a further one in six are not receiving substantial benefit from their aids.

Typically, those who are referred for hearing assessment recognise that they have had a hearing problem for around 10 years or more, are aged in their mid-seventies and have a substantial hearing problem. The older that people are when they present for assessment and intervention, the more difficult they find adaptation to and care of their hearing aids. It often takes 10 years for an individual to recognise that they have a hearing problem (but a shorter time for significant others).

The impact of this degree of hearing impairment and reduced ability to communicate is substantial. Communication difficulties associated with hearing impairment cross the whole health and social care spectrum. They can lead to depression, social withdrawal and problems with employment and access to information sources. People with hearing impairment are highly likely to have other problems (there is a 40% co-morbidity) such as tinnitus and balance disorders which contribute in part as risk factors for falls and other accidental injury. Imbalance and falls in older people are frequent causes of loss of independence, avoidable illness and mortality.

Over the next 15 years hearing impairment will be an increasing population problem, because of the ageing population profile. It is likely to increase by 10–15% in population terms, without any shift in the prevalence of hearing impairment.

The Modernising Hearing Aid Services programme has recently been completed in England, with similar programmes in Wales, Northern Ireland and Scotland. This has provided hearing aid departments with new, digital signal processing hearing aids, and with the infrastructure, patient management systems, information technology and training to provide a quality service and deliver the national patient journey from referral to follow-up. As part of this initiative there is much work concerned with meeting need in the population and meeting a demand that appears to be increasing. Skill mix, use of private sector partnerships and telemedicine all feature strongly in providing capacity to that service.

At present there are in excess of 3000 professionals working in the services, delivering about 500,000 patient journeys per year (1.5–2 million appointments and associated open access clinics) and fitting 700,000 hearing aids. This service costs in the region of £120 million per year to the NHS. However, long waits for hearing tests and the subsequent fitting of hearing aids have been a major issue across the NHS audiology departments. Diagnostic waiting times data released in July 2006 by the Department of Health estimated that around 250,000 patients are waiting for either a first assessment or a reassessment of hearing loss. The direct referral pathway for hearing assessment for adult-acquired hearing loss has not been included in the 18-week delivery programme, as that programme only covers referral to a medical specialist. However, work to underpin the development of the 18-week pathway principles and definitions identified that adult hearing services need a specific action plan to address these long-standing problems. This work has identified options to reduce significantly the unit cost of assessment and fit of digital aids through a redesigned service specification. Part of that solution may be to introduce a primary-care based service that could include a screening test element to bring better, more uniform referrals in primary care.

The degree of unmet need, the late age of presentation of most patients and the problems they have in adapting to hearing aids at an older age suggest that screening for hearing impairment in older people ought to be investigated as a

priority. New technology, such as audiometric screeners and automated otoacoustic emissions (AOAE), is highly promising as a screen. AOAE is currently used to identify newborn deafness in the Newborn Hearing Screening Programme (NHSP). It, and other more traditional methods, should be evaluated to see whether it is cost-effective in identifying adult hearing problems that could benefit from intervention in a younger population (e.g. 55–74 years) than those who present for hearing assessment (e.g. 70–90 year olds).

Objectives

The objectives of this study were to show that hearing loss has a high enough prevalence in the older population to justify screening, if effective and acceptable methods are available, and that take-up and benefit can make a measurable outcome difference in quality of life.

Design of the research

The research was organised in four strands:

1. A population study of people aged 55–74 years, the objectives of which were:
   - to find the prevalence of reported hearing problems in the UK population and compare with other ear, nose and throat problems that people report
   - to find out the use of primary care and specialist hearing services as a function of severity of hearing problems and age
   - to assess the public's attitudes to screening and, in particular, the public's take-up of hearing screening and the hearing-impaired public's take-up of hearing aids as an intervention for hearing disability
   - to examine the extent to which the population, using a representative subset of the random sample, might benefit from amplification and the factors that influence this benefit
   - to examine what screening techniques might be best to identify those who would get benefit from amplification
   - to examine the extent to which benefit might be realised in the real world by providing a hearing aid.
2. A clinical effectiveness study using a controlled trial to examine the acceptability of benefits from candidature for and performance of differently organised screening programmes aimed at identifying those who might benefit from intervention (and the extent of the benefit). People who were screened by questionnaire who admitted a hearing problem and those who did not were invited for assessment. Following assessment, a minimal hearing loss criterion was used to offer intervention through one of two types of hearing aid processing strategies which were assigned at random.
3. A retrospective case–control study:
   - to examine the very long-term (>10 years) compliance of patients in using their hearing aids after early identification
   - to determine the extent to which early-identified hearing-impaired people have better outcomes than equivalent people identified later.
4. Examination of the costs and cost-effectiveness of different potential screening programmes.

Setting

Strand 1, the population study, was designed as a population study in the UK, with stages 2–4 being conducted on a sample of these from Nottingham and Southampton.

Strand 2, the clinical effectiveness study, was conducted in general practices in Nottingham and Bath using a systematic or opportunistic screen.

Strand 3, the retrospective case–control study, compared a group of early-identified hearing aid users, identified at an early age in Cardiff, with control matched for age, gender and occupation in Cardiff, Glasgow and Manchester.

Participants

Strand 1 had 34,362 respondents in Great Britain, who replied to the postal questionnaire, 506 who were interviewed, 351 who were assessed for benefit from amplification and 87 who were fitted with a hearing aid.

Strand 2 received 1461 replies from the first-stage questionnaire screen, with 306 people assessed in the clinic, of whom 156 were fitted with hearing aids.

Strand 3 traced 116 previously fitted hearing aid users, who had been identified by a screen, and then conducted a case–control using 50 of these for whom complete data were available, matching with two control groups of 50 people.

Interventions

The major prospective interventions were to introduce amplification through offering people with minimal hearing impairment hearing aid(s)

in a rehabilitative setting. In strand 1 these were offered as a monaural in-the-ear (ITE) hearing aid and in strand 2 people who met the criteria were randomised to be offered two different ITE hearing aids to be fitted bilaterally. Strand 3 used unilateral and bilateral hearing aids.

Main outcome measures

The main outcomes measures were:

- prevalence of hearing problems and degree to which services meet need in 55–74-year age group
- public acceptability and individual benefits of hearing screening and intervention as a function of demographic and hearing domain-specific characteristics
- improvement in quality of life
- screening costs and cost-effectiveness as a function of proposed programmes.

Results

In Strand 1 it was found that:

- 12% of people aged 55–74 years have a hearing problem that causes moderate or severe worry, annoyance or upset
- 14% have a bilateral hearing impairment of at least 35 dB HL
- only 3% currently receive intervention, through the use of hearing aids
- these hearing problems, which mainly affect ability to hear speech in noise, have a mean reported duration of about 10 years
- over 90% of people interviewed felt that hearing screening was acceptable, especially if associated with their GP's practice.

Good amplification was shown to benefit about one in four of the population and the degree of hearing loss predicted benefit well. In a population intervention trial with a single hearing aid, less benefit was received when measured in real-world situations than in the laboratory. However, overall, there was a strong correlation between benefit from amplification and from using hearing aids.

Questionnaires and audiometric screens gave good screening operating characteristics (sensitivity, false-alarm rate, positive predictive value) while, overall, more technically advanced options such as otoacoustic emissions and speech in noise tests did not perform as well.

In strand 2, one- and two-stage screening programmes were examined in systematic and opportunistic screening programmes. The systematic screening programme was more acceptable and gave a better response. The offer of two hearing aids was accepted by about 70% of those who were offered an aid. This increased to 95% for those with 35 dB HL or poorer. There were substantial worthwhile benefits (+1 SD) in terms of domain-specific outcomes such as hearing in noise performance and hearing aid benefit outcome inventories, and moderate benefits measured in health utility [Health Utilities Index (HUI) and Short Form 6 Dimensions (SF-6D)] from amplification for this target group (35+ dB HL). Generalisability of uptake will be affected by a number of factors (service setting, research participation incentives) that will need to be explored in translating the research into service.

In strand 3, the retrospective case control study showed that long-term hearing aid use was low, unless hearing impairment was quite high (e.g. 35 dB HL). Those identified early had greater benefit through additional years of use/better adaptation to use than those of the same age and hearing impairment who were fitted with hearing aids later.

In strand 4, the different screen programmes were modelled and judged in terms of d′, cost and cost per quality-adjusted life-year (QALY) against different gold standards. The 35 dB HL better ear average hearing impairment level was found to be a good, robust and justifiable target group for screening. In identifying this target group, the most efficient and practicable method was to use two questions in primary care concerning hearing problems and a hearing screen using a pure tone at 3 kHz 35 dB HL (that was used in the hearing aid clinic, but could be used in primary care if costs per device were appropriate). The average cost of the screening programme was £13 per person screened or about £100 if treatment costs were included.

The benefits and costs were examined using the HUI and the SF-6D. Making the conservative assumption that identification gives 9 additional years using hearing aids (average gain if identified earlier, i.e. 63 rather than 72 years of age), the 9-year costs of screening and intervention were in the range of £800–1000 per QALY when using the HUI and about £2500 using the SF-6D metric. Sensitivity analysis showed that at the lower confidence interval using the HUI outcome metric the current costs of providing hearing aid services would have to increase by about an order of magnitude for the usual criterion of £20,000 per QALY to be exceeded.

Conclusions

Hearing impairment of moderate degree in adults is a highly prevalent major public health problem with a large impact on people's lives, which is left too late before access to services is achieved. One in ten people aged 55–74 years is substantially impaired and would benefit from referral. Lack of intervention impacts on activity and causes substantial participation restriction (handicap) in older people. Amplification gives substantial benefit to these people and this benefit can be realised by provision of good-quality hearing aids to people with this high degree of need.

A simple systematic screen, using an audiometric screening instrument, has been shown to be acceptable to people in the age range 55–74 years, is likely to provide substantial benefit and may be cost-effective to those in that target group. Hearing screening appears to meet the National Screening Committee's criteria in most respects, provided screening is targeted at those with at least 35 dB HL better ear average. Based on the research carried out here there is sufficient evidence to support a larger and more definitive study of hearing screening.

In addition, if screening is targeted on the younger age range, it will identify more people who are currently not likely to self-refer, where the additional benefits (e.g. from 10 years earlier identification) are more likely to be found. However, it should be noted that its benefit is not solely restricted to this group at present (as older people who would greatly benefit have not had any screening and have not self-referred).

Recommendations for research

The following are recommended for future research:

- A prospective randomised controlled trial of one- and two-stage hearing screen is needed to identify bilateral 35 dB HL or worse hearing impairment in 60–70-year-old people and intervene in a primary care trust setting using current NHS hearing aids (behind the ear)
- A prospective pilot of hearing screen triage is needed to identify people who should be referred for and benefit from audiological assessment and provision of hearing aid in a primary care trust setting.
- A simple, low-cost, audiometric screening device could be developed and trialled
- A trial is needed of a Hearing Direct, telemedicine alternative to questionnaires, combined with a low-cost audiometric screen device.
- A workforce review should be conducted to estimate the impact of introducing the screen on the audiological workforce in general and to look at the workforce requirements for different levels of staff to assist patients through the patient journey.
- Modelling of different screening programmes and their cost and financial impact should be carried out.

Chapter 1
Introduction

Background

Each year in England, approximately 400,000–500,000 hearing-impaired patients are offered hearing aids and accept them. Their median age has increased from about 70 years in the early 1980s to about 74 years in 1999.[1] Part of the reason for this age increase in receiving services is because there are very long waits across England for audiology services; but many are seeking services at a later age and not benefiting from services when they could (some of these people may not have sought services in the past). Only about half to one-third of hearing-impaired people provided with hearing aids are first time hearing aid users. The average age of first time users is about the same as the population with hearing aids.[2] The major cause of sensorineural hearing impairment is age-related hearing pathology which has a major focus around the cochlear outer hair cell functioning. Hearing impairment usually develops very slowly in those who have acquired it as they grow older. It is argued that many people and their families would have substantial benefit if they had had access to hearing services and been offered a hearing aid much earlier than they do currently.

The National Study of Hearing (NSH)[2] estimated that while 20% of the adult population have a bilateral hearing impairment at 25 dB hearing level (HL) and above, at least 10% would substantially benefit from a hearing aid. Less than 4% used an aid in the 1980s.[2] There was a need to update these data and estimate how many people would benefit from modern well-fitted hearing aid(s) and to examine strategies by which people might be either case-found or screened for benefit from amplification and provision of a hearing aid.

This study concentrated on a particular age group, 55–74 years, because this is when the prevalence of hearing impairment starts to increase substantially, year on year. From this group it should be possible to identify and help people who have hearing problems but do not present themselves for a hearing assessment for hearing aid(s) until many years later.

It is estimated from the NSH that about 6% of people aged 55–74 years use a hearing aid. About half of this population have at least a 25 dB HL hearing impairment (averaged over 0.5, 1, 2 and 4 kHz) in one ear and about 30% have this degree of impairment bilaterally. Seventeen per cent have bilateral impairment of 35 dB HL or worse. Those who may benefit from hearing aids far exceed the number who actually have them. In addition, if they received them earlier in life, the long-term benefits to those individuals and their families would be greater. The hearing aid services would also benefit by not having to spend so much time enabling elderly patients to use hearing aids, as they would have had the aids for several years by that time.

Several studies[3–6] have reported the underdetection of hearing impairment. It is well recognised that hearing impairment has a particularly high prevalence, especially in elderly populations. There have been many comments on the implications for quality of life of this underdetection. Jerger and colleagues[4] state what other authors report, that "many old persons and their relatives are reluctant to confront the reality of hearing handicap and try to hide the fact that they need sound amplification". Studies report using screening and intervention programmes to improve this situation.[7,8] In particular, it has been suggested that primary care services could be used to screen for hearing impairment, possibly alongside other screening interventions.[9–12]

Several studies in the UK have shown that it is possible to screen and fit hearing aids to hearing-impaired people earlier than they currently present[13–15] However, no study has yet estimated in the UK population the extent to which screening would successfully identify those who may benefit from hearing aids and the factors that may be important in determining the extent of benefit.

Objective

The aim of this study was to show that:

- hearing loss has a high enough prevalence in the older population to justify screening if effective and acceptable methods are available

- take-up and benefit can be shown to make a measurable outcome difference in quality of life.

Approach taken in this study

At all stages the study was within the framework of a patient journey, and measuring acceptability to the patient was central.

Previous work through GP-based case-finding, which targeted people in the 50–65-year-age group, has shown that hearing aid use can be at least tripled.[13,14] However, these studies are deficient in five respects:

1. Previous studies were carried out in the mid- to late 1980s in Wales, and need generalising and updating in England and Wales.
2. A broader view (over a wider age range, 55–75 years) of acceptability of screening and take-up of hearing aids, including in-the-ear (ITE) devices, is needed, stratified by age, gender and occupational group.
3. A comparison of new, more sensitive, screening techniques, such as otoacoustic emissions and computerised speech testing, is needed.
4. The organisational, opportunity and cost implications of introducing hearing screening to the community need to be clearly enumerated.
5. There is a need to examine whether early intervention pays off over the longer term (e.g. 10 years or more after intervention).

This study makes good these shortcomings, with three strands of investigation.

Strand 1, the population study, addresses deficit 2 and examines the issues of acceptability and take-up of screening in the population as well as the factors involved in the take-up and use of services (e.g. hearing aids) for those with hearing problems. Strand 1 looks at:

- the prevalence of reported hearing disability overall and hearing impairment in the population for the age group 55–74 years
- the public's views on different ways of offering screening
- the extent to which the public take up screening offers
- the operating characteristics of different hearing screening methods
- the incremental value of different hearing assessment methods above hearing threshold
- the use of hearing aids once fitted, and reported benefit
- the reported and measured benefit from the hearing aids and intervention as a whole.

This strand then feeds through to strand 2, the clinical effectiveness study. This is an appraisal of the effectiveness of different screening methods in finding people who would benefit optimally from intervention and rehabilitation, that is, addressing deficit 3. It also addresses deficits 1, 2 and 4, in that it was a field trial of the apparently best screening tools in real programmes run by two different NHS hearing aid services. It incorporates the idea of primary care services as vehicles to identify those who would benefit from intervention. It also enables the extent to which it is possible to attain more efficient and uniform referrals from primary care to be examined.

Strand 3, the retrospective case–control study, addresses deficit 5, in that it is a long-term follow-up of the people who participated in the early aiding studies in Wales.[13,14]

This research is particularly timely as the elderly hearing-impaired population who are potential hearing aid candidates is known to be growing at a rate of 1% per annum.[16,17] There is also concern about the appropriateness of current service models, where demand can vary considerably owing to the huge unmet need and varying policy on referral.

Policy context

The Modernising Hearing Aid Services (MHAS) programme has recently been completed in England, with similar programmes in Wales, Northern Ireland and Scotland. This has provided hearing aid departments with new, digital signal processing (DSP), hearing aids and with the infrastructure, patient management systems (PMS), information technology (IT) and training to provide a quality service and deliver the national patient journey from referral to follow-up. On-elbow training has been supplied to all services and a new graduate entry programme has been initiated.

In 2001 the Department of Health published a National Service Framework for older people in which reducing disability and maximising independent living are stated aims. This programme of research was timely in that it was designed specifically to screen for a condition

known to be very prevalent especially in older people, but for which services are variable and do not meet the need of the public. If the evidence base for the benefits of a screening programme to identify those with substantial unmet need who then benefit from intervention is shown to be strong, then it will help the case for the further targeted development of hearing services. This could then be incorporated into a revised patient journey and care pathway (www.mrchear.info/doas).

Long waits for hearing tests and the subsequent fitting of hearing aids have been the norm across the NHS. Diagnostic waiting times data released in July 2006 by the Department of Health estimated that around 250,000 patients are waiting for either a first assessment or a reassessment of hearing loss. The direct referral pathway for hearing assessment for adult-acquired hearing loss has not been included in the 18-week delivery programme, as that programme only covers referral to a medical specialist. However, work to underpin the development of the 18-week pathway principles and definitions identified that adult hearing services need a specific action plan to address these long standing problems. This work has identified options to reduce significantly the unit cost of assessment and fitting of digital aids through a redesigned service specification. The Department of Health is also seeking NHS pioneers to develop 'proof-of-concept' for system change solutions. Recommendations from this research could provide pioneering opportunities to improve significantly waiting times in audiology, which are among the longest for all physiological measurement disciplines. The NHS 18-week programme has shown that adult audiology has some of the longest waits from referral to treatment, and proposes a national action plan (www.18weeks.nhs.uk/public/) and has developed a number of ideas to promote access, some of which would rely on using appropriate screening tests to triage patients or appropriate screening programmes to enable access to services for those with unmet need. Such a test could also bring better, more uniform referrals from primary care practitioners, who may also be in a better position to help their patients.

The case for screening and support

To make a further impact on improving quality of life of hearing-impaired people, early detection of hearing impairment and acceptance of hearing aid amplification are essential. This report describes the prevalence of hearing impairment, the unmet need for aiding in the population, the opinions of users and non-users of services, the efficiency of screening tools, the uptake of and benefits obtained by early aiding and the costs.

Screening can identify people currently not using hearing aids who would benefit. However, following screening, not everyone who is suitable will accept the offer of a hearing aid, although this number would be expected to increase with improved design. Uptake of aids after screening in this study was 36%. There is a need for improved support for those who accept a hearing aid to ensure that aids are used effectively and the user is supported in the learning and adaptation period to increase the number who experience significant benefit from the use of an aid (36% of those identified following screen and fitted with an aid reported significant benefit).

Methodological challenges

Population studies are intrinsically complex. Studies involving general practice at a time of considerable organisational uncertainty in the NHS are also complex. At the time the studies were proposed, we had reasonable expectations of recruiting a large enough sample to give good statistical generality and power. In the event, the study did not recruit as many patients as had been proposed. This was due to organisational issues, but also because the benefits observed were far greater than expected. So, we feel that the results are strong enough as a basis for making screening recommendations that can add to discussion on care pathways (such as the NHS Do Once and Share Programme) and also make a beneficial impact on patients' lives.

The results and recommendations do not ask service providers and patients to change practice, or to undergo invasive tests or painful or difficult treatment. The benefits shown here encourage service development and patient behaviour in existing directions: care pathways and different models of care based on better informed triage (screening) and empowering primary care to manage the burden of hearing disability in the community, rather than be held hostage to it.

Hearing impairment is complex. Losing hearing is not life threatening, although it can diminish quality of life and has led to loss of employment in some cases. It can have a substantial impact on

activity, and moderate hearing impairment has been equated to chronic long-term pain such as is experienced by people with a slipped disc. Because hearing loss nearly always develops gradually, patients do not see it as a dramatic health problem requiring urgent intervention. Many people are not aware of milder hearing loss: "people don't speak so clearly these days". Hearing loss arises predominantly from loss of function in the outer hair cells, which cannot be restored. So it is a condition that has to be managed rather than cured, and some of the incentives for other screens do not apply: screening for early identification and treatment will not save lives, although it is argued that it will gain years of higher quality life. This study looks closely at the level of hearing impairment at which intervention/providing a hearing aid is most likely to be effective and acceptable.

Establishing the 'best' screening programme is not an exact science. 'Best' will vary for a number of reasons: the balance between specificity, false alarm rates, true-positive rates, cost, acceptability and risk will vary according to the problem, the treatment outcomes, costs per screen and case found, the nature of the intervention, and so on. In this report we extract key dimensions and see how they can be combined to give an acceptable, efficient and affordable screening programme with measurable worthwhile benefits, and identify for which population the screen would be most effective in detecting remediable unmet need.

Chapter 2

Strand 1: population study

Introduction

Stage 1 of the population study consisted of a postal questionnaire which served three purposes:

- Prevalence data were gathered on all major ear, nose and throat (ENT) symptoms.
- Prevalence data were gathered on hearing aid ownership and use.
- A random sample of 55–74 year olds was identified as participants for subsequent stages of the population study.

Stage 2 examined detailed views on hearing services and hearing screening. Both of these stages were carried out by the National Centre for Social Research (NCSR), which is independent of the NHS. This provided a robust set of current data on which to base future possible approaches to hearing screening for adults.

Stage 3 of the population study aimed to identify the most efficient tool to screen for ability to benefit from aiding. Four types of screening tool were used:

- pure tone screening
- a simple questionnaire
- otoacoustic emission (OAE) tests
- purpose-designed speech tests.

No telephone or Internet screening tools were used.

Stage 4 involved fitting participants with a single ITE hearing aid. Ability to benefit from aiding (in stage 3) was measured using a laboratory-based speech test, so stage 4 was designed to gain real-world measures of benefit.

In 2001 the Department of Health published a National Service Framework for older people in which reducing disability and maximising independent living are stated aims. This programme of research was timely in that it was designed specifically to screen for a condition known to be very prevalent, especially in older people. If the screening programme is shown to be successful, then it will help the case for the further development of hearing services that support independence and the maintenance of good mental health in older people.

The UK National Screening Committee (NSC) assesses proposed new screening programmes against a set of internationally recognised criteria covering the condition, the test, the treatment options, and effectiveness and acceptability of the screening programme. Assessing programmes in this way is intended to ensure that they do more good than harm at a reasonable cost. Health in old age is one of the areas that the NSC will be considering in coming years, and so this research is relevant and timely.

Methods

Overview

The population study was conducted in four stages which together formed strand 1:

- Stage 1: a postal questionnaire sent out to 26,160 households selected at random in various parts of England, Wales and Scotland. This consisted of questions on all ENT symptoms and use of services.
- Stage 2: a stratified sample of 506 respondents was then interviewed in Nottingham and Southampton to gain further detail on use and perception of services. To inform the interview, a series of focus group meetings was held with representatives of all the main audiological professional groups, charities and patient groups. In addition, a group of key advisors were consulted throughout the study on all aspects.
- Stage 3: following the interview, all willing respondents were invited to a clinic visit for a set of potential screens for ability to benefit from aiding. They also had a full hearing assessment and tests of predicted ability to benefit. This clinic visit was completed by 351 participants.
- Stage 4: a further subset of the participants (n = 89) was fitted with a unilateral hearing aid to obtain a true measure of benefit.

Stage 1: postal survey

A postal survey was carried out during autumn 1998 among a random sample of households in certain areas of England, Scotland and Wales. The survey was administered by the NCSR, formerly Social and Community Planning Research (SCPR). Addresses were initially selected either from the Postcode Address File (PAF) or the Scottish Community Health Index (CHI). Households were asked to complete the questionnaire for all members aged 14 years or over. The main aims of the postal survey were:

- to identify a sample of people aged 55–74 years to take part in the face-to-face interview (stage 2)
- to estimate the prevalence of ENT symptoms, particularly hearing loss in the population
- to measure the incidence of referral to GPs and hospitals for hearing and other ENT problems.

The sample was drawn as two separate exercises: 14,060 addresses from England, Scotland and Wales (listed in columns 1 and 2 in *Table 1*) and 12,100 addresses from Scotland (listed in columns 3 and 4).

The 14,060 addresses in England and Wales were split into six areas (based on postcode geography) and a separate sample was selected in each area. An additional sample was selected in Greater Glasgow. Within each area, names on the electoral register were sorted by either postcode or local authority and then by address. Names were then selected systematically from the ordered list. The 14,060 addresses were selected with equal probability from all addresses on the electoral register within a defined region of each city.

Increased numbers of households were sampled in Nottingham and Southampton because these were the cities in which the face-to-face interviews (stage 2) would be taking place. An additional 60 addresses were selected for the pilot (30 in Nottingham and 30 in Southampton).

The sample of 12,100 addresses in Scotland was selected from the Scottish CHI, which lists everyone who is registered with a GP. However, in three health boards (Lothian, Forth Valley and Greater Glasgow), addresses were sampled from the electoral register as no ethical committee agreement was given to use the CHI.

The questionnaire was posted to one named person selected for each chosen address. The questionnaire was eight sides long (see Appendix 1) and contained approximately 50 questions, which included the following areas:

- hearing difficulty, in general and in specific situations
- hearing handicap
- use of hearing aids
- family history of hearing difficulty
- other ENT problems: tinnitus, dizziness, nasal symptoms, voice problems, tonsillitis and other throat problems
- handicap arising from all other ENT problems
- GP and hospital consultations regarding all ENT problems
- ENT surgery
- current occupation and basic demographics.

The main postal survey work took place between August and October 1998. An initial letter and questionnaire were sent out, followed by a postcard reminder and a further two questionnaire

TABLE 1 *Selected sample size for postal survey*

Area	Sample size	Area	Sample size
Southampton	4030	Forth Valley	1000
Nottingham	4030	Grampian	1000
Bath	1000	Borders	1000
Cardiff	1000	Dumfries	1000
Afan Valley	1000	Tayside	1000
Other England and Wales	2000	Lothian	1000
Greater Glasgow	1000	Western Isles	100
		Ayrshire	1000
		Argyll	1000
		Fife	1000
		Lanark	1000
		Highlands	1000
		Greater Glasgow	1000

reminders. After that non-responders received one further reminder letter with a shortened version of the questionnaire on the back.

Of the 14,060 addresses sampled from the electoral register,

- 10,191 (73%) were returned. 7895 of which were completed questionnaires
- 1055 were classed as 'deadwood', i.e. returned by the Post Office or by other people as the address was untraced, vacant or demolished
- the remaining 1241 consisted of questionnaires that were returned uncompleted for other reasons, mainly refusals.

In this sample, the average number of individuals per household aged 14 years or over was 2.1. This resulted in a sample of 16,493 individuals.

Of the 12,100 addresses sampled from the CHI and ER in Scotland,

- 8176 (68%) were returned; 7096 of which were completed questionnaires
- 796 were classed as deadwood, i.e. returned by the Post Office or by other people as the address was untraced, vacant or demolished
- the remaining 284 consisted of questionnaires that were returned uncompleted for other reasons.

In this sample, the average number of individuals per households aged 14 years or over was 2.2. This resulted in a sample of 15,300 individuals. This showed an acceptably high response rate for this type of work, and no further attempt was made to contact the non-respondents.

Non-response rate

All population surveys have a significant minority of non-respondents. However, the sample selection and possible bias produced by 30% non-response merits discussion here, since it could be more likely that respondents will have hearing impairment than non-respondents.

It is reasonable to assume that non-responders may have had a lower prevalence of hearing loss levels likely to cause the individual and their social group concern. The sample weights were adjusted to take into account the gender and age distribution in the population, although this may not have eliminated all the bias. However, self-reported hearing loss is a poor indicator of prevalence. It often takes 10 years for an individual to recognise that they have a hearing problem (but a shorter time for significant others). People may mistake their hearing status, by both nature and severity, for other factors: "people don't speak clearly nowadays". Jerger and colleagues[4] state what many authors report, that "many old persons and their relatives are reluctant to confront the reality of hearing handicap and try to hide the fact that they need sound amplification". So this may mean that the estimate of the population prevalence of more severe levels of hearing loss may be lower than the actual prevalence in the population.

The weights for the final data set were produced by post-stratifying the sample data by age and gender within seven regions: Nottingham, Southampton, Bath, Cardiff, Afan Valley, rest of England and Wales, and Scotland.

As a basis for weighting, only cases with a valid value for the key question Q3 in the questionnaire 'Any difficulty with hearing' were used. The complete data set consisted of 34,362 cases, but only 31,793 had a valid value for this question. Therefore, these 31,793 cases performed as the basis for the analyses and weighting.

The weighting was done by seven regions as the sampling fractions varied by region. The analysis should always be done by region and using proportions. In addition to the region and Q3, the weighting used information about the age and the gender of the respondent. There were 31,793 cases that had valid values for all of these variables.

Stage 2: interview survey

Focus group meetings

To inform the interview, a series of four focus group meetings was held. Invitations (235) were sent to representatives of all the main audiological professional groups, ENT departments, health visitors, hearing aid users, charities and patient groups, such as the Royal National Institute for Deaf People (RNID) and Hearing Concern. A brief description of the project was also sent to the main audiological, medical and ENT professional bodies. Of the 174 people with replied, 84 attended.

Day-long meetings were held at:

- the Medical Research Council (MRC) Institute of Hearing Research in Nottingham on 25 August 1998 (18 attended)
- the RNID in London on 25 September 1998 (19 attended) and 9 October 1998 (23 attended)
- the Welsh Hearing Institute in Cardiff on 12 October 1998 (24 attended).

The main aims of the focus groups were:

- to obtain opinions on
  - the current hearing aid service and provision
  - improvements that need to be made to the service
  - various aspects of the project, specifically the interview stage (strand 1, stage 2)
- to inform both professionals and hearing aid users about the project.

Those who attended the focus groups were asked to rate their local hearing aid service and the service nationally on a scale of 0 to 10. Overall, the mean local score from all four groups was 5.8 and the mean national score was 4.5. In general, people were concerned about variability in the quality of service provision across the country. Similar themes were raised. Some of the main recommendations were:

- Primary care teams need educating so that people are referred and not turned away from the service.
- The image of hearing aids and publicity need to be improved.
- National training standards and practice guidelines are needed within the audiological profession.
- Counselling is vital for realistic expectations and better acceptance of hearing aids.
- Hearing aids should use better technology and be acceptable cosmetically.
- More inter-relationships are needed between services within the hospital, especially care of the elderly departments.
- The hearing aid service needs more funding, in every aspect of the service.

There were mixed views on whether a screening programme would be beneficial. If it were to take place, improved technology, publicity, counselling provision and funding were, as above, considered to be vital. Access could include a range of venues, including GP surgeries, a high-street shop and well-person clinics, where the hearing screen would be part of a series of other health checks. The audiological service would need to improve to accommodate the extra referrals from screening. Following on from the screen, management needs to occur relatively quickly.

A detailed report was produced for the project team of findings from all four focus groups. There were valuable suggestions from the groups on the interview stage of the project, such as on the wording of the initial letter, questions, including family members, recruiting the interviewers and payment of expenses. Advice was also given on how to encourage people to take part in the project and to try a hearing aid after the test session, particularly if they have a mild hearing loss, and how to persuade members of the general public to take up the screen in a national or targeted screening programme.

All agreed that both the public and the professions needed to be informed of the project's outcome.

Interviews

The selected sample consisted of 623 individuals aged 55–74 years who had responded to the postal survey. As the plan was to invite all interview survey respondents to a clinic visit in Nottingham or Southampton (stage 3 of the population study), the sample was restricted to individuals living in these areas.

The sample was designed to include a useful number of cases in each of the following categories, based on answers to the postal survey:

- people with hearing aids
- people with hearing problems but no hearing aid
- people with no hearing problems.

The group of most interest to the study comprised individuals whose answers to the postal questionnaire indicated that they might benefit from a hearing aid, but who did not currently use one; this group, therefore, formed the largest proportion of the selected sample. The precise breakdown of the selected sample is set out in *Table 2*.

TABLE 2 *Selected sample for interview survey*

	Nottingham	Southampton	Total
Individuals with:			
a hearing aid	51	52	103
a hearing problem, but no hearing aid	201	199	400
no hearing problem	60	59	119
Total	312	311	623

Within each category identified in *Table 2*, respondents to the postal survey aged 55–74 years were selected at random for inclusion in the interview survey. As the postal survey had gathered information on up to five adults in each household, there were cases where more than one person was sampled within a household.

The interview (see Appendix 2) covered the following topics:

- specific problems that people have with their hearing, what makes people decide they have a hearing problem and what prompts them to seek help
- use of and opinions about hearing services (both NHS and private)
- use, experiences, knowledge and expectations of hearing aids
- knowledge of other devices and services for those with hearing problems
- other health problems and overall quality of life
- knowledge of and attitudes towards screening tests.

Interview length varied considerably depending on whether the respondent had a hearing problem and whether they used a hearing aid, owing to the filters in the questionnaire. The average length was 35 minutes.

A self-completion questionnaire was left with the respondent to return by post. It contained the standard Short Form 36 (SF-36) questions about general health,[18] and it was expected to take 5–10 minutes to complete.

Nineteen NCSR interviewers were briefed, and issued with comprehensive project instructions and notes on the questionnaire, including special instructions for contacting and interviewing people with hearing difficulties. The interviewers were not NHS employees, and therefore were more likely to be able to elicit honest comments from participants.

The initial contact with prospective interviewees was an advance letter on MRC-headed paper, signed by the principal researcher (Professor Adrian Davis) and by the senior researcher from NCSR. The letter referred to the postal survey of the previous year and explained the purposes of this face-to-face follow-up study.

Interviewers were required to make at least four calls to the address, on different days of the week and at different times of day (including at least one evening and at least one weekend call, if necessary).

The survey sample was a named sample. Information on age and gender was provided to interviewers to assist them with their initial contacts, and to help them to identify the sample member in the rare cases where the selected person had failed to give their name at the postal survey stage.

Table 3 shows the responses to the interview survey.

In total, 506 individuals responded to the interview survey over a period of 8 weeks in March and April 1999. This represents an overall response rate of 83% of the in-scope sample. Altogether, 453 individuals (74% of the in-scope sample) agreed to visit the clinic for hearing tests (stage 3). No weighting was applied to the data by NCSR at this stage as it was not intended to use the data to obtain population estimates.

Stage 3: clinic visit

The clinic visit involved a total of 351 participants who had already responded to the postal questionnaire (stage 1) and the interview (stage 2). In total, 213 were seen in Nottingham at the MRC Institute of Hearing Research (IHR), and 138 were seen at the Institute of Sound and Vibration Research (ISVR) in Southampton. The visit lasted for around 3–3$\frac{1}{2}$ hours and comprised a series of tests and questionnaires administered by experienced graduate audiologists. Audiologists from each clinic spent time at the other clinic ensuring that equipment was uniform and protocols were strictly followed.

Everyone who participated in the stage 2 home interview was invited to take part in the stage 3 clinic visit. Participants had been selected for stage 2 according to their responses to the stage 1 questionnaire. *Table 4* shows the breakdown of the three groups selected for stage 3.

There were insufficient numbers of participants for stage 3 after everyone who had completed stage 2 had been invited, so an additional sample of people with hearing problems and no hearing aids was selected and invited. This resulted in raising the numbers of participants for stage 3.

During the clinic visit, participants were tested using several potential screening tools. Speech in

TABLE 3 *Responses to interview survey*

	So'ton (*n*)	So'ton (% of those in scope)	Notts (*n*)	Notts (% of those in scope)	Total (*n*)	Total (% of those in scope)
Total issued sample	311		312		623	
Out of scope[a]	1		11		12	
In scope	**310**		**301**		**611**	
Interview						
Unproductive	**63**	**20%**	**42**	**14%**	**105**	**17%**
Refusal to office	11	4%	7	2%	18	3%
Refusal to interview	40	13%	24	8%	64	10%
No contact	4	1%	0	0%	4	1%
Other reason	8	3%	11	4%	19	3%
Productive	**247**	**80%**	**259**	**86%**	**506**	**83%**
Self-completion						
Unproductive	**120**	**39%**	**92**	**31%**	**212**	**35%**
No interview	63	20%	42	14%	105	17%
Refusal	7	2%	8	3%	15	2%
Not returned	50	16%	42	14%	92	15%
Productive	**190**	**61%**	**209**	**69%**	**399**	**65%**
Clinic visit						
Unproductive	99	32%	60	20%	159	26%
No interview	63	20%	42	14%	105	17%
Refusal	36	12%	18	6%	54	9%
Productive (i.e. agreed)	**212**	**68%**	**241**	**80%**	**453**	**74%**

[a] The 'out of scope' category consists of respondents who could not be traced (there was no other 'deadwood' in the sample).

TABLE 4 *Selection of stage 2 respondents who were invited into stage 3*

	Invited to stage 2	Participated in stage 2	Invited to stage 3	Participated in stage 3	Stage 3 participation rate (%)
Hearing aid	103	95	95	61	63
Hearing problem, no hearing aid, original sample from stage 2	400	325	325	199	61
Hearing problem, no hearing aid, additional sample from stage 1	NA	NA	106	51	48
No hearing problem	119	86	86	40	47
Total				351	

NA, not applicable.

noise testing was carried out to measure predicted ability to benefit. Potential screening tools were assessed against this, and a reading span test was included to determine the extent to which cognitive ability might influence ability to benefit from aiding. Pilot work had been undertaken on all these tests to refine the procedures, determine the number of trials required, determine the most appropriate signal-to-noise ratio (SNR), and so on, and to ensure that the entire test battery could be completed satisfactorily in a single test session.

Participants all also underwent a full audiological and clinical assessment. This included otoscopy and tympanometry, pure tone audiometry and measurement of uncomfortable loudness levels, as well as a clinical history. All of these assessments were carried out using standard clinical procedures.

Finally, participants took away and returned several questionnaires covering personality, lifestyle, attitudes to hearing rehabilitation and quality of family life. The clinic session was structured in the same way for all participants so that the tests, particularly those that demanded most concentration, were interspersed with questions. All participants had a short break with refreshments half way through the session.

Screening tools

The screening tests fall into four distinct groups:

- pure tone screening
- questionnaire screening
- OAE screening
- speech tests.

Pure tone screening

The objective was to present a 30-dB HL warble tone at frequencies of 1 and 4 kHz through earphones to each ear separately and record a positive or negative response.

A MEG warble tone handheld screening device was modified to allow earphone presentation, and calibrated to ISO 389-1 (2000) for a TDH-39P earphone.[19] This test was carried out in a quiet office, below 35 dB(A), rather than a sound attenuating booth, to test the screen in a typical environment. The earphone was, however, housed within a sound attenuating audiocup.

Participants were asked to respond according to the British Society of Audiology's (BSA's) recommended procedure for pure tone audiometry.[20–22] Starting with the ear reported by them to have better hearing, signals were presented at 50 dB HL, simply to ensure a consistent response before proceeding to 30 dB HL. Three presentations at 30 dB HL of 1–2 seconds' duration were then given at 1 kHz, followed by three presentations at 4 kHz. The interstimulus intervals were at least 1–2 seconds, and rhythm in presentation pattern was avoided. The number of positive responses made by the participant at 30 dB HL at each frequency was recorded. The second ear was then tested in the same way.

Questionnaire screening

The first four screening questions that the participants had already answered in the survey part of the population study at stages 1 and 2 (see Appendix 3) were repeated.

Participants were also asked questions from part 1 of the Glasgow Hearing Aid Benefit Profile (GHABP).[23] This involved their imagining four predefined listening situations for which they rated the amount of difficulty they experienced (initial disability), and how much this worried, annoyed or upset them (handicap).

OAE screening

All OAEs were recorded from participants seated in a comfortable chair in a sound-attenuating booth with the door shut. Both ears were tested, the left ear followed by the right ear. Two types of OAE were recorded:

- transient evoked otoacoustic emissions (TEOAEs)
- distortion product otoacoustic emissions (DPOAEs).

TEOAEs were measured using three different recording methods: Otodynamics ILO88, Otodynamics Echocheck and IHR maximum length sequences (MLSs):

- ILO88 (v5.6): traces were recorded in the 'preset' non-linear mode using clicks presented via an adult general-purpose serviceable (SGS) probe. The gain was set to 0 dB for all participants, which resulted in click levels of approximately 80 and 70 dB peak equivalent sound pressure level (pe SPL) when measured against a known 1-kHz tone in an IEC 126 2cc coupler. Each recording comprised 260 'good' sweeps of a four-click ensemble; three equal clicks of one polarity followed by a fourth click of the opposite polarity and three times the amplitude. The recording window was 20.48 ms, with a 2.5-ms post-click pause, resulting in a click rate of approximately 48 per second. Noise rejection was routinely set to the default setting of 4.6 mPa and was increased when necessary. Two replications were recorded from both ears.
- Echocheck (v2.13): this handheld screening device recorded TEOAEs using clicks presented in a non-linear mode via an adult general purpose serviceable (SGS) probe. Otodynamics reported acoustic stimulation levels of 84 ± 3 dB, which were measured at approximately 80 and 70 dB pe SPL when using the method mentioned for ILO88 click stimuli. Clicks were presented at approximately 80 per second and recording was made either until the SNR exceeded 6 dB, at which point the recording was automatically terminated, or until a recording time of 1 minute was reached. The response amplifier was set to 1.6–3.6 kHz. There was no facility to view the TEOAEs. Whether a TEOAE

was present or not was indicated on the front of the Echocheck by a series of lights. A green light indicated that a TEOAE was present, whereby the SNR of the response was ⩾6 dB, a yellow light indicated a possible TEOAE, where the SNR was ⩾3 dB and <6 dB, no light indicated no response (SNR < 3 dB) and an orange light indicated an invalid response. More detailed information about the recorded response was available on a printout that showed the overall test result; that is, pass or refer, the total number of stimuli presented, the number of valid stimuli, the relative strength of the TEOAE (dB) and the relative strength of the noise (dB). When a result was other than a green light the test was repeated.

- MLS: this method for recording TEOAEs has been described in detail by Thornton.[24,25] In conventional recording of TEOAEs the rate of click presentation is limited by the length of the recording window. This method uses MLSs to allow clicks to be presented at high rates and although the responses overlap, a sequence-specific deconvolution procedure enables the responses to be extracted and plotted in a conventional format. TEOAEs were recorded using the IHR Programmable Otoacoustic Emission Measurement System (POEMS) described by Cope and Lutman.[26] The adult probe was manufactured by IHR and supplied with the POEMS unit. TEOAEs were recorded at four click opportunity rates (40, 500, 2000 and 5000 per second), each at 70 and 60 dB pe SPL, when measured using the calibration procedure described for the ILO88. An extra set of recordings was made at 50 dB pe SPL at 5000 per second in order to obtain an input/output function. The number of clicks was set so that the test time for each recording was approximately 12 seconds, resulting in a total number of clicks of 500, 3072, 12,288, and 30,720 respectively, for the rates 50–5000 per second.

The MLS order for the conventional rate was 1 and for the rates above this the order was set to 11. The recording window was set to 17 ms with a post-click pause of 5 ms. A configuration file was set to run the test sequence automatically. The system was very sensitive to physiological noise from the participant such as swallowing and movement, which resulted in the amplifier overloading. In some cases, it was very clear that there had been overloading because the recorded trace was extremely noisy. However, there were occasions when overloading occurred and although this was not obvious on the trace there remained the possibility that the trace was still contaminated. To prevent this, if there was any indication of overloading, the trace was repeated. Occasionally, some traces could not be recorded because overloading was always present. Two replications were recorded for each set of test conditions.

DPOAEs were recorded using two systems: Etymotic Research ER-10C system and Maico Eroscan ER-34 handheld screener.

- Etymotic Research ER-10C system was used in conjunction with some software written by one of the investigators (MEL). Tones were presented via the ER-10C probe coupled to the ear with an expanding foam earplug. A 'mini DP-gram'[27] was recorded over a restricted frequency range between 2904 and 3096 Hz, referenced to F2 at 48-Hz intervals. The F1/F2 ratio was set to 1.22 and the 2F1-F2 DPE recorded. Four mini DP-grams were recorded at L1 amplitude of 65, 55, 45 and 35 dB SPL as measured in an IEC711 ear simulator. The L1/L2 difference was 10 dB; this ratio was used as previous work had shown that an L1–L2 differential of 10 dB was better able to identify normal from impaired hearing. One-hundred sweeps were recorded for each average, with a rejection level set to 10 dB. The frequency range centred on 3 kHz was chosen as Lutman and Hall[27] had shown that DPOAEs measured at 3 kHz were more sensitive to identifying whether hearing is normal or not.
- Eroscan ER-34 is a handheld screener for measuring DPOAEs. The screener was coupled to the ear with a rubber ear-tip and was held in the ear while the DPOAEs were recorded. DPOAEs were recorded using tones at six frequencies, where F2 was equal to 2, 2.5, 3, 4, 5 and 6 kHz. The F1/F2 ratio was 1.2 and the 2F1-F1 DPOAE was recorded. The intensity of L1 was 65 dB SPL and that of L2 was 55 dB SPL as measured in an IEC 711 ear simulator. The averaging time was short, only 2 seconds. The Eroscan was set so that for each frequency a 'pass' was declared when the SNR was at least 5 dB, and an overall pass was achieved if there was a pass at three or more frequencies. The device showed only the overall pass on the handset, although the results could be printed off, showing the intensity of the primaries as recorded by the device, the DPOAE signal intensity, the noise level and the pass or fail results. One replication was obtained from each ear.

Speech test screening

The triplet test

The objective was to present simple, meaningful, monosyllabic words to the participant in two different listening conditions:

- one that simulated an unaided condition
- another that simulated an aided condition.

The difference in ability to detect the words between the two conditions was a measure used as a screen for benefit.

The words used were numbers (0–9, excluding 7) and alphabet letters (A to S) presented in groups of three (e.g. C3F, G5K). To enable this screen to be practical in a variety of situations, it was necessary to present the words at a suprathreshold level through earphones, rather than in a sound field. The words were therefore processed to simulate a sound field through TDH-50P earphones, and also (for the aided condition) to simulate using bilateral hearing aids with a National Acoustics Laboratory prescription for hearing and fitting, revised version [NAL (R)].[28] To use the test as a screen, it was not possible to calculate the NAL (R) prescription individually for each participant, so a NAL (R) prescription was calculated using the median pure tone thresholds for 55–74 year olds from the NSH.[2]

Participants sat in a sound-attenuating booth, wearing TDH-50P earphones. The words were all stored as waveform files on a personal computer (PC), and were played through a GSI-16 audiometer which enabled calibration checks. Participants listened to three lists of words, spoken by a male speaker (one practice, one unaided and one aided), and repeated back to the tester whatever they heard. A list comprised ten sets of triplets, so these were 30 items in total. Each of the three words that made up the triplet was chosen at random by the software from a set of waveform files. Each word was scored as correct if it was repeated accurately by the subject and in the correct order, otherwise it was scored as incorrect. The first list was presented at a level equivalent to 55 dB(A) in the sound field for the mean of the peaks of the words, with accompanying speech-shaped noise with the same spectral content as the speech, at 65 dB(A). This was unaided and was used as a practice. Assuming that the participant understood the task, the unaided condition was repeated and then followed by the aided condition.

Just follow conversation

The objective was for the participants to listen to running speech, in both the unaided condition and the simulated aided condition (as described above for the triplet test), and to adjust the intensity level so that they were just able to follow the meaning of the speech.[29] The difference in intensity level required for the participants to just follow conversation in each condition was used as a screen for benefit from aiding.

The speech comprised a male speaker reading a passage about urban myths from the magazine *New Scientist*, and had been processed for presentation through TDH-50P earphones simulating a sound field. The speech was further processed to reduce all frequencies below 1500 Hz by 20 dB, because the present sample was likely to show mild high-frequency hearing impairment. This test had been suggested by Arlinger (Linköping University, Department of Technical Audiology: personal communication, PS, 1998) as being most sensitive to hearing in the low frequencies.

Participants sat in a sound-attenuating booth, wearing TDH-50P earphones. The speech was stored as a waveform file on a PC, and was played through a GSI-16 audiometer which enabled calibration checks. The starting intensity level was set individually at a level judged to be too quiet for participants, and they were instructed to use an ascending technique. Participants adjusted the speech a total of five times, each presentation starting at a different intensity level to try to avoid any bias. The first presentation was unaided and was for practice only, and after that, two measurements were made in each condition. The participants adjusted the intensity level using buttons on a touch screen in each case. If there was a discrepancy of more than 4 dB between replications, then a third measure was taken for that condition. Patients were reinstructed as necessary.

Speech in noise testing

The Four Alternate Auditory Feature (FAAF) test[30] was used as a speech in noise test, to obtain a gold-standard measure of ability to benefit from hearing aids, with which to compare the potential screening tools. Five lists of 80 items each were presented to the participants:

- one practice list
- two lists that simulated an unaided sound field condition
- two lists that simulated an aided condition.

Participants sat in a sound-attenuating booth and all lists were presented binaurally through TDH-50P earphones. The words were all stored as waveform files on a PC, and were played through a GSI-16 audiometer which enabled calibration checks.

Signals had been processed to simulate a sound field where the mean of the peaks of the words were presented at 55 dB(A). The accompanying speech-shaped noise with the same spectral content as the speech was also presented at 55 dB(A). For the aided condition, the signals were processed further to simulate for each individual participant the use of bilateral hearing aids with a NAL (R) prescription.[28] Participants responded via a touch screen, and after a satisfactory practice list which simulated the unaided condition, half of them completed the lists in the order: unaided, aided, unaided, aided, and the other half completed the lists in the order: aided, unaided, aided, unaided. After three lists, all participants were given a break with refreshments.

Cognitive ability

Cognitive ability was assessed by means of reading span, which is a working memory test designed to tax memory storage and processing simultaneously. The test used in the present study was based on that reported by Daneman and Carpenter[31] and Baddeley and colleagues,[32] and was designed by Rönnberg and colleagues.[33]

Sentences were presented to the participants on a visual display unit (VDU) one word at a time. There was no auditory signal. Half of the sentences presented were nonsensical (e.g. the train sang a song) and half made sense (e.g. the girl brushes her teeth). The participant was asked to respond 'Yes' for a normal sentence and 'No' for a nonsensical sentence immediately after each sentence. After a sequence of sentences (three to six sentences), the participant was asked to recall either the first or the final words of each previously presented sentence in their correct serial order. The order first or last was randomised. The percentage score of correctly recalled words provided one measure, and the percentage score of correctly recalled words in the correct serial order provided a second measure. Additionally for this study, the percentage of sentences correctly identified as nonsense or sense was scored.

Audiological and clinical assessment

Otoscopy and tympanometry

Following otoscopy, all participants showing no clinical contraindications underwent tympanometry and acoustic reflex testing to assess the status of the middle ear. This was required to classify participants into groups of sensorineural, conductive or mixed hearing loss. It was also required in order to provide good management for the participants.

Tympanometry was carried out using a probe tone of 226 Hz, and acoustic reflexes were measured, using a predetermined sequence of stimuli, until a definite normal quality acoustic reflex was obtained, or the sequence was completed with no such response. One data point only, therefore, was recorded for each ear, which allowed ears to be grouped as having normal, raised or absent reflexes.

Pure tone audiometry

Pure tone thresholds were measured according to the British Society of Audiology's recommended procedures.[20–22] A Grason Stadler GSI-16 audiometer with TDH 50P earphones and a radioear B71 bone vibrator was used, which was calibrated at 3-monthly intervals throughout the study to ISO 389-1[19] and ISO 389-2.[34] Thresholds were measured in a sound-attenuating booth, which enabled measurement of air conduction thresholds accurately down to –10 dB HL, and bone conduction thresholds accurately down to 0 dB HL. The better hearing ear, as judged by the participant, was tested first, and the following frequencies were tested: 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz by air conduction, and 0.5, 1 and 2 kHz by bone conduction.

Uncomfortable loudness levels

The minimum intensity that was judged by the participant to be uncomfortably loud was measured monaurally through earphones at pure tone frequencies of 0.5, 1, 2 and 4 kHz. The procedure recommended by the BSA[35] was followed, using the same audiometer and sound-attenuating booth as for pure tone audiometry.

Clinical history

All participants underwent a structured interview which included:

- severity, duration and type of any hearing difficulty, tinnitus and dizziness
- relevant family history
- occupational noise history
- completion of the GHABP, whereby participants nominated up to a further four listening situations in which it was important for them to hear as well as possible; for each situation

separately, they answered the questions on initial disability and handicap
- Health Utilities Index (HUI):[36] the HUI3 was used with permission in both strand 1 and strand 2. It was used prospectively on all occasions. The HUI3 questionnaire[37,38] measures a person's capacity to function in eight domains related to vision, hearing, speech, mobility, dexterity, emotion, cognition and pain. It was used in a more abbreviated format at follow-up in strand 1 only if the patient agreed that nothing had changed under a particular domain heading. Participants were asked to complete only sections of the HUI for which they had indicated a problem at their stage 2 interview (e.g. vision, mobility, dexterity). A revised version of the questionnaire was used (which still enabled scores on each of the eight dimensions to be estimated) for the following reasons. Some questions in the standard HUI3 questionnaire are conceptually and linguistically complex. For example, in the section on pain, the response options combine three concepts: the frequency and intensity of pain and discomfort, the degree of disruption to normal activities, and the extent to which discomfort is relieved by drugs. In line with a previous UK study which looked at the health utility benefits of alleviating hearing impairment,[39,40] the wording of some questions was changed so that they would be more easily understood by English speakers in the UK, and some questions were simplified by decomposing the issues that they addressed into separate questions. The revised response options permitted a straightforward mapping onto the response options in the original questionnaire. Thus, the standard HUI3 scoring algorithm[38] could be used to estimate the health utility of each person in the study.

This study used the HUI3 measures of the utility of states of health based on preferences expressed by a sample of the population of Ontario, Canada. A limitation stems from the desirability of basing estimates of cost-effectiveness on measures of social preference obtained from the same general population as the one from which patients are drawn.[41] The use of the HUI3 in the present study violates this principle. However, pending a UK valuation of the health states in the HUI3,[42] it is not possible to judge whether the absolute values of the present estimates of cost-effectiveness are appropriate for the UK (see ref. 40, p. 586). However, it can be assumed to be a very good proxy for this population.

Questionnaires covering personality, lifestyle, attitudes to hearing rehabilitation and quality of family life

At the end of the clinic visit, all participants were given four questionnaires to complete and return. These were:

- Crown Crisp Experiential Index[43]
- Hearing Attitudes in Rehabilitation[44]
- Auditory Lifestyle and Demand Questionnaire (ALDQ) (see Appendix 4)
- Quality of Family Life (QoFL) (see Appendix 5).

At the end of the session, all participants were informed of the test results and, where appropriate, offered management. Those whose hearing thresholds met the audiological criteria for the Oticon Microfocus ITE hearing aid, as described below, were considered candidates for stage 4 of the study, and were invited to participate.

Stage 4: hearing aid trial

Participants and selection

Stage 4 of the study was carried out at the MRC Institute of Hearing Research Clinical Section (IHRCS), Nottingham, and the ISVR, University of Southampton. Participants seen at stage 3 who fulfilled the following criteria were invited to take part in stage 4:

- not an existing hearing aid user
- hearing threshold levels averaged across 0.5, 1, 2 and 4 kHz of 25 dB or poorer in the better hearing ear
- an air–bone gap averaged across 0.5, 1 and 2 kHz less than or equal to 15 dB
- air-conduction thresholds within the Microfocus fitting range.

Occasionally, participants who already had a hearing aid but made little or no use of it, and were therefore classified as new users, were invited to take part. In Nottingham 64 participants and in Southampton 27 participants took part. Twelve patients in Nottingham were fitted with DSP Digifocus hearing aids.

Study protocol

Informed, written consent was obtained from all the participants before their taking part in the hearing aid trial. Participants attended for at least four sessions. Three short sessions of 30–60 minutes each were required for impression taking, hearing aid fitting and hearing aid fine-tuning. If necessary, participants could have more

than one fine-tune appointment. Three months after the fine-tune appointment the participants attended the clinic for a follow-up appointment which lasted for 2–3 hours. Travel expenses were offered and in many cases, taxis were prearranged and paid for by IHRCS and ISVR. Participants were informed that they were entitled to keep the hearing aid on successful completion of the trial. Participants who were unable to complete the study or who were unhappy with their hearing aid on completion were offered a standard NHS instrument. Prior agreement had been obtained with participants' local audiology services to fund the future maintenance of these instruments through their normal facilities.

Type of hearing aid

Participants were fitted unilaterally with Oticon Microfocus half concha ITE hearing aids. Microfocus is a digitally programmable, analogue two-channel device, with non-linear amplification in the low-frequency channel and linear amplification in the high-frequency channel. The fitting software offers a three-step approach to fitting to ease acclimatisation to amplified sound, with the final setting providing the optimum prescribed gain.

The hearing aid was fitted to the poorer hearing ear unless there was a clinical reason or the participant had a particular preference. The aids were fitted according to the manufacturer's protocol with the aim of reaching the final step by the end of the final fine-tune session. Real ear measurements (REMs) were not used to fit the aids.

Test procedure

Impression appointment

Ear-mould impressions were taken according to routine clinical practice.

The five specific needs for the Client Oriented Scale of Improvement (COSI)[45] were identified and rated in order of significance.

Fitting appointment

The hearing aid was programmed according to Oticon's Adaptive Speech Algorithm (ASA) in Otiset, which uses the participant's air-conduction thresholds. The aid was fitted to the participant and fine-tuning was carried out where appropriate based on the participant's feedback (i.e. the sound of their own voice). Participants were shown how to use and insert their hearing aid, and how to fit batteries, and were given general rehabilitation advice.

The unaided part of the Abbreviated Profile of Hearing Aid Benefit (APHAB)[46] was administered.

REMs were recorded with the Siemens Unity (Nottingham) and Portarem 2000 (Southampton) in the following conditions: unaided using speech-weighted noise (SN) at 65 dB SPL, occluded ear response using SN at 65 dB SPL, real ear aided response (REAR) using white noise (WN) at 50 dB SPL, SN at 65 and 80 dB SPL, and real ear insertion gain (REIG) using the same noise type and intensity levels as for REAR. REMs were used primarily as an outcome measure.

Participants were asked to complete a structured diary before their 3-month follow-up, outlining their experiences with the new hearing aid. The diary has been designed by the hearing aid manufacturer Oticon to identify specific areas of difficulty and of benefit.

Fine-tune appointment

Approximately 1 week after the fitting appointment the participants attended for a fine-tune appointment, primarily to ensure that there were no problems with the hearing aid. In most cases, the aids were reprogrammed to Adaptation Manager 3. Changes were made to the aids according to the participants' feedback. General rehabilitation advice was given as required.

Follow-up appointment

Approximately 3 months after the fine-tune appointment the participants returned to the clinic for the final appointment. The GHABP was carried out for all six domains. Participants were asked to think back to before they were given their hearing aid(s) when answering the initial disability and handicap questions. The COSI was completed using the specific needs identified at fitting.

The HUI3[36] was readministered (having been initially carried out at the stage 3 visit). The change in utility associated with the intervention was thereby estimated by subtracting the original (baseline) score from the current score.

Two limitations in relation to potential bias arising from assessment of before-and-after utility need to be discussed: the social desirability bias associated with the use of audiologists, and recall bias given the retrospective measurement of 'before' utility. The audiologist is not unbiased, nor are the staff who score the questionnaires and enter the data into the computers. It may be possible that some bias entered into the determination of benefit, but it is not easy to see how this might have been done

in such a way as to influence the dose–response relationship between hearing impairment and outcomes seen in the study. In relation to the recall bias given the retrospective measurement of 'before' utility, the same method was used as in a previous study, looking at the benefits of alleviating hearing impairment,[47] in which patients were asked (3 months after hearing aid fitting) to estimate responses to the HUI3 questionnaire at two time-points. First, retrospectively, patients were asked to estimate how they would have completed the revised HUI3 questionnaire, had they been asked to do so before hearing-aid fitting (thus enabling their preintervention HUI3 score to be calculated); and, secondly, they were asked to complete the HUI3 questionnaire based on their current postfitting performance (thus enabling their postintervention HUI3 score to be calculated). The change in utility associated with the intervention was thereby estimated by subtracting the retrospective score from the current score.

The APHAB, asked with and without the hearing aid, was also carried out by interview with the audiologist.

A quality of life questionnaire, the SF-36,[18] and the QoFL, were given to the participant to fill in at home and return by post in a prepaid envelope. Responses to 11 of the questions on the SF-36 questionnaire[48] were used to estimate a score on the Short Form 6 Dimensions (SF-6D),[49] although it is not always necessary for all 11 questions to be fully completed for a SF-6D score to be calculated.[50] The SF-6D is composed of six dimensions (physical functioning, role limitations, social functioning, pain, mental health and vitality), each of which has between four and six levels. Based on the preferences elicited from 611 UK residents, using the standard gamble technique,[51] regression analysis was used to estimate utility scores for each of the SF-6D health states.[49] SF-6D scores were estimated using the consistent version[52] of the SF-6D algorithm,[53] upon which utility scores are estimated to range between 0.296 (645655) and 1 (111111).

REMs were repeated as outlined above, except where there had been no change at the fine-tune appointment.

The FAAF test was used as a speech-in-noise performance test[30] to measure hearing aid benefit. The noise used was SN, which is wideband noise equal to the average, long-term speech spectrum for the FAAF speech signals. The speech and noise were presented via a loudspeaker positioned 1.5 m in front of the participant. A practice run unaided at 55 dB(A) was completed before testing. The test was performed in the unaided and aided conditions at a level of 55 dB(A) and SNR of 0, and at a level of 65 dB(A) and SNR of –5. A complete list of 80 words was carried out for each of the four test conditions.

The crowded logMar[54] was used to measure visual acuity at a distance of 3 m using both eyes together (with and without glasses) and then each eye individually.

The Reading Span Test outlined at stage 3 was carried out if the participant had not completed the test at stage 3 or had scored below 20%.

If necessary, further fine-tuning of the hearing aid was carried at the end of the test session. At the end of the appointment, the care of all participants was transferred to the local hearing aid department.

Results from stages 1, 2 and 3

Results from stage 1, postal survey

The complete data set consists of 34,362 individual cases, but to obtain population weights, to adjust for age and gender in the areas of Britain that were sampled, valid data had to be present for the main hearing screening question, 'Do you have any difficulty with your hearing?' Weights were imputed for missing age and gender. The number of cases available for analysis was reduced to a total of 31,793 cases.

The weighting was done by seven regions (Nottingham, Southampton, Bath, Cardiff, Afan Valley, rest of England and Wales, and Scotland), as the sampling fractions varied by region.

Prevalence data

Table 5 shows the prevalence of all major ENT symptoms aged 14 years and above. *Table 6* shows the results by age in 20-year age bands and by gender. The overall crude prevalence figures have been adjusted to represent the proportions of age and gender within the areas that were sampled. There is little difference between the crude prevalence figures and the overall adjusted prevalence figures, and therefore the remaining columns of *Table 6* relate to the crude data.

TABLE 5 *Reported prevalence of all major ENT symptoms, aged 14 years and above (total* n *= 31,793 individuals)*

Problem	Overall crude prevalence (%) (95% CI)	Overall adjusted prevalence (%)
Current problem		
Q3: Any hearing difficulty	19.5 (19.1 to 20.0)	18.8
Q4: Conversation in noise	22.0 (21.6 to 22.5)	21.4
Q5a: Hearing on right (some vs none)	13.7 (13.3 to 14.1)	13.3
Q5b: Hearing on left (some vs none)	13.9 (13.5 to 14.2)	13.5
Q6a: Hearing TV (some vs none)	19.4 (19.0 to 19.9)	18.8
Q6b: Conversation in group (some vs none)	20.2 (19.8 to 20.7)	19.5
Q13a: Tinnitus (ever vs never)	18.2 (17.8 to 18.6)	17.7
Problem in the last 12 months		
Q14a: Blocked nose	13.2 (12.8 to 13.6)	13.3
Q14b: Runny nose	14.8 (14.4 to 15.2)	14.8
Q14c: Sneezing	6.4 (6.2 to 6.7)	6.5
Q14d: Hayfever	19.3 (18.8 to 19.7)	19.9
Q17a: Voice – croakiness	6.9 (6.6 to 7.2)	6.8
Q17b: Voice – loss or weakness	6.7 (6.4 to 7.0)	6.6
Q17c: Voice – abnormal change in sound	4.3 (4.1 to 4.5)	4.2
Q19: Severe sore throat/tonsillitis	30.9 (30.4 to 31.5)	31.5
Ever had problem		
Q23a: Dizziness in which things spin around (ever vs never)	22.2 (21.8 to 22.7)	21.7
Q23b: Unsteadiness, light-headedness or feeling faint (ever vs never)	30.1 (29.6 to 30.7)	27.4
Q23c: Dizziness in which respondent seems to move (ever vs never)	14.9 (14.5 to 15.3)	14.5

Confidence intervals (CIs) calculated using Wilson's method.

Almost one-fifth of the sample answered 'yes' to the question 'Do you have any difficulty with your hearing?' and this rose to almost one-third of the sample in the age range 55–74 years, as seen in *Table 6*.

Other ENT symptoms were near to this prevalence: dizziness, which encompasses a range of pathologies as well as vestibular, sore throat, the prevalence of which decreases with age, and nasal problems. Voice problems were less prevalent. For more detail on the prevalence of nasal problems, using data that were collected as part of the pilot for this study, see Jones and colleagues.[55]

Nottingham and Southampton (see *Tables 7* and *8*) were the areas in which subsequent parts of strand 1 were carried out. Inspection of the prevalence data from these two areas indicated that they were representative of the entire sample and it was therefore appropriate to carry out stages 2–4 of strand 1 in those cities.

Tables 9 and *10* show the same prevalence data, but broken down for manual and non-manual occupations. People in manual occupations reported more ENT symptoms of all types. This is more evident in men than in women, and in the older age groups.

Table 11 shows that 31% of the whole sample reported some degree of hearing difficulty on at least one of the questions in the postal questionnaire. This rose to 54% in the 55–74 year olds (*Table 12*).

Hearing difficulties increased steadily with age, the prevalence being higher in men than in women. *Tables 11* and *12* also show the high prevalence of co-morbidity of ENT symptoms: hearing, balance and tinnitus. In 55–74 year olds, about 40% of those reporting hearing difficulties also report tinnitus, and about 20% of those reporting hearing difficulty also report both tinnitus and dizziness. If hearing difficulties are identified and managed, there is added potential benefit for patients as other ENT symptoms, in particular tinnitus and dizziness, are also managed.

Use of services

Despite the large numbers of people reporting hearing loss, only a small proportion of them have

TABLE 6 *Reported crude prevalence (%) of all major ENT symptoms, by gender and 20-year age bands (total* n *= 31,793 individuals)*

Problem	Males				Females				Overall			
Age (years)	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**
Current problem												
Q3: Any hearing difficulty	7.0	20.6	41.0	54.4	6.7	14.4	22.7	40.3	6.8	17.3	31.6	46.3
Q4: Conversation in noise	8.7	22.2	42.3	58.0	9.9	18.3	25.5	42.3	9.3	20.1	33.8	49.1
Q5a: Hearing on right (some vs none)	3.8	12.5	30.7	48.0	3.9	8.9	16.4	35.0	3.9	10.6	23.4	40.6
Q5b: Hearing on left (some vs none)	4.3	13.0	30.9	47.1	4.3	8.8	16.5	34.9	4.3	10.8	23.6	40.1
Q6a: Hearing TV (some vs none)	7.2	19.8	39.6	53.0	7.5	14.0	22.9	43.1	7.4	16.7	31.1	47.3
Q6b: Conversation in group (some vs none)	6.1	20.1	41.4	57.7	7.0	15.7	25.4	44.3	6.6	17.8	33.2	50.0
Q13a: Tinnitus (ever vs never)	9.6	15.6	27.9	36.2	13.7	17.3	23.5	27.4	11.6	16.5	25.7	31.2
Problem in the last 12 months												
Q14a: Blocked nose	15.3	13.1	10.3	8.9	16.9	14.5	10.1	7.1	16.1	13.8	10.2	7.9
Q14b: Runny nose	14.4	13.1	12.5	18.1	18.0	16.8	14.2	11.5	16.2	15.0	13.3	14.3
Q14c: Sneezing	6.3	6.1	5.9	10.2	8.4	5.9	5.0	6.6	7.4	6.0	5.4	8.1
Q14d: Hayfever	26.6	18.3	11.1	9.9	28.7	20.9	11.7	8.0	27.6	19.6	11.4	8.8
Q17a: Voice – croakiness	4.4	4.3	6.6	8.5	8.4	8.8	7.9	9.9	6.5	6.7	7.2	9.3
Q17b: Voice – loss or weakness	3.4	4.3	5.8	9.5	8.7	9.0	7.3	9.8	6.1	6.8	6.5	9.7
Q17c: Voice – abnormal change in sound	3.7	2.8	5.2	7.7	4.2	4.8	4.8	5.2	3.9	3.8	5.0	6.3
Q19: Severe sore throat/tonsillitis	36.3	28.1	18.0	11.8	50.2	35.6	22.2	11.5	43.4	32.0	20.1	11.6
Ever had problem												
Q23a: Dizziness in which things spin around (ever vs never)	11.6	15.1	21.9	26.5	24.8	28.8	29.3	31.6	18.3	22.2	25.6	29.4
Q23b: Unsteadiness, light-headedness or feeling faint (ever vs never)	18.7	21.4	26.6	32.8	38.7	39.9	33.9	35.7	28.9	31.0	30.3	34.4
Q23c: Dizziness in which respondent seems to move (ever vs never)	8.4	10.2	14.1	17.6	17.6	20.3	17.5	17.5	13.0	15.4	15.8	17.6

TABLE 7 *Reported crude prevalence (%) of all major ENT symptoms, by gender and 20-year age bands for Nottingham*

Nottingham	**Males**				**Females**				**Overall**			
Age (years)	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**
Problem												
Current problem												
Q3: Any hearing difficulty	6.7	20.1	41.5	51.1	6.6	14.3	23.7	37.6	6.6	17.0	32.5	43.2
Q4: Conversation in noise	7.9	22.4	43.1	54.6	11.1	18.2	23.6	40.7	9.5	20.2	33.4	46.5
Q5a: Hearing on right (some vs none)	3.8	13.1	30.9	47.5	4.0	9.0	15.9	30.0	3.9	10.9	23.5	37.2
Q5b: Hearing on left (some vs none)	4.0	13.0	28.4	46.8	4.7	9.9	16.8	31.5	4.3	11.4	22.6	37.9
Q6a: Hearing TV (some vs none)	7.5	19.1	39.8	45.2	8.7	13.4	21.7	38.6	8.1	16.1	30.6	41.4
Q6b: Conversation in group (some vs none)	5.5	21.6	39.9	53.3	9.3	16.0	22.7	40.3	7.4	18.6	31.3	45.8
Q13a: Tinnitus (ever vs never)	13.4	17.7	25.5	31.5	14.1	19.1	24.2	30.0	13.7	18.4	24.9	30.6
Problem in the last 12 months												
Q14a: Blocked nose	14.2	11.7	9.1	8.7	16.1	13.0	11.5	7.5	15.2	12.4	10.3	8.0
Q14b: Runny nose	12.3	12.7	13.2	13.8	17.1	13.6	14.9	10.9	14.7	13.2	14.0	12.1
Q14c: Sneezing	6.4	7.0	5.5	10.1	8.1	5.2	5.0	4.3	7.3	6.1	5.2	6.7
Q14d: Hayfever	27.4	18.4	13.0	6.7	31.3	17.7	13.5	8.6	29.4	18.0	13.2	7.8
Q17a: Voice – croakiness	4.2	4.5	6.7	9.4	8.6	6.9	8.7	11.8	6.4	5.8	7.7	10.7
Q17b: Voice – loss or weakness	3.5	4.4	6.0	11.8	8.8	6.8	7.8	9.8	6.2	5.7	6.9	10.6
Q17c: Voice – abnormal change in sound	2.6	2.9	6.2	8.6	3.9	3.9	4.8	5.9	3.2	3.4	5.5	7.1
Q19: Severe sore throat/tonsillitis	38.0	29.3	19.9	18.0	48.3	35.1	24.6	15.0	43.3	32.2	22.3	16.3
Ever had problem												
Q23a: Dizziness in which things spin around (ever vs never)	12.8	15.4	21.1	24.4	26.4	32.3	32.0	29.6	19.7	24.2	26.6	27.4
Q23b: Unsteadiness, light-headedness or feeling faint (ever vs never)	20.6	21.0	24.9	30.8	39.0	43.0	36.5	31.0	30.0	32.4	30.8	30.9
Q23c: Dizziness in which respondent seems to move (ever vs never)	9.9	10.0	12.4	17.9	18.2	23.9	22.6	18.0	14.2	17.2	17.6	18.0

TABLE 8 *Reported crude prevalence (%) of all major ENT symptoms, by gender and 20-year age bands for Southampton*

Southampton	Males				Females				Overall			
Age (years)	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**
Problem												
Current problem												
Q3: Any hearing difficulty	7.8	23.7	38.2	52.8	6.4	14.8	23.2	40.5	7.1	19.1	30.7	46.4
Q4: Conversation in noise	8.8	25.4	39.7	57.8	9.7	20.0	26.9	42.4	9.3	22.6	33.4	49.6
Q5a: Hearing on right (some vs none)	3.4	12.6	26.5	48.1	2.9	8.7	16.5	35.8	3.1	10.6	21.6	41.8
Q5b: Hearing on left (some vs none)	3.6	14.2	27.1	47.3	2.8	8.3	16.8	35.4	3.2	11.2	22.1	40.9
Q6a: Hearing TV (some vs none)	7.8	21.6	35.9	51.7	5.4	14.8	22.2	41.1	6.5	18.0	29.1	45.9
Q6b: Conversation in group (some vs none)	5.4	22.6	40.0	61.0	4.7	15.1	28.0	41.3	5.0	18.7	34.1	50.4
Q13a: Tinnitus (ever vs never)	11.2	14.2	29.4	37.4	13.5	15.7	25.4	24.9	12.3	15.0	27.6	30.9
Problem in the last 12 months												
Q14a: Blocked nose	13.9	12.5	9.6	6.1	13.8	11.3	9.1	7.8	13.9	11.9	9.3	7.0
Q14b: Runny nose	14.1	12.3	12.6	14.6	14.2	14.9	13.3	13.4	14.1	13.6	12.9	13.9
Q14c: Sneezing	7.6	6.1	5.3	10.1	10.2	7.4	4.1	4.9	8.9	6.8	4.7	7.3
Q14d: Hayfever	31.6	21.8	14.8	10.2	31.1	23.6	13.7	9.8	31.5	22.6	14.2	9.9
Q17a: Voice – croakiness	4.1	3.5	6.5	7.8	6.6	7.6	7.8	10.3	5.4	5.6	7.2	9.1
Q17b: Voice – loss or weakness	3.4	3.2	4.7	8.5	7.3	8.9	6.9	11.6	5.4	6.1	5.8	10.2
Q17c: Voice – abnormal change in sound	3.9	2.7	4.6	8.9	3..4	4.2	4.6	7.0	3.6	3.5	4.6	7.9
Q19: Severe sore throat/tonsillitis	35.2	24.8	18.2	12.8	50.7	32.0	23.2	11.7	43.1	28.5	20.7	12.4
Ever had problem												
Q23a: Dizziness in which things spin around (ever vs never)	12.8	18.2	22.9	22.6	25.2	30.2	29.5	33.0	19.0	24.3	26.2	28.1
Q23b: Unsteadiness, light-headedness or feeling faint (ever vs never)	21.3	24.5	27.3	26.4	41.5	40.6	32.4	36.4	31.5	32.7	29.8	31.7
Q23c: Dizziness in which respondent seems to move (ever vs never)	9.6	12.7	15.4	13.8	19.3	21.5	16.4	16.1	14.5	17.2	15.9	15.0

TABLE 9 *Reported crude prevalence (%) of all major ENT symptoms, by gender and 20-year age bands for manual occupations*

Manual	**Males**				**Female**				**Overall**			
Age (years)	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**
Problem:												
Current problem												
Q3: Any hearing difficulty	7.8	23.4	46.3	56.4	9.2	16.5	27.8	44.0	8.1	21.5	42.6	54.5
Q4: Conversation in noise	10.4	25.2	47.7	62.2	10.2	22.9	31.1	44.0	10.3	24.5	44.4	59.4
Q5a: Hearing on right (some vs none)	3.9	15.4	36.7	53.9	5.6	11.5	20.6	39.3	4.3	14.3	33.5	51.7
Q5b: Hearing on left (some vs none)	4.9	15.9	37.7	53.8	5.8	11.4	22.1	42.4	5.1	14.7	34.7	52.0
Q6a: Hearing TV (some vs none)	8.0	23.1	44.4	55.6	9.3	14.9	27.3	45.3	8.3	20.9	41.0	53.9
Q6b: Conversation in group (some vs none)	6.2	22.8	45.6	60.0	9.2	18.6	32.8	44.2	7.0	21.6	43.0	57.5
Q13a: Tinnitus (ever vs never)	9.3	18.5	32.0	39.1	15.9	20.2	25.8	36.0	10.9	18.9	30.7	38.6
Problem in the last 12 months												
Q14a: Blocked nose	14.8	12.7	10.4	8.3	16.9	14.8	12.3	14.0	15.3	13.2	10.8	9.2
Q14b: Runny nose	12.8	11.6	11.9	17.1	18.7	16.1	14.5	15.1	14.3	12.8	12.4	16.8
Q14c: Sneezing	6.3	5.9	6.5	9.6	7.2	5.2	5.7	8.1	6.5	5.7	6.3	9.4
Q14d: Hayfever	21.8	16.2	9.6	6.9	26.2	18.9	11.0	9.3	22.8	16.8	9.8	7.3
Q17a: Voice – croakiness	3.9	3.8	6.8	8.3	6.8	8.2	10.1	17.2	4.7	5.0	7.4	9.7
Q17b: Voice – loss or weakness	3.4	4.0	5.6	9.4	8.7	9.0	8.9	16.7	4.8	5.3	6.3	10.5
Q17c: Voice – abnormal change in sound	2.7	2.9	5.6	7.3	3.7	6.2	6.1	10.5	2.9	3.8	5.7	7.8
Q19: Severe sore throat/tonsillitis	35.4	26.5	17.6	11.7	44.8	35.1	25.4	17.2	37.8	28.7	19.1	12.5
Ever had problem												
Q23a: Dizziness in which things spin around (ever vs never)	10.2	15.5	23.8	29.5	25.6	29.6	33.8	43.5	14.0	19.2	25.7	31.7
Q23b: Unsteadiness, light-headedness or feeling faint (ever vs never)	16.7	20.1	27.5	31.3	35.8	40.2	39.1	50.0	21.5	25.3	29.6	34.2
Q23c: Dizziness in which respondent seems to move (ever vs never)	7.8	10.3	16.7	20.3	19.0	22.7	21.7	24.7	10.6	13.6	17.6	20.9

TABLE 10 *Reported crude prevalence (%) of all major ENT symptoms, by gender and 20-year age bands for non-manual occupations*

Non-manual	Males				Females				Overall			
Age (years)	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**
Problem:												
Current problem												
Q3: Any hearing difficulty	7.6	18.4	35.1	51.1	5.8	13.6	21.7	39.5	6.5	15.7	28.7	45.7
Q4: Conversation in noise	8.2	19.2	36.7	54.8	8.9	15.3	22.8	41.1	8.5	17.0	30.1	49.1
Q5a: Hearing on right (some vs none)	4.4	9.4	24.1	41.2	2.7	7.0	13.4	27.0	3.4	8.1	19.1	35.5
Q5b: Hearing on left (some vs none)	4.6	9.9	23.9	39.2	3.2	7.2	13.7	30.8	3.8	8.5	19.4	36.1
Q6a: Hearing TV (some vs none)	7.6	16.6	34.4	50.1	6.4	12.8	20.9	40.9	6.9	14.6	28.4	46.6
Q6b: Conversation in group (some vs none)	7.0	17.8	36.8	54.0	5.6	14.3	23.9	43.7	6.2	16.0	31.1	50.1
Q13a: Tinnitus (ever vs never)	10.3	13.1	23.0	33.2	11.6	15.1	21.9	27.3	11.0	14.1	22.5	31.0
Problem in the last 12 months												
Q14a: Blocked nose	15.8	13.5	9.9	8.3	16.9	14.8	10.9	8.3	16.4	14.2	10.3	8.3
Q14b: Runny nose	15.6	14.4	12.4	19.0	18.4	17.6	17.5	13.9	17.2	16.1	14.7	17.1
Q14c: Sneezing	6.7	6.2	4.8	8.8	9.2	6.1	5.8	8.4	8.1	6.2	5.3	8.6
Q14d: Hayfever	28.8	20.3	13.2	13.5	29.4	23.2	14.8	10.7	29.1	21.8	13.9	12.4
Q17a: Voice – croakiness	4.3	4.6	5.6	8.0	8.7	9.4	7.8	12.0	6.9	7.1	6.6	9.5
Q17b: Voice – loss or weakness	3.0	4.3	5.3	9.2	8.7	10.0	7.3	9.3	6.3	7.2	6.2	9.2
Q17c: Voice – abnormal change in sound	2.7	2.5	4.6	6.7	3.7	4.4	4.8	4.2	3.3	3.5	4.7	5.8
Q19: Severe sore throat/tonsillitis	37.7	29.8	18.4	11.2	50.5	37.0	24.1	12.4	45.0	33.5	20.9	11.6
Ever had problem												
Q23a: Dizziness in which things spin around (ever vs never)	12.4	14.4	19.1	22.3	25.4	28.2	29.6	32.7	19.9	21.5	23.7	26.1
Q23b: Unsteadiness, light-headedness or feeling faint (ever vs never)	19.5	22.1	25.4	33.3	41.9	40.4	36.3	35.2	32.4	31.5	30.2	34.0
Q23c: Dizziness in which respondent seems to move (ever vs never)	8.8	9.6	10.9	13.3	18.2	18.8	16.4	16.7	14.2	14.3	13.4	14.6

TABLE 11 *Reported prevalence of hearing problems, tinnitus and balance problems and their coexistence*

	Overall crude prevalence		Overall weighted prevalence (%)
	n	% (95% CI)	
All sample			
Hearing	10,386	31.0 (30.5 to 31.5)	30.5
Hearing and tinnitus	3,901	11.7 (11.4 to 12.1)	11.4
Hearing and balance	4,864	15.4 (15.0 to 15.8)	14.9
Tinnitus and balance	3,491	11.0 (10.7 to 11.3)	10.7
Hearing, tinnitus and balance	2,328	7.4 (7.1 to 7.7)	7.2

Hearing problem = yes to any of Q3, Q4, Q5a, Q5b, Q6a, Q6b; tinnitus problem = yes to Q13a; balance problem = yes to any of Q23a, Q23b, Q23c.
Confidence intervals calculated using Wilson's method.

TABLE 12 *Reported crude prevalence of hearing problems, tinnitus and balance problems and their coexistence, by gender and 20-year age bands*

		14–34 years		35–54 years		55–74 years		⩾75 years	
		n	%	*n*	%	*n*	%	*n*	%
Hearing	Male	728	14.4	1931	33.2	2134	54.1	663	68.2
Hearing and tinnitus		220	4.4	610	10.5	879	22.4	300	31.2
Hearing and balance		292	6.2	688	12.5	819	21.8	283	30.9
Tinnitus and balance		237	5.0	443	8.0	520	13.8	173	18.9
Hearing, tinnitus and balance		118	2.5	319	5.8	432	11.6	156	17.2
Hearing	Female	843	16.1	1663	26.3	1480	36.4	708	55.7
Hearing and tinnitus		316	6.1	600	9.5	629	15.6	263	21.0
Hearing and balance		514	10.4	974	16.3	830	21.4	369	30.6
Tinnitus and balance		476	9.6	755	12.5	606	15.6	213	17.8
Hearing, tinnitus and balance		224	4.5	432	7.2	418	10.8	178	15.0
Hearing	Overall	1574	15.3	3597	29.6	3622	45.1	1372	61.1
Hearing and tinnitus		536	5.2	1211	10.0	1510	18.9	564	25.4
Hearing and balance		807	8.3	1663	14.4	1652	21.6	652	30.7
Tinnitus and balance		713	7.3	1200	10.4	1128	14.7	386	18.2
Hearing, tinnitus and balance		342	3.5	752	6.6	851	11.2	334	15.9

consulted their GP or visited hospital, or have a hearing aid.

As shown in *Table 13*, only one-third of those with moderately annoying hearing difficulty have consulted their GP in the previous 12 months, compared with half of those with severely annoying hearing difficulty.

Of those who have consulted their GP about hearing, *Table 14* shows that only 38% also went to hospital. This compares with 29.6% people who consulted with tinnitus, 19.5% who consulted with nose problems, 19.8% people who consulted with voice problems, 5.4% people who consulted with throat problems and 16.8% people with balance problems being referred to hospital.

Table 15 shows the proportion of those who visited their GP and went to hospital for each major ENT symptom, broken down into gender and 20-year age bands. Only 41% in the age band 55–74 years went to hospital after visiting their GP with hearing problems.

Tables 16–18 show data on the use of hearing aids. Only 3.4% of the whole sample report that they use a hearing aid nowadays. This rises slightly to 5.7% people in the age range 55–74 years. Of those who report severe annoyance with hearing difficulty, less than half of them use a hearing aid. The majority of respondents obtained their hearing aid free from the NHS. There are many more people who could potentially benefit from aiding than have currently used the service.

TABLE 13 *Percentage of people who have consulted GP and/or hospital in the previous 12 months, against degree of annoyance of hearing problems*

In the last 12 months have you been to your own doctor (GP) or referred to a hospital about problems with hearing?	No		GP only		Hospital and/or GP		GP and hospital	
	n	%	*n*	%	*n*	%	*n*	%
No problem	21,527	97.7	405	1.8	515	2.3	110	0.5
Not at all annoying	2,564	92.5	152	5.5	209	7.5	57	2.0
Slightly annoying	3,570	80.8	554	12.5	849	19.2	295	6.7
Moderately annoying	1,007	67.4	243	16.3	486	32.6	243	16.3
Severely annoying	376	52.5	130	18.2	340	47.5	210	29.3

TABLE 14 *Proportion of those who visited GP and went to hospital, against major ENT symptoms*

Proportion of those who visited GP and went to hospital Overall	*n*	%
Hearing	924	38.0
Tinnitus	381	29.6
Nose	419	19.5
Voice	159	19.8
Throat	222	5.4
Balance	432	16.8

TABLE 15 *Proportion of those who visited GP and went to hospital, against major ENT symptoms, gender and 20-year age bands*

Proportion of those who visited GP and went to hospital		14–34 years		35–54 years		55–74 years		⩾75 years	
		n	%	*n*	%	*n*	%	*n*	%
Hearing	Male	50	28.4	155	36.6	193	43.2	94	48.0
Tinnitus		19	31.1	70	39.3	83	31.7	28	28.6
Nose		63	19.4	76	22.2	57	27.3	20	29.0
Voice		5	10.0	11	15.9	25	34.2	15	42.9
Throat		40	5.9	14	3.2	22	9.6	11	19.6
Balance		26	19.7	51	22.7	81	22.1	29	21.5
Hearing	Female	64	25.9	143	36.3	124	38.9	89	49.4
Tinnitus		25	19.4	69	31.9	57	26.0	23	24.0
Nose		53	13.5	78	16.5	51	21.7	17	25.4
Voice		15	9.8	41	17.6	29	22.1	15	30.6
Throat		71	5.3	35	4.0	19	5.4	7	10.3
Balance		48	12.0	93	15.5	65	14.5	26	12.4
Hearing	Overall	114	27.0	298	36.4	317	41.3	183	48.5
Tinnitus		44	23.2	139	35.3	40	29.0	51	126.3
Nose		116	16.1	154	18.9	108	24.3	37	27.2
Voice		20	9.9	52	17.2	54	26.5	30	35.7
Throat		111	5.5	49	3.8	41	7.0	14.5	18
Balance		74	13.9	144	17.5	146	17.9	55	15.9

Across the age range of interest, there is a clear increase in uptake of aids with age. At the age of 55 years, there are 2.8% people using a hearing aid, compared with 11.5% at the age of 74 (*Figure 1*).

Figure 2 shows the numbers of people reporting that they are severely worried, annoyed or upset by each of the ENT symptoms that they report. It is striking that hearing difficulties and tinnitus increase steadily with age. This indicates that the

TABLE 16 *Reported prevalence of hearing aid use, and possession of NHS and private hearing aids*

	Overall crude prevalence		Overall weighted prevalence (%)
	n	% (95% CI)	
Q9A: Nowadays, do you usually wear a hearing aid?			
No	32,019	95.7 (95.4 to 95.9)	95.5
No, but have tried one	318	1.0 (0.9 to 1.1)	1.0
Yes, some of the time	490	1.5 (1.3 to 1.6)	1.5
Yes, most of the time	643	1.9 (1.8 to 2.1)	2.0
Q9B: Did you get your hearing aid from			
Free through NHS	1,139	81.0 (78.9 to 83.0)	81.6
Privately, paying for it	172	12.2 (10.6 to 14.0)	12.0
NHS and privately	95	6.8 (5.6 to 8.2)	6.5

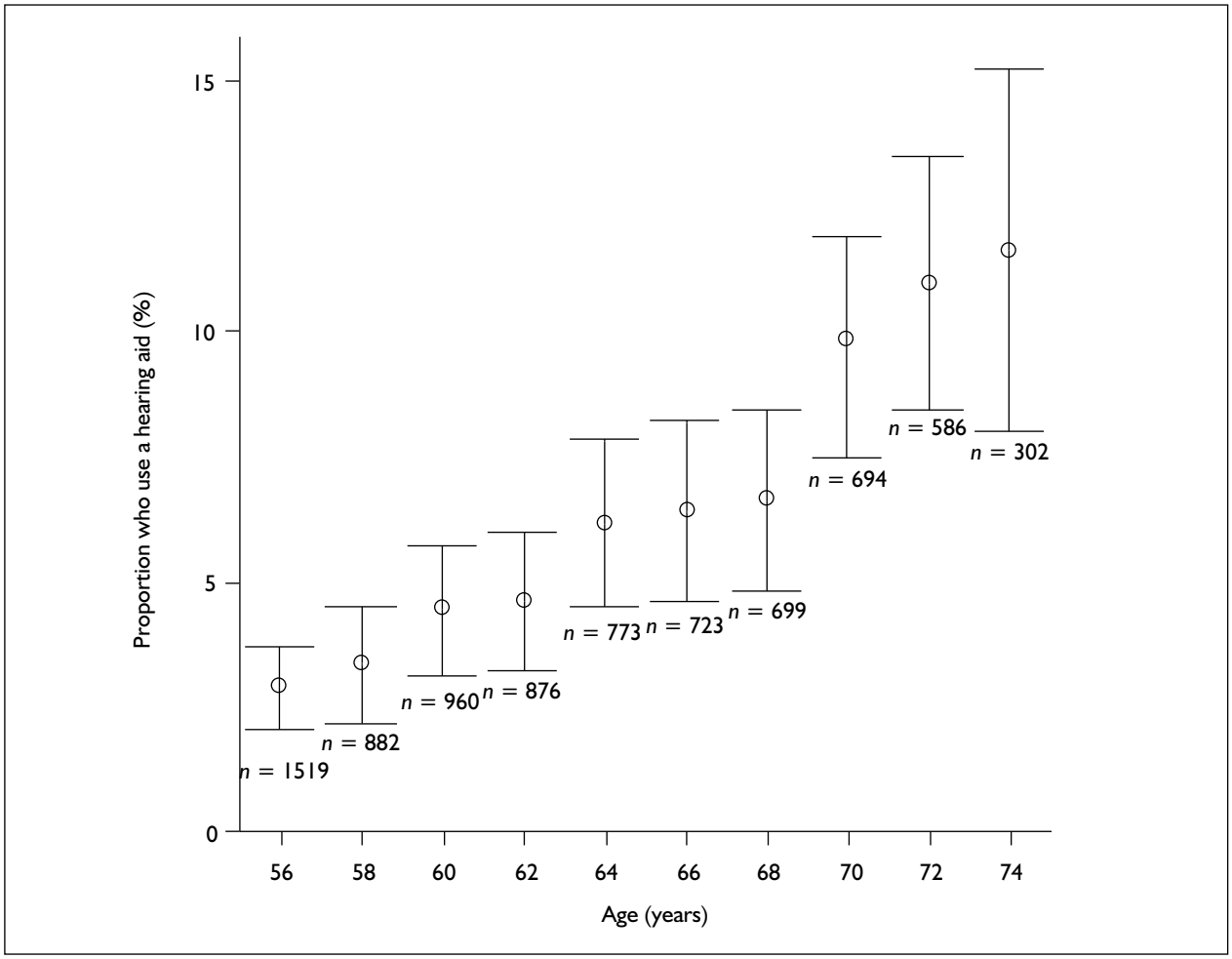

FIGURE 1 *Proportion of respondents who use a hearing aid nowadays, by age (errors bars = 95% CI of the mean)*

55–74-year-old age group would be very appropriately targeted with hearing screening, to try to avoid the rise in the prevalence of severe handicap at age of 75 years and above.

In summary, these results show that hearing problems are a significant public health problem, with a substantial number of adults aged 55–74 years reporting severe problems with their hearing and considerable co-morbidity. In relation to this, hearing services manifestly do not meet their needs, being too little, too late.

Results from stage 2, interview survey

Stage 2 provides a validation of the postal questionnaire and asks about the duration of

TABLE 17 *Reported crude prevalence (%) of hearing aid use, and possession of NHS and private hearing aids, by gender and 20-year age bands*

	Males				Females				Overall			
Age (years)	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**	**14–34**	**35–54**	**55–74**	**⩾75**
Q9A: Nowadays, do you usually wear a hearing aid?												
No	99.6	98.5	90.4	69.2	99.3	98.5	94.5	78.4	99.4	98.5	92.5	74.5
No, but have tried one	0.1	0.5	2.3	3.8	0.3	0.5	1.3	3.9	0.2	0.5	1.8	3.8
Yes, some of the time	0.1	0.5	3.4	11.4	0.2	0.4	1.9	6.6	0.2	0.5	2.6	8.7
Yes, most of the time	0.2	0.5	3.9	15.6	0.2	0.6	2.3	11.1	0.2	0.5	3.1	13.0
Q9B: Did you get your hearing aid from												
Free through NHS	90.0	79.3	77.3	77.4	91.7	91.5	84.8	82.4	89.5	85.5	79.9	79.8
Privately, paying for it	10.0	14.1	15.9	12.2	8.3	6.4	6.2	13.0	10.5	10.2	12.5	12.5
NHS and privately	0.0	6.5	6.8	10.4	0.0	2.1	9.0	4.6	0	4.3	7.6	7.6

TABLE 18 *Reported prevalence of hearing aid use, against annoyance caused by hearing problems*

Q8: How much does any difficulty in hearing worry, annoy or upset you?	Q9A: Nowadays, do you usually wear a hearing aid?							
	No		No, but have tried one		Yes, some of the time		Yes, most of the time	
	n	%	*n*	%	*n*	%	*n*	%
Not at all annoying	2,720	97.2	25	0.9	34	1.2	18	0.6
Slightly annoying	4,065	90.9	103	2.3	184	4.1	120	2.7
Moderately annoying	1,057	70.0	104	6.9	151	10.0	199	13.2
Severely annoying	323	44.6	55	7.6	85	11.7	262	36.1

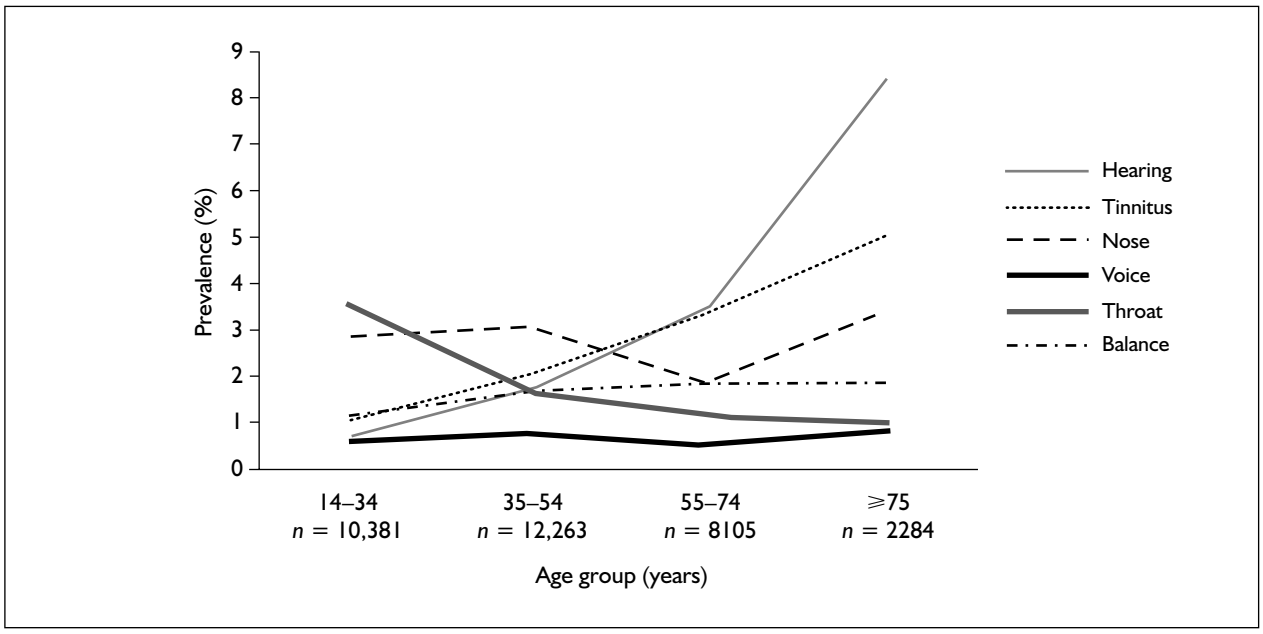

FIGURE 2 *Prevalence of severe annoyance caused by major ENT symptoms, plotted in 20-year age bands*

deafness or hearing impairment, and then gives more detail on use and perceptions of services, and views on hearing screening for 55–74 year olds. Participants were selected for stage 2 according to their responses to the stage 1 questionnaire. There were three groups:

- those reporting no hearing difficulty
- those with hearing aids already
- those who reported hearing difficulty but had not sought help; the majority, who formed the target group.

Using respondents from stage 1 of the study, 623 individuals aged 55–74 years were invited to take part in the 35-minute interview in their own home. In total, 506 people were interviewed in Nottingham and Southampton: 54% were male and 46% female, 259 were in Nottingham and 247 in Southampton, and 62% were from non-manual occupations and 38% from manual occupations.

Of the 506 interviewees, 86 had reported no difficulty in hearing, 95 had reported difficulty and had a hearing aid, and 325 (the majority, and the group of most interest) had reported difficulty but had no hearing aid.

All the percentages presented in this report for the stage 2 interviews are adjusted for the proportions of these three groups in the stage 1 sample. They are not, however, adjusted back to the British population, as earlier adjustments for this purpose showed very little difference. The adjusted percentages presented below may be taken therefore to represent the whole British population.

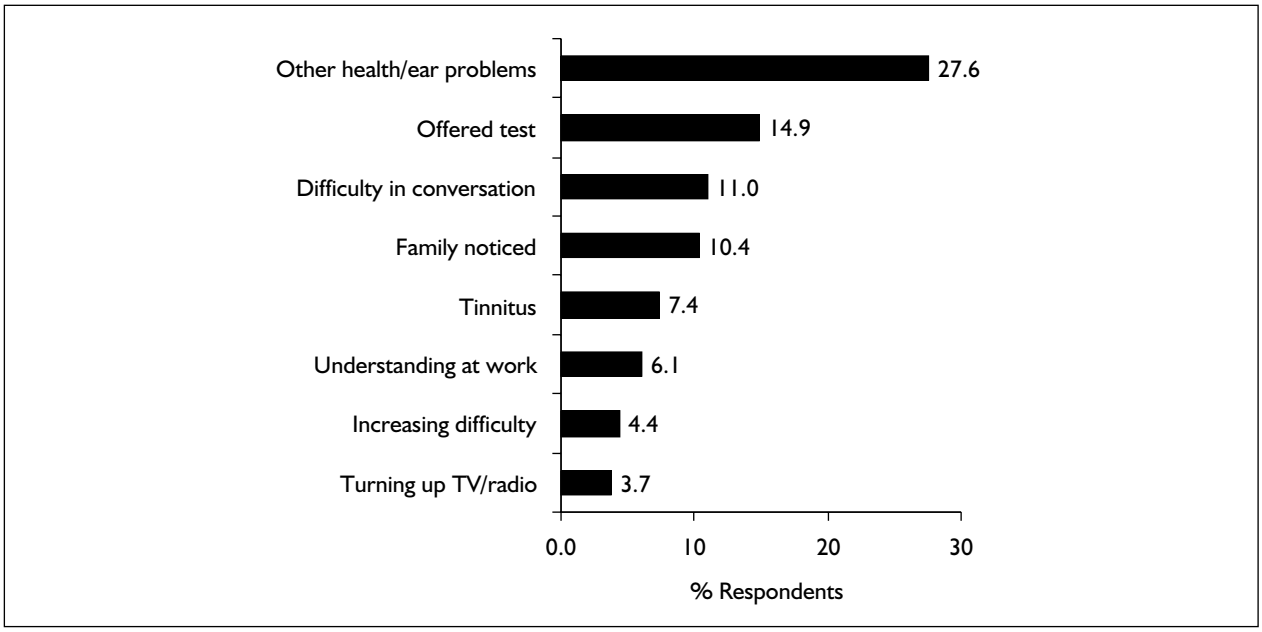

FIGURE 3 *Reasons for using services (% population adjusted). "Most people have a hearing problem for a long time before they get advice about it. What made you get advice about your hearing problem at the time you did?" (n = 200 individuals).*

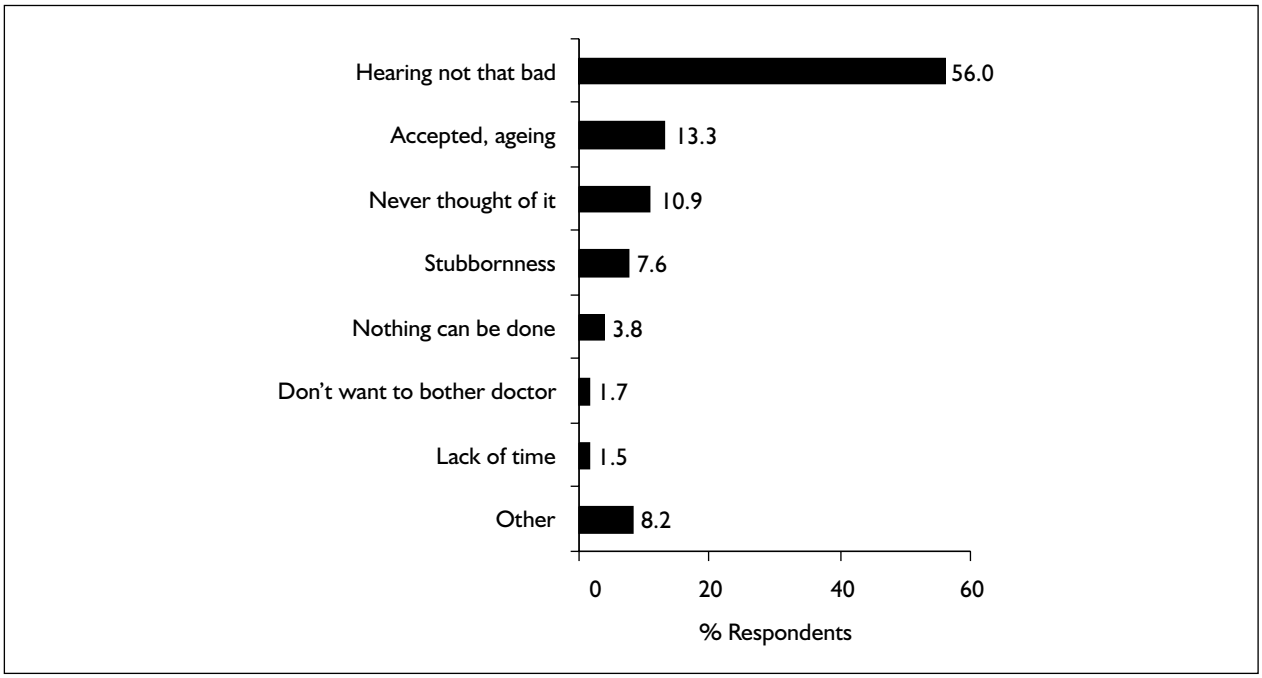

FIGURE 4 *Reasons for not using services (% population adjusted). "Why have you not chosen to ask anyone for advice about your difficulty in hearing?" (n = 167 individuals).*

Use of services

The onset of hearing difficulty was in adulthood rather than childhood in 94.5% of cases. Over half of these people (200 out of a possible 367) had received some advice about their hearing difficulties; of these, 84% had received their first advice from a GP, nurse or other health professional, rather than family and friends, or an organisation for people with hearing problems or a private hearing aid supplier, and 44% had received advice from an ENT or NHS audiology clinic. These proportions of people who visited their GP and then hospital validate the figures seen in the postal questionnaire stage of the study.

Figures 3 and *4* show the reasons that people reported for either using the services or not using the services. These reasons come from an open

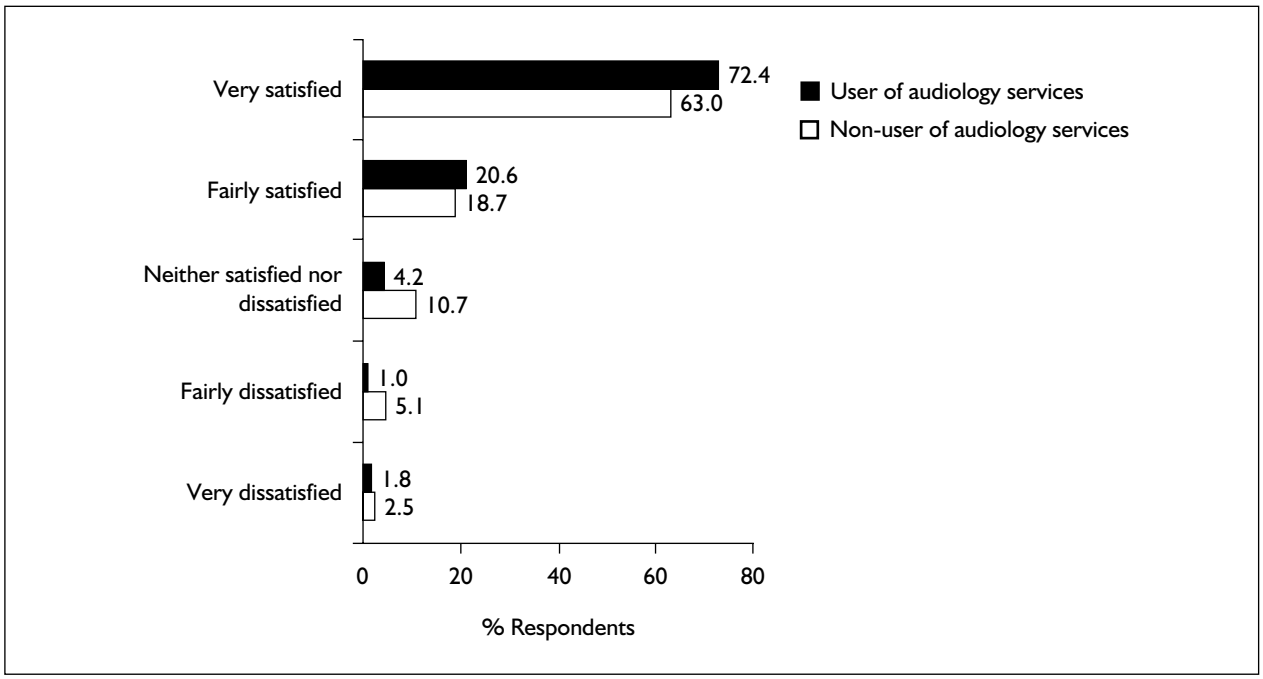

FIGURE 5 *Satisfaction with primary care services (n = 171 unadjusted) (% population adjusted)*

question, coded retrospectively. *Figure 3* is based on responses from 200 individuals, although, as stated earlier, all the percentages presented in this report for the stage 2 interviews are adjusted back to the stage 1 sample, which may be taken therefore to represent the whole British population. The figure shows the eight most frequently cited reasons (individuals were able to respond with as many reasons as they wished). The two most commonly stated reasons for consulting are not direct patient concern about hearing; they are: other health/ear problems, and that they were offered an appointment.

Figure 4 is based on responses from 167 individuals and, again, the eight most frequently cited reasons are shown in the figure.

The most commonly stated reason for not consulting was that they did not consider their hearing to be sufficiently poor. Out of 167 people, 83 (50%, weighted 56%) people said that they had not sought help for that reason. Of these 83 people, hearing threshold data are available for 53 (64%) of them from stage 3 of the study. The pure tone threshold by air conduction averaged over 0.5, 1, 2 and 4 kHz is 21.8 dB for the better ear and 26.6 dB for the worse ear:

- nine people (17%, weighted 12%) had worse ear threshold averages above 35 dB and 11 people (21%, weighted 10%) had better ear threshold averages above 35 dB
- 25 people (47%, weighted 27%) had worse ear threshold averages above 25 dB
- 16 people (30%, weighted 17%) had better ear threshold averages above 25 dB.

Therefore, in at least one-quarter of this population-weighted sample, when they report that their hearing is not that bad, a hearing test would find that this is probably not the case.

Satisfaction with services

Those who had used primary care and audiology services were generally satisfied with them, as shown in *Figures 5* and *6*.

As shown in *Figure 5*, 72.4% people who subsequently used audiology services reported they were very satisfied with primary care services, with 93% of them being fairly or very satisfied. As might be expected, there was a significant difference in satisfaction with primary care services between those who subsequently used audiology services and those who did not ($\chi^2 = 22.7$, 1 df, $p \leq 0.01$). Those who became users of audiology services more frequently reported being very satisfied (72.4% compared with 63.0%).

Figure 6 shows that 60.2% reported that they were very satisfied with audiology services, with 89.4% being fairly or very satisfied. Although it is not shown in the figure, a significantly greater percentage of people with hearing aids reported

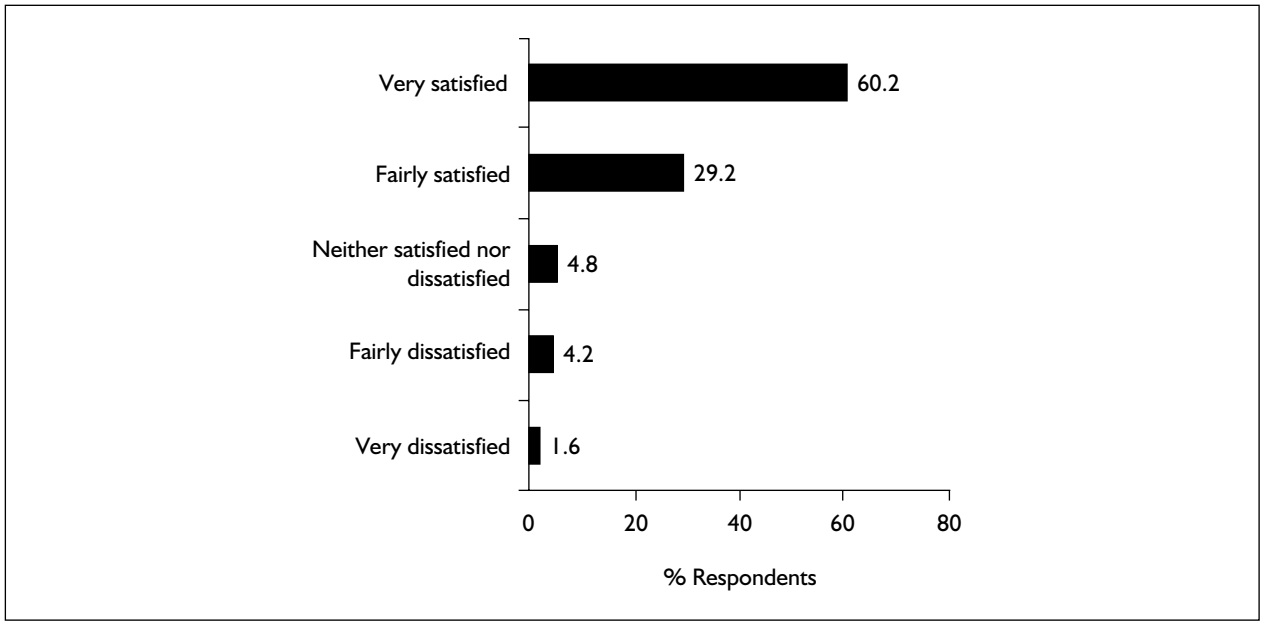

FIGURE 6 *Satisfaction with audiology services (n = 115 unadjusted) (% population adjusted)*

being very satisfied, compared with people without hearing aids ($\chi^2 = 33.7$, 1 df, $p < 0.01$).

Everyone was then asked for their views on audiology services, regardless of whether they had used the services, by 'thinking about your own experiences or about what you have heard'. In general, opinions were very high, especially of staff in audiology services, with over 90% of respondents replying 'all' or 'most of the time' to the statements that: staff were experts in their job, they take time to explain things to you, and they give good advice on coping with everyday life with a hearing problem.

Of most concern were the length of time a patient has to wait for a hearing aid after being tested, followed by the size of aid: 48.8% agreed or strongly agreed that the time they had to wait was too long, and 54.5% agreed or strongly agreed that the aids were too large.

The views differed between the users and the non-users of the audiology service, in that 63.5% non-users agreed or strongly agreed that the wait was too long, compared with 30.6% of the users. There is either a perception among non-users that the wait is worse than it really is, or users forget how long they waited.

In general, respondents were satisfied with the services, the users having higher opinions of the audiology service than the non-users. There were no particular systematic differences in views between the respondents in Nottingham and those in Southampton. The main concerns expressed were (accurately) the waiting time and the size of the NHS hearing aids.

Opinions and expectations of hearing aids

Overall, 64.0% of respondents agreed or strongly agreed that NHS aids give good-quality sound, while 75.6% agreed or strongly agreed that NHS clinics use up-to-date technology. Opinions that the aids produced high-quality sound and were using up-to-date technology were not borne out by reality. Hearing aids issued by the NHS at the time of this survey used technology that was around 20 years old. They were of lower quality compared with what was then available in the private sector.

This was perhaps reflected in some of the differences that were seen between the users and the non-users in their rating of the hearing aids. Although the users reported higher satisfaction than non-users with services, their opinions on the aids were significantly worse. While 59.1% of users thought that hearing aids made sounds clearer, this compares with 81.1% of non-users, who would have had a less informed view. This difference is significant ($\chi^2 = 138.5$, 1 df, $p < 0.01$).

Similarly, 65.0% of users thought that an aid would help to locate sounds better, compared with 90.8% of non-users. This difference is significant ($\chi^2 = 227.0$, 1 df, $p < 0.01$). This discrepancy indicates a need for the aids to be of higher

technical specification, or fitted differently (bilaterally), so that people's expectations are more often met.

Acceptability of hearing aids

Table 19 shows the numbers and population-adjusted percentages of respondents who, after being shown a person wearing a particular hearing aid, replied 'yes' to the question, 'were you aware that this sort of hearing aid existed?' Data presented are based on the total sample of 506 respondents.

The data accurately reflect the fact that at the time, the vast majority of NHS hearing aids were behind the ear (BTE) types. Respondents who had hearing loss greater than 35 dB (pure tone thresholds averaged over 0.5, 1, 2 and 4 kHz in the better ear) were significantly more frequently aware of each type of hearing aid (χ^2 test), except for the body-worn aids.

Regardless of whether the respondents were aware of the existence of all these aids, the interviewer progressed to ask, 'how acceptable would you find the appearance of the hearing aid if you were to wear it?' *Figure 7* shows the responses.

Not surprisingly, the smaller aids were judged to be more acceptable than the larger aids. While

TABLE 19 *Awareness of the existence of five types of hearing aid (% population adjusted)*

Hearing aid	*n*	% population adjusted
Body worn	317	60.2%
Behind the ear	435	81.9%
In the ear	270	48.6%
In the canal	125	14.5%
Small canal	56	7.4%

19.1% people found an ITE aid very acceptable, the figure rises to 75.4% for those who found an in-the-canal aid very acceptable.

The majority of people (89.1%) found the BTE aids either acceptable or very acceptable. This figure rises to 91.2% for the ITE aids and 99.9% for the canal aids.

The BTE were judged very acceptable by significantly more users of the service (and more people with hearing loss, defined as better ear average (0.5, 1, 2 and 4 kHz) threshold of ⩾35 dB HL) than by non-users, who tended to choose the next category of acceptability. Perhaps the users are less concerned about appearance because they appreciate the benefits to hearing, or perhaps the people who are less concerned about appearance are those who use the services and use the aids.

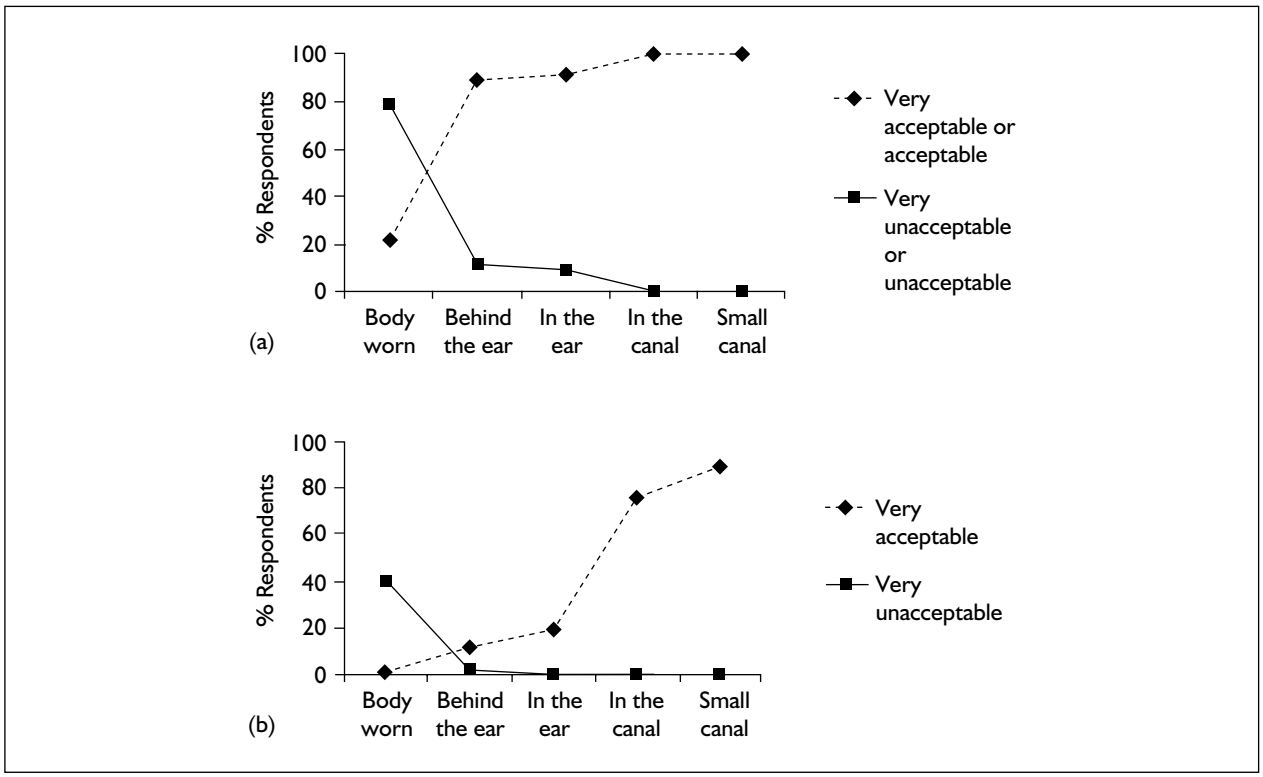

FIGURE 7 *Percentage of participants reporting acceptability of the appearance of each type of hearing aid, were they to use it*

It is clear that for the age group of interest in this study, smaller hearing aids would have a higher take-up rate among new users than larger ones.

Attitudes towards screening

The interview showed that most respondents (85.3%) are aware of screening tests of some type, and almost everyone (96.8%) thought that they were a good idea: 81.2% said that they would have a hearing screen even if they did not think that they had a hearing problem, and 13.2% thought that they would be nervous about it.

When asked about the location of the hearing screen, 98.9% said that they would go to their own primary care centre, 87.6% would fill in a short questionnaire for their GP, 85.8% would be screened at home, over 75% would go to another primary care centre, to a hospital, or be screened at work, and 42.8% said that they would go to the premises of a local hearing aid supplier.

The questions about screening at home and at the premises of a hearing aid supplier showed significant differences between Nottingham and Southampton, in that around 20% fewer people were agreeable to screening at these two locations in Southampton. Note that this was done before the public private partnership (PPP) provision of hearing aids, which is now ongoing in over 70 hearing aid centres, with very high approval ratings from customers and clients. (The NHS Purchasing and Supply Agency has awarded a national framework agreement for the supply of hearing aid services to the NHS through a PPP arrangement with two organisations: David Ormerod Hearing Centres and Ultravox Holdings plc. The agreement began on 1 October 2003 for an initial period of 2 years, with an optional extension period of up to a further 3 years.)

The interview gave an independent assessment of what the population thought of hearing and audiology services, their experience and their knowledge of and thoughts about different types of screening. It emerged strongly from the interviews that screening for hearing in the age group 55–74 years is regarded very positively, and this is particularly the case if linked to their own GP or their primary care centre.

Results from stage 3, clinic visit

Everyone who participated in the stage 2 home interview was invited to take part in the stage 3 clinic visit. Participants had been selected for stage 2 according to their responses to the stage 1 questionnaire. (*Table 4* showed the breakdown of the three groups selected for stage 3.)

There were insufficient numbers of participants for stage 3 after everyone who had completed stage 2 had been invited, so an additional sample of people with hearing problems and no hearing aids was selected and invited. This resulted in raising the numbers of participants for stage 3 (as shown in *Table 4*).

In total, the clinic visit was completed by 351 participants: 213 in Nottingham and 138 in Southampton. Participants' ages (rounded to the nearest 0.1 year) were between 55.0 and 76.3 years at the time of the clinic visit, with a mean age of 66.4 (SD 5.9 years). There was no significant difference in the ages of participants tested in Nottingham and Southampton.

There were more men tested than women (*Figure 8*), and there was a range of socio-economic status recorded for the participants (*Figure 9*). Classes 10, 20 and 30 are non-manual, while 35, 40 and 50 are manual workers (0 represents missing data and 90 represents those participants who were unclassified).

The hearing threshold levels by air conduction of the participants are summarised in *Table 20*. *Figure 10* shows the left and right ear air conduction thresholds averaged over 0.5, 1, 2 and 4 kHz. There were no significant differences in any of the pure tone averages between sites.

Repeatability of screening questions

Responses to the four screening questions that participants answered in stages 1, 2 and 3 are compared in *Tables 21* and *22* to give an indication of consistency.

Question 1: 'Do you have any difficulty with your hearing?'

Of the 296 people who answered the question in all three stages, 44 (15%) said 'No' in all three stages and 189 (64%) said 'Yes' in all three stages. In total, 79% of respondents were consistent in answering this question at all three stages of the study (*Table 21*).

Question 2: 'Do you find it very difficult to follow a conversation if there is background noise (such as TV, radio, children playing?)'

Of the 297 people who answered this question in all three stages, 43 (15%) said 'No' in all three stages, and 121 (41%) said 'Yes' in all three stages. In total, as shown in *Table 22*, 56% respondents were consistent across all three stages of the study.

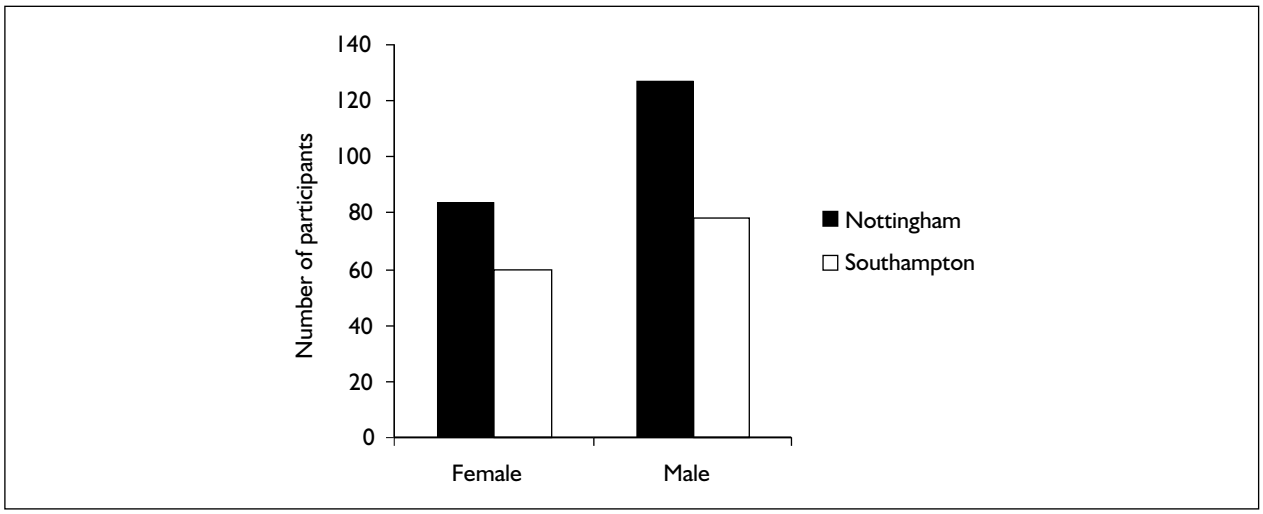

FIGURE 8 *Gender and site distribution of participants in stage 3*

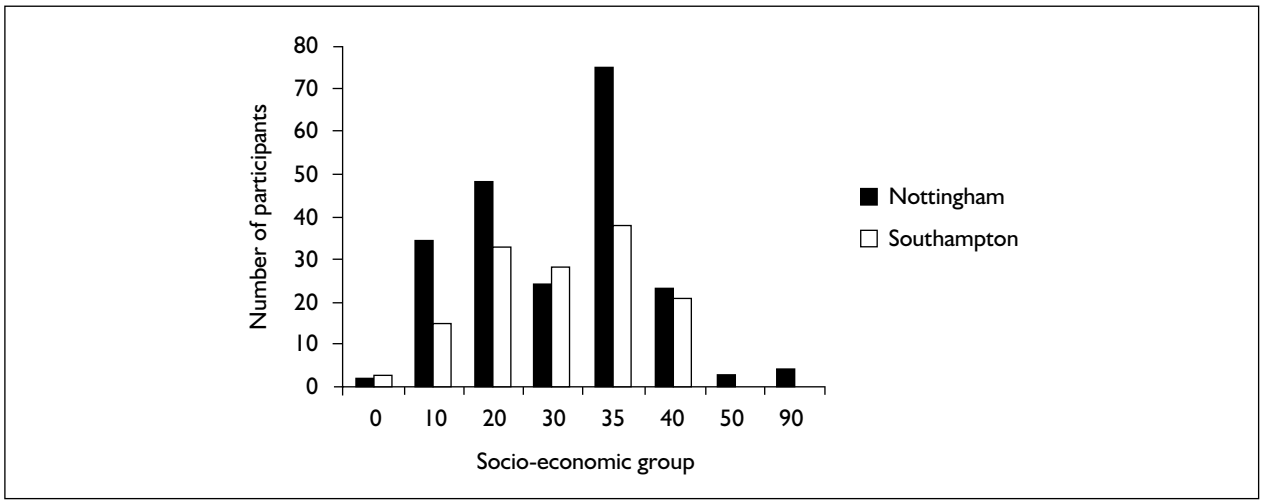

FIGURE 9 *Socio-economic distribution of participants in stage 3*

TABLE 20 *Pure tone air conduction threshold averaged over 0.5, 1, 2 and 4 kHz*

	n	Minimum	Maximum	Median[a]	Mean	SD
Left ear	351	0.00	125.00	28.7	30.9	17.8
Right ear	351	–1.25	125.00	29.4	33.6	20.7
Better ear	351	–1.25	100.00	25.0	27.3	15.2
Worse ear	351	0.00	125.00	33.5	37.2	21.6

[a] Medians were calculated from grouped data.

Question 3: 'How well do you hear someone talking to you when that person is sitting on your right side in a quiet room?'

Question 4 asked the same question but for the left side

There were five response options: no difficulty, slight difficulty, moderate difficulty, great difficulty or cannot hear at all on that side. The consistency for these two questions was similar to that on the previous two questions. Of the 296 people who answered Q3 on three occasions, 43% answered the same at each stage, and 87% answered within ± 1 category at all three stages. The corresponding percentages for Q4 were 44% and 83%.

All four screening questions showed acceptable consistency over a period that was over many months in some cases. Question 1, 'Do you have

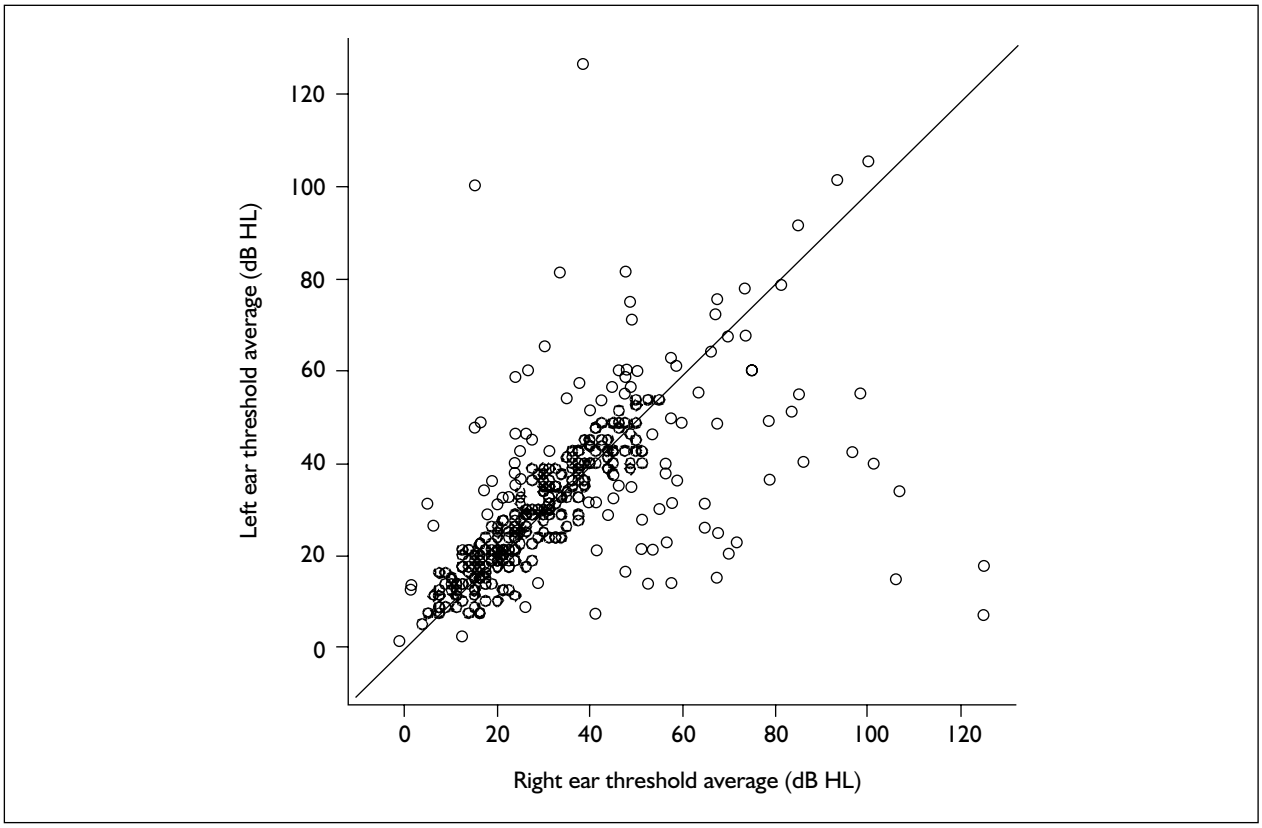

FIGURE 10 *Left and right ear air conduction thresholds averaged over 0.5, 1, 2 and 4 kHz*

TABLE 21 *Repeatability of screening question 1: Do you have any difficulty with your hearing?*

		Stage 1		
		No	**Yes**	**Total**
Stage 2	No	110 (22%)	43 (9%)	153
	Yes	27 (5%)	322 (64%)	349
	Total	137	365	502
		Stage 2		
		No	**Yes**	**Total**
Stage 3	No	55 (25%)	23 (8%)	78
	Yes	18 (6%)	203 (68%)	221
	Total	73	226	299

any difficulty with your hearing?' gave the best repeatability.

Effectiveness of screening tools

Defining cut-offs for each screening test

A screening test needs to have a cut-off value where the results above or below it constitute a pass or a fail. Some of the screening methods used here already have these cut-offs defined by the categorical nature of the results produced. So, for the screening question Q1, 'Do you have any difficulty with your hearing?' which only has two response options, a 'yes' response is a fail and a 'no' response is a pass. The same is true for the screening question Q2, 'Do you find it very difficult to follow a conversation if there is background noise such as TV, radio or children playing?' The screening questions 3 and 4 had five response options, described elsewhere, ranging from 'no difficulty' to 'cannot hear at all'. These

TABLE 22 *Repeatability of screening question 2: Do you find it very difficult to follow a conversation if there is background noise such as TV, radio or children playing?*

		Stage 1		
		No	**Yes**	**Total**
Stage 2	No	97 (19%)	91 (18%)	188
	Yes	42 (8%)	272 (54%)	314
	Total	139	363	502
		Stage 2		
		No	**Yes**	**Total**
Stage 3	No	81 (27%)	67 (22%)	148
	Yes	20 (7%)	132 (44%)	152
	Total	101	199	300

two questions were dichotomised, so 'no difficulty' constituted a pass and any difficulty, that is, 'slight difficulty' to 'cannot hear at all', constituted a fail. Similarly, for the screening audiometry that used one intensity level at 30 dB HL, presented for 1- and 4-kHz tones, a fail for each frequency was defined as the participant hearing none of the three tones presented, to either ear. Hearing a single tone in either ear constituted a pass.

All the other screening tests produced a range of continuous results; for example, the reproducibility variable for the ILO TEOAEs ranged from 0 to 100%. Ideally, a priori cut-offs would be defined before any analyses aiming to establish efficiency of screening tests. There were no data available that related the screening tests used in this study and for this age group to the participants' ability to benefit with a hearing aid using the FAAF test results, to guide this. Therefore, for each screening method, a receiver operating characteristic (ROC) plot was produced using the Statistical Package for the Social Sciences (SPSS) that plotted sensitivity and false alarm rate (FAR; 1 – specificity) for each potential cut-off value available (*Figure 11*). The value that provided both the highest sensitivity and FAR (equating to the d′ value) was chosen as the cut-off value.

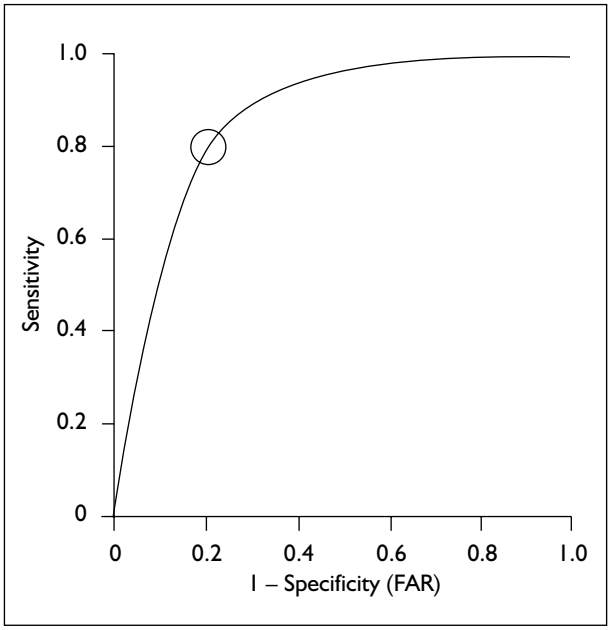

FIGURE 11 *SPSS-generated ROC curve for the SNR of the 3-kHz band for the ILO OAEs. The circle shows the best sensitivity and FAR.*

dprime

The d′ value is a guide to the overall effectiveness of the screen in detecting the condition. A higher d′ is better. Each d′ calculation essentially maps the difference between two distributions in standard deviation (SD) units. d′ can be considered as the distance between the two distributions (those with hearing impairment we wish to target and those we do not,) and the criterion of how biased the selection from the target group is (this may be adjusted, but for single binary categorical questions is fixed). For example, a difference such as 0.48 (2.53–2.05) SD units shown for the d′ for warble tones and steady-state pure tones can be interpreted as quite large, while 0.14 (2.5–2.36) SD can be seen as quite small. It seems that hearing level varies systematically with the number of warble tones heard, which is good for some applications, whereas the steady-state pure tone is more of a step-function in terms of the underlying distribution of HL. The steady-state pure tone is therefore better for screening.

In this case, for the SNR within the 3-kHz band for the ILO OAEs, the best sensitivity and false alarm rate were 81% and 22%, respectively, which occurred at a cut-off value of 1 dB. For some screening methods more than one parameter was included for this ROC analysis. This ROC analysis was applied to the following screening methods and parameters:

GHABP: initial disability and handicap questions

- Triplet test: unamplified score, amplified (simulated aided) score and benefit measure (amplified minus unamplified scores)
- Just follow conversation: amplified (simulated aided) intensity level required for participant to just follow, and benefit measure (unamplified minus amplified level)
- ILO TEOAEs: response, overall reproducibility, SNR and reproducibility for the five frequency bands centred on 1, 2, 3, 4 and 5 kHz plus the mean of the 2- and 3-kHz SNR
- Etymotic DPOAEs: SNR at the four P1 intensity levels, 65, 55, 45 and 35 dB SPL
- Eroscan DPOAEs: SNR at the frequencies 2, 2.5, 3, 4, 5 and 6 kHz.

For the MLS TEOAEs, there were many derived variables (reproducibility and amplitude values for four rates, at four recording windows, 6–16, 6–11, 12–16 and 9–13 ms postclick, for up to three intensities, amplitude/rate slopes for both the linear and non-linear recordings). A discriminant function analysis was carried out to identify which of these variables was best able to separate those who showed FAAF benefit against those who did not show FAAF benefit. A subset of these parameters was then used in the ROC analysis, shown in *Figure 13* (see below).

The Echocheck data were not subjected to the ROC analysis, as preliminary analyses showed that many more people were passing the Echocheck screen (SNR > 6 dB) than for the equivalent parameter on the gold-standard ILO TEOAE measurement system. With the Echocheck, 28% of people with a pure tone average threshold greater than 25 dB HL had TEOAEs measured with an SNR greater than 6 dB. This was much higher than the same sample that had TEOAEs measured with the ILO system, where only 3% showed an SNR across 2 and 3 kHz greater than 6 dB. The mean of the 2- and 3-kHz bands for the ILO system is equivalent to the frequency response of the TEOAEs recorded by the Echocheck, so these are equivalent responses for comparison purposes. This difference is probably because the design of the Echocheck focuses on responses from neonate ears, rather than adult ears.

Although pure tone audiometry was not used as a screening test, data from the audiogram were used, notably whether or not a participant heard 3 and 4 kHz at 35 and 40 dB HL, respectively, as these were shown to have good sensitivity and FARs.

Definition of ability to benefit from amplification

The outcome against which the screening tests were measured was FAAF benefit that was derived from a statistical method. Analysis of benefit from the speech in noise task was carried out using a generalised linear model using the GLM software, with binomial error distribution assuming that individual responses are independent. This enabled an individual cut-off to be estimated at $p < 0.05$ in terms of whether amplification or aiding was statistically significant or not.

Although the FAAF benefit outcome was the gold standard the efficiency of the screening tests was also compared with the better ear pure tone threshold averaged across 0.5, 1, 2 and 4 kHz at 30 and 35 dB HL [better than average (BEA)] to allow comparison with other studies and comparison with the clinical effectiveness trial of this study (strand 2).

ROC plots

Figure 12 shows the ROC plot for statistically significant FAAF benefit for the audiometry (screening and pure tone), various combinations of screening questionnaire questions, GHABP initial disability and handicap and screening speech tests. This and the following plots show the 95% confidence intervals for sensitivity and FAR. When the confidence intervals do not overlap, this shows that the two tests differ significantly. In this situation the level of significance is well beyond 5%, but using a conservative criterion of this form is preferable in view of the multiplicity of comparisons possible. The audiometric screens show a significantly better performance than the speech and questionnaire screens.

Figure 13 shows the ROC plot for parameters of the OAE tests that showed the best sensitivity and FAR against statistically significant FAAF benefit. The best OAE screens were from the ILO88: the reproducibility and SNR for the 3-kHz region. This was followed by the SNR at 2.5 and 3 kHz using the Eroscan.

Figure 14 shows the audiometric and speech screens, the best performing OAEs and best

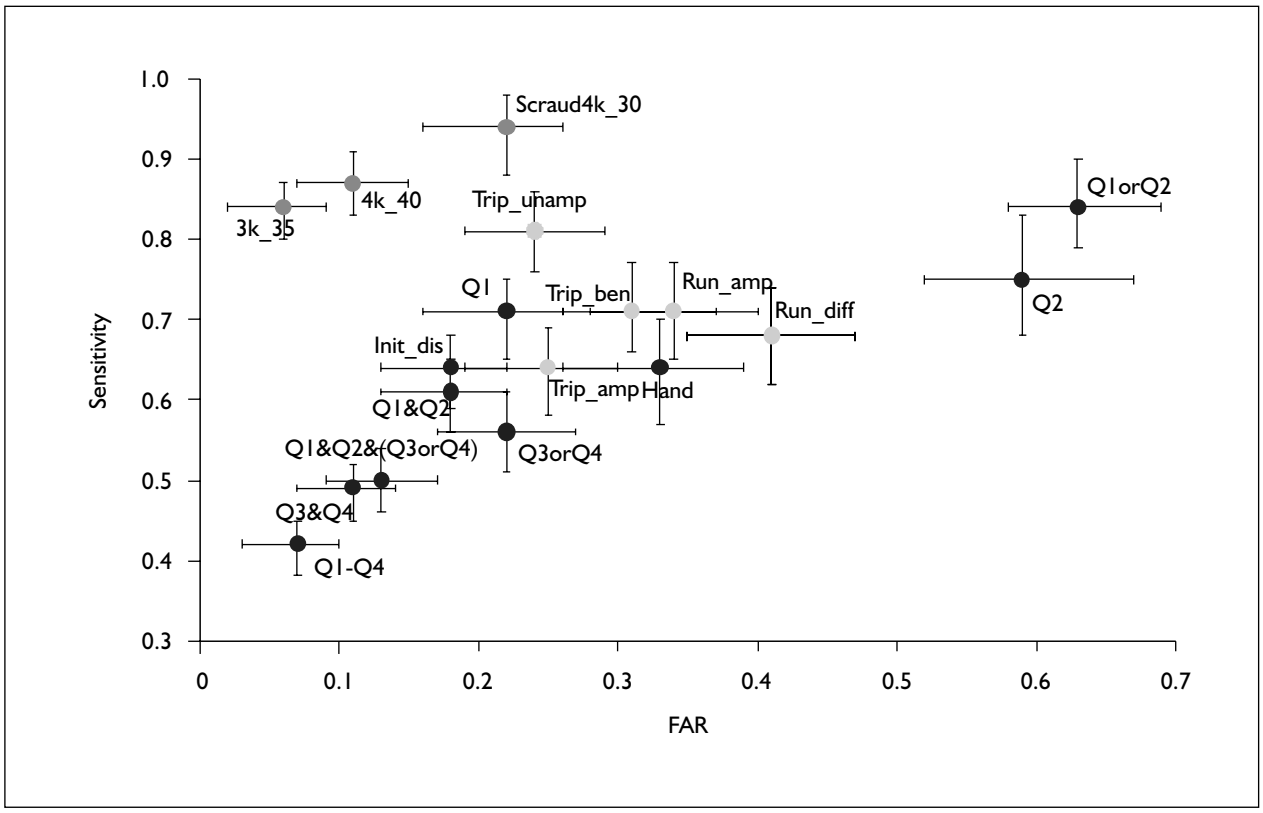

FIGURE 12 *Sensitivity and FAR for audiometric, speech and questionnaire screens using statistically significant FAAF benefit as the gold standard (error bars = 95% CI)*

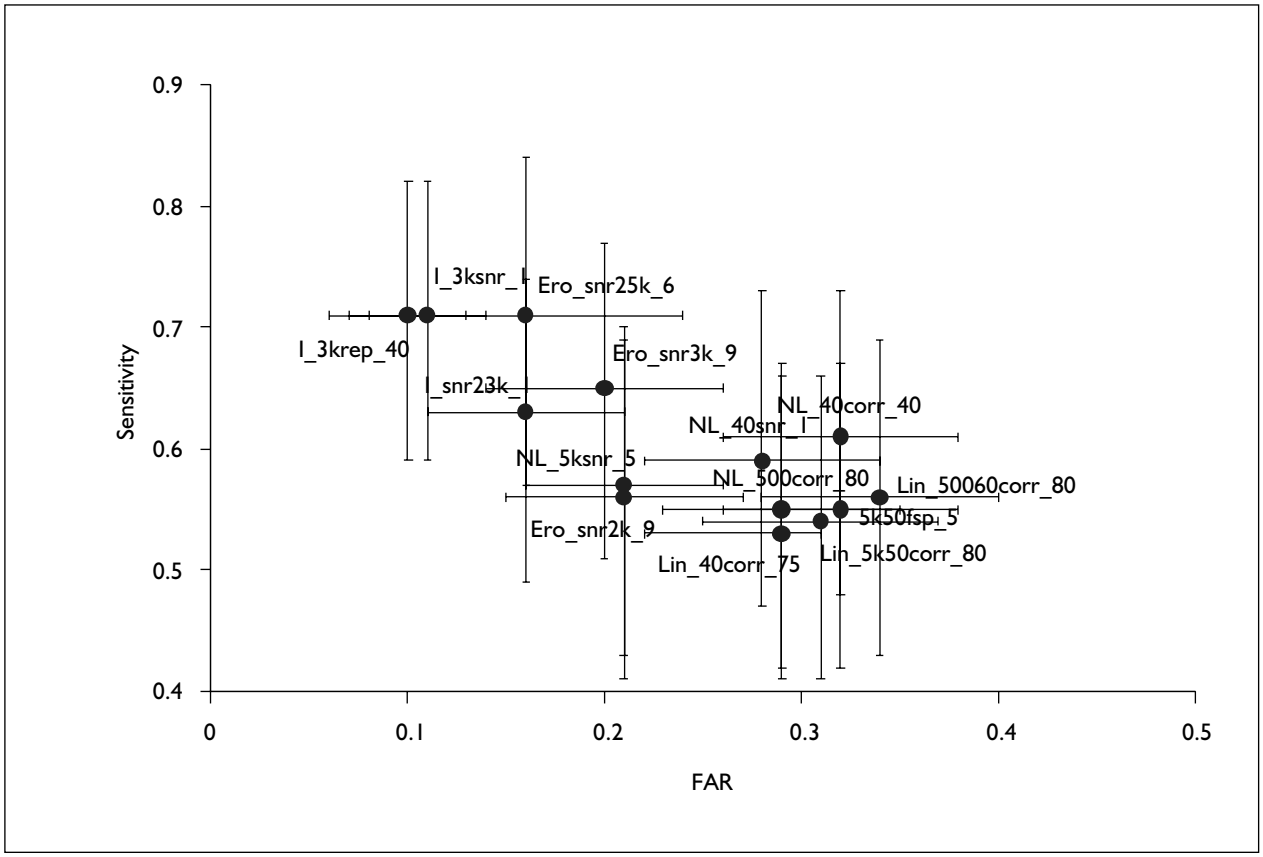

FIGURE 13 *Sensitivity and FAR for OAE screens using statistically significant FAAF benefit as the gold standard (error bars = 95% CI)*

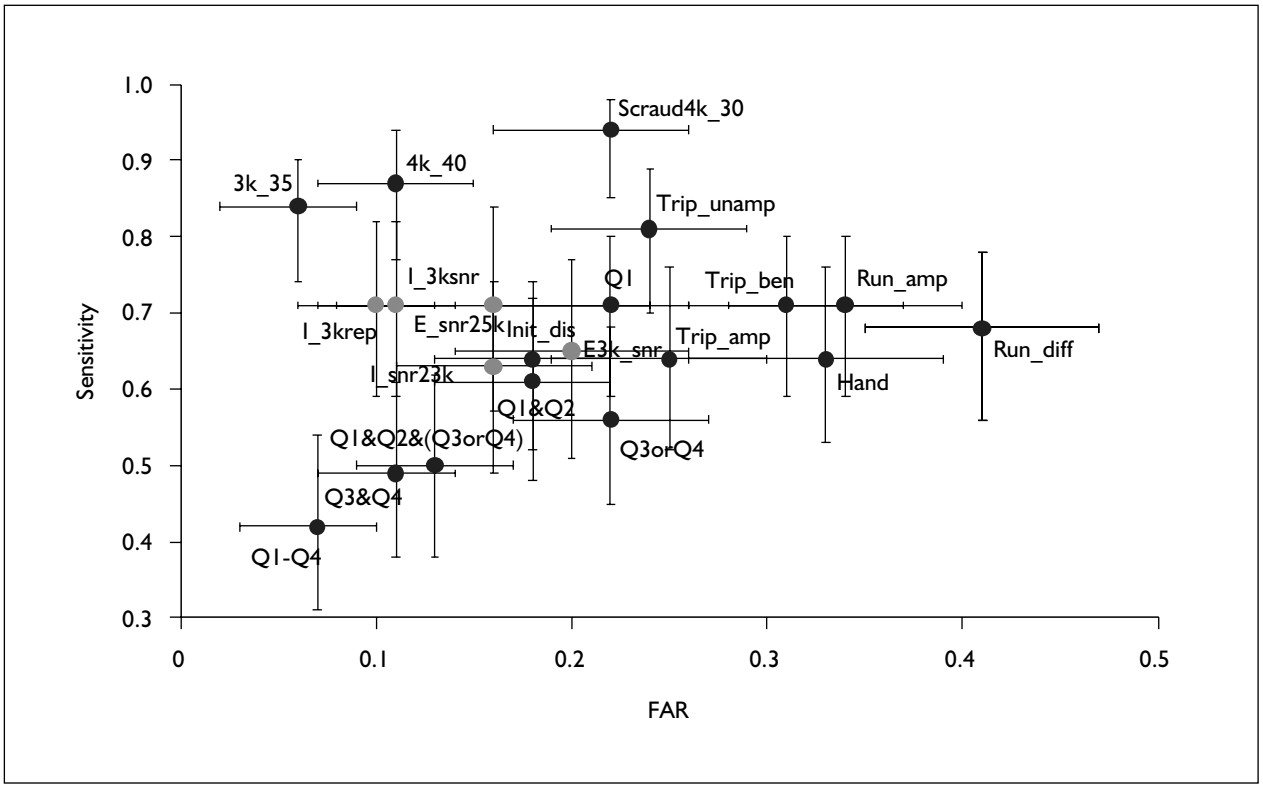

FIGURE 14 *Sensitivity and FAR for the best performing from all the four types of screen using statistically significant FAAF benefit as the gold standard (error bars = 95% CI)*

screening question combinations for statistically significant FAAF benefit. It is clear that the audiometric screens as a group show the best screening performance. The screening speech tests overlap with the OAEs and perform less well than the audiometric methods, whereas the screening questions and GHABP perform the least well in a screening capacity.

Figures 15 and *16* show the sensitivity and FARs of the screening audiometry and questionnaires for the BEA with cut-offs at 30 and 35 dB HL.

These figures demonstrate similar findings to *Figures 12–14*, which used statistically significant FAAF benefit as the outcome, in that the audiometric tests outperformed the questions. This was particularly the case when the BEA cut-off was set at 35 dB HL. This was used to inform the design of strand 2 of the study, the clinical effectiveness trial.

Summary of findings: population study, stages 1, 2 and 3

Stage 1 of the population study has updated prevalence estimates of

- reported hearing disabilities
- other ENT symptoms
- use of services in the adult populations
- hearing impairment in 55–74 year olds.

In 55–74 year olds

- 40% are estimated to have a pure tone threshold (averaged across 0.5, 1, 2 and 4 kHz) greater than 25 dB HL in the worse ear
- 29% are estimated to have a pure tone threshold of greater than 25 dB HL in the better ear.

In this age group of interest, almost one-third of the sample answered 'yes' to the question 'Do you have any difficulty with your hearing?' This is in contrast to the 5.7% people in the sample who use a hearing aid nowadays. There is potentially considerable unmet need in the population, indicating that there are many more people who could potentially benefit from amplification from using hearing aids than have currently used the service.

Hearing difficulties and tinnitus increase steadily with age, and there is a clear increase in uptake of aids with age. The 55–74-year-old age group

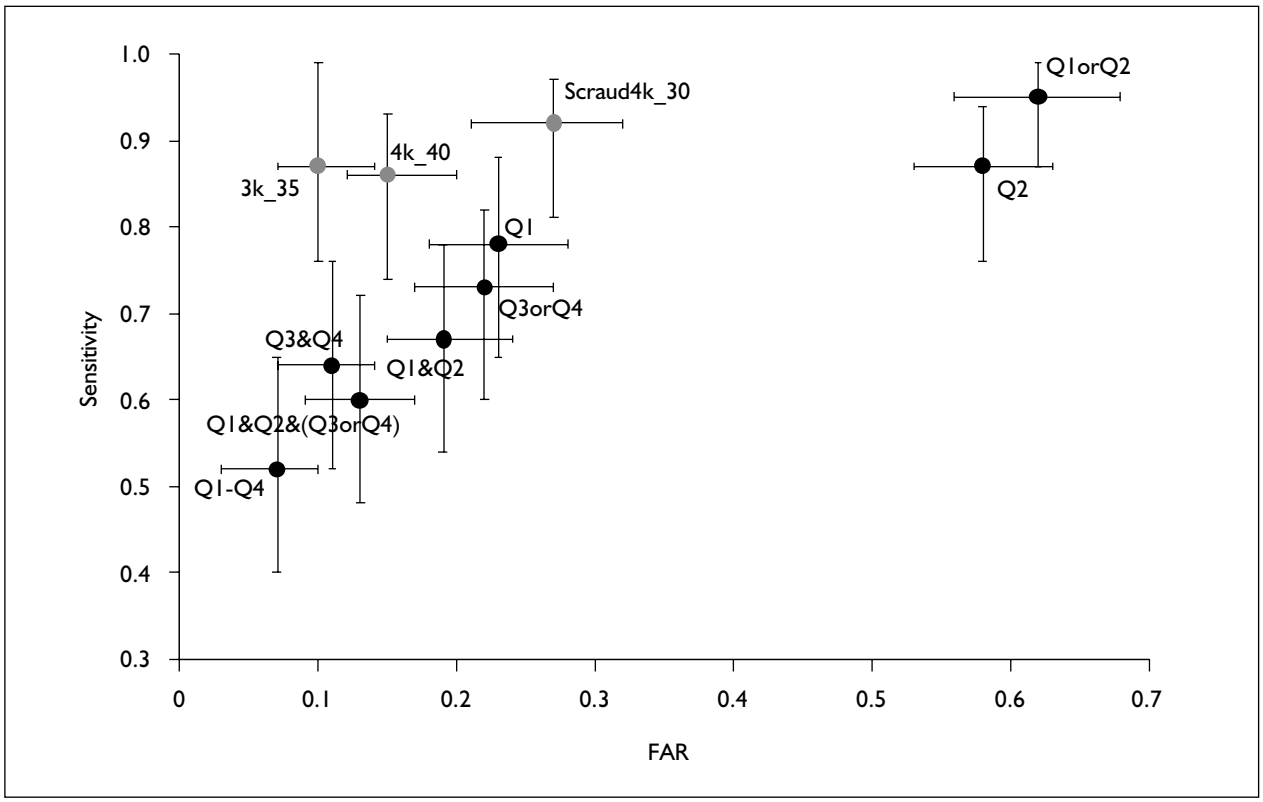

FIGURE 15 *Sensitivity and FAR for pure tone and questionnaire screens using BEA >30 dB cut-off as the gold standard (error bars = 95% CI)*

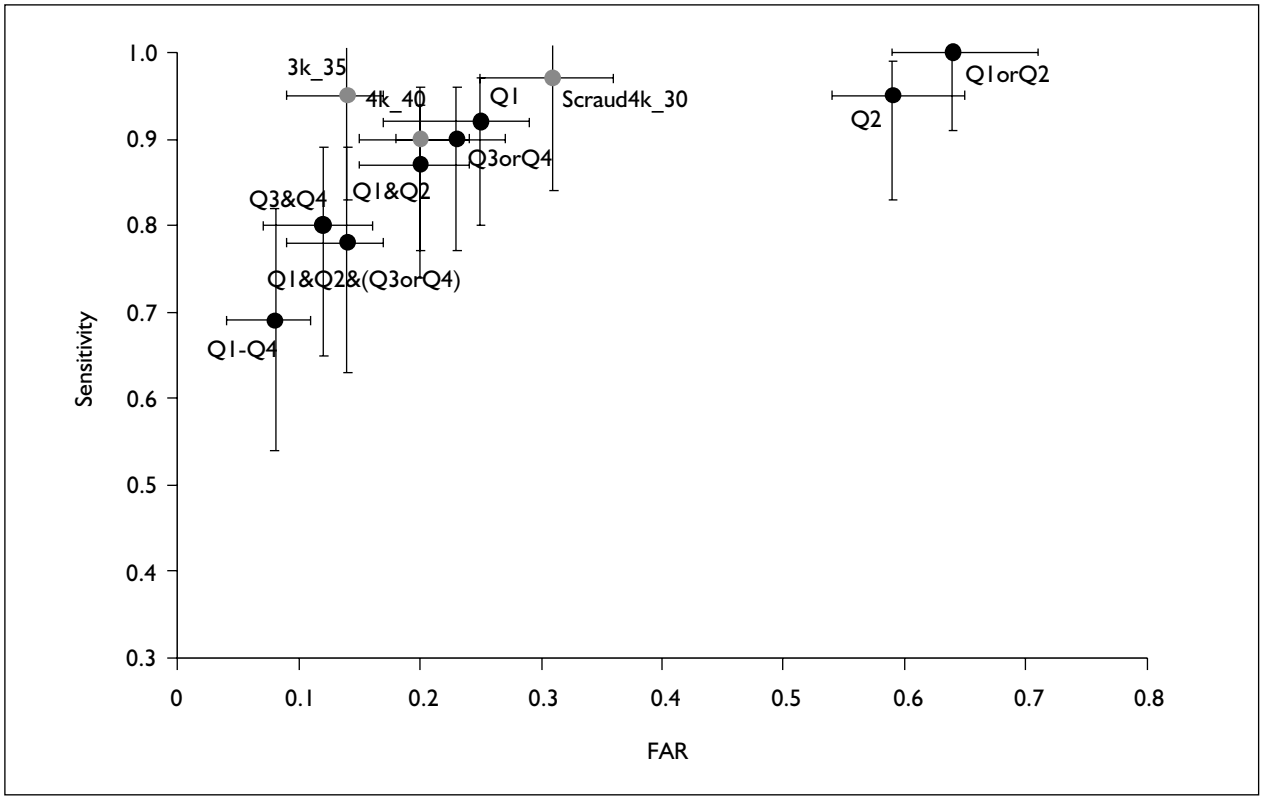

FIGURE 16 *Sensitivity and FAR for pure tone and questionnaire screens using BEA > 35 dB cut-off as the gold standard (error bars = 95% CIs)*

would be very appropriately targeted with hearing screening, to try to avoid the rise in the prevalence of severe hearing handicap. This is indexed by those who are severely annoyed, worried or upset about their hearing; at the age of 75 years and above, this is about 60%. Only 50% of those with such handicap use amplification at the age of 55–64 years, reducing to about 40% at 54–74 years and about 20% at 75 years and older. Earlier referral could reduce this handicap and deal with co-morbidity, especially leading to treatment of other ENT symptoms; in particular, there is a high proportion of hearing-impaired people who also report tinnitus and dizziness.

In general, those respondents who were referred were satisfied with the audiology services: the users had higher opinions of the service than the non-users. The main concerns expressed were (accurately) the waiting time and the size of the NHS hearing aids. This latter issue is likely to be continually expressed as a concern, although novel solutions such as use of Hearing Direct, PPPs and use of universal open ear fittings, are currently improving the waiting times in many areas of the UK.

Smaller hearing aids were preferred by respondents and would have a higher take-up rate among new users than larger ones. Screening for hearing in the age group was regarded positively, particularly if linked to GP or primary care centre. Both of these findings were implemented in strand 2, the clinical effectiveness trial.

The screening tools were all candidates for use in strand 2 in that they were all easily administered and acceptable to the participants. Taking into account the performance of the OAEs and the speech tests, as shown in the ROCs, and the fact that they require more complex and costly equipment, the screening tools recommended for strand 2 were the questions and screening audiometry.

Results from stage 4, hearing aid trial, and comparison with stage 3, bilateral amplification experiment

The ability to benefit from amplification in the sound-attenuating booth with TDH-49 earphones may not generalise to the situation of using a single hearing aid in the soundfield, or in real life.

This part of the study, which was additional to the original proposal, therefore examines the relationship between the ability to benefit from amplification using earphones and from using a hearing aid. An ITE hearing aid was used in this study, since the participants had shown at stage 2 that this was preferable to a BTE aid. A single hearing aid was fitted because that was the current practice in the NHS at that time. An aid was fitted to the better ear in 27% of participants (37 dB HL better ear, 42 dB HL worse ear) and the worse ear in 73% of participants (38 dB HL worse ear, 32 dB HL better ear).

So, in addition to identifying the most appropriate screening tool for use in 55–74 year olds, we were also interested in

- estimating how many people aged 55–74 years would benefit from amplification and aiding
- whether the ability to benefit from amplification is predictive of ability to benefit from a hearing aid
- what factors are most important in determining the benefit or final level of 'aided' performance obtained; among these factors, the extent to which cognitive factors may influence benefit and aided ability to understand speech in noise was a major interest
- the extent to which early aiding was associated with a gain in quality of life or of family life.

It was hypothesised that those people with better cognitive function might gain greater benefit from the amplification, and particularly from non-linear amplification given from particular hearing aid provision.

Results

The estimate for the population using a hearing aid in the National Ear, Nose and Throat Survey for those aged 55–74 years of age was 6%, although in the Nottingham and Southampton areas this was 6.9%.

The estimate of those with worse hearing ears with average hearing thresholds of at least 25 dB HL was about 40%. In this study there were 33% at this degree of impairment who did not use a hearing aid. If the results were referred to the better ear there are about 29% with average hearing thresholds of at least 25 dB HL, with 22% who did not currently use a hearing aid, decreasing to 13% and 8% at 35 dB HL. This updates the NSH data and gives a current picture that can be relied upon given current services and populations.

Participants who exceeded the 25-dB HL criterion on the worse ear were offered a single hearing aid, after discounting those who were outside the fitting range for the Microfocus hearing aid (supplied by Oticon), and those who had a conductive component to the hearing impairment (27% in total) or who already had hearing aid(s) (23%).

Fourteen per cent declined to take part in the study to use the Microfocus hearing aid, leaving 36% who were fitted with the hearing aid, for whom completed 3-month follow-up appointments were obtained for 86 out of 88 people. This suggests that the sample who accepted to use a hearing aid was representative of about 15% of the population in the 55–74-year age range.

The results of analysing the FAAF scores for the 55 dB(A) +0 dB signal-to-noise ratio (s/n) on an individual basis showed that about 36% of those fitted gained a statistically significant improvement in the FAAF scores, which is about 6% of this age-specific population. This does not mean that those others fitted with hearing aids had no benefit overall or that those who had a significant improvement in FAAF scores actually benefited on a day-to-day basis. However, they did achieve a statistically better score on a speech in noise task.

There were so many plausible explanatory variables that were available for analysis that it has not been possible to look systematically at them all or to go beyond exploring elementary interactions; there were only 86 people with data. The major variables on which the current analysis concentrated were:

- demographic variables (age, gender and occupational group; age was divided for the sake of these analyses into less than 68 years, and 68 years and older)
- hearing impairment variables (hearing in the fitted ear for aiding, hearing in the better ear for amplification, the presence or absence of a distortion product emission at 3 kHz using a criterion of 9 dB from the Eroscan device)
- the ALDQ (taking a cut-point at the median, with a higher score indicating a more varied acoustic environment)
- a derived measure from the cognitive reading span test described above, yielding four categories.

The four categories were derived from a principal components analysis of the three measures (answers, order, sense) that stem from the task. There were two significant components. The first loaded highly onto the answers and the order variables (a 'phonological' memory score, labelled 'memory'), and the second loaded highly on the sense variable (a long-term semantic memory score, labelled 'sense').

The two components were arbitrarily divided into two ranges (<0 and $\geqslant 0$) and were combined to give four categories 'low memory and low sense', 'high memory and low sense', 'low memory and high sense' and 'high memory and high sense'. Substantial analyses were carried out before those reported here, using these variables and their interactions and including other variables [in particular, the REMs, e.g. unaided articulation index (AI),[56] REIG using white noise and speech-shaped noise at different levels].

The major problem was the stability of the results, owing to a large number of explanatory variables (more than seven) and the need to include different sets of interactions. In the analyses reported here, only the second order interactions which included cognitive function were analysed. If further factors or continuous explanatory variables were included, then the design matrix was singular and least squared estimates were not uniquely estimable. The analyses have been restricted here to the performance speech test scores as outcomes.

Bilateral amplification experiment (stage 3)

Overall about 26% of the population had been estimated in stage 3 to benefit statistically from bilateral amplification using the NAL(R) fitting strategy, of whom about 6–7% already used a hearing aid or aids. *Figure 17* shows that there was a significant variation in the proportion who benefited from amplification as a function of age (23 versus 34%, $\chi^2 = 4.4$, 1 df, $p < 0.03$, $n = 325$), with greater benefit for older people, controlling for fitted ear hearing level factor and as a function of the cognitive factor 'answers' (30 versus 20%, $\chi^2 = 3.8$, 1 df, $p < 0.05$).

The phonological memory factor shows that low scores are associated with higher benefit and higher scores with lower benefit. This stems from lower unaided scores for those with low memory score. There is a different pattern for the long-term semantic memory score, showing that elderly people with a high sense score obtain greater benefit (this is significant in the sample, $\chi^2 > 10$, 3 df, $p \sim <0.01$, but not in the weighted analysis, $\chi^2 < 5$, 3 df, and is therefore less robust).

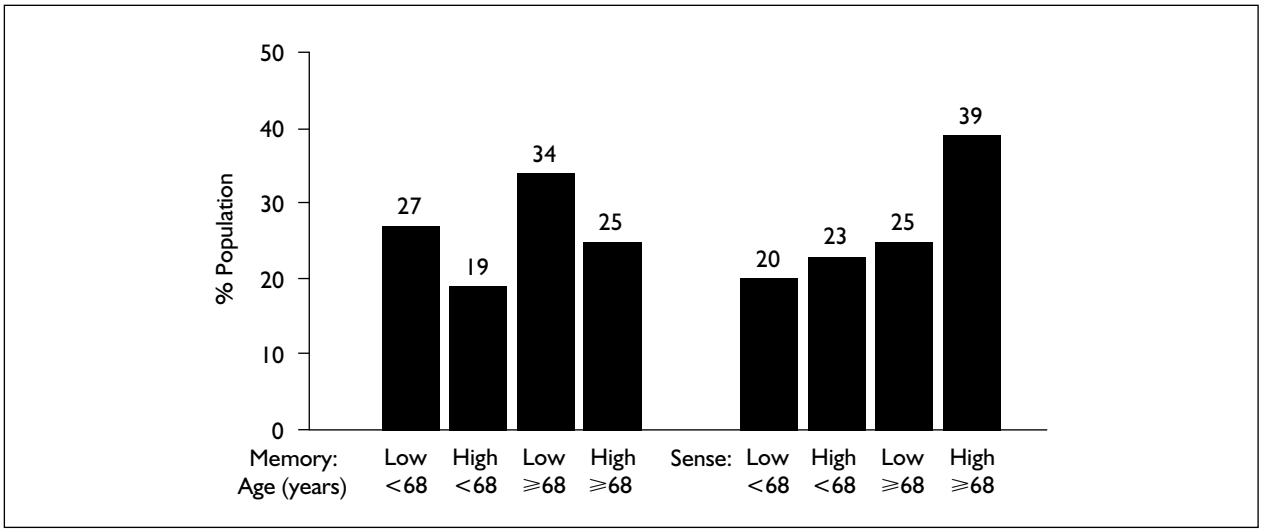

FIGURE 17 *Percentage of population who would benefit from bilateral amplification as a function of age, memory and sense scores*

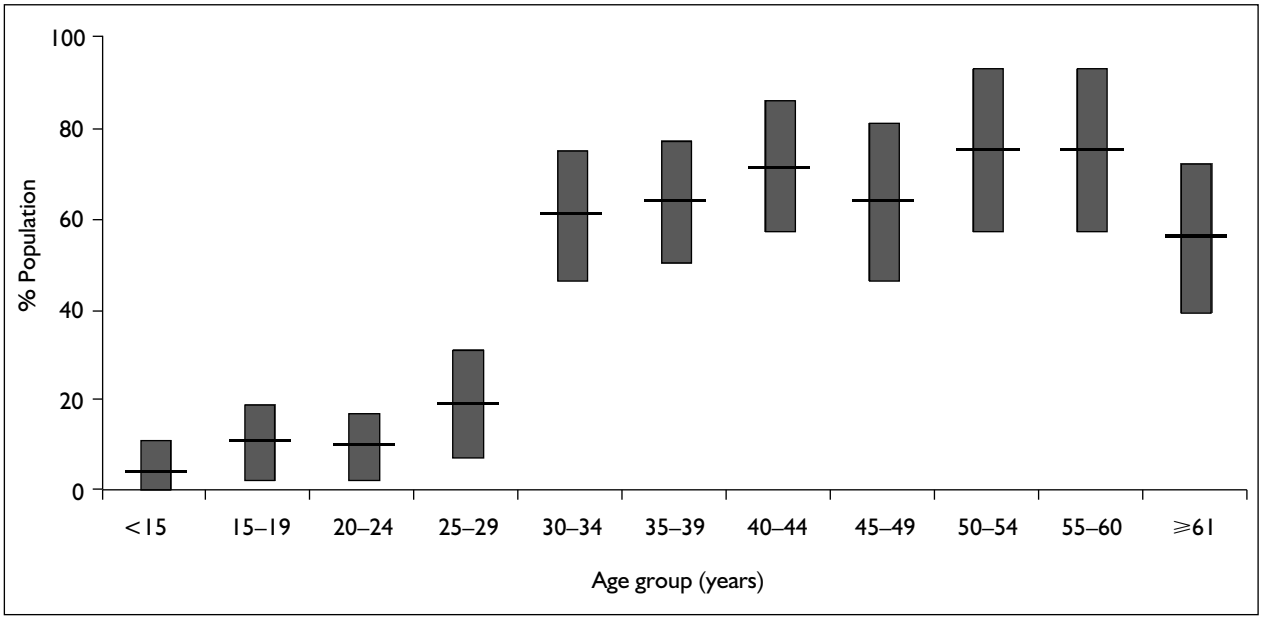

FIGURE 18 *Percentage who benefit from amplification as a function of hearing impairment in the worse ear (0.5, 1, 2 and 4 kHz)*

Figure 18 shows the percentage of the population that would benefit (with 95% CI) from the amplification as a function of worse ear hearing impairments. This shows there is a steep function for this particular speech in noise test that increases substantially between 20–24 dB HL average and 30–34 dB HL average. At 25–29 dB HL there are about 20% who are shown statistically to benefit from amplification; this rises to about 60% at 30–34 dB HL and averages about 70% thereafter. This helped to guide the candidature criterion for first time users for the next phase of the study.

Examining further the extent to which demographic, audiological or cognitive factors affected performance on the speech in noise task, the data were filtered into those in whom the worse ear average was at least 25+ dB HL. This enabled a comparison with those who were offered a hearing aid (this gives greater power for the analyses, which were additionally carried out on the subset of data from those who actually received the hearing aids). *Figure 19* shows the means for the unamplified and amplified FAAF test scores as a function of four cognitive test score categories (low memory and sense, high memory and low

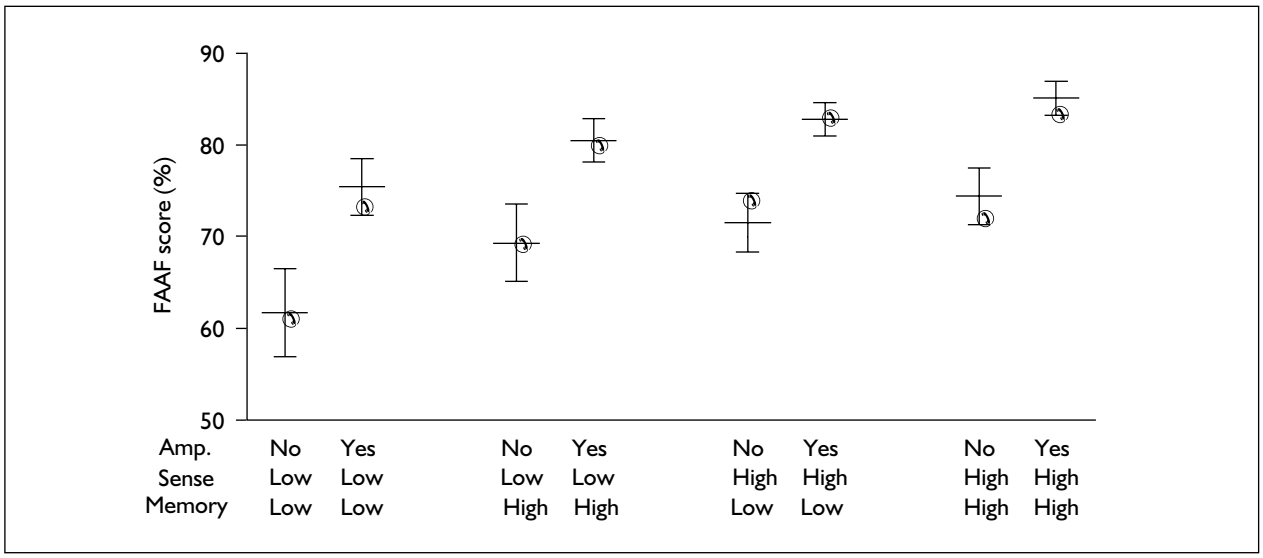

FIGURE 19 *Speech reception scores with and without bilateral amplification [linear strategy using a NAL (R)] using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of scores on a cognitive test. The error bars are ±95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

sense, low memory and high sense, and high memory and sense).

The analysis of variance (ANOVA) tables are shown in *Table 23*, with $n = 176$ completing the amplified tests and 169 completing the unamplified tests.

It is quite clear in *Figure 19* that the unamplified and amplified FAAF scores increase across the four cognitive categories, and that there is a large, demonstrable and reliable effect. *Figure 19* shows the raw scores with 95% confidence intervals and in addition the weighted least squares (WLS) estimates for those points, taking into account the explanatory factors shown in *Table 23*.

So there is a main effect on unaided FAAF scores of

- gender: men scored worse
- auditory lifestyle and demands: those with higher demands scored lower
- age: those in the higher age (divided at 68 years) category scored substantially less
- DPOAE: those with DPOAE less than 9 dB scored less
- better ear average: those who were above the median better ear average scored substantially worse

and these factors were independent of each other.

The cognitive factor shown in *Figure 19* shows that if both elements (memory and sense) were low, then there were lower unaided FAAF scores; if they were both high then there were higher scores; otherwise scores were intermediate.

For the aided scores, there were only two effects (cognition and better ear average) in common with the unaided scores. This seems to indicate that the bilateral amplification brought most people up to a common plateau of good performance. There was an additional effect of occupational group, such that those in non-manual occupations had a FAAF score around 6% higher.

Figure 20 shows the difference between the amplified and the no amplification condition, which is termed 'benefit' from amplification.

This shows that there is an apparent greater benefit for the low memory and sense group compared with those who have a high memory and sense score. This is significantly different ($p < 0.05$, Scheffé) in a univariate comparison, but not when adjusted for all elements in the ANOVA (*Table 23c*), as the WLS estimates show that there is no difference in the low/low and the high/high condition. The ANOVA in *Table 23c* shows that the hearing level in the fitted ear (F-HL) is a significant factor, with participants with at least 38 dB HL average showing about twice the benefits scores of those with less than 38 dB HL (~19% versus 7%). The DPOAE is an additional independent significant factor (~15% versus 7%) with those giving +9 dB s/n at 3 kHz obtaining less benefit.

TABLE 23 *ANOVA for the bilateral amplification condition using the FAAF score (%): (a) analysis of the no amplification condition, (b) the amplified condition, and (c) the difference (benefit) between these conditions*

Source	df	Type III SS	Mean square	*F*	*Pr > F*
(a) No amplification condition					
Gender	1	1858.101173	1858.101173	28.47	<0.00
AudLife	2	433.419323	216.709661	3.32	0.03
Age (68 years)	1	361.985862	361.985862	5.55	0.01
Occupational group	1	16.499654	16.499654	0.25	0.61
Cog	3	786.163299	262.054433	4.02	0.00
AudLife * Cog	6	465.319534	77.553256	1.19	0.31
Age (68Y years) * Cog	3	471.559414	157.186471	2.41	0.06
DPOAE	1	520.701026	520.701026	7.98	0.00
BEA	1	6737.700662	6737.700662	103.25	<0.00
Cog * BEA	3	371.271924	123.757308	1.90	0.13
R^2 = 0.66931, CV = 10.60359, RMSE = 8.078236, bilateral unamplified FAAF score = 76.18396					
(b) Amplified condition					
Gender	1	22.864367	22.864367	0.70	0.40
AudLife	2	61.014480	30.507240	0.94	0.39
Age (68 years)	1	14.916412	14.916412	0.46	0.49
Occupational group	1	223.134181	223.134181	6.85	0.00
Cog	3	698.682580	232.894193	7.15	0.00
AudLife * Cog	6	155.130796	25.855133	0.79	0.57
AGE (68 years) * Cog	3	150.998514	50.332838	1.55	0.20
DPOAE	1	14.831136	14.831136	0.46	0.50
BEA	1	1766.506329	1766.506329	54.24	<0.00
Cog * BEA	3	95.700039	31.900013	0.98	0.40
R^2 = 0.459586, CV = 6.830940, RMSE = 5.706697, bilateral amplified FAAF score = 83.54190					
(c) Difference between conditions					
Gender	1	1391.981285	1391.981285	30.84	<0.00
AudLife	2	216.947198	108.473599	2.40	0.09
AGE (68Y)	1	219.977181	219.977181	4.87	0.02
Occupational group	1	121.438229	121.438229	2.69	0.10
Cog	3	32.915806	10.971935	0.24	0.86
AudLife *Cog	6	291.196143	48.532691	1.08	0.38
AGE (68Y)*Cog	3	121.847275	40.615758	0.90	0.44
DPOAE	1	758.424693	758.424693	16.80	<0.00
BEA	1	1737.456733	1737.456733	38.49	<0.00
Cog * BEA	3	158.478617	52.826206	1.17	0.32
R^2 = 0.546334, CV = 89.32108, RMSE = 6.718243, benefit from bilateral amplification = 7.521453					

The independent variables are all factors in these tables with cut-points being made in an a priori manner, usually based on the median level on that variable. AudLife represents the factor associated with low or high scores on the ALDQ; Cog represents the four cognitive categories explained in the text. The better ear results were used for hearing impairment and DPOAE.
CV, coefficient of variation; RMSE, root mean square error.

Figure 21 shows the no amplification and bilateral amplification FAAF scores as a function of hearing impairment on the better ear as well as of the cognitive scores, where the difference between low/low and high/high scores is about 17.8% (95% CI 3.5 to 32.1%, Scheffé) and 12.5% (95% CI –1.9 to 26.9%) for no amplification and amplification scores, when adjusting for other factors in *Tables 23* (a) and (b). The benefit scores as a function of hearing level and cognition are shown in *Figure 22*. For those with better ears at least 38 dB HL the benefit is reasonably steady at 15–20%, with gains being nearer 5% for those with less than 35 dB HL. There is no statistically significant effect of cognitive function.

Hearing aid experiment (stage 4)

The FAAF scores for the subset of people (n = 88) who were offered and accepted a hearing aid are shown in *Figures 23–26*.

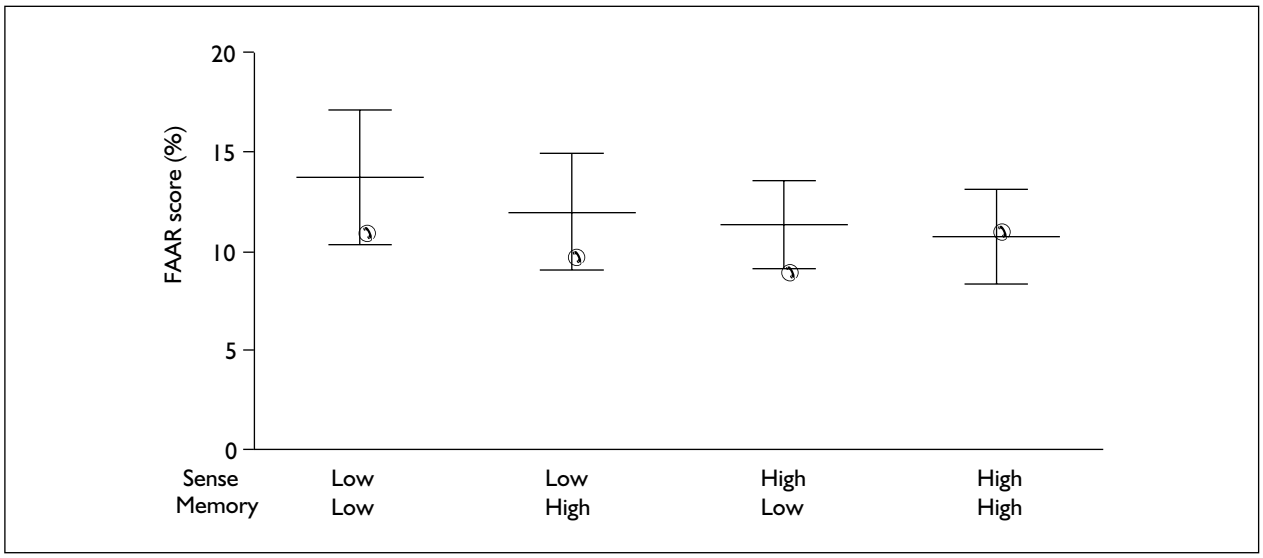

FIGURE 20 *Speech reception benefit scores from bilateral amplification [linear strategy using a NAL (R)] using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

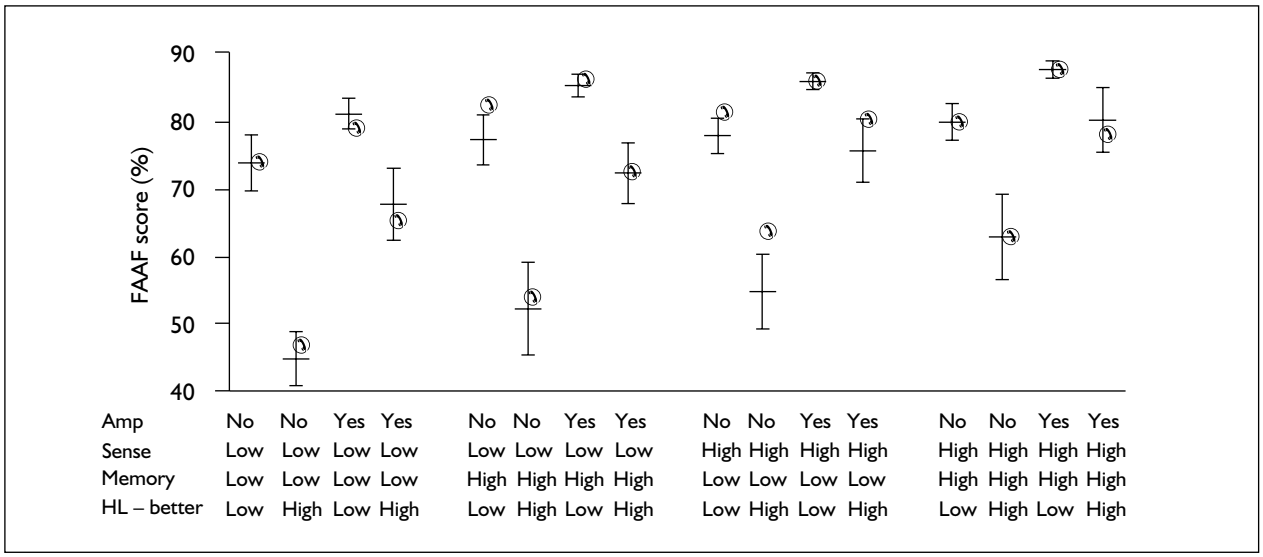

FIGURE 21 *Speech reception scores with and without bilateral amplification [linear strategy using a NAL (R)] using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of better ear hearing impairment (cut-off at 38 dB HL) and scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

The outcomes of the ANOVA are shown in *Tables 24* and *25* (n = 76 with all completed measures).

There is a main effect of hearing impairment (on the fitted ear, cut-off at 38 dB), age, and an interaction between cognitive scores and hearing impairment, all of which are in the same directions as for the amplification conditions; that is, older and more impaired people score lower, and those with lower cognitive scores and poorer hearing thresholds score much lower, as shown in *Figure 25*. In other words, poor cognitive scores lead to worse speech in noise performance in those with greater hearing impairments, in unaided and aided conditions.

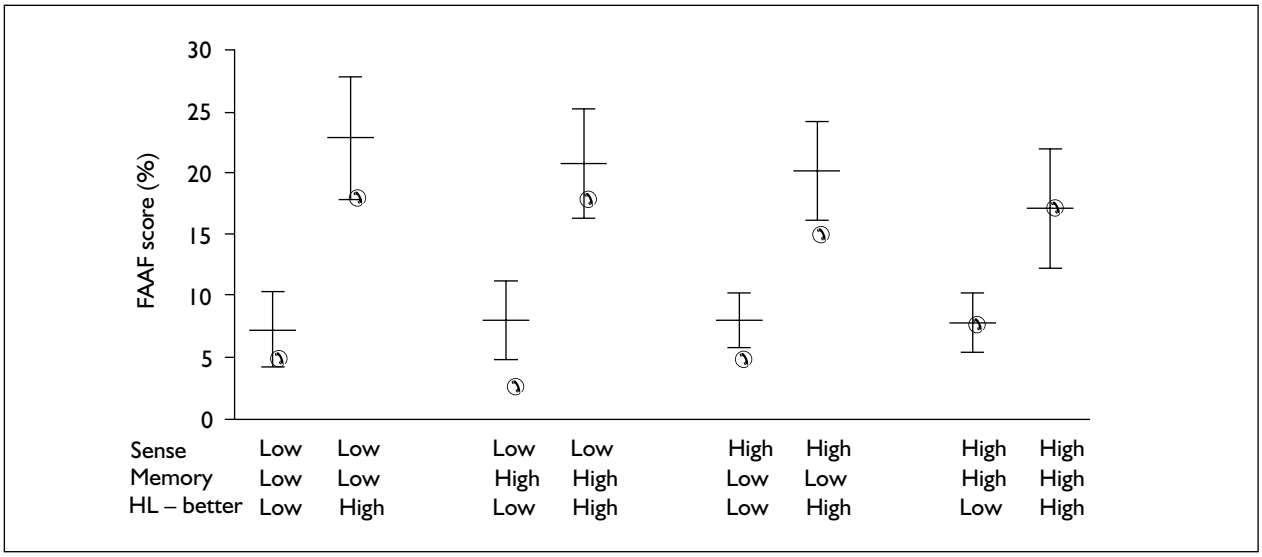

FIGURE 22 *Speech reception benefit scores from bilateral amplification [linear strategy using a NAL (R)] using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of better ear hearing impairment (cut-off at 38 dB HL) and scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

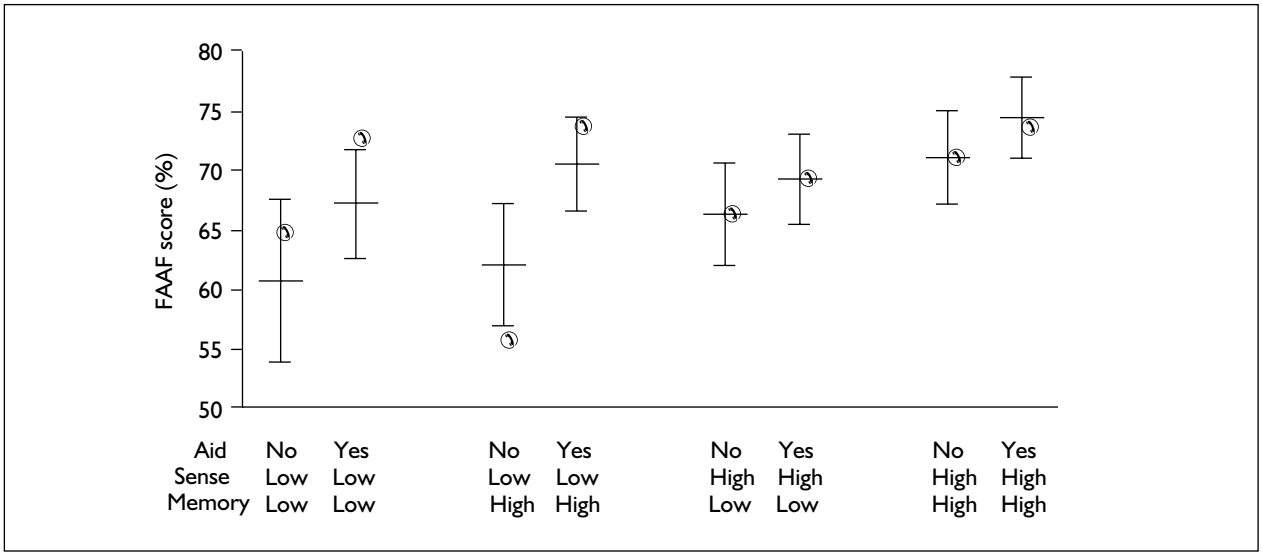

FIGURE 23 *Speech reception scores with and without unilateral aiding using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

There were main effects on aided FAAF scores of

- gender (men worse)
- auditory lifestyle and demands (more demands worse)
- hearing impairment
- age
- cognitive performance
- two interactions with cognitive performance for auditory lifestyle demands and degree of hearing impairment.

The interaction of cognitive performance with auditory lifestyle and demands is such that

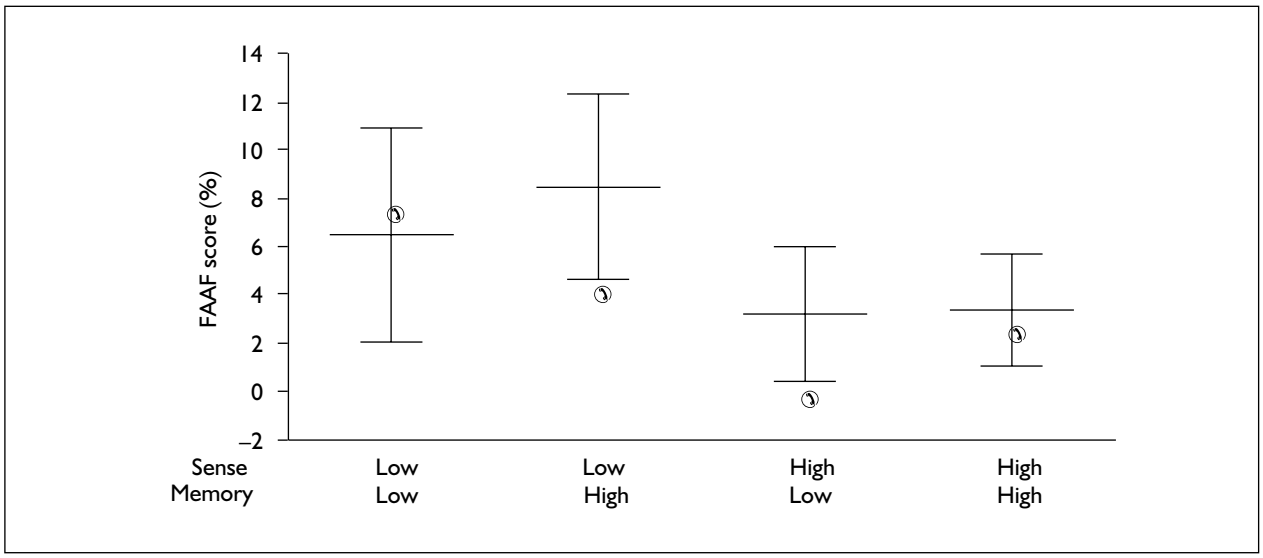

FIGURE 24 *Speech reception benefit scores from unilateral aiding using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

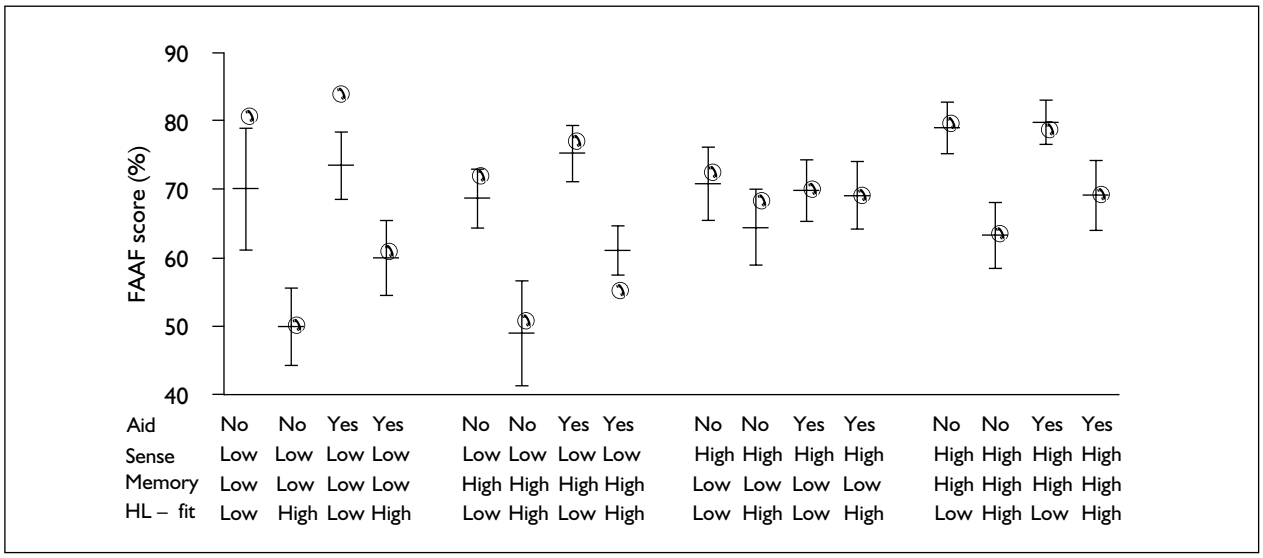

FIGURE 25 *Speech reception scores with and without unilateral aiding using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of hearing impairment on the fitted ear (Lo < 38 dB HL; Hi ⩾ 38 dB HL) and of scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid or aids.*

- there is a no cognitive effect in those with greater auditory lifestyle and demands (ALDQ)
- there is a greater memory effect for those with lower ALDQ scores.

The interaction of cognitive performance with hearing impairment (*Figure 25*), is similar to that for the unaided condition, with

- larger effects of sense for those who are more impaired
- hardly any effect for those who are less impaired.

The benefit from aiding is shown in *Figures 24* and *26*, with accompanying ANOVA analyses in *Table 24(c)*. DPOAE has the largest effect and is additive with hearing impairment in the fitted ear.

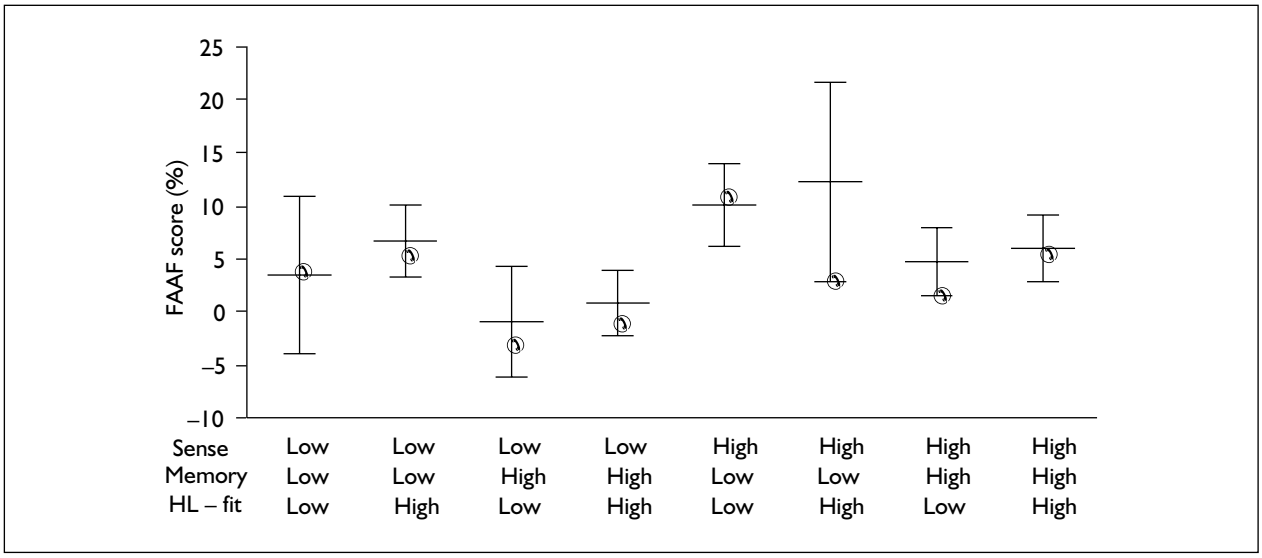

FIGURE 26 *Speech reception benefit scores from unilateral aiding using FAAF test at 55 dB(A) speech, +0 dB SNR (80 trials each condition, 80 practice) as a function of hearing impairment on the fitted ear (Lo < 38 dB HL; Hi ⩾ 38 dB HL) and of scores on a cognitive test. The error bars are 95% CI, the dot represents the WLS model fit, partialling out other factors in the model, using population weights. The participants were selected randomly from the population and did not previously wear a hearing aid and aids.*

There is about a 10% difference between the benefits for those who have a 9 dB DPOAE at 3 kHz and those who do not, with the difference over hearing impairment being smaller. The effect of hearing impairment on benefit can be seen in *Figure 26*, with those having higher impairments always showing greater benefit. There is a trend for the benefits of aiding to decrease with the higher cognitive scores (see *Figures 24* and *26*), especially across the sense domain. Analysis using just the sense domain gives interactions of that domain score with ALDQ and age ($p < 0.01$) and marginal interaction with degree of hearing impairment ($p = 0.08$). As noted earlier, the extent of benefit is determined predominantly by the score in the unaided performance, as there is less variability in the aided score.

Relationship between amplification and hearing aid benefit

Taking the scores for the 'aided' task and the 'amplified' task for each condition (no aid or amplification and aid or amplification) and analysing those differences, there is a 7% advantage for the no amplification versus the no aid condition, a 12% advantage between bilateral amplification and aiding, and a 5% greater benefit score for the bilateral amplification versus the aiding. These differences are to be expected because it is easier to perform well under earphones than in a soundfield with one hearing aid. However, the real world is more like the hearing aid condition for many aid users. The difference was not additive and was predicted in part by cognitive performance (e.g. the difference between amplified and aided going from +20, +10, +6, to +2 for the four cognitive conditions).

A regression on the aided FAAF scores using the bilateral amplification scores as a predictor shows that there is a highly significant relationship with the aided response increasing 1:1 in terms of the amplification score, with an intercept of about 14%. There is an R^2 of about 50%, which is good but by no means an indicator of a very tight relationship. If all factors included in the above analyses are included in the WLS regression then the R^2 increases to over 70%, which is good. The relationship is shown in *Figure 27*, with *Figure 28* showing the relationship between benefit from aiding and benefit from amplification.

Taking benefit from bilateral amplification into account, about 13% of the variance is accounted for, which increases to 66% when all the factors in *Table 25* are also taken into account. So the benefit from aiding, when shown as conditioned on benefit from bilateral amplification, is related to the cognitive scores, with only the low memory, low sense group showing an additional estimated WLS effect of + 16% (i.e. the bilateral amplification underestimates the benefit for these people substantially), the other cognitive conditions showing no difference.

TABLE 24 *The ANOVA for the hearing aid condition using the FAAF score (%): (a) the analysis of the no aid condition, (b) the aid condition, and (c) the difference (benefit) between these conditions*

Source	df	Type III SS	Mean square	*F*	*Pr > F*
(a) No hearing aid condition					
Gender	1	52.433391	52.433391	1.19	0.28
AudLife	2	194.832952	97.416476	2.21	0.11
F-HL	1	2193.574135	2193.574135	49.68	<0.00
Cog	3	311.666831	103.888944	2.35	0.08
Age (68 years)	1	772.560996	772.560996	17.50	0.00
F-HL * Cog	3	511.696488	170.565496	3.86	0.01
AudLife * Cog	6	327.802673	54.633779	1.24	0.30
Cog * Age (68 year)	3	139.761836	46.587279	1.06	0.37
DPOAE	2	90.730854	45.365427	1.03	0.36
Occupational group	1	13.063105	13.063105	0.30	0.58
R^2 = 0.699088, CV = 9.350729, RMSE = 6.644581, unaided mean = 71.05949					
(b) Hearing aid condition					
Gender	1	134.653388	134.653388	4.88	0.03
AudLife	2	171.605282	85.802641	3.11	0.05
F-HL	1	1348.814008	1348.814008	48.91	<0.00
Cog	3	226.766828	75.588943	2.74	0.05
Age (68 years)	1	343.139362	343.139362	12.44	0.00
F-HL * Cog	3	639.942683	213.314228	7.73	0.00
AudLife * Cog	6	373.813254	62.302209	2.26	0.05
Cog * Age (68 years)	3	208.021837	69.340612	2.51	0.06
DPOAE	2	110.615820	55.307910	2.01	0.14
Occupational group	1	86.939204	86.939204	3.15	0.08
R^2 = 0.743525, CV = 7.075728, RMSE = 5.251689, aided mean = 74.22118					
(c) Difference between conditions					
Gender	1	19.0351945	19.0351945	0.77	0.38
AudLife	2	0.7488043	0.3744021	0.02	0.98
F-HL	1	102.2000546	102.2000546	4.12	0.04
Cog	3	149.6552050	49.8850683	2.01	0.12
Age (68 years)	1	85.9507047	85.9507047	3.47	0.06
F-HL * Cog	3	69.5252845	23.1750948	0.93	0.43
AudLife * Cog	6	192.5592625	32.0932104	1.29	0.27
Cog * age (68 years)	3	120.9775773	40.3258591	1.63	0.19
DPOAE	2	371.3997197	185.6998599	7.49	0.00
Occupational group	1	32.6021321	32.6021321	1.31	0.25
R^2 = 0.634169, CV = 157.5264, RMSE = 4.980484, benefit mean = 3.161682					

The independent variables are all factors in these tables with cut-points being made in an a priori manner, usually based on the median level on that variable. AudLife represents the factor associated with low or high scores on the ALDQ; Cog represents the four cognitive categories explained in the text. The better ear results were used for hearing impairment and DPOAE.

The benefit from aiding is about 1:3.3 with respect to the benefit from bilateral amplification (i.e. 9% benefit from bilateral amplification would predict about 3% from unilateral hearing aid provision in the soundfield).

The SF-36 and the HUI instruments were used to assess the quality of life before and after hearing aid fitting and the extent to which the quality of life might change, positively, after hearing aid fitting. The QoFL measure was used to look at the changes in family quality of life. The HUI gave a benefit of 0.069 (95% CI 0.035 to 0.104), the SF-6D showed a benefit of 0.0125 (95% CI –0.0012 to 0.037), and the QoFL showed a benefit of 0.019 (95% CI –1.9 to 5.8). Only the HUI measure showed robustly significantly increased utility.

TABLE 25 *ANOVA table as per* Table 24(c)*, but including amplification benefit as a predictor variable*

Source	df	Type III SS	Mean square	*F*	*Pr > F*
Cog	3	363.4461436	121.1487145	5.37	0.00
Gender	1	75.1060274	75.1060274	3.33	0.07
DPOAE	1	271.9761686	271.9761686	12.06	0.00
HL-fitted	1	52.4871286	52.4871286	2.33	0.13
Age (68 years)	1	19.8340840	19.8340840	0.88	0.35
Occupation group	1	9.5708757	9.5708757	0.42	0.51
Cog*HL-fitted	3	246.0623298	82.0207766	3.64	0.01
AudLife	2	21.3874016	10.6937008	0.47	0.62
Benefit from bilateral amplification	1	201.4345549	201.4345549	8.93	0.00

R^2 = 0.664278, CV = 152.5821, RMSE = 4.749357, benefit mean = 3.112658

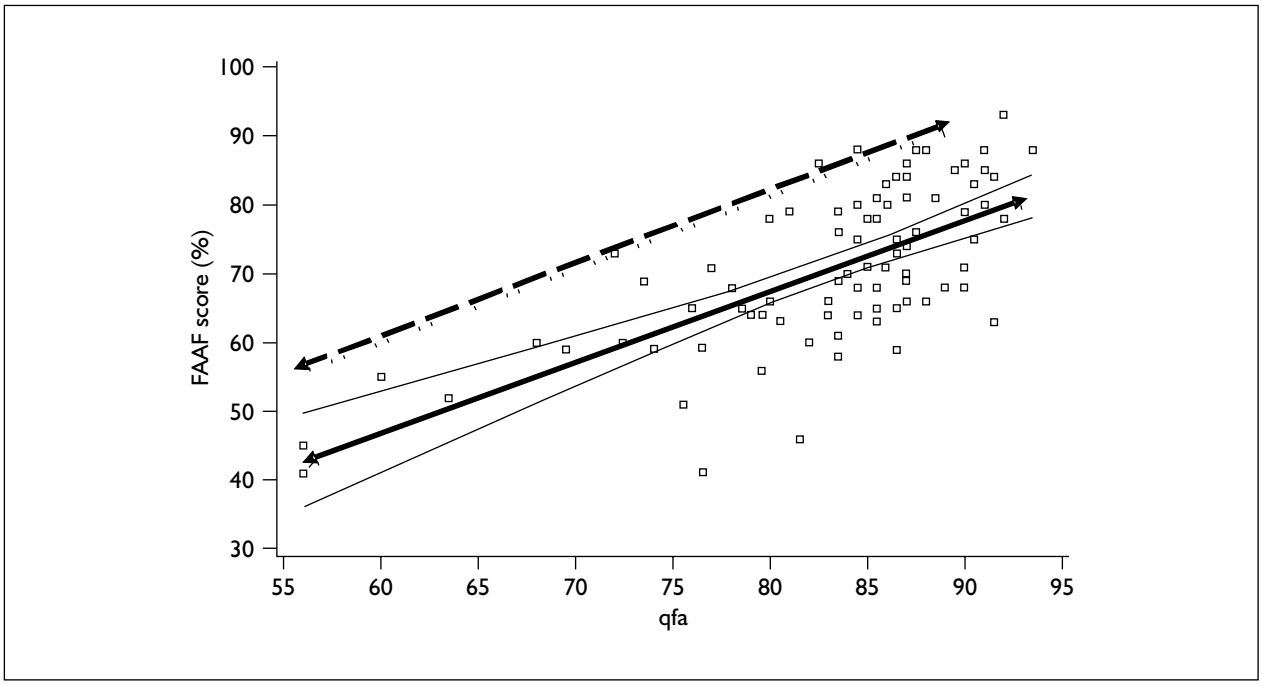

FIGURE 27 *FAAF score (%) using unilateral hearing aid fitting as a function of the score from bilateral amplification, together with mean fit and 95% CI.* R^2 *= 48%,* B *= 1.0 (SE 0.12), intercept-14.3. Dashed line gives the equal score line.*

Discussion

The large number of people with hearing problems in the 55–74-year-old population who do not have a hearing aid and who have not consulted anyone was evident. About 6.9% of the Nottingham and Southampton population of this age (6% nationally) have a hearing aid, but at least 40% have impaired hearing. The extent to which good bilateral amplification, using the NAL (R) fitting strategy, enables people to perform better in the FAAF task at 55 dB(A) speech, +0 dB s/n was demonstrated to be quite substantial in one in five of that population when those already aided were discounted. There are substantial benefits from amplification in this situation, which represents a quiet level of speech in moderately difficult noise conditions. This is a real advantage for people in those conditions.

However, care is needed when considering the results based on speech tests done at one intensity level and one SNR, and using one type of competing noise. There may be inadequacies about any generalisations concerning ability to benefit from amplification and provision of hearing aids. An additional concern was for the stability of the data, given the large number of

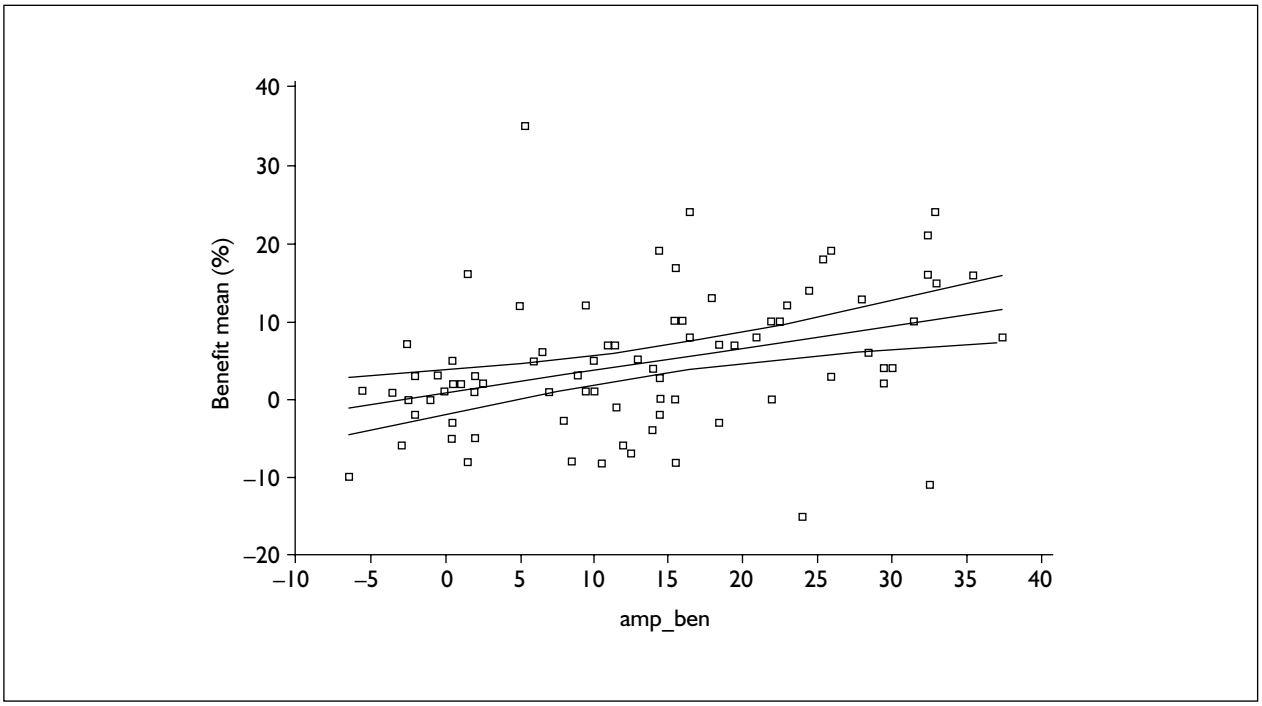

FIGURE 28 *Benefit (%) from unilateral hearing aid fitting as a function of benefit from bilateral amplification, together with mean fit and 95% CI.* R^2 *= 13%, but 68% for whole model. B = 0.29 (SE 0.08).*

explanatory variables (between subject) that were available and the relatively small number of participants (about 300 for the amplification and 80 for the hearing aid trial). However, the study did start with a large random sample and one of its strengths is that the results can be generalised to potential new users. Thus, the analyses conducted were done as WLS analyses to examine the implications in the population of 55–74 year olds as a whole. This is the first time that this has been done.

Table 26 shows data from all six dimensions of the GHABP. In terms of use, benefit and satisfaction, the hearing aid users in the present study compare favourably with users from MHAS. Disability is also reduced by a similar percentage in each group.

There were substantial differences as a function of age, degree of hearing impairment and cognitive factors related to phonological memory, with those with good memory skills benefiting less. This is due to the better scores in the unamplified conditions and possibly relates to the sensitivity of the FAAF test in the bilateral amplification condition, or it could be a natural ceiling in performance by more cognitively able people. It was easier to show a large improvement for those with poorer memory skills, but in other listening situations that require greater effort, those with good cognitive skills may be significantly benefited by amplification through hearing aids.

As expected, there were effects of age and hearing impairment that were reasonably easy to explain in terms of poorer no amplification or no aiding scores for older and more impaired people. There was a similar, but additive, effect for the presence of a DPOAE at 3 kHz. If it was present at 9dB s/n then there was less benefit (owing to a better unaided response). The effect of occupational group was also as expected, with poorer scores in unaided and no amplification conditions.

The ALDQ influence is less easy to explain, with those with more demanding auditory lifestyles achieving lower no amplification scores and unaided scores, leading to slightly higher benefits.

The memory and sense domains that were derived from the reading span test possibly tap into two different functions. The first may be an indicator of phonological memory or of ordered event memory, while the second may indicate the extent to which semantic distinctions can be appropriately processed. It was not expected that the second of these would have any influence and it is horribly skewed in its distribution, with most people scoring in the region of 80–90%. It was also affected by the number of sentences in an interesting way: performance improved as the

TABLE 26 *GHABP data for participants in the present study, compared with those presenting themselves to the MHAS*

Group		Initial disability (%)	Initial handicap (%)	Use (%)	Benefit (%)	Residual disability (%)	Satisfaction (%)
Early intervention present study	Mean	59.62	53.59	69.8	60.52	33.59	64.53
Mean BEA = 33 dB HL	SD	13.65	19.49	24.8	19.96	11.54	21.01
MHAS new patients with BEA ≤40 dB HL	Mean	47.6	45.2	64.5	47.6	23.1	50.9
Mean BEA = 32 dB HL	SD	16.4	24.3	33.2	25.3	15.7	26.8
MHAS new patients with BEA ≥41 dB HL	Mean	55.1	49	74.5	54	24.6	55.8
Mean BEA = 50 dB HL	SD	18.2	26.1	29.6	23.1	17.7	25

number of sentences increased. This suggests that the frequency of switching the participants' attention from trying to understand the sentence and pass judgement on its sense to trying to remember parts of those sentences was an important factor in the accuracy of lexical decisions. However, it should be noted that performance on the memory task was very poor in most participants and the need for a more sensitive task is needed. There is no need to go beyond three sets of sentences with these participants as they did not perform at ceiling for this initial task. There was no correlation between the extent to which subjects' performance was influenced by the number of sentences in each block and their FAAF scores or any benefit. There is a need, therefore, to explore other specific cognitive functions that may be more sensitive in elderly people, such as memory, attention (including switching attention) and effort.

There is a substantial effect of cognitive function on aided and bilateral amplified performance on the FAAF task, which was influenced by degree of hearing impairment in the aided condition. There was a very large effect of sense for those who were more impaired: those who had good memory and sense scores on the whole did better in all conditions, and as a consequence were less able to show a significant benefit. This is interesting if it is mirrored in terms of real-world performance: for someone with good cognitive performance, who experiences difficulty with hearing and is found by a screen or who presents to a GP for the first time, there may be some difficulty showing benefit in this domain (i.e. fairly quiet speech in noise). This, in turn, may lead to motivational difficulties in continuing to use the aid, which may be of considerable benefit in other respects (e.g. attention and effort to environmental or background sounds) and in other listening situations. It may also be that different hearing aid strategies may be more beneficial to people with different cognitive profiles (e.g. good cognitive performers may benefit more from particular strategies of amplification).

Implications

In this study, about 40% of 55–74 year olds had impairment in at least one ear of 25 dB HL or above and 27% have bilateral impairment at this level, with 11% being impaired bilaterally at 35 dB HL or above.

The performance of a random sample of participants aged 55–74 years on speech in noise tasks shows that significant statistical benefit was obtained from bilateral amplification in over 20% of the population who do not currently use a hearing aid. The level of performance with amplification was influenced by cognitive factors, but not the benefit *per se* (better cognitive function is equally facilitative in both conditions).

The opportunity to offer all those who exceeded the 25-dB HL criterion in the worse ear a Microfocus hearing aid was accepted by about 40%, with 16% declining, and the remainder were excluded for pathological and logistic reasons (e.g. hearing loss profile not suitable for aid). This is a very high rate of acceptance. The statistical power of showing aided speech in noise benefit was not as great in this instance, but 24% showed a statistical advantage with the hearing aid,

indicating that an additional 10% of the population would benefit substantially from a hearing aid in a quiet speech in noise environment. Those with poorer cognitive function would show greater benefit overall and less disadvantage in very bad speech in noise environments.

The overall pattern of results supports screening and providing hearing aids to those who do not currently have an aid (or aids), and suggests that there would be considerable population benefit.

There seems to be good correspondence between the bilateral amplification scores and the hearing aid scores. However, at least, two main questions for further research remain:

- Would bilateral aiding strategies approach the scores obtained by bilateral amplification (which were estimated as 14% higher)?
- Would different hearing aids and fitting strategies be more appropriate for people with different performance levels on memory and sense tasks?

Chapter 3

Strand 2: clinical effectiveness trial

Introduction

Following on from the population study (strand 1), the clinical effectiveness trial (strand 2) examined the effectiveness of a screening programme to identify people in the 55–74-year age group who would benefit from a hearing aid.

The population study had shown that, among those screens used, an audiometric screen was the most effective screen to identify people who would benefit from a hearing aid, in terms of high sensitivity and low false alarm rate.

However, delivery of the audiometric screen requires specialised equipment that needs to be operated by trained personnel, with all the associated costs. In addition, the target population has limited access to the audiometric screen owing to location and the availability of trained people to carry out the tests. We therefore decided to trial a two-stage screening programme using the screening questions from strand 1 (stage 2) followed by an audiometric screen (see Appendix 3). The screening questions had a wide range of sensitivity and much higher FARs than the audiometric screen. The range of sensitivity of the questionnaires varied considerably depending on what outcome criteria were chosen. If an audiometric criterion was chosen, such as at least 35 dB HL (see *Figure 48*) then the questionnaires were very sensitive (>90%, and were not statistically inferior in that respect to the audiometric screens). The problem with the questionnaire was the high FAR.

The FAR itself is highly dependent on the whole questionnaire and the context in which it is given; for example, if the questionnaire is given only to those selected as likely to have hearing problems, the FAR will be much lower. In the design a major goal was to make the screen as accessible as possible to the intended population. It was decided that a good questionnaire, delivered by post in a systematic way to a defined population, would make this screen more readily accessible to the whole target population than the audiometric screen. We also wanted to test the opportunistic approach to delivery, for example. making the questionnaire available to people who visit a general practice. This could be a viable alternative if those at risk of hearing problems attended a general practice and were involved at the practice in answering the questionnaire.

With these considerations in mind, the clinical effectiveness trial was designed as a controlled trial of a two-stage screen:

- a questionnaire with five screening questions used as the first stage
- an audiometric screen used as the second stage.

The way in which the questionnaire was delivered was either:

- systematic (sent to all in the age range) or
- opportunistic (available only in GP clinic).

Hearing aids in the clinical effectiveness trial: issues and context

One of the problems that is commonly acknowledged as a reason for low take-up of hearing aids among people with a hearing impairment is that the BTE aids are less acceptable than ITE hearing aids, for cosmetic and other reasons. Data from stage 2 of the population study also showed this, and so ITE aids were used in the clinical effectiveness trial.

When the clinical effectiveness trial was being planned, DSP hearing aids were being introduced into the NHS as part of the MHAS.[57] At that time the benefits of DSP aids over analogue aids were not conclusive, but the increased cost implication of using DSP aids was known. Therefore, it was decided to offer both types of aids to those who took part in the study as part of the hearing aid trial in a randomised allocation. The goal was randomisation, but in practice there were times when clinical and patient preferences had to be addressed, making optimal randomisation impossible. For example, a DSP aid can be more readily adjusted to fit a steeply sloping hearing loss than an analogue aid, in which case clinical need would override any randomisation to an analogue aid. Similarly, bilateral aids were being fitted routinely in the MHAS programme, and so the decision was to fit aids bilaterally in this study too. However, clinical and patient preference also

needed to be addressed here. If a patient had a unilateral hearing loss, it would not have been clinically sensible to fit two aids. There were also occasions when a patient specified a strong preference to have one aid, in which case only one aid was fitted.

The aims of the clinical effectiveness trial were:

- to provide estimates of the effectiveness of the two-stage screen with the different screening approaches (systematic and opportunistic)
- to assess the service implications of the increased hearing aid take-up that results from screening
- to assess the short-term acceptability and benefit from screening by undertaking a randomised control trial (RCT) of take-up of different types of hearing aid.

The main outcomes from this trial were:

- the take-up of the screening opportunity
- the take-up of the offer of a hearing aid(s) following screening
- the patient-reported and measurable speech in noise benefits of the two different hearing aid types
- patient-reported quality of life.

Outcomes data from strand 2 are later used in Chapter 5 as part of the in-depth analysis and discussion of the organisational and cost consequences of introducing such a screening and treatment package, and the costs of hearing aid screening and provision.

Methods

Participants and selection

The study was carried out at the MRC IHRCS, Nottingham, and the Royal United Hospital (RUH), Bath. A two-stage screen comprising a questionnaire and screening audiometry was used. General practices were approached and asked to distribute the screening questionnaire to patients within their practice in two ways, as either

- a systematic screen, where the questionnaire was sent to patients aged 55–74 years on the GP's register, or
- an opportunistic screen, where the screening questionnaire was made available to patients attending the GP's surgery and the patient was given the opportunity to take up the screen.

This study was done at a time when general practice was undergoing major changes and it was not easy for practices to commit time and attention to research. Initially, two practices were approached at each site; one offered to take the systematic approach and so the other used the opportunistic approach, with the questionnaires left in a pile in the waiting room. It became clear early on in the study that the opportunistic approach at both sites was yielding a much lower questionnaire return than the systematic screen. Thus, additional general practices were randomly selected and recruited to offer the opportunistic screen.

In Nottingham, six general practices took part; one systematic and five opportunistic. In Bath, seven general practices took part; one systematic and six opportunistic.

In Nottingham, for the practice that used the systematic approach, half of the patients received the systematic questionnaire from and signed by the GP, and the other half received the questionnaire from IHRCS signed by the lead investigator (ACD).

It was hypothesised that the take-up of the systematic screen would be greater from those contacted directly by their GP. The patients then returned the questionnaire to either IHR Nottingham or RUH Bath in a prepaid, self-addressed envelope. In Bath, the systematic questionnaire was signed only by the head of the audiology service at the RUH.

The opportunistic screens were also delivered in different ways to give information on the practicality and outcomes of different approaches. In Bath and in two of the practices in Nottingham, the questionnaires were simply left in a pile in the waiting room with a sign drawing the attention of patients aged 55–74 years to them. In the other three Nottingham practices, the receptionist asked patients attending the practice whether they were in the age group 55–74 years and, if so, they were asked to fill in the questionnaire and return it to the reception.

Study protocol

A flowchart describing the study protocol is shown in *Figure 29*.

The first stage of the screen, the screening questionnaire, was the same as that used in the population study, strand 1 (see Appendix 6). All the respondents aged 55–74 years who returned

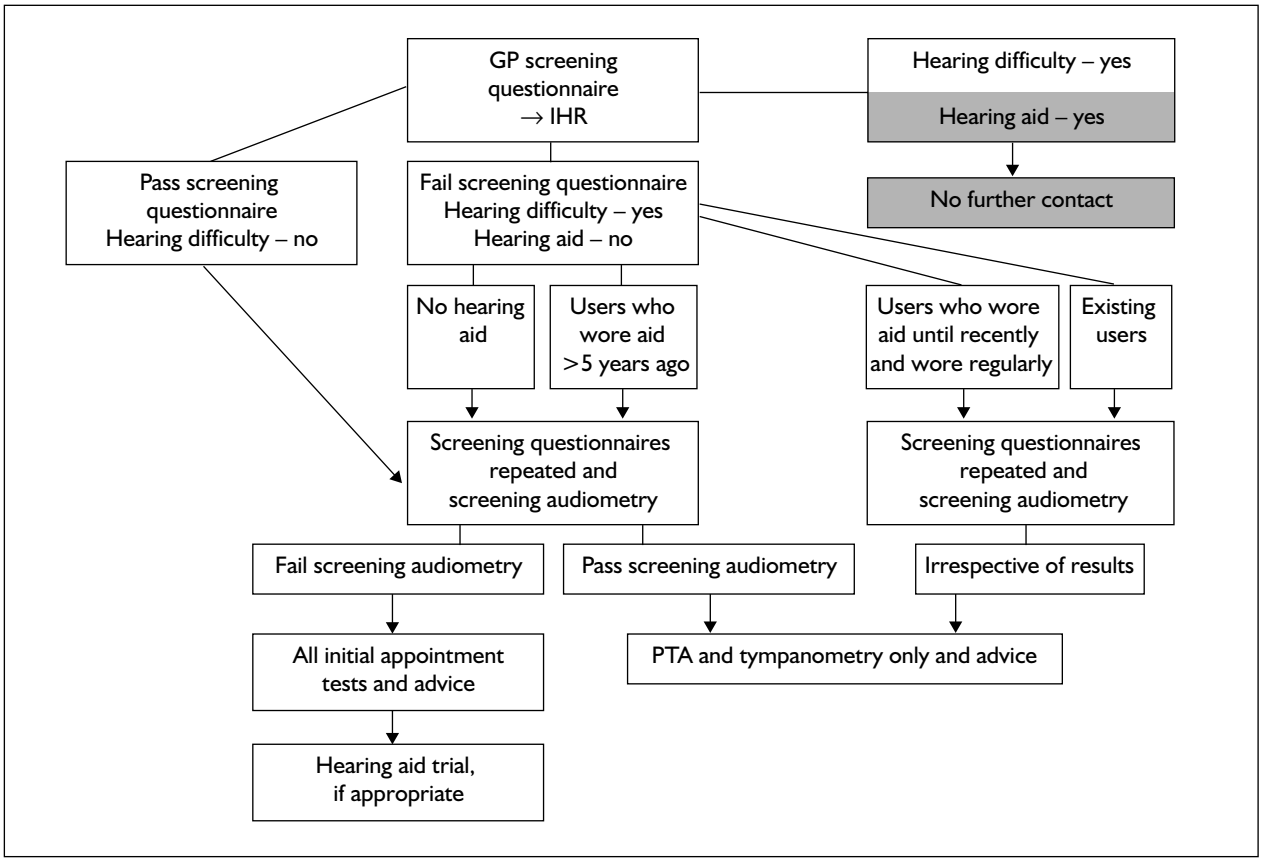

FIGURE 29 *Flowchart describing the study protocol*

the questionnaires and who had answered 'Yes' to Q1, 'Do you have any difficulty with your hearing?' and 'No' to Q5, 'Do you use a hearing aid nowadays?', that is, those who failed the screen, were invited into the clinic at IHR or RUH for a hearing assessment. These were the study's target group: people with a hearing impairment who did not have a hearing aid.

To ensure that the screening questionnaire was sensitive in identifying people who had no difficulty with their hearing, a subgroup of respondents who had replied 'No' to Q1 and 'No' to Q5, that is, those who passed the screen, were also invited into the clinic for a hearing assessment.

Informed, written consent was obtained from all the participants before their taking part in the hearing assessment. An attendance fee of £25, plus any travel expenses, was offered. In many cases, taxis were prearranged and paid by IHR and RUH to improve the take-up of invitations to the clinics. Because of this the data reported should be seen as being quite optimistic in terms of the initial audiometric screen take-up. However, it was important for the purposes of this study to recruit enough patients to the second stage audiometric screen to address the issue of where the candidature criterion for a hearing aid should be placed.

The results collected for the first stage of the screen show

- the take-up of the screening questionnaire
- the return rate for the different categories of patients
- the numbers who attended the clinic for hearing assessment in Bath and Nottingham.

The second stage of the screen, screening audiometry, was carried out in the clinic, before the full hearing assessment. Participants who heard all of the screening tones presented passed the audiometric screen. Those who failed to hear one or more of the presented tones failed the screen. Those participants who failed the audiometric screen were then invited to take part in the randomised hearing aid trial (HAT). In addition, participants who passed the screening audiometry but who had a low-frequency hearing loss identified later by pure tone audiometry, or

who reported significant hearing difficulties either on the screening questionnaire or at interview in the clinic were also invited to take part in the HAT.

There was no attendance fee for further visits, although travel expenses were reimbursed or taxis arranged.

The participants followed the full patient process of the MHAS programme, which at that time comprised

- a fitting appointment
- a fine-tune appointment, plus other fine-tune appointments if necessary
- a final follow-up appointment approximately 3 months after the fine-tune.

The participants were informed at the time of consenting to take part in the HAT that after the study was completed, they could either keep the hearing aids or return them.

Hearing aids

Two types of ITE hearing aid were used in the HAT:

- a DSP aid, the Oticon Digifocus II (DFII)
- a digital, programmable, linear analogue hearing aid, the Oticon Ergo.

Both types of hearing aid were ordered as half-concha with a volume control and telecoil. About one-third of the hearing aids were being made as full concha as it was not possible for the manufacturer to fit the components of both the volume control and telecoil in the half concha shell, in the first few patients. As the smaller, half concha ITE aids had been shown to be more acceptable in strand 1, it was decided that either the volume control or telecoil, or both, in that order of priority, should be left out to ensure that a half concha aid was provided.

The aids were fitted according to the manufacturer's protocol. Hearing aids were programmed using Otiset, according to the air-conduction hearing thresholds, and were adjusted according to patient feedback. REMs were not used in the initial fitting of the aids. However, aid adjustments were sometimes made at later appointments on the basis of the REMs in conjunction with patient report.

At the time of the study, patients were fitted with bilateral aids routinely as part of the MHAS programme and so bilateral aids were offered to all the participants taking part in the HAT unless hearing was normal in one ear. Some participants chose to accept only one aid. The type of aid allocated was based on a computer-generated random number list. However, if clinical need indicated that the other aid type was more suitable, then that aid was fitted. Examples of this were

- if the participant had a high-frequency hearing loss and normal low-frequency hearing, DFIIs were offered because of more flexible frequency shaping
- if the hearing loss was outside the DFII fitting range, an Ergo would be fitted
- if the participant had a conductive hearing loss, the linear Ergo would be fitted.

Test procedure: initial assessment

The tests carried out were dependent on the screening questionnaire responses and the results of the screening audiometry, shown in *Figure 29*.

Before the appointment, two quality of life questionnaires were filled in: the (SF-36[18]) and the HUI, and also the QoFL questionnaire (see Appendix 5), in addition to the ENT postal questionnaire used in strand 1 and a clinical questionnaire. The screening questionnaire was repeated in the clinic by interview with an audiologist, to assess clinical validity (see Appendix 6).

Screening audiometry was conducted as follows. In Nottingham, an A&M Unity PC audiometer and in Bath, a GNResound Aurical audiometer were used to present steady and warble tones via TDH-50P earphones in the following order: 4 kHz at 35, 40 and 45 dB HL, and 3 kHz at 30, 35 and 40 dB HL. Audiometers were calibrated to ISO 389 (parts 1 and 2). Each tone was presented twice and the participant was instructed to press a button when they heard the tone, according to the BSA-recommended procedure.[20] Although participants were seated in a sound-attenuating booth the door was kept open to be more representative of how screening audiometry would be carried out in the community, for example at a GP's surgery.

Otoscopy was performed and oto-immittance testing was performed using a Grason–Stadler Tympstar (Nottingham) and Madsen Zodiac 901 (Bath) to assess middle-ear function. This comprised a tympanogram and a check for the presence of the acoustic reflex at 1 kHz or broadband noise.

A clinical history was taken that asked about the following:

- hearing
- tinnitus and balance disorders
- time since hearing loss had been noticed and then reported to the GP
- family history of hearing impairment and severe tinnitus
- biographical data including socio-economic group.

Part one of the GHABP[23] was carried out using the software on GNResound Auditbase. This comprises questions on initial disability and handicap in four prespecified situations and up to four open-ended situations that were nominated by the participant where it was important for them to hear as well as possible.

Pure tone audiometry was performed. Air-conduction thresholds were obtained at 0.25, 0.5,1, 2, 3, 4, 6 and 8 kHz, and not-masked bone-conduction thresholds at 0.5, 1 and 2 kHz. If there was a 15 dB HL air–bone gap at two or more frequencies, masked bone-conduction testing was performed for both the left and right ears. BSA-recommended procedures[20] were followed.

Uncomfortable loudness levels were measured from both ears at 0.5, 1, 2 and 4 kHz.[35]

DPOAEs were obtained in Nottingham using the Maico Eroscan handheld screener.

At the end of the test session, participants who were suitable for the HAT were asked whether they wished to take part and written consent was obtained. Ear-mould impressions were taken and an appointment was made for hearing aid fitting for approximately 4 weeks later.

Hearing aid trial

Test procedure: fitting appointment

The hearing aids were programmed using Otiset, according to the participant's air-conduction thresholds, with a default setting of Adaptation Manager 2 for DFII aids and AGC slow for Ergo aids. The aids were fitted to the participants and fine-tuned in about half of the participants (n = 88/153) according to their feedback (e.g. voice sounded too hollow). Explanation of hearing aid use, insertion of aids and batteries along with general rehabilitation advice was given.

REMs were recorded with the Unity (Nottingham) and Aurical (Bath) in the following conditions:

- unaided using speech noise (SN) at 65 dB SPL
- occluded ear response using SN at 65 dB SPL
- REAR using white noise (WN) at 50 dB SPL, SN at 65 and 80 dB SPL
- REIG using the same noise type and intensity levels as for REAR.

REMs were used primarily as an outcome measure.

Two cognitive tests were performed: a reading span test and a vigilance test.

The reading span test[58] required the participant to repeat six blocks of either three or four sentences. After each sentence the participant indicated whether the sentence was sensible or not (sense). After each block of sentences the participant had to remember either the first or last word in each sentence (answers), in the order that the words were presented (order). The vigilance test was developed by IHR, based on the principle of a visual monitoring test with numbers used by the Iowa Cochlear Implant Group,[59] which was modified and used letters instead of numbers. Participants were presented with single letters continuously in a consonant–vowel–consonant–vowel (C-V-C-V) order and they had to indicate when three consecutive C-V-C letters formed a word (e.g. mat in the string b-o-m-a-t-u-). The test was performed twice, initially with the letters presented at a rate of one every 2 seconds and then repeated at a presentation rate of one per second.

There were two hearing aid benefit measures: the FAAF test and the APHAB.

The FAAF test[30] was used as a speech performance test to measure hearing aid benefit. The mean of the peaks of the FAAF speech items was set to 55 dB(A). Two types of background noise were used: SN (broadband) and ICRA6 (International Collegium for Rehabilitative Audiology) (two speaker, one female, one male, processed babble) noise.

The sentences within the ICRA noise were presented in four conditions at two levels and two SNRs [55, 60 dB(A) speech, 0, +5 dB s/n]. The SN was wideband and was equal to the average, long-term speech spectrum of the speech signals and set to 55 dB(A). The speech and noise were presented via a loudspeaker positioned 1.5 m in front of the participant. The test was performed in the unaided condition only at the assessment stage.

The APHAB[46] was carried out by interview with the audiologist. There are four scales for the APHAB:

- ease of communication (EC)
- effects of background noise (BN)
- effects of reverberation (RV), such as listening to sounds across a large room
- aversiveness (AV), which looks at uncomfortable loudness of background sounds such as traffic and alarm bells.

The mean of these scores provides a global score. At the same time as the APHAB was being collected the HUI3[36] was also administered.

Test procedure: fine-tune appointment

The participants had a fine-tune appointment, approximately 1 week after the fitting appointment, primarily to ensure that there were no problems with the hearing aids. In most cases, the DFII aids were reprogrammed to Adaptation Manager 3 and Ergo aids were reprogrammed to AGC fast. REMs were repeated as for the fitting appointment. Changes were made to the aids primarily according to the participant's feedback and occasionally according to REMs to achieve an optimal fit. General rehabilitation advice was given as required.

Test procedure: follow-up appointment

Approximately 3 months after the fine-tune appointment the participants returned for the final appointment. The GHABP was carried out for all six domains. Participants were asked to answer the initial disability and handicap questions for the time prior to receiving their hearing aids. The remaining domains – use, benefit, residual disability and satisfaction – were used to assess the outcome of the hearing aid fitting. An additional outcome measure was obtained, the global score, which was derived from the mean of the four outcome measures. The residual disability score was reversed so the score followed the same direction as the other outcomes (i.e. 0% worst score, 100% best score). In many cases, the GHABP prompted discussion about different areas of the participant's life that were relevant to hearing. Rehabilitation advice was given as required.

These outcomes were discussed with the patients as part of the rehabilitation process. For example, positive feedback was given when the outcomes were good, or further rehabilitation advice was given specific to the areas where the outcomes were poor. If necessary, further adjustments were made to the aid(s).

REMs were repeated in many cases, except occasionally when there had been no change at the fine-tune appointment.

The FAAF test was carried out both unaided (not using a hearing aid at the time) and aided (using a hearing aid), using the same conditions as at the fitting appointment. The test was carried out before any adjustments were made to the hearing aids.

The HUI was repeated, as was the APHAB, where the questions were asked with and without the hearing aids. The SF-36, QoFL and the ALDQ (see Appendix 4) were given to the participant to fill in at home and return by post in a prepaid envelope.

At the end of the appointment, the care of all the participants was transferred to the local hearing aid department.

Results

Take-up of the screening questionnaire

In total, 1698 screening questionnaires were distributed at the general practices in Nottingham and 1100 were distributed in Bath. The overall response rate (i.e. questionnaires that were filled in and returned as a proportion of the questionnaires that were taken) was 52%; lower in Nottingham (43.5%) than in Bath (65.5%). *Figures 30–34* show the patient flow from questionnaire take-up to final 3-month follow-up for the systematic and opportunistic screens for Nottingham, Bath and both sites combined.

In Nottingham, 41% and 49% of questionnaires were returned for the opportunistic and systematic delivery, respectively, and in Bath the response rate was 60% and 68%. *Figure 35* shows the take-up of the screening questionnaire for the different delivery methods for the Nottingham GPs.

For the systematic delivery the return rate was higher for the questionnaires sent from the GP than for those sent from the MRC (49% versus 41%). For the opportunistic delivery the return rate was higher when the receptionist alerted the patient to the questionnaires than when the questionnaires were left in a pile in the waiting room (50% versus 36%). The response rates for the Bath GPs, who all used the same delivery method (pile in a corner), were 85%, 74%, 44%, 8%, 44% and 90%.

Of the total sample that returned the questionnaires and reported that they had some difficulty with their hearing, 20% reported that they already had a hearing aid, 21% in Nottingham and 18% in Bath.

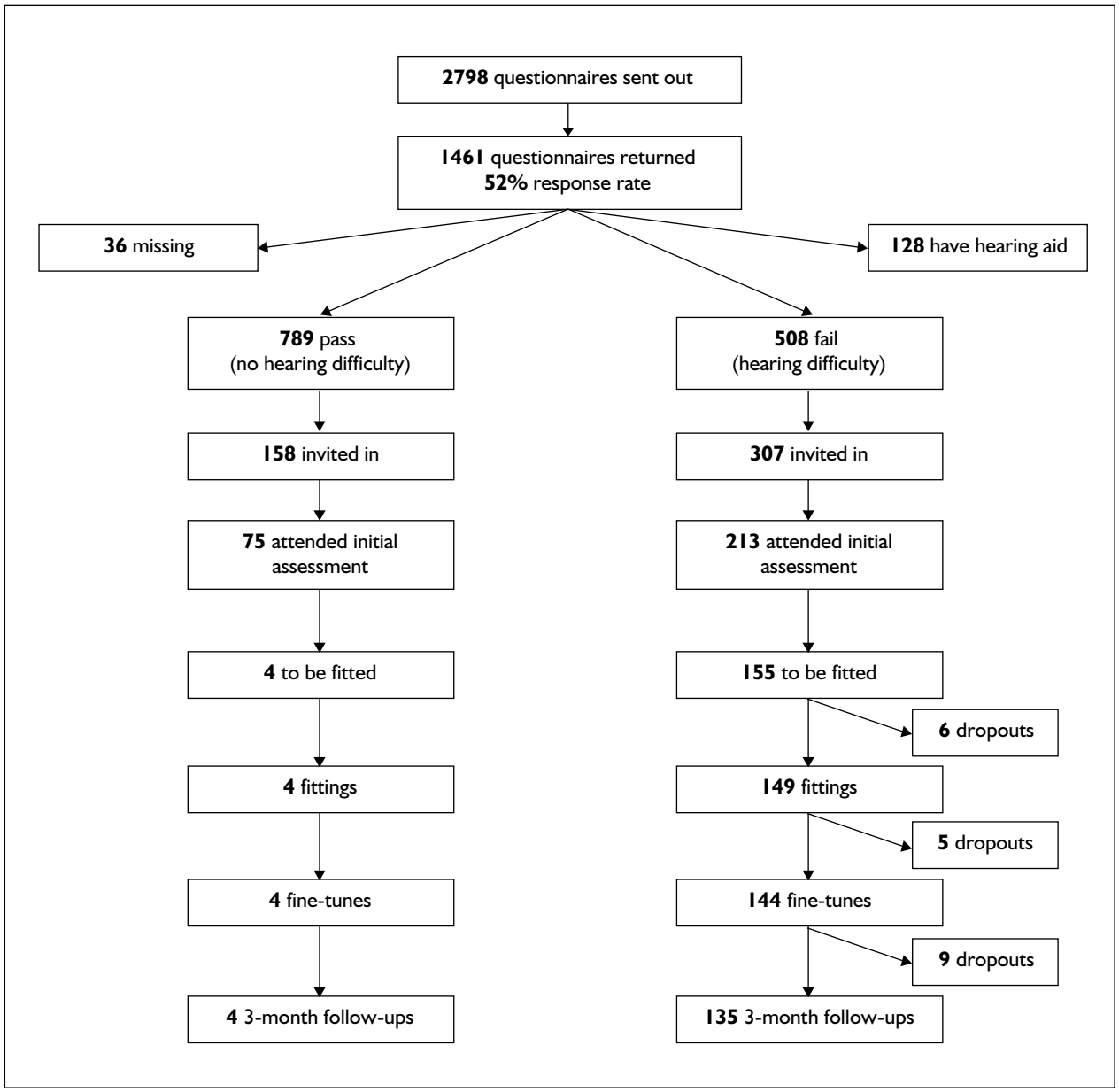

FIGURE 30 *Participant flow for the study overall*

Take-up of hearing assessment

In Nottingham, 96% of those people who failed the questionnaire screen (n = 266) were invited to come into the clinic for a hearing assessment and 184 (72%) attended. In Bath, the take-up of hearing assessment from the 52 participants who failed the screen and were invited to the clinic was 47 (90%), higher than in Nottingham.

Across GP practices, the take-up of the hearing assessment was more consistent and higher than the take-up of the questionnaire (*Figure 36*).

In Nottingham, 388 people reported that they had no difficulty with their hearing, 52% of all those who returned their questionnaires. Of these, 130 were invited for a hearing assessment as control participants, of whom 56 (43%) attended.

In Bath, 401 people reported no difficulty with their hearing, 56% of those who returned the questionnaires. Of these, 19 attended the clinic as control participants.

Demographics

The demographics of participants who attended the initial assessment appointment based on whether they failed or passed the GP screening questionnaire are shown in *Table 27*.

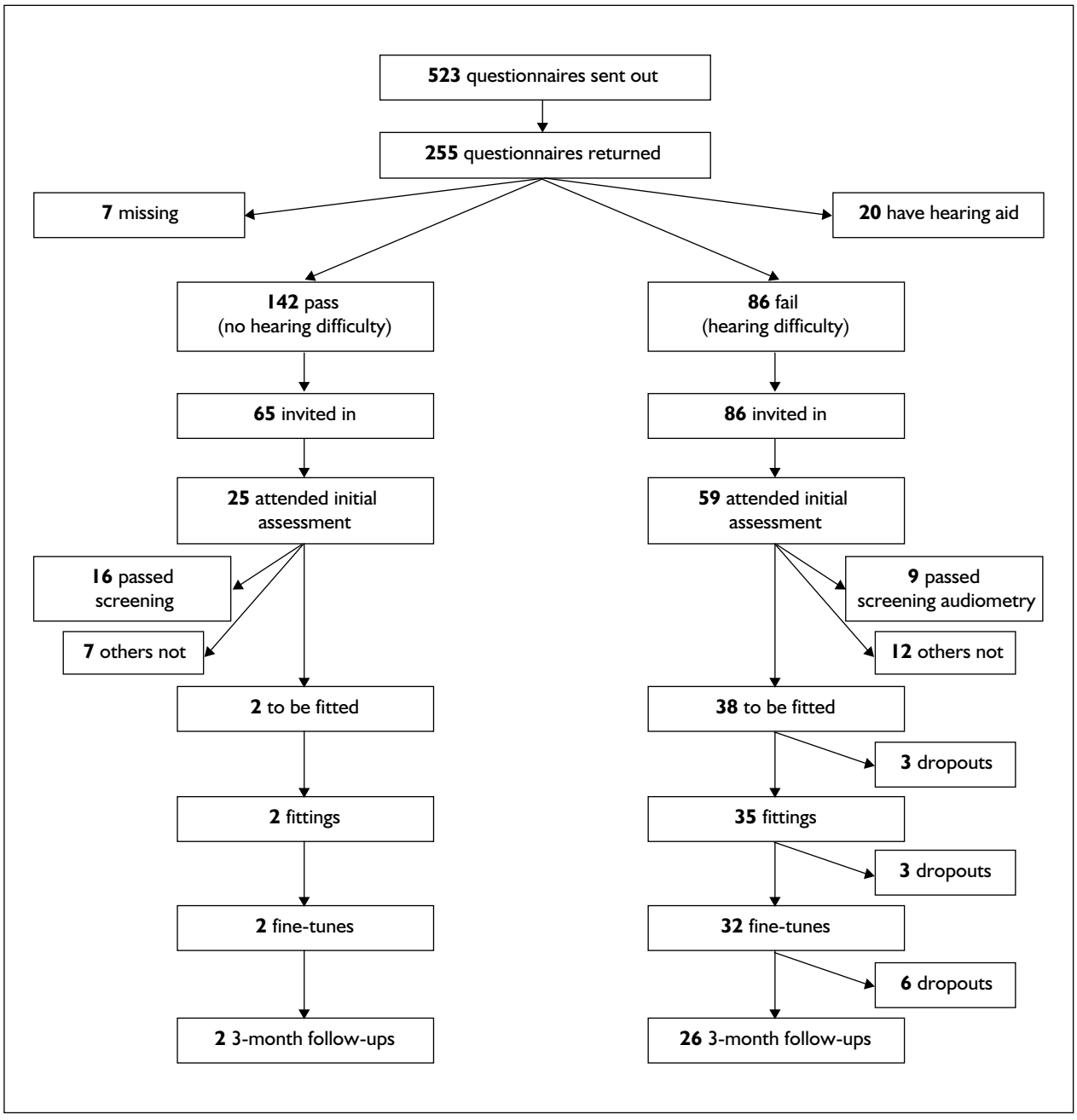

FIGURE 31 *Participant flow for Nottingham systematic screen*

For each site there was no significant difference in age between the groups who passed and those who failed, although the Bath participants were significantly older (mean 67.8 years) than the Nottingham participants (mean 64.8 years) (*t*-test, $p < 0.001$).

There were no significant differences in the better ear average (BEA) or worse ear average (WEA) across 0.5, 1, 2 and 4 kHz, between the Nottingham and Bath samples, although hearing was significantly better in those who passed the screen (*t*-test, $p < 0.001$).

There were no differences in gender between Nottingham and Bath, although the occupational grouping in Nottingham was significantly lower than that in Bath (Mann–Whitney, $p = 0.03$). There were very few people in the socio-economic group (SEG) category 'unskilled' in the Bath sample ($n = 2$; 4%) whereas there were 14% ($n = 33$) in the Nottingham sample.

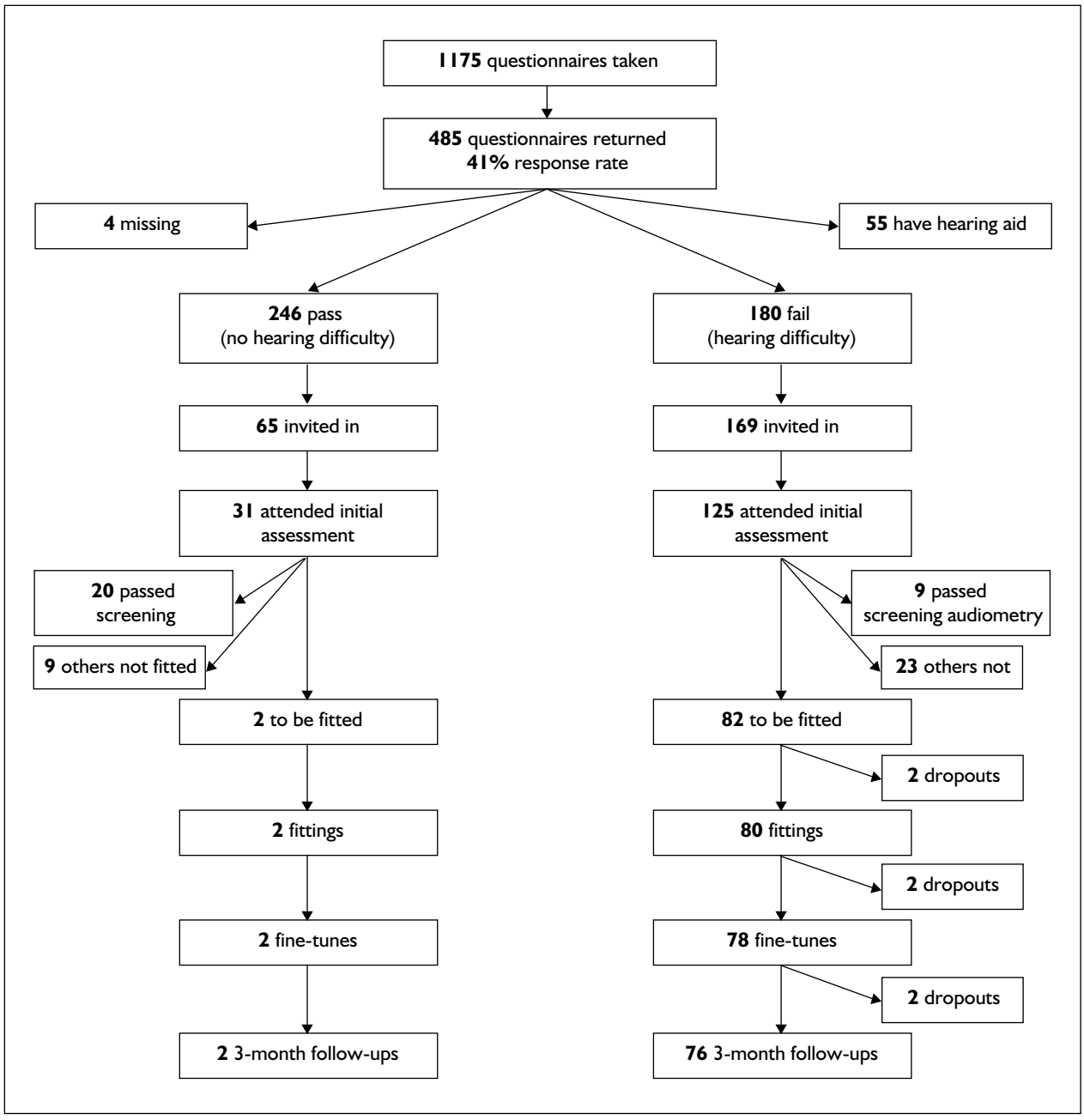

FIGURE 32 *Participant flow for Nottingham opportunistic screen*

Duration of hearing loss of those who failed the screening questionnaire

For those who attended the clinic and reported hearing difficulties, the median, interquartile range (IQR) and range of duration of hearing loss and time since the participants visited their GP are shown in *Figure 37*.

The mean duration of self-perceived hearing loss reported was 10 years, with a median between 5 and 6 years (the distribution was highly skewed). The duration of hearing loss increased to about 12 years for those who accepted hearing aids in this study. Although a large number of participants had reported hearing loss (45%) to their GP, none of these participants had been referred for any intervention, such as referral for a hearing test or a hearing aid.

Representativeness of clinic sample

The representativeness of those who attended the clinic compared with those who did not attend was examined in terms of age at the time the questionnaire was filled in, gender and the broad

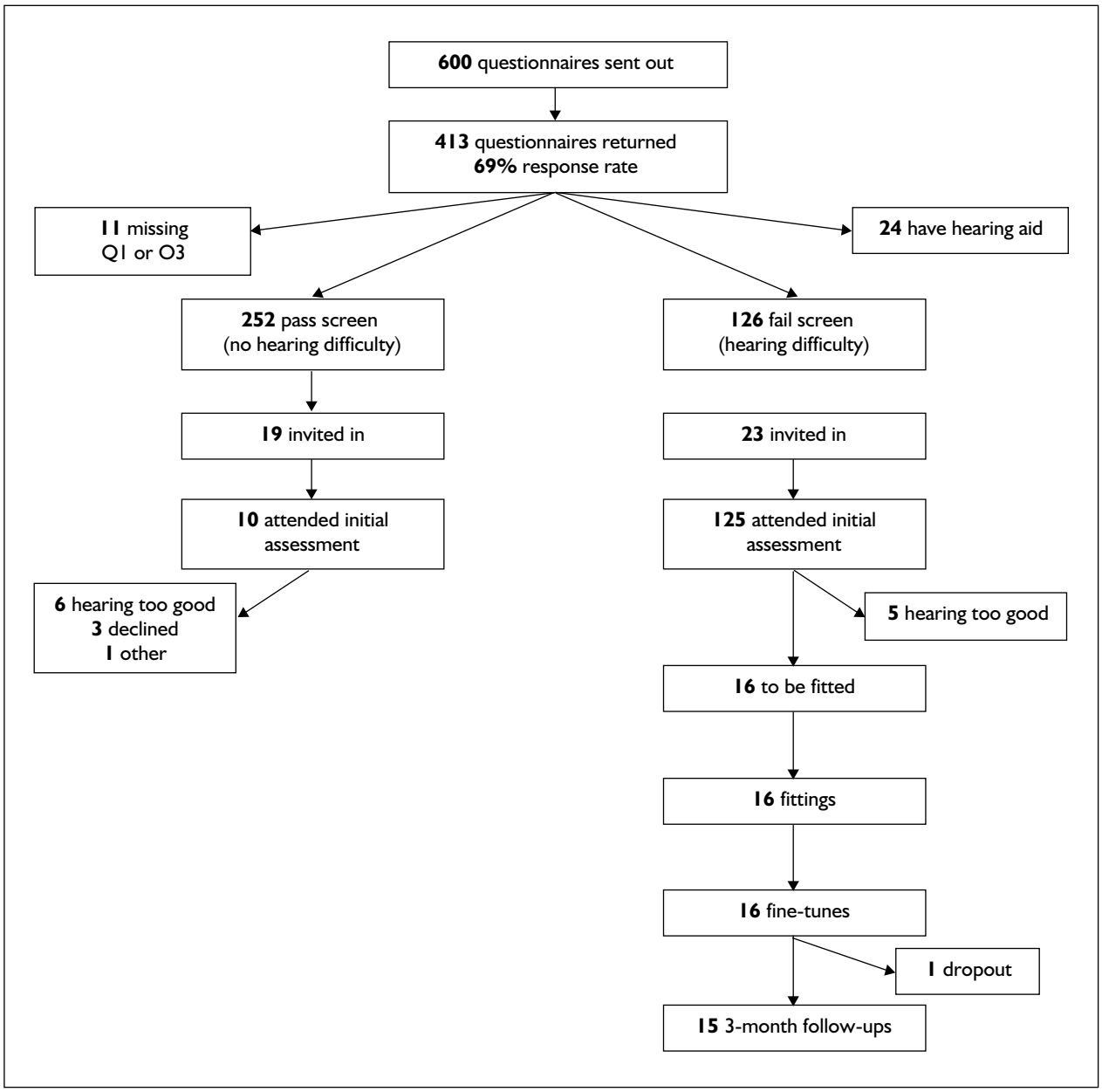

FIGURE 33 *Participant flow for Bath systematic screen*

categories of hearing difficulty from questions 3 and 4 on the screening questionnaire. This was done separately for those who failed and passed the screening questionnaire. The means and standard deviations are shown in *Table 28*.

There was no difference in age, gender or hearing difficulty between those who attended or did not attend for both the fail and pass groups for both Nottingham and Bath samples. This suggests that the sample attending the clinic was representative of the sample that returned the questionnaires. It is not possible to examine the occupational group further as this was not recorded on the questionnaire alone, but it can be assumed that the same difference between Bath and Nottingham would be found with the 'manual' occupational group being 57% in Nottingham and 34% in Bath.

Take-up of hearing aids

All participants who failed to hear one or more of the screening audiometry tones were invited to take part in the HAT. In addition, people who had low-frequency losses or who reported particular hearing difficulty even if their hearing loss was only slight were also invited to take part. In Nottingham, 124 participants agreed to be fitted

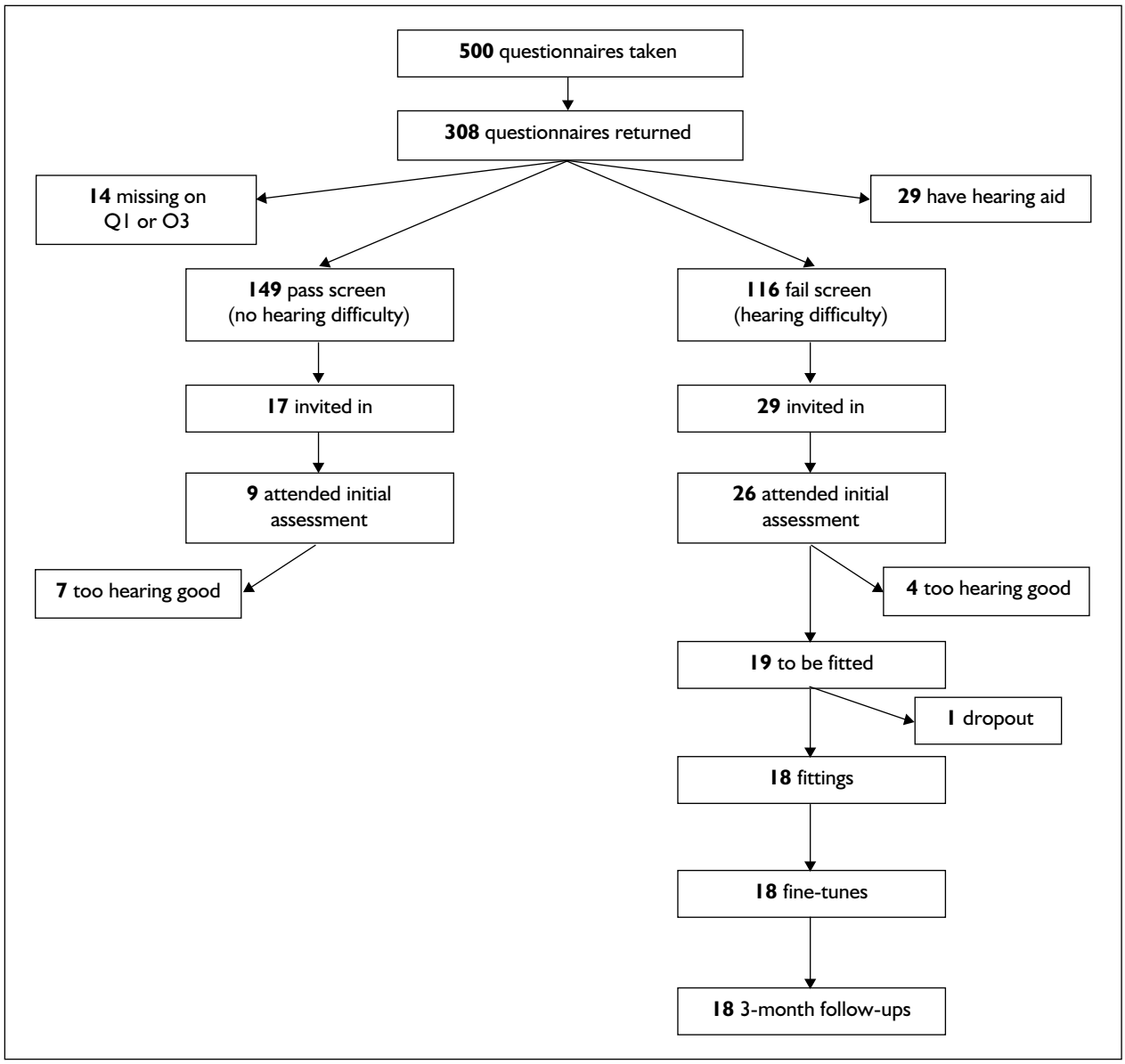

FIGURE 34 *Participant flow for Bath opportunistic screen*

with hearing aids, although five participants dropped out before the fitting appointment, so only 119 were fitted. In Bath, 34 of the 35 participants who agreed to take part in the HAT were fitted with hearing aids.

The BEA, WEA, age and gender of those who failed the questionnaire or audiometric screen and then went on either to accept or to decline hearing aids are shown in *Table 29*.

The main reason given by the participants who both failed the two-stage screen (i.e. reported that they had a hearing difficulty and did not hear at least one of the tones during screening audiometry) and declined to try hearing aids was that they thought that their hearing was not poor enough to need a hearing aid. In Nottingham 75% and in Bath 88% gave this as their reason for declining to try hearing aids. Hearing threshold level (HTL) was significantly worse in those who failed either screen and accepted an aid than in those who failed and declined an aid. This is consistent with the main reason given for not taking up the offer of an aid. In Nottingham, those who failed the screening questionnaire and who declined a hearing aid were significantly younger than those who accepted, and significantly more men than women accepted hearing aids. These differences were not significant for those who failed the screening audiometry.

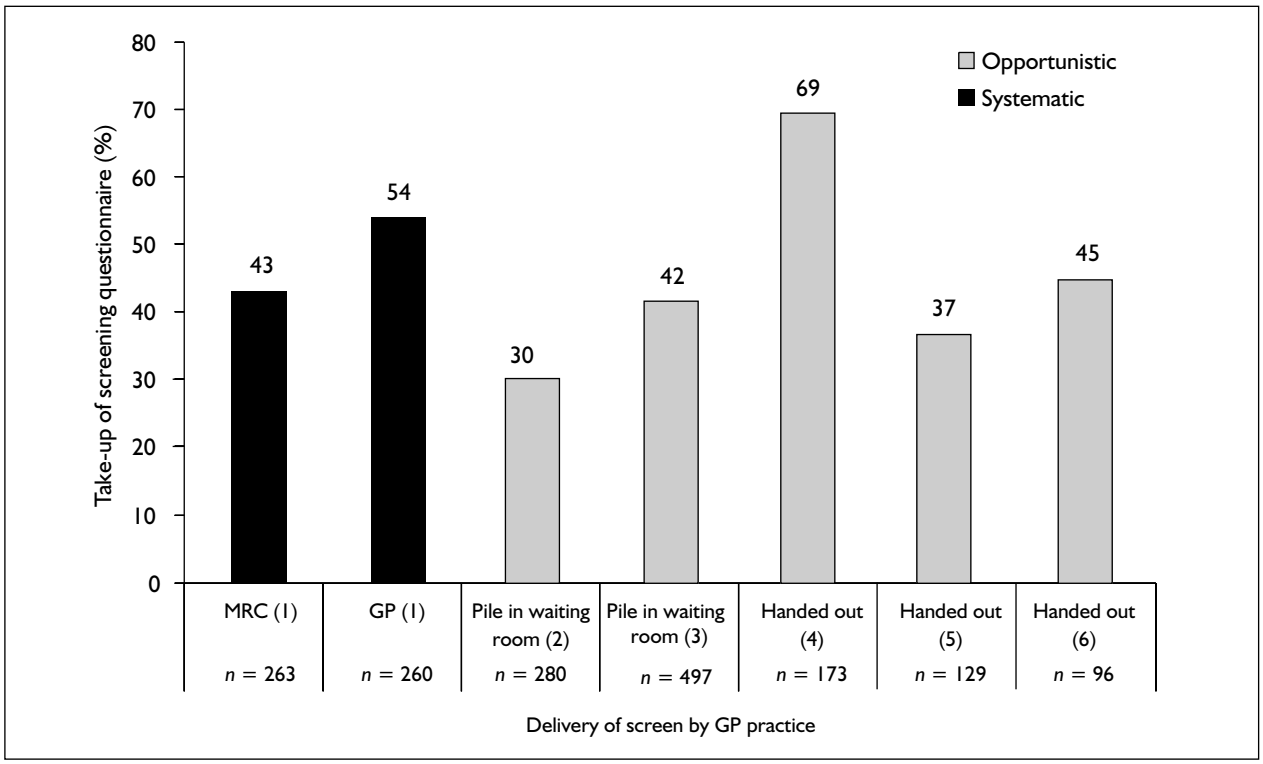

FIGURE 35 *Take-up of screening questionnaire by Nottingham GP practice for the different delivery methods. The systematic results show whether the questionnaire was sent from the MRC or the GP.* n = *the number of questionnaires taken. The surgery number is in parentheses.*

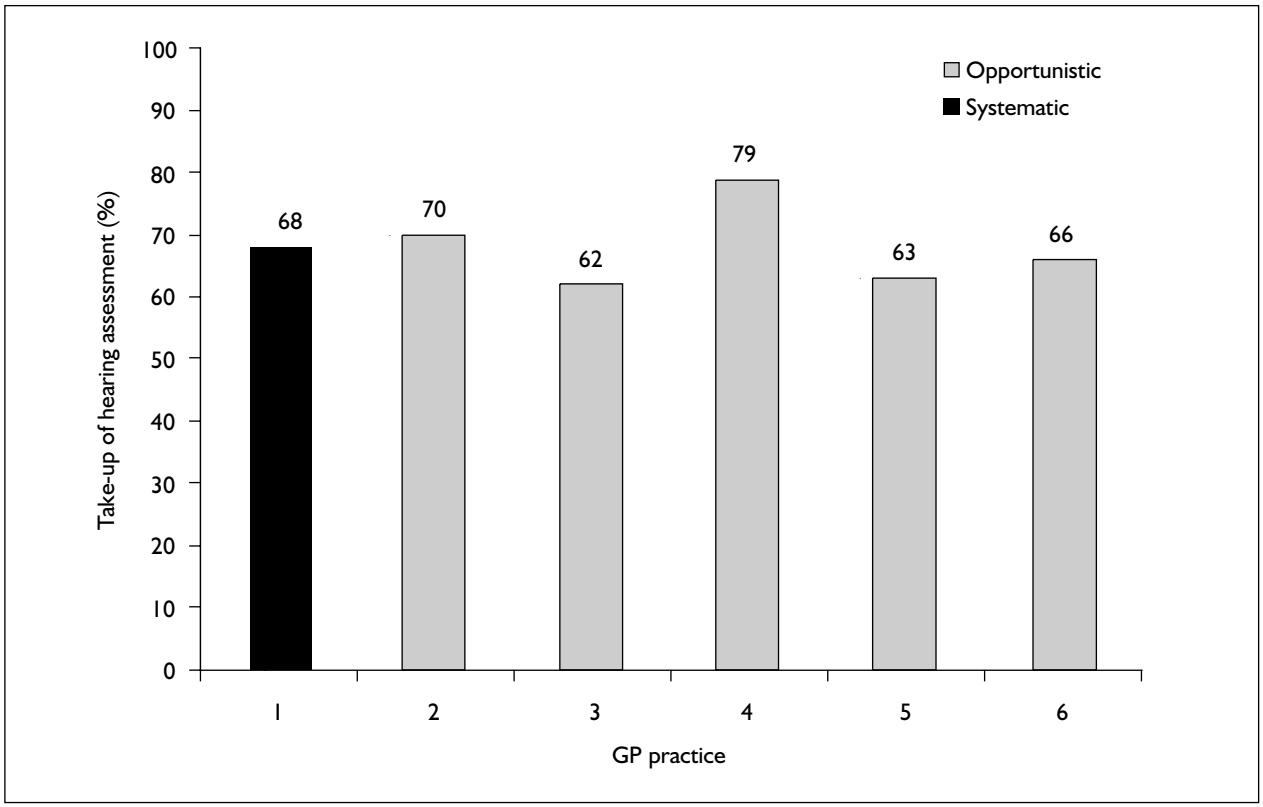

FIGURE 36 *Take-up of hearing assessment among those who failed the screening questionnaire by GP practice (Nottingham)*

TABLE 27 *Demographics of participants who attended the initial clinic appointment*

	Nottingham		Bath	
Screening questionnaire	**Failed**	**Passed**	**Failed**	**Passed**
No. attending clinic	184	56	47	19
Age (years), mean (SD)	65.0 (5.7)	64.5 (5.1)	67.4 (5.4)	68.7 (4.7)
BEA across 0.5, 1, 2 and 4 kHz (dB HL), mean (SD)	26.6 (12.2)	13.2 (8.5)	28.6 (13.5)	14.5 (10.3)
WEA across 0.5, 1, 2 and 4 kHz (dB HL), mean (SD)	36.0 (16.8)	18.6 (16.0)	36.5 (17.2)	18.6 (9.9)
Gender, *n* (%)				
Men	106 (57.6)	27 (51.8)	22 (53.2)	9 (52.6)
Women	78 (42.4)	29 (48.2)	25 (46.8)	10 (47.4)
Occupational group, *n* (%)				
Class I	13 (7.1)	4 (7.1)	3 (6.4)	1 (5.3)
Class II	42 (22.8)	16 (28.6)	16 (34.0)	11 (57.9)
Class IIIN	20 (10.9)	8 (14.3)	7 (14.9)	4 (21.1)
Class IIIM	77 (41.8)	21 (37.5)	19 (40.4)	
Class IV	24 (13.0)	6 (10.7)	–	1 (5.3)
Class V	3 (1.6)	–	–	2 (10.5)
NC	5 (2.7)	1 (1.8)	–	–
Don't know	–	–	2 (4.3)	–

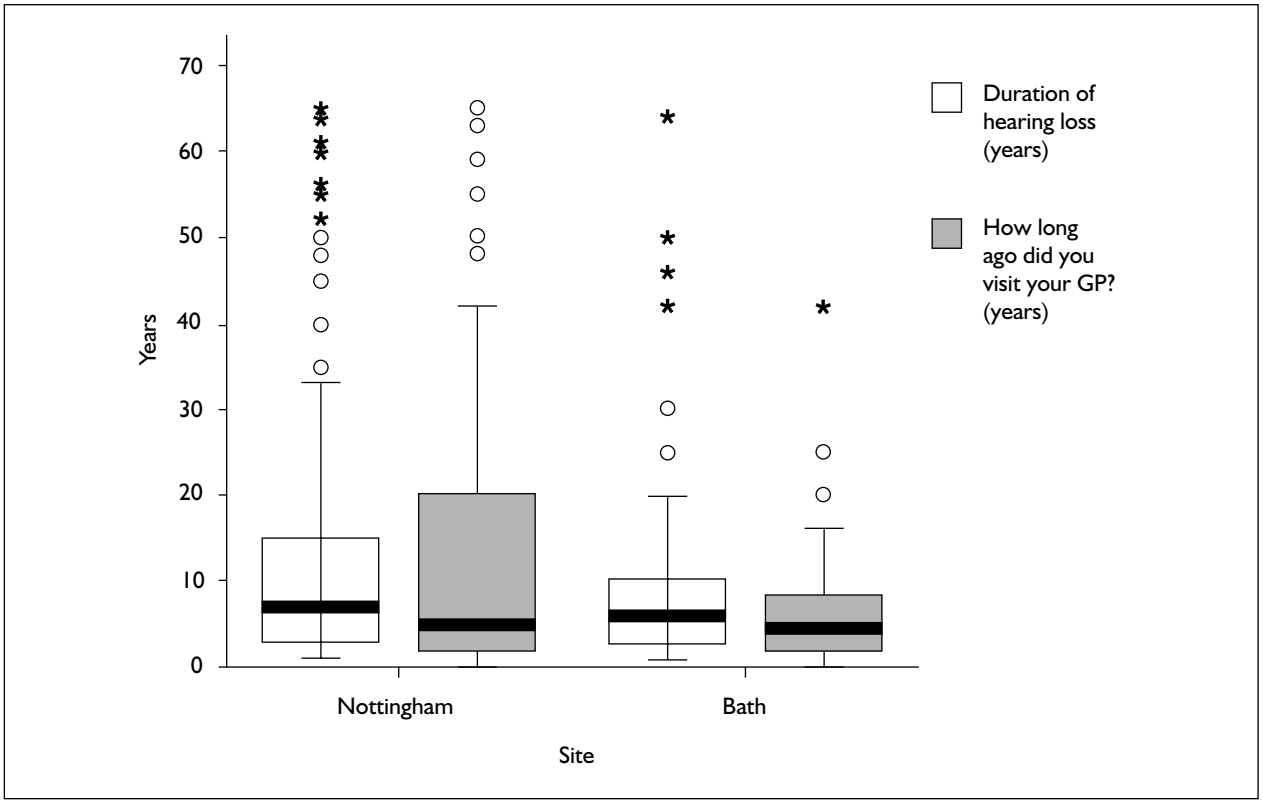

FIGURE 37 *Median, IQR and range of the duration of hearing loss in those people who reported hearing difficulties (Nottingham* n = *174, Bath* n = *46) and length of time since last visited GP about their hearing (Nottingham* n = *78, Bath* n = *21)*

TABLE 28 *Representativeness of sample attending clinic*

	Nottingham				Bath			
	Failed		Passed		Failed		Passed	
	Attend	Non-attend	Attend	Non-attend	Attend	Non-attend	Attend	Non-attend
n	184	88	56	333	47	195	19	382
Age (years), mean (SD)	64.9(5.8)	65.4 (7.3)	64.2 (5.3)	64.7 (5.8)	66.9 (5.5)	65.8 (6.2)	67.6 (4.7)	65.3 (5.8)
Gender, *n* (%)								
Men	106 (57.6)	38 (43.2)	27 (51.8)	141 (57.4)	22 (53.2)	97 (49.7)	9 (52.6)	167 (55.8)
Women	78 (42.4)	50 (56.8)	29 (48.2)	191 (42.3)	25 (46.8)	97 (49.7)	10 (47.4)	213 (43.7)
Q3, *n* (%)								
No difference	64 (34.8)	25 (28.4)	53 (94.6)	304 (91.3)	22 (46.8)	64 (32.8)	19 (100)	361 (94.5)
Sight difference	70 (38.0)	35 (39.7)	2 (3.6)	23 (6.9)	18 (38.3)	70 (35.9)	–	17 (4.5)
Moderate difference	32 (17.4)	21 (23.9)	–	4 (1.2)	7 (14.9)	39 (20.0)	–	1 (0.3)
Great difference	13 (7.1)	7 (8.0)	–	–	–	14 (7.2)	–	–
Can't hear	–	–	1 (1.8)	–	–	2 (1.0)	–	–
Missing	5 (2.7)	–	–	2 (0.6)	–	6 (3.1)	–	2 (0.5)
Q4, *n* (%)								
No difference	55 (29.9)	25 (28.4)	52 (94.6)	307 (92.2)	19 (40.4)	64 (32.8)	19 (100)	356 (93.2)
Sight difference	66 (35.9)	35 (39.8)	2 (3.6)	22 (6.6)	18 (38.3)	70 (35.9)	–	22 (5.8)
Moderate difference	41 (22.3)	18 (20.5)	–	1 (0.3)	6 (12.8)	39 (20.0)	–	–
Great difference	14 (7.5)	9 (10.2)	–	1 (0.3)	3 (6.4)	14 (7.2)	–	–
Can't hear	2 (1.1)	1 (1.1)	1 (1.8)	–	1 (2.1)	2 (1.0)	–	–
Missing	6 (3.3)	–	–	2 (0.6)	–	6 (3.1)	–	4 (1.0)

Age may be different here because the questionnaire was sent out some time before the participant attended the clinic.

TABLE 29 *Hearing threshold levels, age and gender of those who failed each screen and then either accepted or declined a hearing aid*

	Nottingham		Bath	
	Accepted	Declined	Accepted	Declined
Screening questionnaire n	120	60	35	12
Age (years), mean (SD)	66.4 (5.4)	62.6 (5.6)	67.4 (5.8)	67.5 (4.7)
BEA (0.5, 1, 2 and 4 kHz) (dB HL), mean (SD)	31.0 (10.8)	18.5 (10.5)	32.4 (12.1)	18.9 (10.8)
WEA (0.5, 1, 2 and 4 kHz) (dB HL), mean (SD)	40.4 (14.9)	27.6 (17.5)	40.9 (17.3)	24.9 (10.8)
Gender, *n* (%)				
Men	76 (63.3)	27 (45.0)	16 (47.7)	6 (46.1)
Women	44 (36.7)	33 (55.0)	18 (52.3)	7 (53.9)
Screening audiometry n	117	47	32	17
Age (years), mean (SD)	66.7 (5.2)	65.2 (4.9)	67.6 (5.7)	68.9 (4.5)
BEA (0.5, 1, 2 and 4 kHz) (dB HL), mean (SD)	31.2 (11.0)	23.0 (9.7)	32.9 (12.3)	22.2 (10.0)
WEA (0.5, 1, 2 and 4 kHz) (dB (HL), mean (SD)	40.7 (15.0)	35.7 (19.9)	40.9 (17.8)	28.2 (8.0)
Gender, *n* (%)				
Men	76 (65.0)	27 (57.4)	16 (50.0)	8 (47.0)
Women	41 (35.0)	20 (42.6)	16 (50.0)	9 (53.0)

Table 30 shows how the aid type was randomised to the participants and the numbers for aid type and number of aids fitted. Bilateral fittings were accepted in 74% of participants at both sites. There were more DFIIs (74%) fitted than Ergos (26%).

In the majority of cases where only one aid was fitted, this was because either the participant only needed one aid clinically (n = 17) or they thought that their hearing was not poor enough to be fitted with two aids (n = 12).

TABLE 30 *Number and percentage of participants in the randomised and fitted groups*

		1 × DFII	2 × DFII	1 × Ergo	2 × Ergo
As randomised	Nottingham		55		64
	Bath		16		19
As fitted	Nottingham	17 (14%)	57 (48%)	14 (12%)	31 (26%)
	Bath	5 (15%)	18 (53%)	4 (12%)	7 (21%)

The most common reason for deviation from the randomised allocation process was that the randomised aid was not suitable (n = 35). The main reason that DFII aids were fitted when the participant was randomised to Ergos was that the participants tended to have normal low-frequency thresholds (*Figure 38*).

The DFII has a better frequency shaping facility than the Ergo and so was better placed to reduce amplification where HTLs were normal. Reasons why Ergos were fitted instead of DFIIs were the presence of a conductive hearing loss or that the hearing loss was outside the fitting range for the DFII.

Figure 39 shows the BEA for the two groups that received the same aid type to which they were randomised, and the two groups who received a different aid to the one to which they were randomised. Those who were randomised to DFIIs and received Ergos had significantly worse hearing than the other three groups, consistent with the clinical reasons why planned randomisation could not always be achieved.

At the end of the HAT, the vast majority (96%) of participants said that they would continue to wear at least one aid, with 87% reporting that they would continue to wear both their aids. Of the three who said they would not continue to wear their aids, one had problems with ear wax and the other two had very mild hearing losses.

Hearing aid benefit outcomes

Three outcome measures were used to assess hearing aid benefit:

- FAAF test
- GHABP
- APHAB.

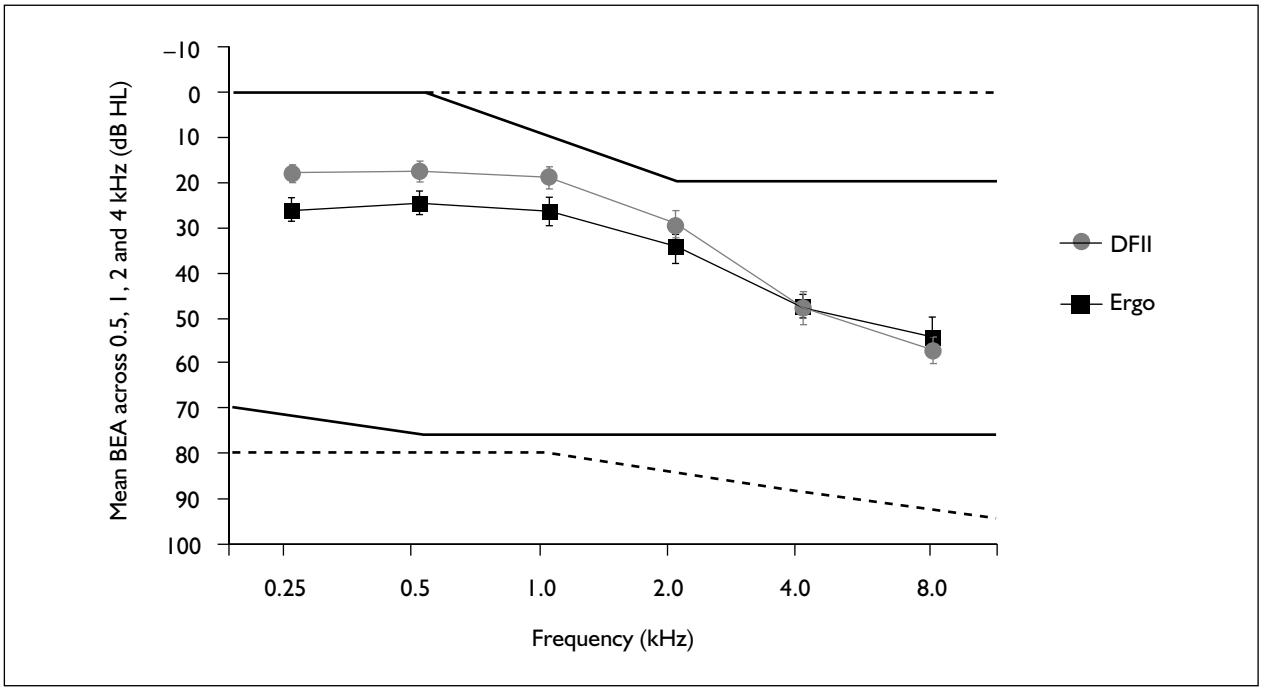

FIGURE 38 *Fitting ranges for the DFII (——) and Ergo (– – –) and mean BEA and 95% CIs for participants fitted with DFII and Ergo aids*

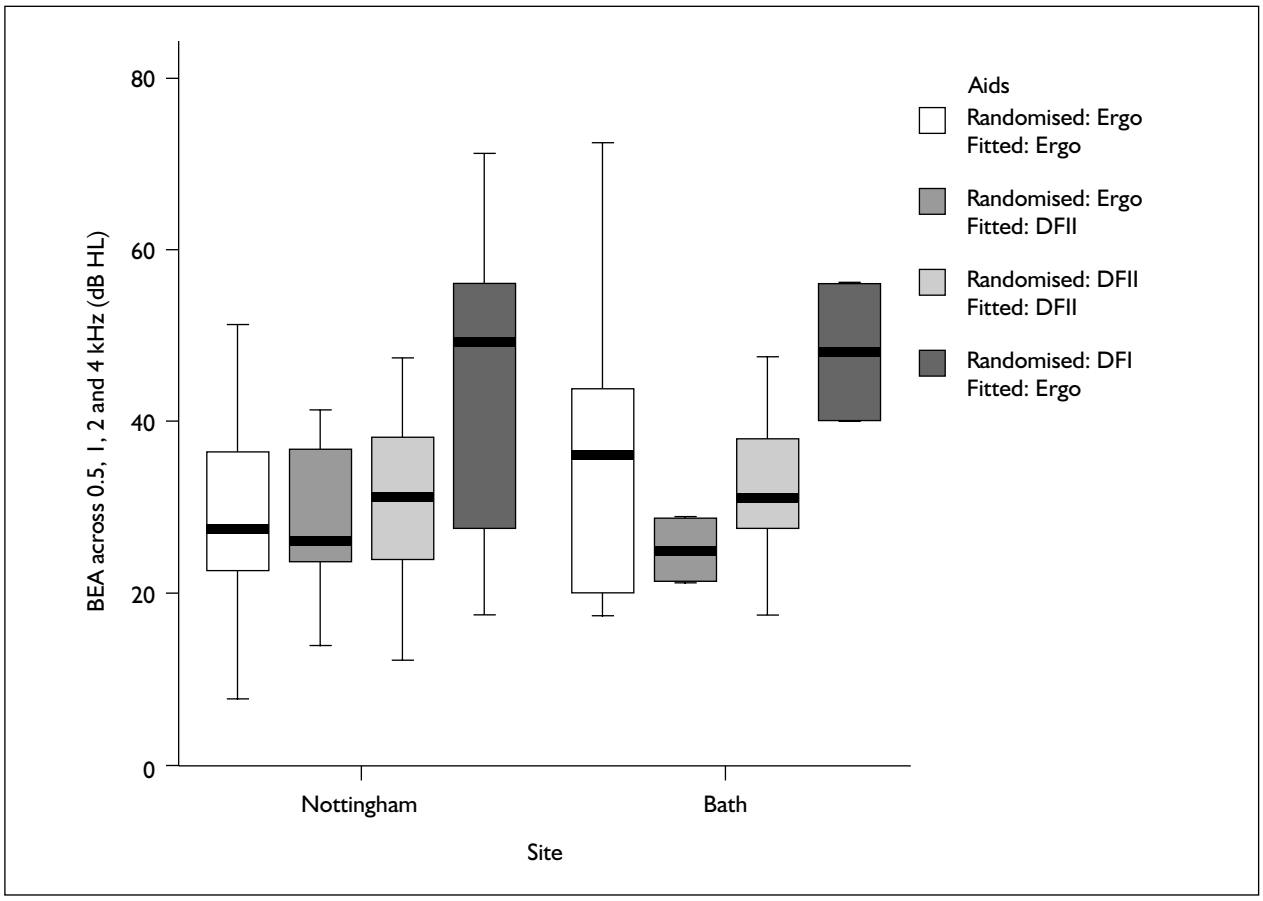

FIGURE 39 *Median, IQR and range of BEA across 0.5–4 kHz for groups according to how they were randomised and fitted by site*

As mentioned previously, the randomised group had different audiological profiles from the fitted group and so the outcome measures were examined for the sample as they were actually fitted (fitted) and the sample who were fitted with the same aid type to which they were randomised (randomised = fitted).

FAAF

Hearing aid benefit was derived from the difference between the aided and unaided FAAF scores. The median, IQR and range of the unaided, aided and benefit FAAF scores measured in speech in noise (SN) for each site are shown in *Figure 40(a)*.The mean and 95% confidence intervals are shown in *Figure 40(b)*.

There was a broad range of results for each of the measures, which was consistent with results seen in strand 1, stages 3 and 4. The Nottingham data in *Figure 40(b)* showed a significant increase in the aided FAAF scores compared with the unaided scores; that is, significant hearing aid benefit is seen. The mean benefit was 9.1 dB. The benefit seen in the Bath data was less (mean 3.9 dB), and reasons for this are explained below.

Although there were no differences in the aided scores between the two sites, the Nottingham sample scored significantly worse on the unaided scores, which resulted in the Nottingham sample showing more FAAF benefit. This could have been a result of the differences in occupational group, where Bath had fewer people in manual occupational groups and more people in higher SEG categories in the 'manual' occupational group.

There were no significant differences for BEA between the two sites overall, but for the male manual occupational groups there was a significant difference in unaided FAAF score (t = 2.3, 38 df, p = 0.03, separate variances), with Bath participants being 18% better. There was also a significant difference in better ear hearing average (t = 2.8, 22 df, p = 0.01, pooled variance), with Bath participants being 7 dB HL better. There were no other gender and occupational group differences in terms of unaided scores or of

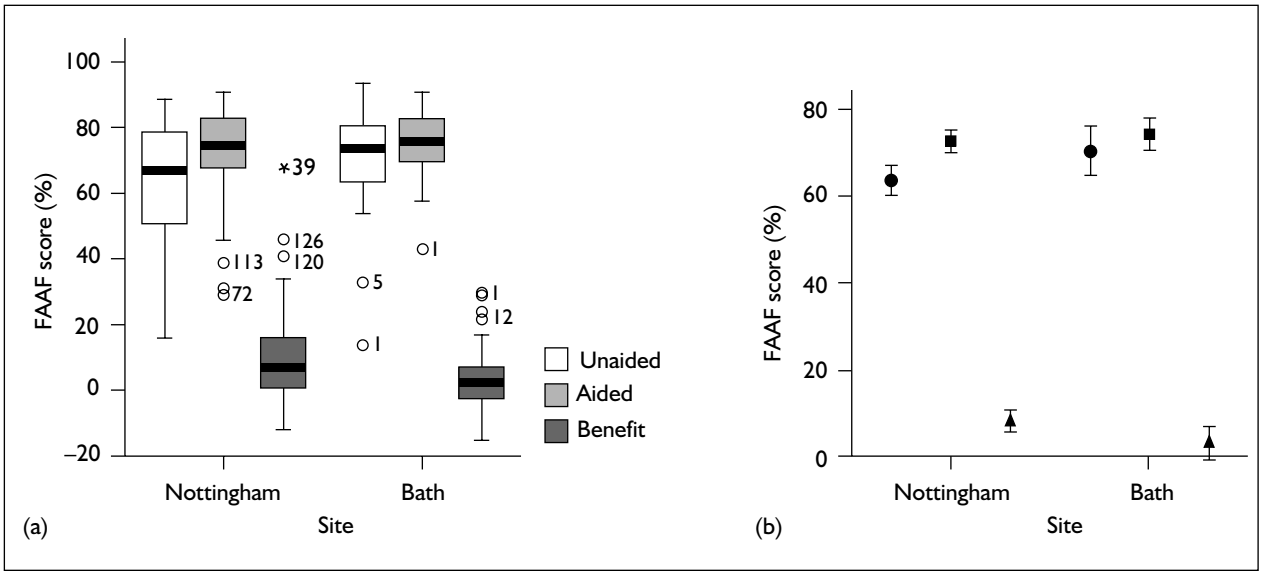

FIGURE 40 *Unaided, aided and FAAF benefit scores obtained at 3-month follow-up: (a) median, IQR and range, and (b) mean and 95% CI. ●, unaided, ■, aided, ▲, benefit.*

hearing level. The difference between sites is fully explained by the performance of male participants in Bath, who had a significantly higher SEG score (t = 2.1, 17 df, p = 0.05, separate variance).

Figure 41(a) shows that the distribution of the mean FAAF scores by BEA group varied between Nottingham and Bath.

It is clear that the unaided scores between sites differ. A possible reason for this is the differences in SEG being compounded by the small number of patients in the Bath sample (n = 33) compared with those in Nottingham (n = 102). *Figure 41(b)* shows the uniform increase in the FAAF benefit score with BEA group, when data sites were pooled. This shows that really substantial benefits were shown at 35–44 dB HL (10.6%, 95% CI 6.6 to 14.5%), which were due predominantly to lower unaided scores at 35–44 dB HL.

To examine further differences in FAAF benefit scores between the Bath and Nottingham samples, the scores were examined by aid type and by fitted and randomised = fitted groups (*Figure 42*).

The participants with Ergo aids showed more FAAF benefit than those with DFII aids. In the Bath sample, there was virtually no benefit seen for the DFII aids for either the fitted or the randomised = fitted groups. This was explained by the unaided and aided scores by aid type shown in *Table 31*.

For the fitted groups, there was no difference between the unaided scores for the Ergo users across sites, or for the aided scores for the DFII users, but there was a significant difference between the unaided scores for the DFII users across sites. Similar results were also seen for the randomised = fitted group, so this effectively ruled out any biases that might be inherent in the fitted group, such as age or hearing loss. This is reflected in the BEA scores shown in *Table 31*.

The testing procedures followed well-defined protocols that were carefully monitored across both sites throughout all phases of the testing: identical software was used and identical daily setting-up procedures were followed to set the output levels of the FAAF speech and noise stimuli. The number of participants who were fitted with DFII aids in Bath was low (n = 20). The difference in unaided DFII score between sites cannot be explained by test procedure or software, but was due to the SEG differences.

GHABP

The mean scores across data from both sites for the GHABP domains for the fitted group and the randomised = fitted group are shown in *Figure 43*. The residual disability scale has been reversed, so a high score represents a good outcome.

Those fitted with DFIIs reported less initial disability than those fitted with Ergos. This was

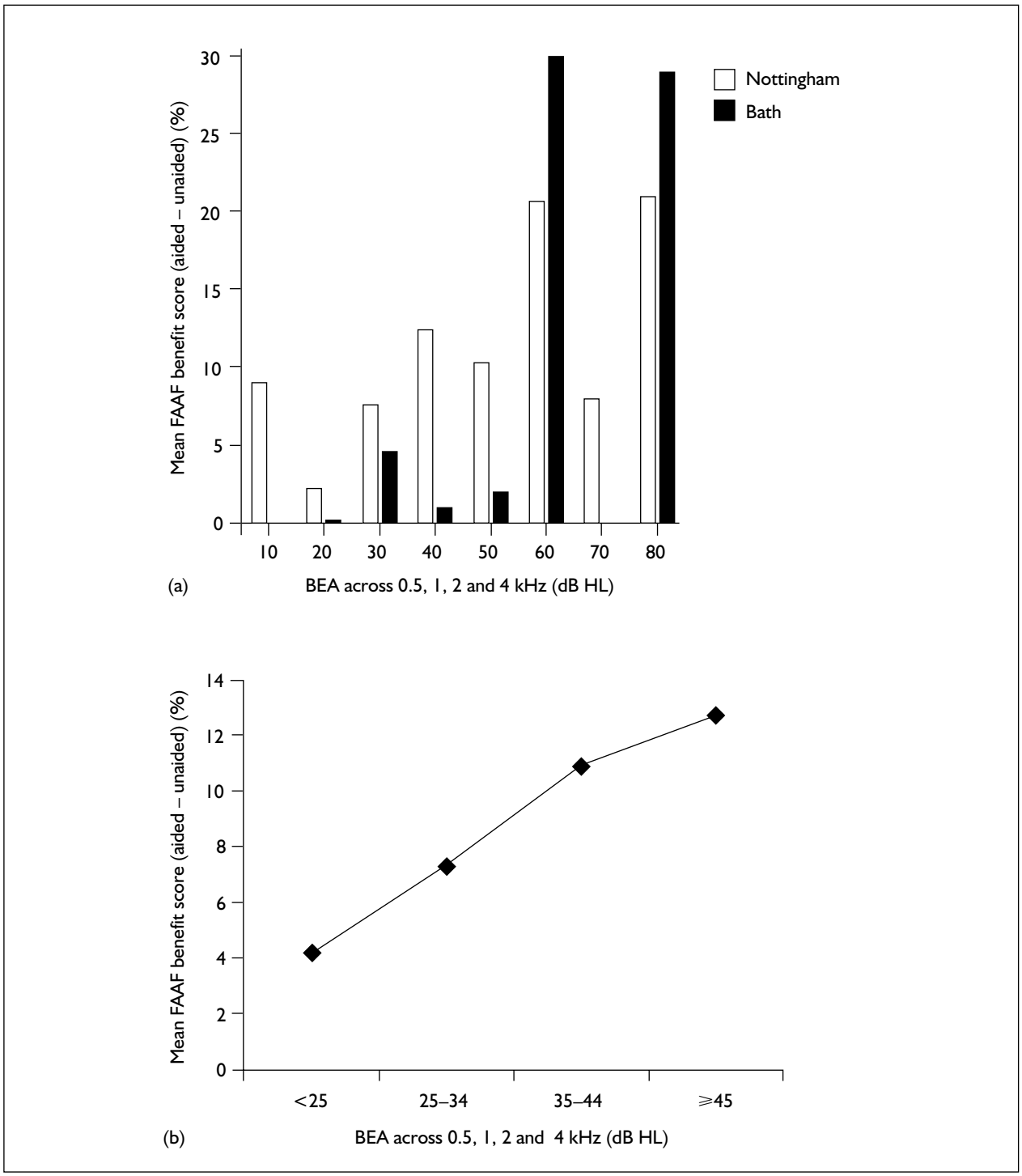

FIGURE 41 *Mean FAAF benefit scores against (a) BEA by site and (b) BEA when site data were pooled*

consistent with the difference in HTLs seen between the participants fitted with DFIIs and Ergos, although this difference was not significant. Overall, participants fitted with DFII aids showed slightly poorer GHABP outcomes than those fitted with Ergos, although these differences were not significant. Similar results were seen in the randomised = fitted group.

The mean GHABP outcome scores by BEA are shown in *Figure 44*.

Benefit, satisfaction and use all showed a steady increase in benefit for BEA greater than or equal to 25 dB. There was no change in the mean outcome measures for BEA less than 25 dB. Residual disability remained fairly constant across

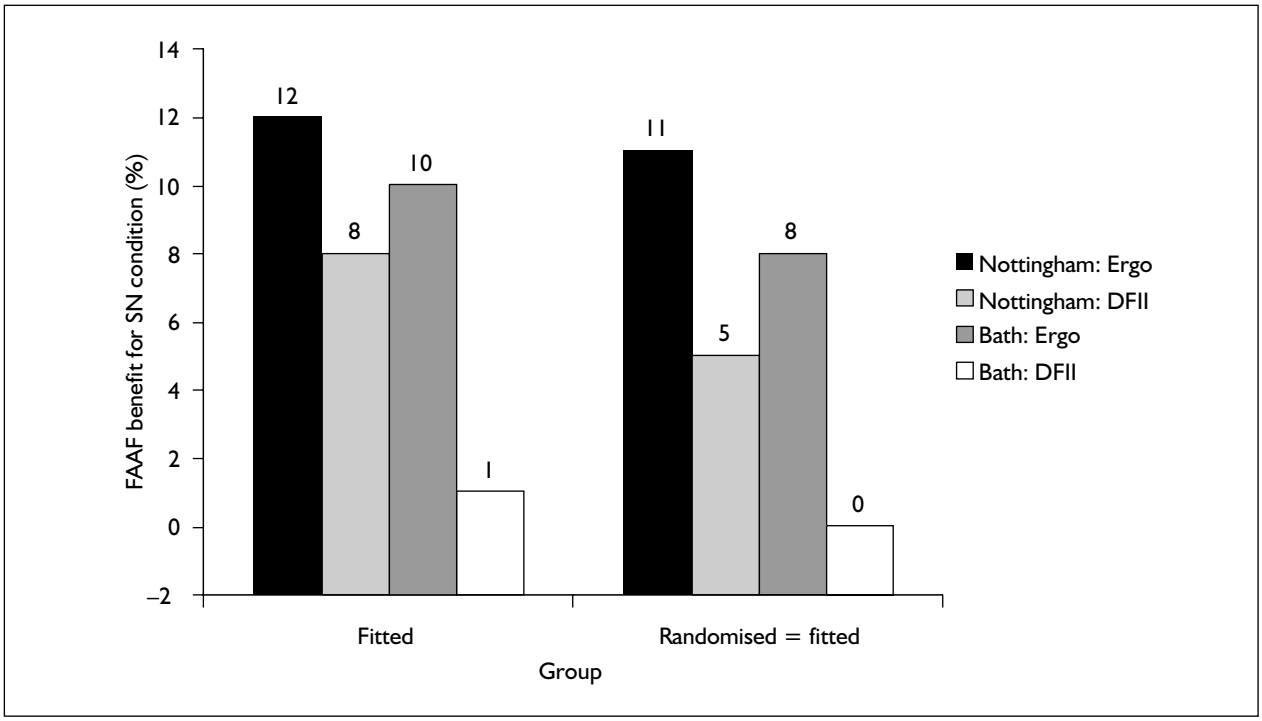

FIGURE 42 *Mean FAAF benefit score site and hearing aid type for the fitted and fitted = randomised groups*

TABLE 31 *Unaided and aided FAAF scores and BEA for fitted and randomised = fitted groups by hearing aid type and site*

		Fitted group		Randomised = fitted group	
		Ergo	**DFII**	**Ergo**	**DFII**
Nottingham	Unaided FAAF (%)	62	66	66	68
	Aided FAAF (%)	74	73	78	73
	BEA (dB HL)	32.7	29.4	29.1	30.4
Bath	Unaided FAAF (%)	65	74	68	74
	Aided FAAF (%)	75	75	77	74
	BEA (dB HL)	38.6	29.5	36.5	31.8

BEA. Although the GHABP outcomes are shown to improve with hearing loss, good outcomes of 50% or better were still reported by participants with only mild losses in the better hearing ear.

APHAB

The benefit scores for each scale were derived from the difference between the scores obtained to questions asked with the aid and without the aid at the 3-month follow-up. Positive scores show hearing aid benefit. The mean benefit scores of the pooled site data are shown in *Figures 45(a)* and *(b)* for the fitted group and randomised = fitted group, respectively, by aid type.

For all scales except for the aversiveness (AV) scale, the participants in the fitted group showed more benefit when hearing aids were worn than without, although this was significant only for the ease of communication scale (*t*-test, $p < 0.01$). The AV scale showed a significantly negative score (*t*-test, $p < 0.001$), which might be expected as one of the largest complaints about hearing aids is that background noises are amplified too loudly. The results were the same for the randomised = fitted group. Differences were shown between the hearing aid types (*t*-test, $p < 0.05$) for the fitted group only, where the Ergo performed better.

For all scales except for the AV scale, there was generally a steady, continuous increase in the benefit scores, with increasing BEA for all the scales (*Figure 46*).

Revealed disability derived from the difference in the initial disability scores without aids at the

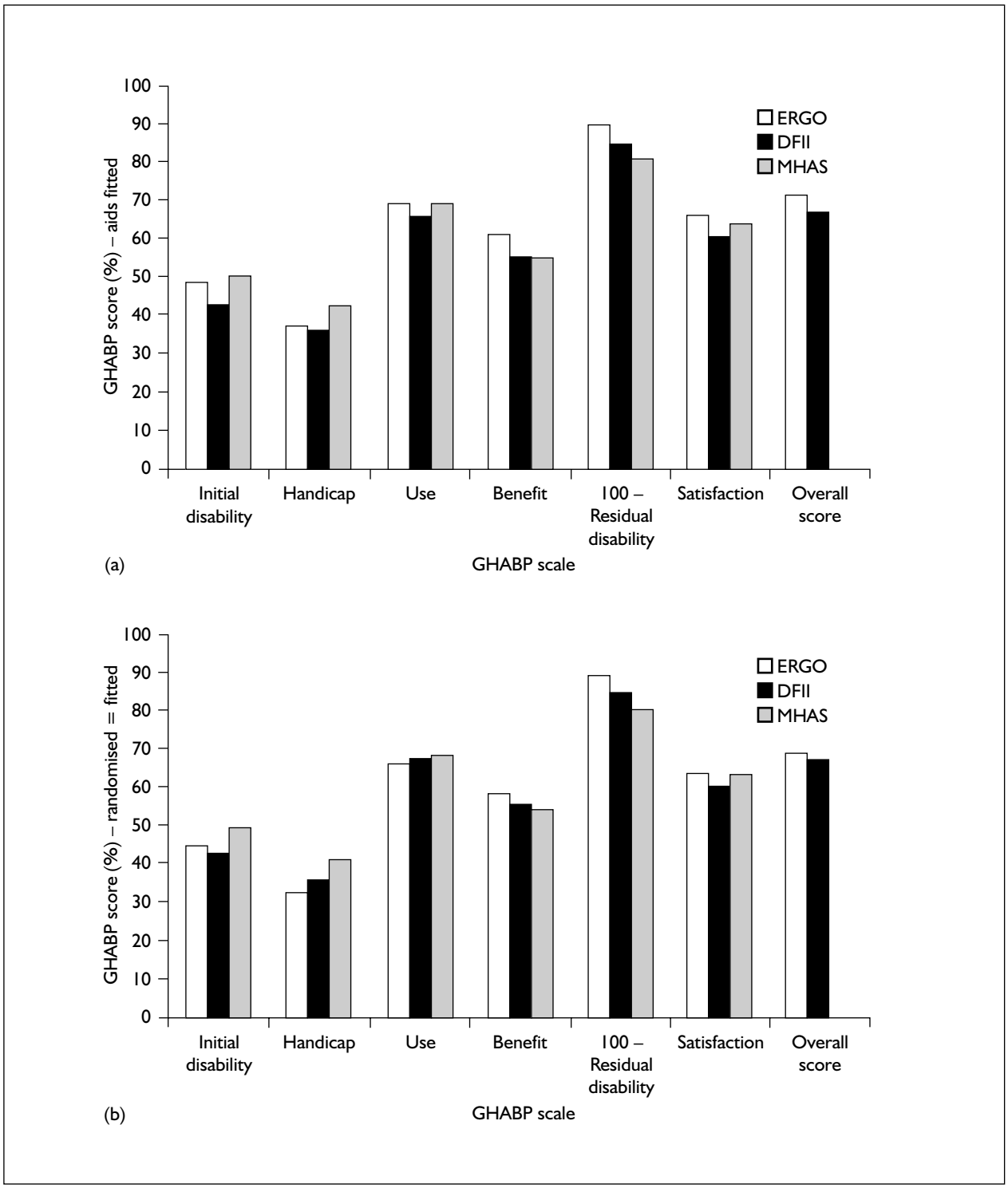

FIGURE 43 *Mean GHABP scores by hearing aid type for (a) the fitted group and (b) the randomised = fitted group*

fitting and at the 3-month follow-up showed the degree of disability that has been revealed to the hearing aid user after they have worn a hearing aid, and how much difficulty they had been having with their hearing before fitting. The results are shown in *Table 32*.

All the scores were negative, with the exception of the AV scale. This showed that participants reported more difficulties when not wearing their aids at the follow-up appointment than they did at the fitting appointment before they received their aids. This has implications as to when the

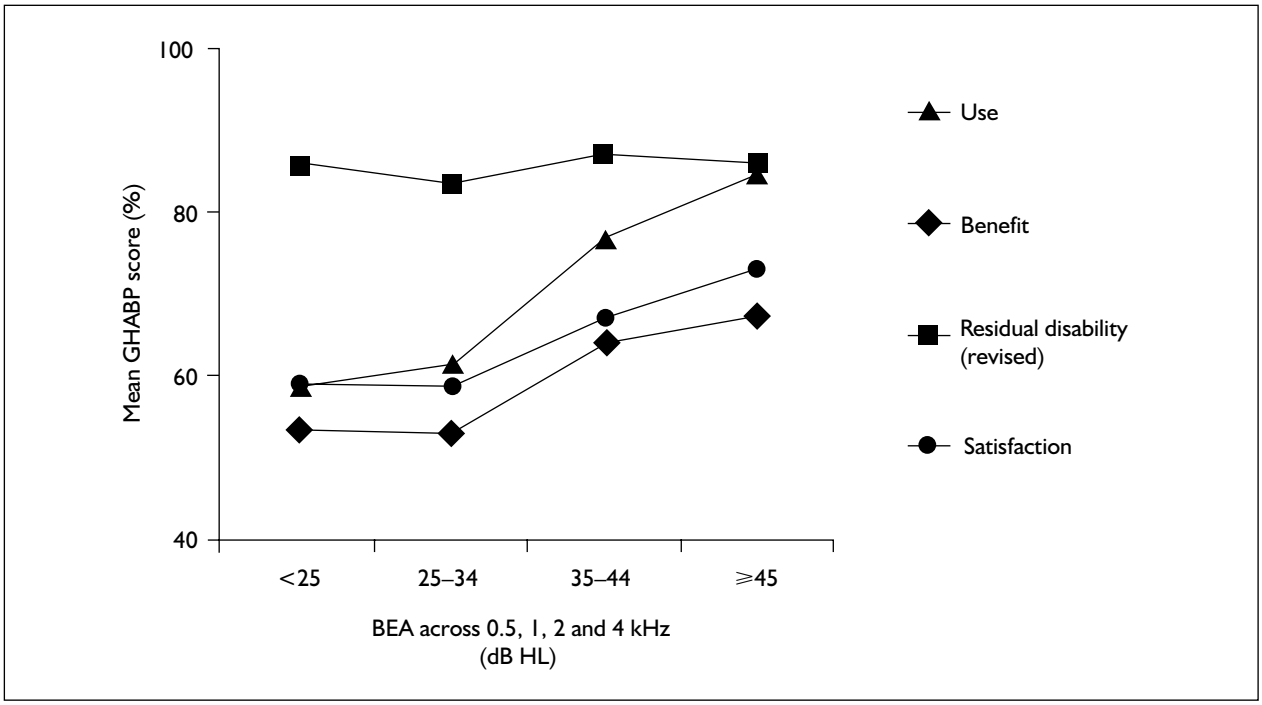

FIGURE 44 *Mean GHABP scores by BEA for the whole sample*

initial disability questions should be asked in the rehabilitation process.

Quality of life outcomes

The quality of life measures were analysed to see whether there were any changes after the intervention of providing hearing aid(s) or to see what factors might influence these measures or their change. In looking at change over time, only those cases where all the data were collected at both the initial visit and the follow-up visit at about 3 months after the provision of hearing aids could be used. Missing data were not inputted within individual questionnaires, which reduced the numbers that are available for analysis accordingly for each outcome variable.

Changes over time

For SF-6D there was a small improvement of 0.016 (SE 0.0079, 95% CI 0.001 to 0.031), with SF-6D improving from 0.744 to 0.759 (t = 1.96, 95 df, p = 0.05), which can be seen as about a 2% relative improvement in the mean and about 10% of the standard deviation of the SF-6D final measure (0.759, SD 0.15). This benefit was attributable mainly to a substantial improvement of 0.014 (t = 3.57, 93 df, p = 0.001) in the social functioning index, where people rate their response to the question 'does your health limit your social activities for none, little, some, most, all of the time?', to which 50% responded 'none' initially, which improved to 62% after provision of hearing aids. This is a 33% relative reduction in social dysfunction, which is a good improvement. No other dimension improved significantly.

For the HUI there was a moderate improvement of 0.075 (SE 0.019, 95% CI 0.038 to 0.112), with HUI improving from 0.713 to 0.788 (t = 4.053, 115 df, p = 0.001), which can be seen as over a 10% relative improvement in the mean and about 38% of the standard deviation of the HUI final measure (0.79 SD 0.20). This was almost totally due to the hearing dimension change from 0.886 to 0.940, which is a change of about 1 SD on the final measure. In reality, this equates to a change of category from not being able to hear and understand what is said without an aid in a group conversation or in a quiet room without a hearing aid, to being able to understand with a hearing aid; so it would be very poor if the intervention was not substantial on this metric.

For the QoFL there was a small improvement of 0.0149 (SE 0.0065, 95% CI 0.003 to 0.028), with the QoFL improving from 0.836 to 0.851 (t = 2.34, 106 df, p = 0.02), which can be seen as about a 2% relative change in the mean and about 15% of the SD of the final QoFL measure (0.0851, SD 0.085).

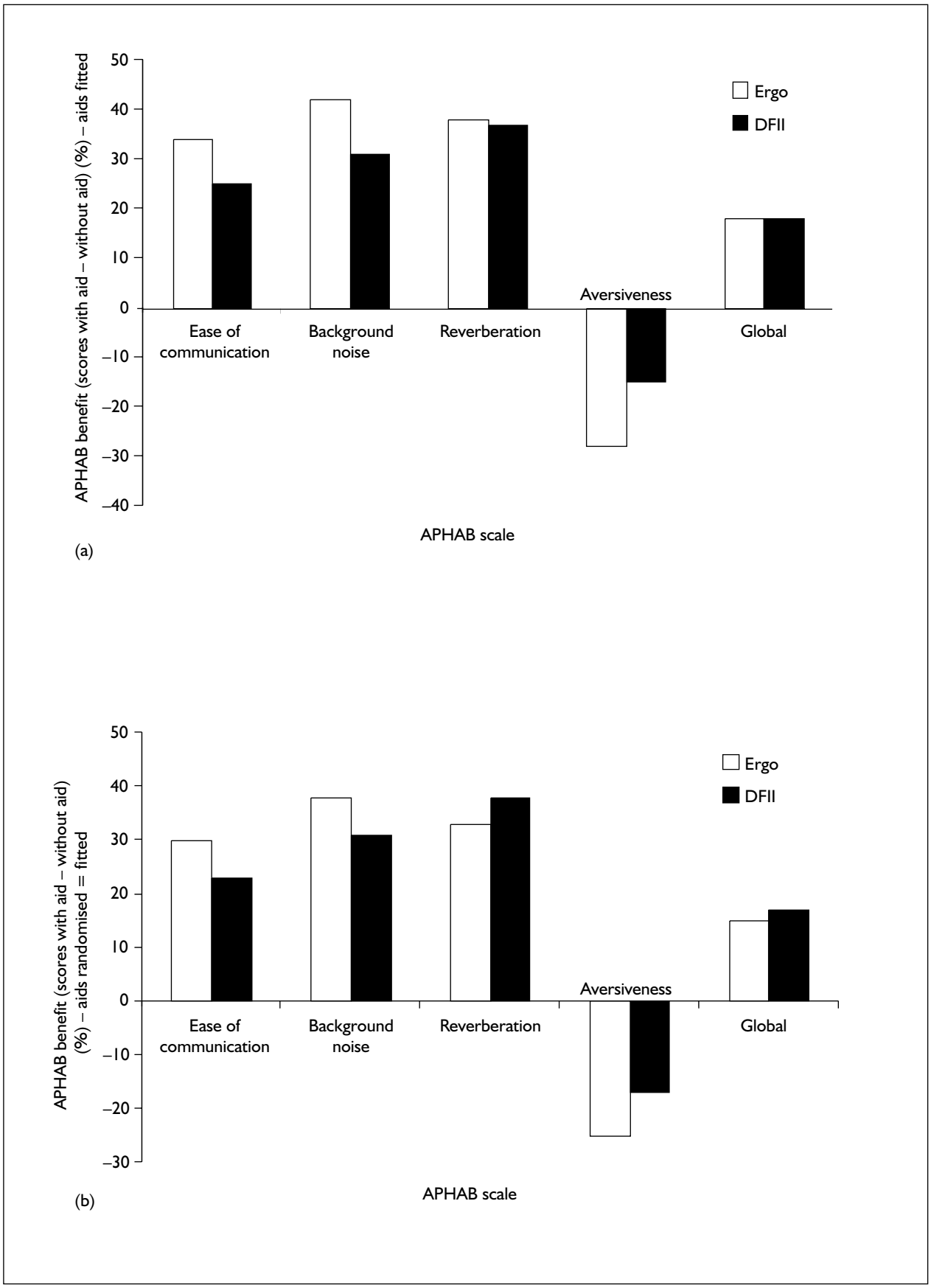

FIGURE 45 *Mean APHAB scores for the whole sample by hearing aid type for (a) the fitted group and (b) the randomised = fitted group*

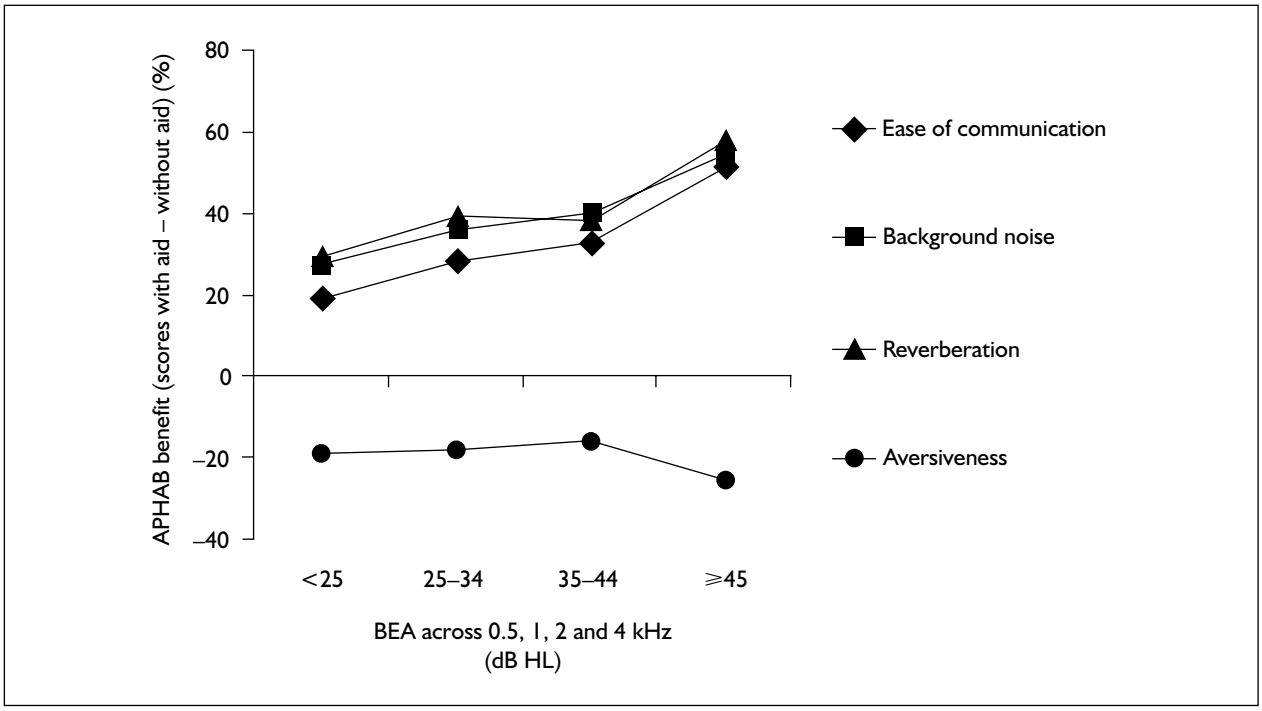

FIGURE 46 *Mean APHAB benefit scores by BEA for the whole sample*

TABLE 32 *Mean revealed disability scores for the APHAB, mean and SD (n = 135)*

Scale	Mean (%)	SD
Ease of communication	–6.1	17.6
Background noise	–4.8	17.9
Aversiveness	7.8	23.6
Reverberation	–2.0	12.1
Global score	–8.7	20.9

The changes seen here are very similar to those seen in strand 1, when hearing aids were fitted, where the improvement in SF-6D was 0.012 versus 0.016 shown here, in HUI was 0.069 versus 0.075 and in QoFL was 0.019 versus 0.015. These changes were consistent and together argue for a small but robust effect. However, to look at the changes in detail, the quality of life measures are not sensitive enough to distinguish different forms of intervention, for which condition-dependent outcome measures are needed. The results obtained in two parts of this study are consistent across the methods that were used to gather quality of life data. These benefits are very similar to those reported by Barton and colleagues.[40]

Factors affecting quality of life

There were weak correlations between the quality of life measure benefits, but stronger correlations between the initial quality of life measure and these correlations were reduced with the intervention. The change in QoFL was related to the change in SF-6D. The change in the HUI score was such that if the benefit was shown on the SF-6D and HUI then there was substantial benefit in QoFL (0.033). If there was disbenefit from the intervention it had no effect on the QoFL; however, if there was lack of agreement between the HUI and SF-6D then there was significant decrease in the QoFL (–0.048). This suggests that the HRQoL measures probably measure different elements of the state and changes (as suggested above) and that it is only when the several elements are improved together that QoFL improves. Indeed, improvement in one domain but not another may lead to poorer QoFL (and hopefully resolution of remaining rehabilitative issues, if action is taken in the future).

To examine the impact of major design aspects on the quality of life the following factors were assigned:

- the degree of hearing impairment (better than 35 dB HL versus 35 dB HL or greater average hearing threshold)
- tinnitus (no current tinnitus or tinnitus)
- whether two hearing aids were used or one
- whether Ergo or DFII hearing aids.

Analysis is reported for aids worn rather than as assigned, as when the intention-to-treat (ITT)

TABLE 33 *Age and BEA across 0.5–4 kHz, and distribution of gender, hearing aid type and number of aids fitted for the present study and the DigIT study*

	Study	
	Present	**DigIT**
Age (years), mean (SD)	66.4 (5.3)	70 (2.9)
BEA (0.5–4 kHz) (dB HL), mean (SD)	30.7 (10.9)	35 (9.8)
Gender, *n* (%)		
Male	72 (64)	55 (57)
Female	41 (36)	41 (42)
Hearing aids fitted		
DFII	74 (62)	61 (64)
Ergo	44 (36)	35 (37)
No. of hearing aids fitted		
Two	88 (74)	8 (9)
One	31 (26)	88 (92)

variable (not in allocated group versus in allocated group) was used in the analysis, essentially the same results were shown. There were no significant main effects or interactions between the ITT factor and the design factors (hearing aid type and number) or patient characteristic (severity of hearing impairment or tinnitus) on the quality of life or QoFL outcomes.

There were no significant effects of the type of hearing aid or fitting on the change in SF-6D or its domains. Nor was there any effect of the degree of hearing impairment in the better ear. There was an effect on initial SF-6D score of the degree of hearing loss in those who reported tinnitus at the time of the initial clinical assessment ($F_{1,94} = 7.3$, $p = 0.008$) where this tinnitus group, who had an average hearing loss of 35 dB HL or more in the better ear, had SF-6D scores that were between 0.12 below the average score (0.74). The major factor that impacted on the degree of benefit measure by SF-6D was related to the groups who had tinnitus ($F_{1,81} = 7.4$, $p = 0.008$), where the change was 0.04 in those who had initially reported tinnitus.

There were no substantial, statistically significant factors that affected the change in HUI scores, before and after provision of hearing aids.

Tinnitus did have an effect on the change in QoFL scores, with a change of 0.029 in those who reported tinnitus initially ($F_{1,87} = 3.64$, $p = 0.059$) compared with 0.005 in those who did not. There was some evidence that this change was greater in those who used the DFII hearing aids than in those who used the Ergo hearing aids. However, those who ended up using the DFII hearing aids were more impaired at the higher frequencies, e.g. 4 kHz 51dB HL for DFII with tinnitus versus 46 dB HL for Ergo with tinnitus. When hearing level at 3 kHz was used as a covariate instead of a factor, this interaction was not significant.

Comparison of outcomes with other studies

The GHABP and APHAB benefit data from the current study were compared against the pilot MHAS study carried out in Nottingham, known as the DigIT study.[60] Comparison was made with this study because the study protocols were very similar and the same hearing aids were used. To be consistent with the current study, only data from DigIT participants aged 55–74 years were analysed. The distribution of age, BEA across 0.5–4 kHz, gender and hearing aids fitted between the present study and the 55–74 year olds in the DigIT study are shown in *Table 33*.

There was a significant difference between age and BEA between the two studies: the DigIT group had more hearing loss and were older (*t*-test, $p < 0.001$).

The distribution of aid type between the two studies was very similar: about two-thirds of the aids fitted were DFII, although significantly more bilateral aids were fitted in the present study than in the DigIT study.

The means of the GHABP and APHAB benefit scores for the two studies are shown in *Figure 47*.

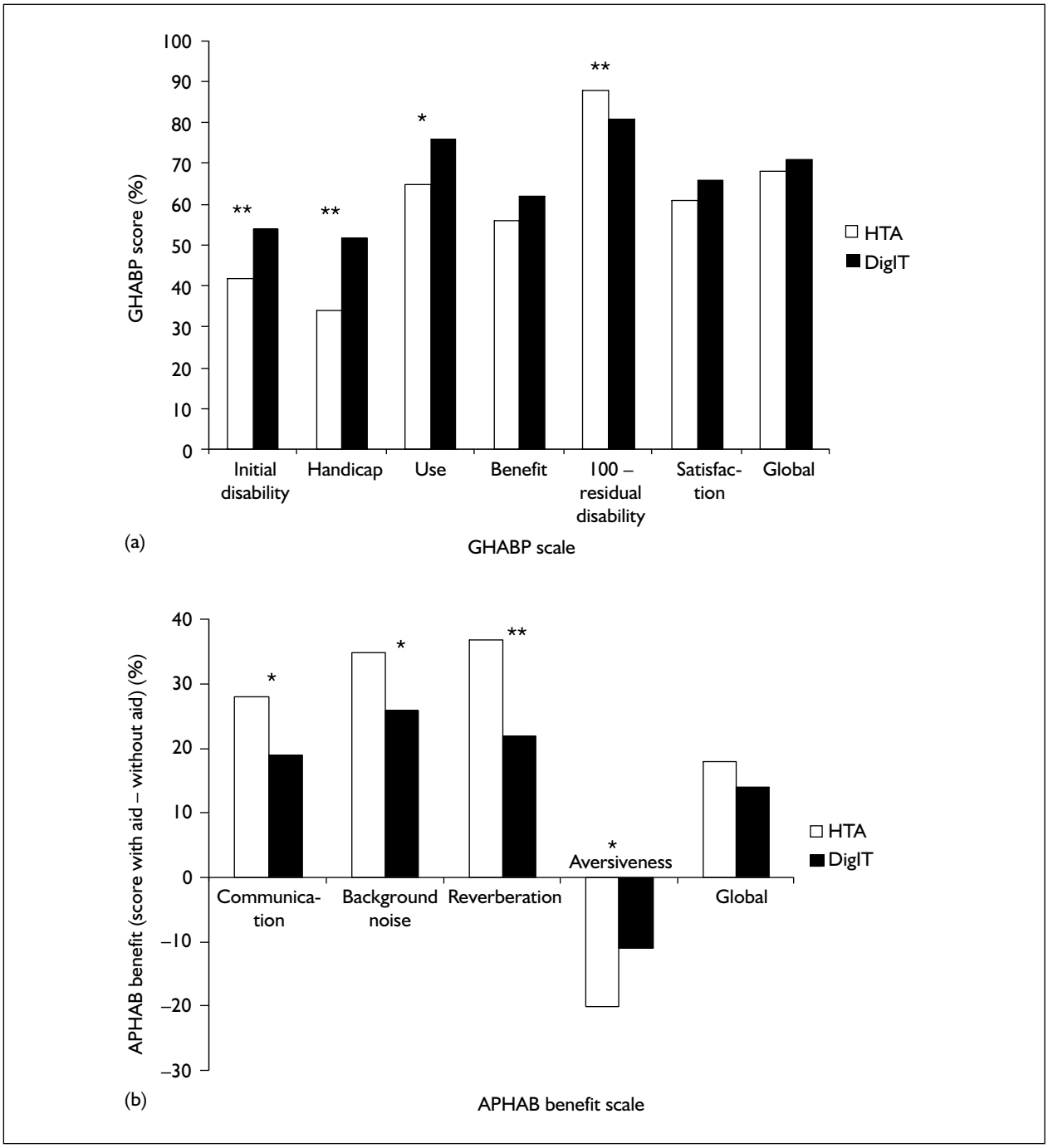

FIGURE 47 *Mean scores for the current and DigIT study for (a) the GHABP and (b) APHAB benefit score.* **p ⩽ *0.001* *p ⩽ *0.01 (t-test).*

The DigIT group showed significantly more initial disability and handicap, poorer residual disability and more aid use, which probably reflects the poorer hearing in this group. Although the DigIT group showed about 5% more benefit and satisfaction than the present study, this difference was not significant.

For all APHAB scales except aversiveness (AV), the present study reported significantly more benefit than the DigIT study. The AV score was negative for both studies, showing that aversion to noise when wearing the hearing aids was worse than when the aids were worn, which is to be expected. The present study reported more AV than the

DigIT study, which may be because hearing levels overall were better in the present study.

Apart from the GHABP use and the APHAB AV scores, the outcomes from the present study were either no different from or better than the outcomes from the DigIT study, despite the latter study group having more hearing loss and reporting more initial disability. As most of the outcome measures here show a trend towards increasing benefit with increased hearing loss, the greater hearing loss and initial disability shown in the DigIT study might suggest that the outcome measures from the DigIT study would, in fact, be better than the present study. However, it is possible that in the present study there may be greater benefits from intervention reflected in the outcome measures because of the way the screening programme brought people into the rehabilitative process earlier than would otherwise have been the case. This would avoid many years of frustration for the individual and for their families.

Clinical validity of screening questionnaire

The screening questionnaire that was filled in either in the GP's surgery or at home was repeated in the clinic by interview with an audiologist. The results for the screening questions 1–4 are shown in *Tables 34* and *35*.

There was very high clinical validity in the GP screening questionnaire and the clinic interview for Q1, 'Do you have any difficulty with your hearing?, and Q2, 'Do you find it very difficult to follow a conversation if there is background noise (such as TV, radio, children playing)?'.

There was more variability for Q3 and Q4: 'How well do you hear someone talking to you when that person is sitting on your RIGHT side (4. LEFT side) in a quiet room?'

For these questions, participants who reported 'No difficulty' on the GP questionnaire were highly consistent in reporting the same response at the interview. Some variability was seen from the participants who said that they had some degree of difficulty on the original questionnaire.

Where a response did differ between the original questionnaire and interview, the interview response generally gave a more positive picture than the response on the GP questionnaire. This may be because the participants were being interviewed in a quiet room by audiologists who are experienced at talking to hearing-impaired people and do so clearly and at an appropriate loudness level. In these optimal conditions the participants may well have experienced less difficulty hearing in the clinic than they thought they did when originally filling in the questionnaire. The advantage of the difference in the responses (GP versus clinic) occurring in this direction (i.e. the original answer results in a more negative response) is that this increases the sensitivity of the screening questions and ensures that those who genuinely have hearing difficulty are identified. The disadvantage is an increased FAR.

TABLE 34 *Repeatability for (a) Q1, 'Do you have any difficulty with your hearing?' and (b) Q2, 'Do you find it very difficult to follow a conversation in background noise?'*

		Original GP questionnaire			
		Nottingham		Bath	
		No	Yes	No	Yes
(a) Question 1					
Clinic repeat	No	52 (93%)	6 (3%)	19 (100%)	2 (4%)
Kappa for *n* and *B* = 0.886, 0.895	Yes	4 (7%)	178 (97%)	0 (0%)	45 (98%)
Overall 0.896					
	Total *n*	56	184	19	47
(b) Question 2					
Clinic repeat	No	52 (81%)	15 (9%)	21 (88%)	5 (12%)
Kappa for *n* and *B* 0.707, 743	Yes	13 (19%)	160 (91%)	3 (12%)	37 (88%)
Overall 0.719					
	Total *n*	65	175	24	42

Numbers in parentheses are percentages of the sample.

TABLE 35 *Percentage deviation from the response on original GP questionnaire to that on clinic response for (a) Q3, 'How well do you hear someone talking to you when that person is sitting on your RIGHT side in a quiet room?' and (b) Q4, 'How well do you hear someone talking to you when that person is sitting on your LEFT side in a quiet room?'*

		Original GP questionnaire				
	Clinic repeat	**No difficulty**	**Slight difficulty**	**Moderate difficulty**	**Severe difficulty**	**Cannot hear**
(a) Question 3						
Nottingham	Better response (%)	NA	48	59	72	–
	Same response (%)	95	47	38	31	–
	Worse response (%)	8	5	3	31	–
Bath	Better response (%)	–	44	86	–	–
	Same response (%)	83	39	14	–	–
	Worse response (%)	17	17	0	-	NA
(b) Question 4						
Nottingham	Better response (%)	NA	39	63	79	33
	Same response (%)	93	51	33	14	67
	Worse response (%)	7	10	4	7	NA
Bath	Better response (%)	NA	66	67	33	–
	Same response (%)	87	11	33	67	100
	Worse response (%)	13	23	0	–	NA

Overall, these results show that there is good agreement in responses given on two separate occasions and so confirm that the screening questionnaire is a valid tool for screening for hearing impairment.

Performance of screening questionnaire

One of the aims of the study was to develop criteria to identify people who would benefit from a hearing aid in terms of their speech in noise benefit. In population terms, it was not possible to obtain the sensitivity and FAR of the screening tests to identify benefit from the FAAF test, which was used to measure speech in noise benefit. This was because the numbers who passed the screen and were fitted with aids was low, and the FAAF test was only carried out in participants who were fitted with hearing aids as part of the study. In Bath, no one who passed the screening questionnaire was fitted with an aid, and in Nottingham only four participants who passed the screening questionnaire were fitted.

As an alternative set of criteria a proxy marker for ability to benefit was used: the BEA across 0.5–4 kHz using cut-offs at 30 db or below and 35 dB or below. These criteria were also used in the stage 3 analysis. There was no significant difference between the sensitivity and FAR between the Nottingham and Bath samples, so the data were pooled. In order for these data to be representative of the general population, a sampling weight was used derived from the initial set of respondents to the screen. The sensitivity and FAR for the different combinations of screening questions are shown in the plots in *Figures 48*. Definitions of pass and fail for each question combination were the same as those used in strand 1, stage 3.

Fine-tuning the screening audiometry

At stage 3 with BEA as the outcome, screening audiometry using a 4-kHz tone presented at 30 dB HL showed a very high sensitivity, of 92% for a 30-dB HL cut-off and 97% for a 35-dB HL cut-off, although the FAR was not so good, at about 30% (see strand 1, stage 3, *Figures 15* and *16*, p. 40). This suggested that using a higher intensity tone would result in an improved FAR. However, this would reduce sensitivity, but as this was already very high, there was room to allow for some reduction in this measure. This was confirmed by examining the pure tone threshold from the pure tone audiogram, where the 4-kHz threshold cut-off at 40 dB HL showed an improvement in the FAR of about 10% while sensitivity remained high, at 86 and 90% for BEA cut-offs at 30 and 35 dB HL, respectively (see strand 1, stage 3, *Figures 15* and *16*, p. 40). However, the pure tone threshold for 3 kHz when using a cut-off at 35 dB HL was shown to be better still.

As a result of these findings, screening audiometry was examined in more detail in strand 2, to

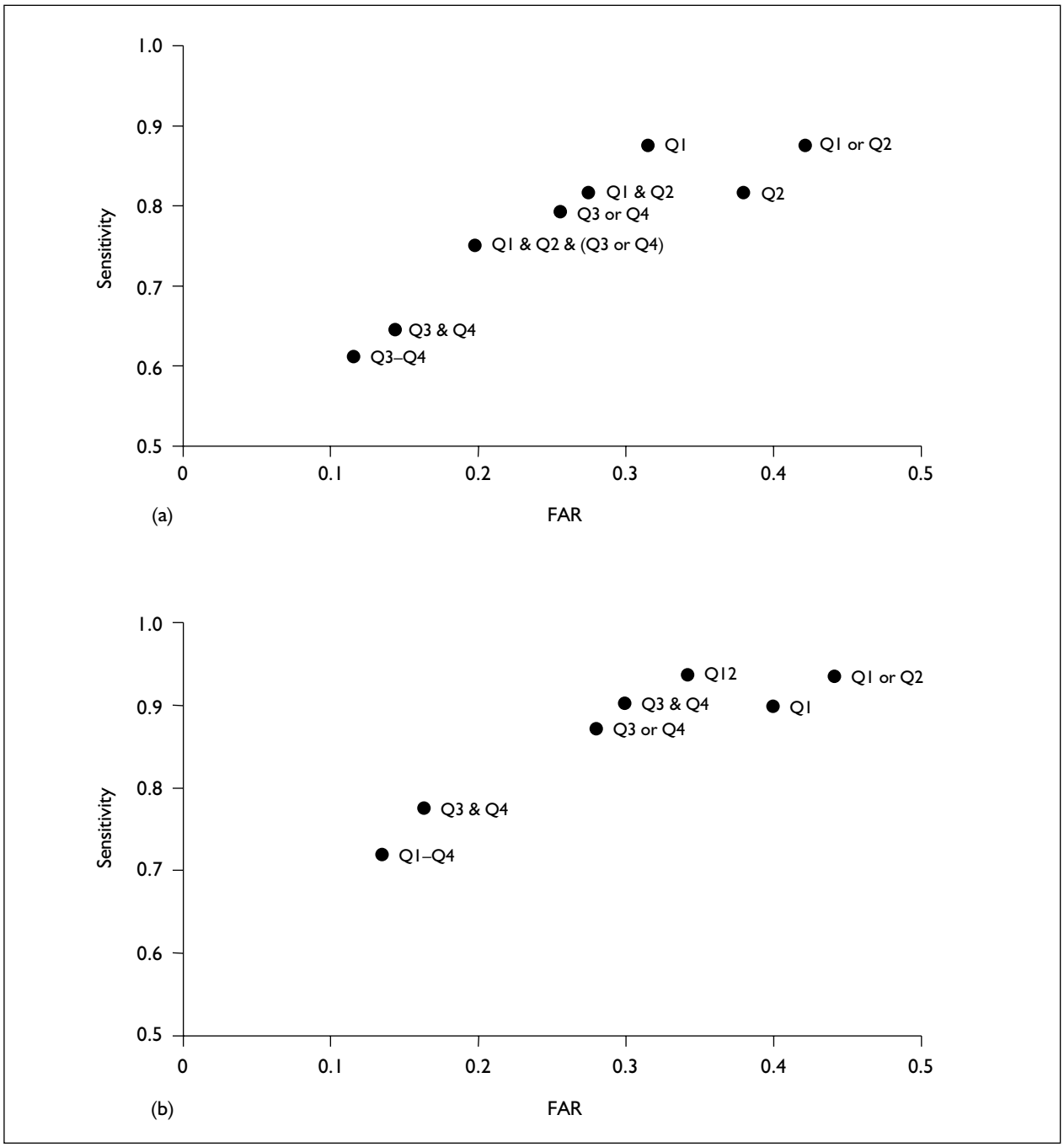

FIGURE 48 *Sensitivity and FAR for the different combinations of screening questions against a BEA cut-off of (a) 30 dB HL and (b) 35 dB HL* (n = *306)*

establish which would be the best frequency and intensity level to use in a screening audiometry context.

Table 36 shows the three different methods used to define the pass and fail criteria for screening audiometry in this strand.

Method 1 defined a pass when both the tones were heard in both ears, with anything else being defined as a fail. Method 2 defined a pass when both the tones were heard in one ear, with anything else defined as a fail. Method 3 defined a fail as hearing none of the tones in either ear, with anything else being defined as a pass.

The analysis reported here used the warble tones as in practice where the test conditions are not soundproofed, warble tones are a more reliable stimulus.[61] *Figure 49* shows the sensitivity and FAR

TABLE 36 *The three different methods that were used to define the pass and fail criteria for screening audiometry in this strand*

No. of tones heard		Result		
Left ear	**Right ear**	**Method 1**	**Method 2**	**Method 3**
2	**2**	**Pass**	**Pass**	**Pass**
2	1	Fail	Pass	Pass
2	**0**	**Fail**	**Pass**	**Pass**
1	1	Fail	Fail	Pass
1	0	Fail	Fail	Pass
0	**0**	**Fail**	**Fail**	**Fail**

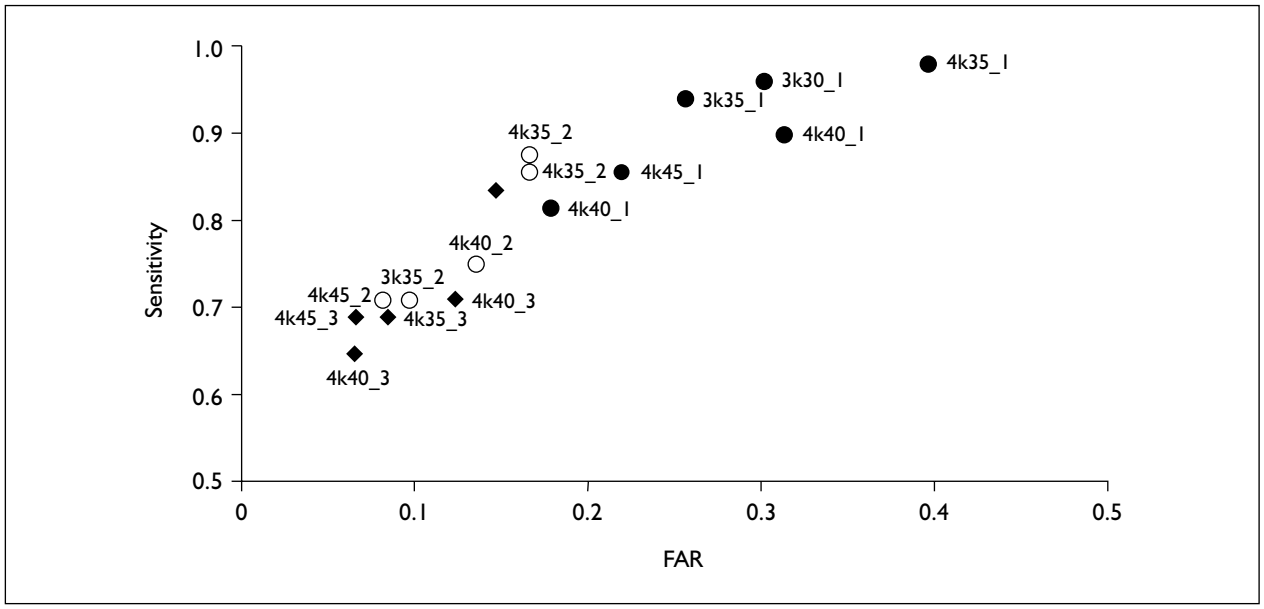

FIGURE 49 *Sensitivity and FAR for the three methods used to define pass and fail for screening audiometry using a cut-off of BEA at 30 dB. The data labels denote the tone frequency, intensity of tone and method used, e.g. 3k30_3 represents 3-kHz tone presented at 30 dB HL using the pass/fail criterion defined by method 3.*

for the six warble tones used for the three methods defined in *Table 36*, using a BEA cut-off of 30 dB HL or below as the outcome.

Method 1 had better sensitivity values than methods 2 and 3, but poor FARs. This is because method 1 required only one tone not to be heard in either ear for the participants to fail, so identifying most participants with a hearing loss. However, this method resulted in poor FAR as participants with relatively good hearing would also fail if they did not hear only one of the 12 presented tones.

Methods 2 and 3 showed very similar results, because there were few participants (<3%) who heard only one of the two tones presented at any specific frequency or intensity. So the rest of the analysis focuses on the pass/fail criteria defined in method 3, that is, hearing no tones in either ear was classed as a fail and anything else was classed as a pass, as this would be the easier of the two methods to use in practice.

Figure 50 shows the sensitivity and FAR for screening audiometry using BEA outcomes at 30 and 35 dB HL. The error bars are 95% confidence intervals.

Not surprisingly, the efficiency of screening audiometry was better overall when the BEA outcome was 35 dB HL, which reflects that most of the intensities for the screening tones were 35 dB HL or greater (5/6).

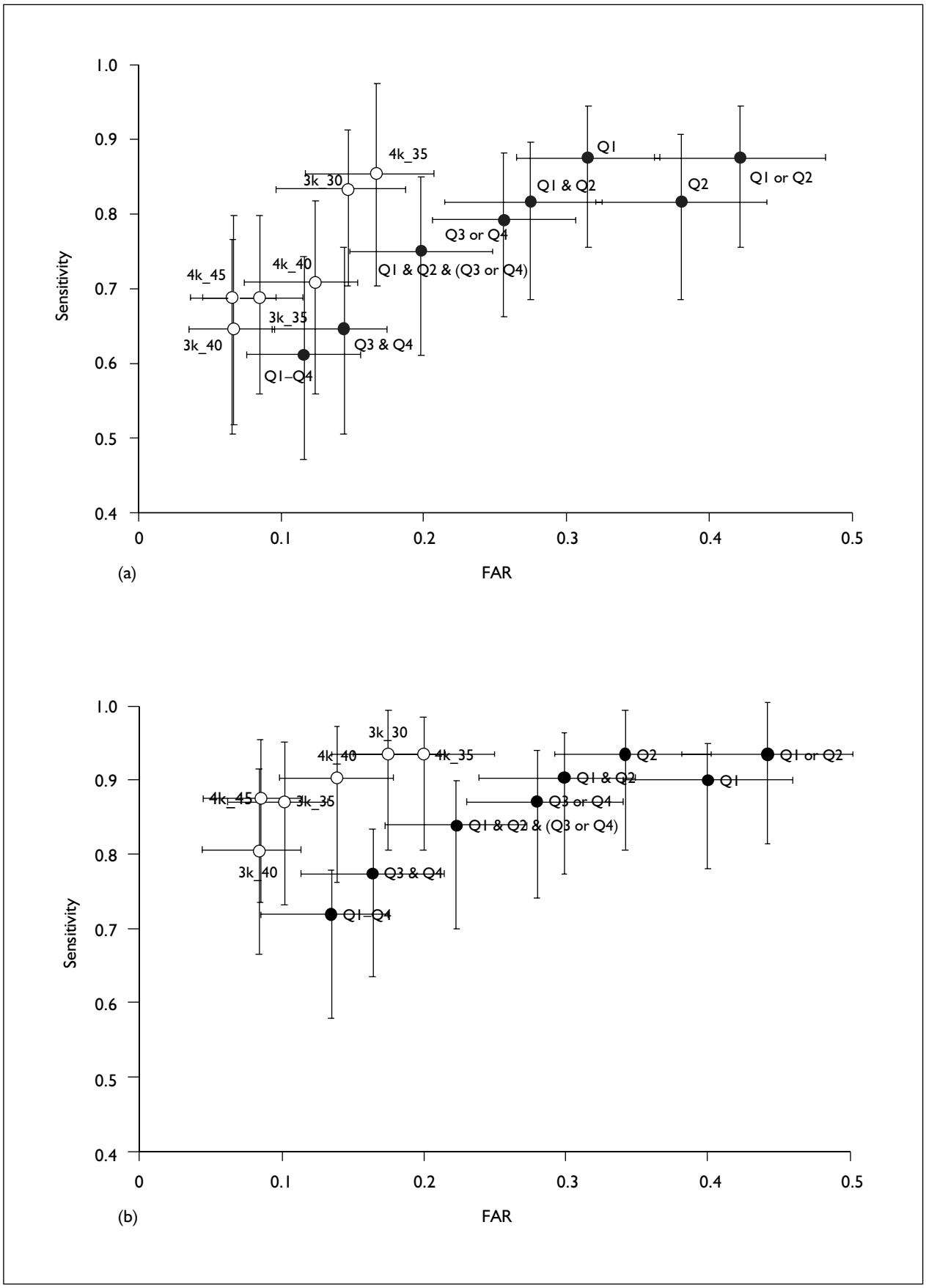

FIGURE 50 *Sensitivity and FAR for screening audiometry using method 3 to define pass and fail and screening questions against BEA at a cut-off of (a) 30 dB HL and (b) 35 dB HL. Error bars = 95% CIs.*

When the BEA outcome with a criterion of 35 dB HL was used, the screening audiometry parameters that produced the best sensitivity and FAR were 4 kHz at 45 dB HL and 3 kHz at 35 and 40 dB HL, with 4 kHz at 40 dB HL performing only slightly worse. For BEA outcome at 30 dB dB HL, no single tone or intensity had better screening efficiency than the others.

Efficiency of screening questionnaire compared with screening audiometry

A systematic analysis of the different screening conditions was carried out against a number of key outcome criteria (see Chapter 5 for a more detailed discussion of different outcome measures). The major outcome criterion considered here is the degree of hearing impairment on the better hearing ear as indicated by the average hearing level (0.5, 1, 2 and 4 kHz). Several different gold-standard criteria were used, but the two most important were 30 and 35 dB HL, where the majority of the new patients who were identified by the population study reported in Chapter 2 were distributed.

Comparison of the plots of the screening questionnaire and screening audiometry methods showed that screening audiometry was a better screen than any of the questions or combination of questions for both BEA outcomes (*Figure 50*). This was similar to the results seen in strand 1, stage 3 (see *Figures 15* and *16*, p. 40).

There was a clear difference in performance between the two methods. In fact, any of the options for screening audiometry showed better screening efficiency than any of the single or combinations of the screening questions. However, screening audiometry is more expensive to carry out (see Chapter 5) and less accessible to the population than a questionnaire. It could be more acceptable and affordable in policy terms to access large numbers using a questionnaire screen approach in which more people might be identified and helped than if only a small number might have access to audiometry screening. This was what was explored using the two-stage screen approach taken in this strand. The two-stage screen was designed to find out how often the individuals who passed the questionnaire screen and were not identified as having a hearing problem turned out to have hearing problems when assessed using audiometric screening.

To assess how the two-stage screen performed, the screening process shown in *Figure 51* was examined.

The performance of this two-stage screening rationale using Q1, Q2 and combination of Q1 and Q2 was examined. The best two-stage combination was when Q1 was used on its own with the screening audiometry, shown in *Figure 52* (although there were no statistically significant differences, hence error bars are not shown in this figure).

If screening for BEA was done at 35 dB HL in this sample, which was weighted to represent the population, using a combination of Q1 followed

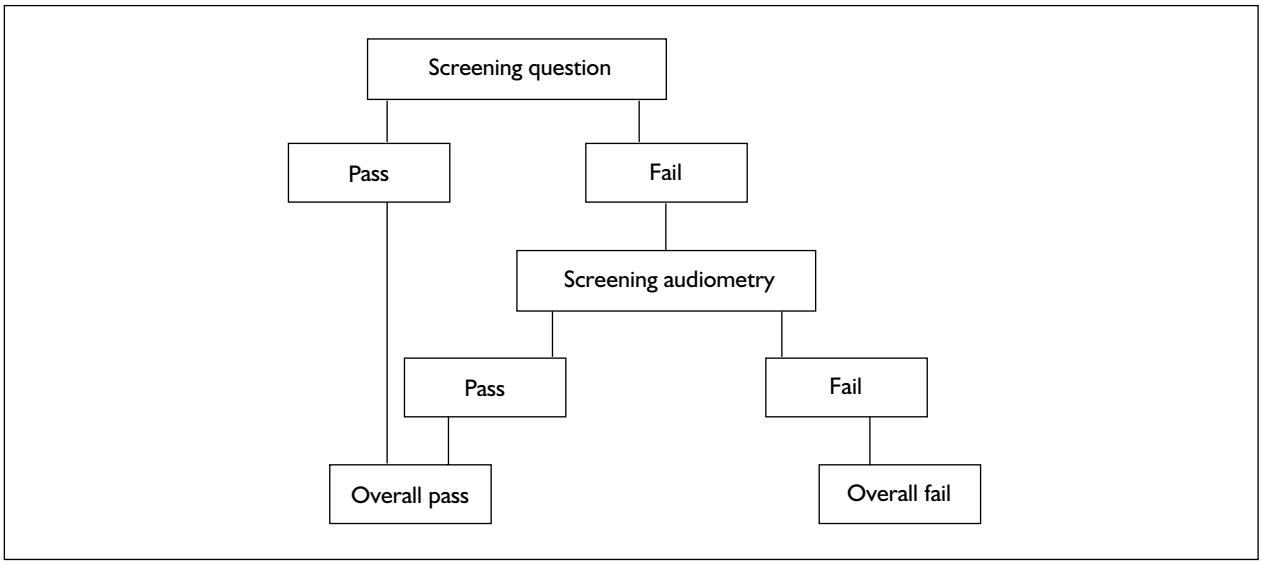

FIGURE 51 *Two-stage screen, where stage 1 is a question from the screening questionnaire and stage 2 is a specific tone and intensity for screening audiometry*

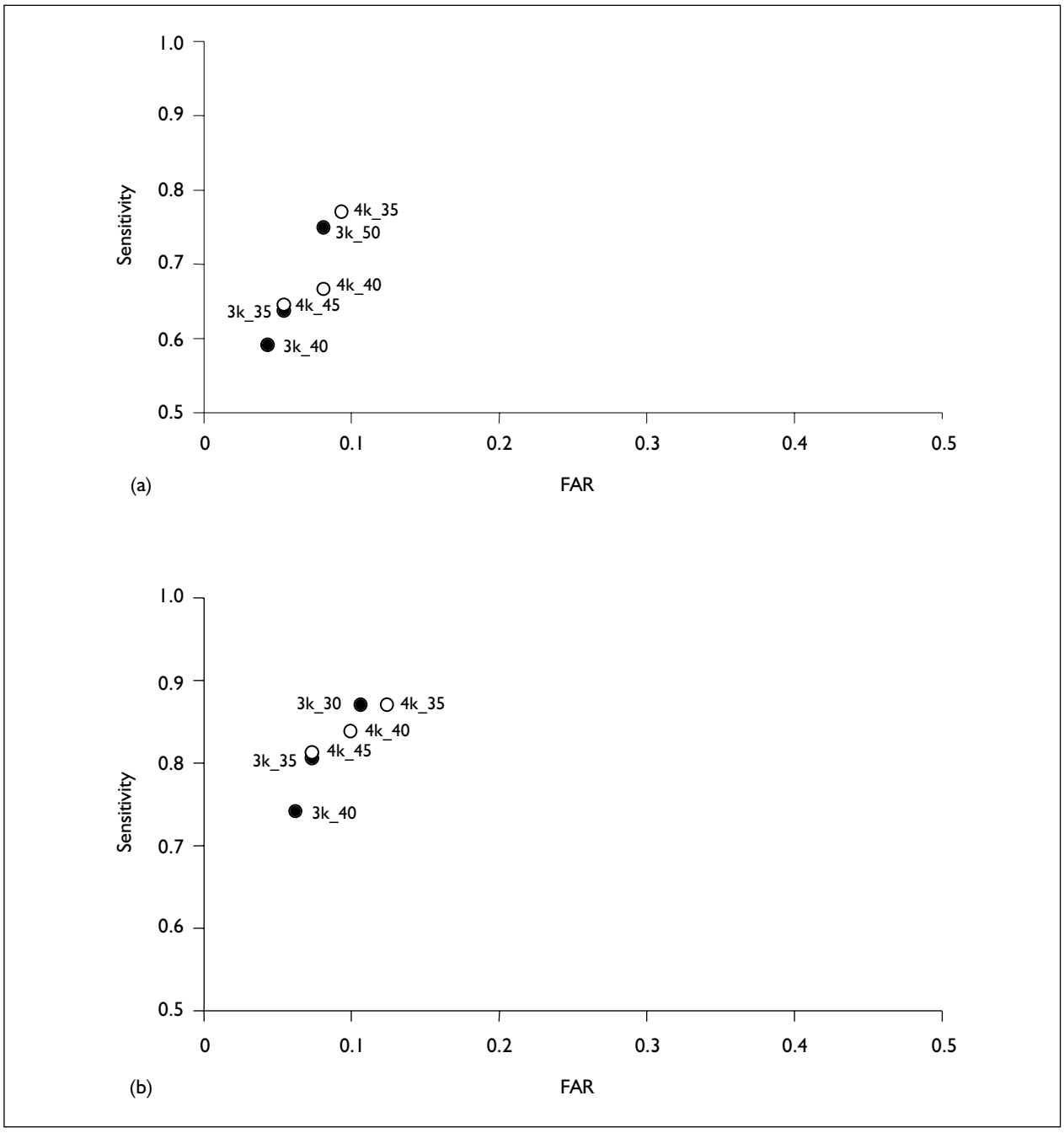

FIGURE 52 *Sensitivity and FAR of the screening audiometry and screening question Q1 combinations using a cut-off of BEA at (a) 30 dB HL and (b) 35 dB HL*

by screening audiometry using 3 kHz at 30 dB HL, the numbers that would pass and fail at each stage are shown in *Figure 53*. This shows that 59.7% (n=183) would pass the screening questionnaire and so would not go on to be screened by audiometry; the mean BEA was 13.4 dB HL. Of those who would pass the questionnaire, only eight (4%) would have gone on to fail the audiometric screen, six of whom had a BEA below 30 dB HL. Of those who would have gone on to have screening audiometry performed, just under half would have failed the screen (n = 56, 45.9%); the mean BEA was 35.4 dB HL. The majority of these (n = 48, 85.7%) accepted a hearing aid.

Of those who passed the overall screen, 18% accepted a hearing aid. However, it must be remembered that all those who failed to hear just one single tone in the screening audiometry were offered an aid, regardless of hearing loss. Only 10% of those (n = 4) had a BEA above 35 dB HL,

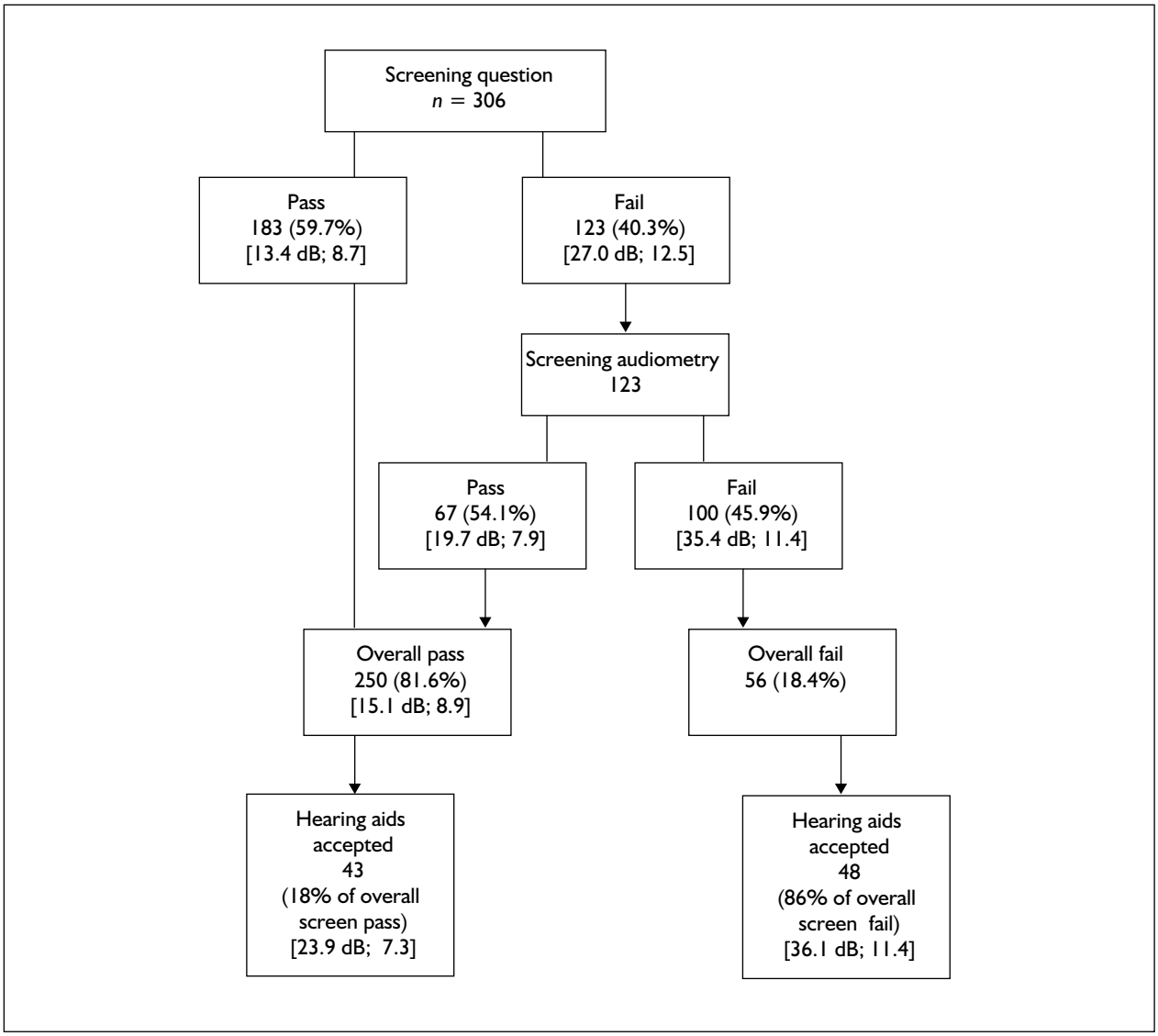

FIGURE 53 *Outcome of the weighted sample for the two-stage screen (Q1 followed by screening audiometry at 3 kHz and 30-dB HL cut-off) and the outcome of hearing aid take-up [mean BEA; SD]*

whereas of those who failed the overall screen, 85% had BEA below 35 dB HL.

Outcome measures for best screen

Using the two-stage screen described in the previous section (Q1 and 3-kHz tone at 30 dB HL), the mean and 95% confidence intervals of four outcome measures (BEA, FAAF benefit, GHABP overall and APHAB overall score) are shown in *Figure 54*.

Those who failed this two-stage screen performed significantly less well on all of the outcome measures (FAAF, GHABP, APHAB) than those who passed the screen. This indicates that this screen has the capacity to identify those who would gain significant benefit from wearing a hearing aid compared with those who would not. The difference in benefit was also reflected in the difference in BEA across those who passed (15.1 dB) and those who failed (35.4 dB HL). Whether the extra numbers identified by the screen (compared with those who would typically come forward and be fitted in the NHS at present) justify the higher cost of offering audiometry screening is a policy issue and will be discussed in Chapter 5.

Additional calculations

Since the strand 2 research originally took place we have done some further calculations to interrogate the data in more depth.

Table 37 shows the sensitivity and FARs for the different audiometric screens that were used as a function of frequency (3 or 4 kHz), level (30, 35,

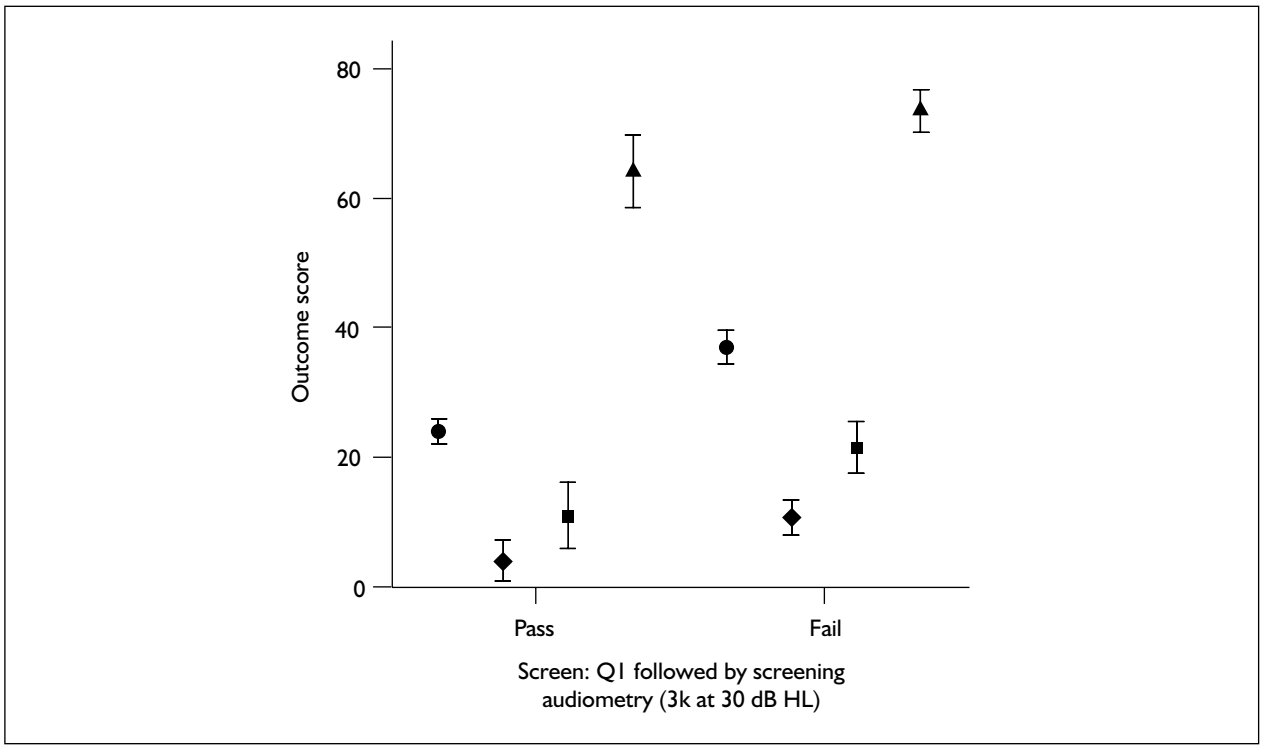

FIGURE 54 *Mean and 95% CI for BEA (●), FAAF benefit (◆), global APHAB benefit (■) and global GHABP (▲) scores for the best screening audiometry and question combinations by screen pass or fail*

40 or 45 dB HL) and presentation (steady or warble tone). A summary statistic, the d′, is also shown to summarise the performance of the screening test for a particular condition. The d′ is a guide to the overall effectiveness of the screen in detecting the condition. A higher d′ is better. The d′ statistic averaged 2.2, with a range of 1.9–2.4 and an SD of 0.1. There were significant main effects of target condition, level and presentation state on d′ and some interactions, notably a frequency by presentation interaction ($F_{1,35} = 79$, $p < 0.001$) where the best estimate of d′ was for the 3-kHz steady tone, was 2.30 compared with 2.10 at 4 kHz and for warble tones was 2.20 at 3 kHz and 2.22 at 4 kHz. *Table 37* shows that the d′ values are systematically lower for the 30-dB HL target and that 3 kHz has a better d′ for steady-state tones and 4 kHz is slightly better for warble tones. *Figure 55* illustrates these results.

A one-stage screen can only be a reality when the costs of the screening protocol are low in comparison to the overall costs. It was not possible at the time to produce a very low-cost audiometric screener. *Table 38* shows a practical two-stage screen arrangement where the first element is asking a question and the second is an audiometric screen.

If a screen is arranged as a series of tests it is very important that the first test has as high a sensitivity as possible. From the work shown in *Figure 55* it is clear that Q1 and Q2 are the most sensitive questions, but have quite a high FAR. *Table 38* has taken these two questions and the combination of questions ‘Q1 or Q2’ indicating a hearing problem as alternative questions in the first stage of a screen programme. These questions are then in series with the screen scenarios explained above. It was clear from *Table 37* that the 30-dB HL target condition did not have as good operating characteristics as the 35-dB HL condition. Therefore, *Table 38* only reports the 35-dB HL criterion condition.

As a single screen, 35 dB HL 3 kHz had a sensitivity of 92% and an FAR of 13% with a d′ of 2.53 using a steady-state pure tone signal, and a sensitivity of 88%, FAR of 11% with a d′ of 2.40 for a warble tone. In combination with Q1, this steady-state pure tone decreases to 85% sensitivity and 9% FAR and a d′ of 2.39, or if Q1 or Q2 was used the sensitivity is unaffected and the FAR increases to 10% with a d′ of 2.22.

The d′ value essentially maps the difference between two distributions in standard deviation (SD) units. A difference such as 0.48 (2.53 – 2.05)

TABLE 37 *Operating characteristics of the audiometric screen to detect two levels of hearing impairment (30 and 35 dB HL BEA average) as a function of frequency (3 or 4 kHz), level (30, 35, 40 and 45 dB HL) and presentation of pure tone (steady or warble)*

Frequency (kHz)	Level (dB HL)	Sensitivity		FAR		d′
		Estimate	95% CI	Estimate	95% CI	
Steady pure tone						
35 dB HL average on better ear criteria						
4	45	0.90	0.79 to 0.95	0.16	0.11 to 0.18	2.28
4	40	0.92	0.82 to 0.97	0.21	0.16 to 0.23	2.21
4	35	0.95	0.87 to 0.99	0.24	0.19 to 0.26	2.35
3	40	0.87	0.75 to 0.93	0.10	0.06 to 0.11	2.41
3	35	0.92	0.82 to 0.96	0.13	0.09 to 0.15	2.53
3	30	0.95	0.87 to 0.99	0.20	0.15 to 0.22	2.49
30 dB HL average on better ear criteria						
4	45	0.73	0.60 to 0.79	0.14	0.10 to 0.16	1.69
4	40	0.78	0.66 to 0.84	0.19	0.14 to 0.21	1.65
4	35	0.84	0.73 to 0.89	0.21	0.16 to 0.24	1.80
3	40	0.70	0.56 to 0.76	0.08	0.04 to 0.09	1.93
3	35	0.75	0.62 to 0.81	0.11	0.07 to 0.12	1.90
3	30	0.90	0.82 to 0.94	0.16	0.11 to 0.18	2.28
Warble tone						
35 dB HL average on better ear criteria						
4	45	0.88	0.77 to 0.94	0.10	0.06 to 0.12	2.46
4	40	0.93	0.85 to 0.98	0.15	0.11 to 0.17	2.51
4	35	0.95	0.87 to 0.99	0.20	0.16 to 0.23	2.49
3	40	0.82	0.68 to 0.89	0.08	0.05 to 0.10	2.32
3	35	0.88	0.77 to 0.94	0.11	0.07 to 0.13	2.40
3	30	0.95	0.87 to 0.99	0.19	0.15 to 0.22	2.52
30 dB HL average on better ear criteria						
4	45	0.69	0.56 to 0.76	0.08	0.05 to 0.10	1.90
4	40	0.75	0.62 to 0.81	0.14	0.09 to 0.16	1.75
4	35	0.87	0.77 to 0.91	0.17	0.12 to 0.19	2.08
3	40	0.65	0.52 to 0.72	0.07	0.04 to 0.08	1.86
3	35	0.70	0.57 to 0.77	0.09	0.06 to 0.11	1.87
3	30	0.90	0.82 to 0.95	0.15	0.11 to 0.17	2.32

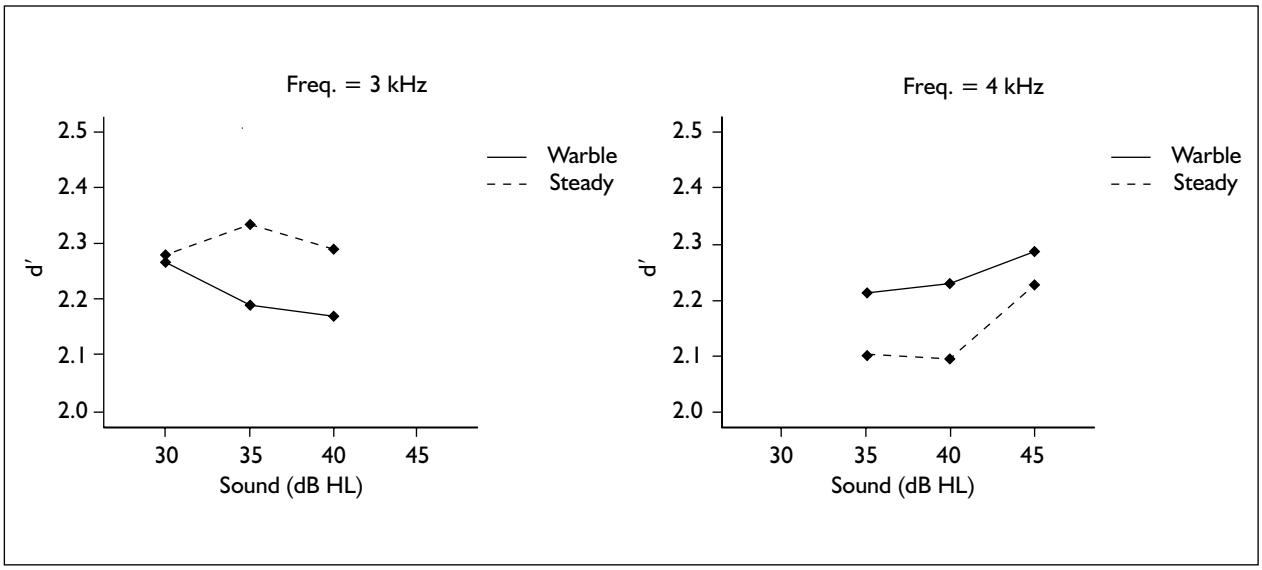

FIGURE 55 *Estimate means of d′ as a function of level, frequency and presentation of tone as a steady state or warble tone*

TABLE 38 *Operating characteristics of a two-stage questionnaire and audiometric screen to detect hearing impairment at 35 dB HL BEA as a function of frequency (3 or 4 kHz), level (30, 35, 40 and 45 dB HL) and presentation of pure tone (steady or warble)*

			Sensitivity		FAR		d′
	Frequency	Level (db HL)	Estimate	95% CI	Estimate	95% CI	
Steady tone							
Q1	4	45	0.83	0.70 to 0.90	0.09	0.05 to 0.11	2.31
Q1 or Q2	4	45	0.83	0.70 to 0.90	0.11	0.07 to 0.13	2.19
Q2	4	45	0.82	0.68 to 0.88	0.10	0.07 to 0.12	2.17
Q1	4	40	0.85	0.72 to 0.91	0.12	0.08 to 0.14	2.20
Q1 or Q2	4	40	0.85	0.72 to 0.91	0.15	0.11 to 0.17	2.06
Q2	4	40	0.81	0.67 to 0.88	0.14	0.10 to 0.16	1.96
Q1	4	35	0.88	0.77 to 0.94	0.14	0.10 to 0.16	2.25
Q1 or Q2	4	35	0.88	0.77 to 0.94	0.17	0.13 to 0.20	2.12
Q2	4	35	0.85	0.72 to 0.91	0.16	0.12 to 0.19	2.00
Q1	3	40	0.80	0.66 to 0.87	0.06	0.03 to 0.08	2.38
Q1 or Q2	3	40	0.80	0.66 to 0.87	0.07	0.04 to 0.09	2.30
Q2	3	40	0.78	0.64 to 0.85	0.07	0.04 to 0.08	2.26
Q1	3	35	0.85	0.72 to 0.91	0.09	0.05 to 0.10	2.39
Q1 or Q2	3	35	0.85	0.72 to 0.91	0.10	0.06 to 0.11	2.33
Q2	3	35	0.81	0.67 to 0.88	0.09	0.06 to 0.11	2.22
Q1	3	30	0.88	0.77 to 0.94	0.12	0.08 to 0.14	2.36
Q1 or Q2	3	30	0.88	0.77 to 0.94	0.14	0.10 to 0.16	2.28
Q2	3	30	0.85	0.72 to 0.91	0.13	0.09 to 0.15	2.16
Warble tone							
Q1	4	45	0.82	0.68 to 0.88	0.08	0.05 to 0.10	2.29
Q1 or Q2	4	45	0.82	0.68 to 0.88	0.08	0.05 to 0.10	2.30
Q2	4	45	0.80	0.66 to 0.87	0.08	0.04 to 0.09	2.27
Q1	4	40	0.87	0.75 to 0.93	0.11	0.07 to 0.12	2.36
Q1 or Q2	4	40	0.87	0.75 to 0.93	0.13	0.09 to 0.15	2.26
Q2	4	40	0.83	0.70 to 0.90	0.12	0.08 to 0.14	2.14
Q1	4	35	0.88	0.77 to 0.94	0.13	0.09 to 0.15	2.33
Q1 or Q2	4	35	0.88	0.77 to 0.94	0.16	0.12 to 0.18	2.19
Q2	4	35	0.85	0.72 to 0.91	0.15	0.11 to 0.17	2.06
Q1	3	40	0.75	0.60 to 0.83	0.06	0.03 to 0.08	2.21
Q1 or Q2	3	40	0.75	0.60 to 0.83	0.07	0.04 to 0.09	2.13
Q2	3	40	0.73	0.58 to 0.81	0.07	0.04 to 0.08	2.10
Q1	3	35	0.81	0.67 to 0.88	0.08	0.05 to 0.10	2.29
Q1 or Q2	3	35	0.81	0.67 to 0.88	0.09	0.06 to 0.11	2.23
Q2	3	35	0.78	0.63 to 0.85	0.09	0.05 to 0.10	2.12
Q1	3	30	0.88	0.77 to 0.94	0.12	0.08 to 0.14	2.38
Q1 or Q2	3	30	0.88	0.77 to 0.94	0.13	0.09 to 0.15	2.30
Q2	3	30	0.85	0.72 to 0.91	0.13	0.09 to 0.15	2.16

SD units shown between warble tones and steady-state tones can be interpreted as quite large, whereas 0.14 (2.5 – 2.36) SD can be seen as quite small. It seems that hearing level varies systematically with the number of tones heard with the warble tone, which is good for some applications, whereas steady state is more of a step-function in terms of the underlying distribution of hearing level. The steady-state pure tone is therefore better for screening but in reality only 14 out of 298 sample cases were not classified the same, which is a small proportion.

The analyses in this chapter concentrate on the warble tone scenario. In Chapter 5 the different potential models for one- and two-stage screening are systematically compared.

Discussion

Take-up of the screening questionnaire

The take-up of the screening questionnaire (filling in the questionnaire and returning it as required) was higher for the systematic than for the

opportunistic delivery. The advantage of a systematic delivery is that a whole-population approach can be taken and all the patients in the age range can be offered a screen. For an opportunistic delivery, the questionnaire is only available to a subsection of the target group (those who attend the GP's surgery), although this is administratively simpler.

In this study the design intention was to use a balanced sample of opportunistic and systematic allocation to practices to test which approach was more effective. The yield for the systematic approach was in line with expectations. However, the yield from the opportunistic screen was so much lower than expected that it was decided to recruit additional GP practices for the opportunistic screen to increase the numbers in the opportunistic sample. It was important to have enough patients from the opportunistic screen proceeding to treatment to test whether the screening approach affected the number, properties and response of cases identified. We did not have any reasons to assume that this change in the design introduced large biases of the type that cluster randomisation is needed to control for, which would in any case have needed a request for additional funding and time. We feel that the design as modified was fit for purpose and provided enough information of good quality.

In light of the allocation process of intervention to general practices, the results need to be treated with some caution. However, the findings in favour of systematic versus opportunistic screening are consistent with findings from the wider literature on screening. Take-up of opportunistic screening at the time of the study may have been adversely affected by the rapid developments and pressures affecting NHS primary care policy and general practice at the time, but changes have continued and do not appear to make it more likely that opportunistic screening will be effective compared with systematic screening.

As predicted, the take-up of the screening questionnaire was higher when the invitation to fill in the questionnaire was signed as coming from the patient's own GP rather than a researcher who was not known to the person. There was great variability in the take-up of the opportunistic screen across GPs' surgeries in both cities. In general, the take-up was higher when the receptionist asked the patient to fill in the questionnaire, rather than when the questionnaire was left in the waiting room, which might be expected.

It is not clear what contributed to the variability by GP practice, although the surgeries that had fewer GPs showed a better take-up. The surgery that had the largest response was run by a single GP, whereas the poorest responses were seen at surgeries that had five and six GPs. Patients may have felt more inclined to 'help' the GP if they knew them better, which would be the case where there were fewer GPs, or perhaps the smaller size of the premises encouraged a greater take-up and return of questionnaires to the reception. The take-up in Bath was much greater than in Nottingham. The Bath respondents had a higher percentage from non-manual social classes (66%) than in Nottingham (44%) [$\chi^2 = 9.42$, 1 df, $p = 0.002$) and were from a more rural community than those in Nottingham, which is more urban. This may have contributed to the better take-up rate.

The hearing assessment

The take-up of the hearing assessment was less variable across GP surgeries and cities, with about three-quarters of those who reported some hearing difficulty on the questionnaire attending the clinic. It may be that answering the questionnaire encouraged patients who had noticed some problems to take action when it was offered. In addition, travel expenses were paid or a taxi was arranged and paid for to encourage take-up of the assessment. Take-up of a hearing assessment in a service context may be less than was seen here because of that. However, this may not be important if using a more targeted approach based on the questionnaire.

Just under half of the participants who attended for a hearing assessment reported that they had already seen their GP about their hearing before taking part in this research. The fact that so many of the sample had been to see their GP about their hearing yet none had been referred on to an ENT consultant or a hearing aid clinic is consistent with our experience[2] and the results from strand 1 (6.9% see the GP in a year about their hearing and 2.6% are referred to an audiology department for a test): that obtaining a GP referral for a hearing test can be a significant hurdle for hearing-impaired people to cross. This indicates a need for educating GPs about the benefit of modern hearing aids, particularly in mild hearing losses in younger people. This could be in the form of guidelines based on this study. More consistent referral patterns may then be seen, especially if inexpensive devices to carry out the screening audiometry could be made available in the GP

surgery. This may also help in more uniform criteria being used for referral on to an audiology department. Only one in five of the participants who filled in and returned the screening questionnaire and who reported a hearing difficulty had a hearing aid. Although this confirms what we already knew[2] – that the number of people with a hearing loss who have hearing aids is low – at least these people were given the opportunity to obtain a hearing aid as a result of this study.

Approximately two-thirds of participants who failed either the screening questionnaire or screening audiometry accepted the offer of a hearing aid. This was higher than anticipated; a take-up of about 50% had been expected. It is likely that the take-up of aids was higher than would be seen in a service context for a number of reasons:

- ITE aids were offered: strand 1 had already shown that these aids are considered more acceptable.[62] (Note that at the time of the study the new open ear fitting options for BTE hearing aids were not available. These BTE hearing aids are less noticeable than the BTE aids used in this study.)
- Participants were offered the aids in a research context: it was made clear when asking for their consent to take part in the hearing aid trial that the aids could be returned if they were not happy with them (although only three patients returned their aids because they were not helpful).
- Although no payment was made to the participant to take part in the hearing aid trial, travel expenses were paid and taxis arranged, which encouraged them to attend.

The mean hearing loss in the better hearing ear was much lower than the average first-time hearing aid user in the NHS (31 versus 42 dB HL) and the mean age was much less (66 versus 74 years). This suggests that there is an unmet need in younger people with milder losses and a greater willingness to try hearing aids than is currently seen in the typical first time users in the NHS. There was also a high uptake of bilateral fittings: 74% were fitted in this study, which is comparable to that observed in the MHAS study.[57]

Hearing aid benefit

Having established a higher than expected take-up of hearing aid fittings, what benefits did the aids confer to the sample participants?

The outcome results from this study were compared with two other studies:

- the MHAS study[57]
- the DigIT study (the MHAS pilot), which was carried out in Nottingham.[60]

GHABP results from participants in the present study were compared with results from a group of patients seen in the MHAS evaluation study who were aged less than 75 years, reported mild losses (mean BEA = 40.6 dB HL) and were fitted with two ITE aids.[50] The outcomes were similar, even though the present sample had less hearing loss.

The GHABP and APHAB outcomes were compared against those from a sample of the DigIT study, who had slightly poorer hearing (4 dB HL on average) and were on average 4 years older than the current study sample. Although the initial disability and handicap scores from the GHABP were significantly poorer in the DigIT sample, reflecting the poorer hearing, only use was shown to be significantly higher in the DigIT group. For the other outcome measures from both the GHABP and APHAB, there was either no difference between the two studies, or significantly more benefit was reported from the present sample.

These results are encouraging. Hearing aid benefit outcome measures are no worse, and at times better, in the younger, less hearing-impaired group from this study. Furthermore, the participants in this study were approached by us to try the hearing aids. Before this, either they had not been sufficiently affected by their hearing difficulty to see their GP about it, or if they had, they had not been referred for a hearing aid. In these instances, it might be expected that the motivation of the sample to use and benefit from hearing aids could be less than those who had persevered and obtained a hearing aid. This was not the case. At the end of the study period, the vast majority of participants (96%) reported that they would continue to wear at least one hearing aid.

All three outcome measures – FAAF, APHAB and GHABP – showed an improvement in all the domains with increasing hearing loss in the better hearing ear (with the exclusion of residual disability and aversiveness). This has implications for the levels of hearing loss that should be considered for screening purposes, which are covered in more detail in Chapter 5. The main reason given why hearing aids were declined was that 'Hearing was not poor enough to need an aid' (81%). This was consistent with the mean

better ear average that was significantly worse for those who accepted a hearing aid (31 dB HL) compared with those who declined (22 dB HL). This also has implications for screening. Although some people with milder losses will accept and benefit from a hearing aid, the screen outcome criteria should be set at a level where people accept that they have a hearing loss to ensure the best take-up and benefit.

Among the hearing aid outcome measures, the most consistent finding was that the Ergo gave more benefit than the DFII. The reason for this is not clear. It could be that the participants who were fitted with Ergos had worse hearing. In addition, those with some conductive component to their hearing losses were more likely to be fitted with Ergos, and these participants were more likely to do better with a linear hearing aid. However, looking at the group who were fitted with the aid who were randomised to this condition (thus removing any bias as far as possible) there is no difference in the unaided FAAF scores, yet the aided FAAF scores with the Ergo are still higher than those from the DFII. Similar results are seen with the GHABP and APHAB outcomes.

Screening options

It is clear that screening audiometry is a more effective screen than any of the questions on the screening questionnaire, used separately or in combination. This is highly consistent with the results in strand 1, stage 3. If it is economically viable then this approach would be best. The pros and cons of each approach have been mentioned previously in the sections 'Introduction' (p. 55) and 'Results' (p. 60). A brief examination of the outcome of a two-stage screen, comprising Q1, 'Do you have any difficulty with your hearing?' with screening audiometry (hearing a 3-kHz tone at 30 dB HL or not) and weighting the sample in this study to the general UK population, in terms of hearing aid take-up and hearing loss, suggests that this type of screening approach retains sufficient sensitivity to those who have a hearing loss and would accept a hearing aid. If cost were not a problem and one wanted to detect as many hearing-impaired people as possible, then this 'best', most inclusive, two-stage screening test battery might be considered the best screen, and will be considered so here. In Chapter 5 cost and other practicalities will enter into the modelling of the screening process.

There is a very large number of one- and two-stage approaches and these are explored in more detail in Chapter 5. In general, the outcome measures were significantly better in those who would be classified as 'failed' on the two-stage screen and were fitted with aids than in those who passed and were fitted with hearing aids. A more comprehensive analysis looking at different screening methods, outcomes and costs is reported in Chapter 5.

Two years after most of the participants had been fitted with their hearing aids, a subset (nine) of those who reported that they would continue to wear their aids after the study completed was invited to a focus group to give their views on their experiences with the aids. The details of this are given in Appendix 7. In brief, the main points of the discussion were that participants were

- highly supportive of the idea of screening for ability to use a hearing aid
- enthusiastic about the service they had received
- still wearing their hearing aids regularly
- positive that the hearing aids had enriched their quality of life.

A 3-year follow-up study of the whole sample is currently being planned to obtain a broader view.

Conclusions

The number of people reporting hearing difficulty in primary care aged 55–74 years was high (21%). Of those who reported having substantial hearing difficulty, the numbers who had a hearing aid was low (20%).

A systematic screen in primary care performs better than an opportunistic screen in identifying those who may benefit. The screening questions were excellent in their reliability.

Hearing aid benefit increases with increasing hearing loss, therefore targeting people with a significant hearing loss (i.e. BEA $\geqslant$35 dB HL) would be effective and give better domain-specific outcomes, and might not swamp the services with those who may need additional fine-tuning help to benefit from the DSP hearing aids. Individuals fitted with hearing aids obtained substantial benefit in speech in noise, especially when average hearing levels were greater than about 35 dB HL.

There were significant gains in quality of life using a range of questionnaire approaches, including quality of family life. These gains were shown as greatest in the HUI instrument, where the gains were very large in terms of an effect size approaching 40% of the SD.

Screening audiometry has a lower false alarm rate than a screening questionnaire: however, a two-stage screen where the first stage is a questionnaire may be more accessible, reach a larger number and identify a larger number, and be more cost-effective.

The most effective frequency for screening seems to be 3 kHz at 35 dB HL using a steady-state pure tone, with the highest d′ being shown for a criterion of 35 dB HL for this combination.

Screening of 55–74 year olds results in hearing aids being offered, accepted and fitted to large numbers of younger people who have less hearing loss than those who routinely present in the NHS.

Younger, less impaired people identified by a screen gain at least as much benefit from hearing aids as typical first-time NHS users. A screen may enable them to be fitted with aids earlier than unscreened people, giving up to 10 additional years of benefit.

Continued use of hearing aids fitted to people who are younger and less impaired than the typical first time hearing user is very high.

Chapter 4

Strand 3: retrospective studies

Summary

The aim of the studies in strand 3 was to investigate the long-term outcome of hearing aids fitted to individuals of pre-retirement age after population hearing screening.

The main objectives were:

- to investigate the proportion of people who would continue using their aids after being fitted under a proactive system of service
- to search for predictors of long-term use
- to investigate the long-term benefit of hearing aids fitted after pre-retirement screening.

Out of the 176 people who 12 years earlier (at the age of 50–65) had been fitted after screening, 116 were traced and followed up; 27 had died and 33 had moved to unknown addresses. The latter had, at screening, similar hearing loss to those who were traced. Fifty out of the 116 (43%, 95% CI 34 to 52%) were using hearing aids at follow-up.

A strong predictor of aid use was the better ear hearing level at fitting. Seventy-five per cent (95% CI 53 to 89%) of people with better ear thresholds (averaged over 0.5, 1, 2 and 4 kHz) of 40 dB HL or worse continued using aids. Opting for bilateral fitting was another strong predictor of continuing use. Moderately or severely annoying tinnitus was a factor that increased the chances of a person rejecting their aids.

The 50 people who continued using their aids were compared with controls of the same current age, hearing levels, gender and SEG (manual or non-manual) who were fitted at a hearing aid clinic. The controls were fitted at an older age (by 10 years), as it is typical for people to delay seeking help until they are elderly. The group who were fitted after early screening reported better outcome in terms of hearing aid use, benefit, satisfaction and hearing activity limitations than those who were fitted at an older age under a responsive system.

These findings suggest that early proactive fitting is more beneficial than late fitting at a hearing aid clinic, for those who continue using their hearing aids. The current responsive system of service may be depriving many people of the maximum benefit they would obtain if a proactive service was established. However, pre-retirement screening alone, without postfitting counselling and support, should be expected to result in a significant proportion of people rejecting their hearing aids in the long term.

Introduction

Currently, hearing rehabilitation is offered on a responsive basis. Among those who need a hearing aid, only those who seek help obtain one.

There are two problems associated with the responsive model of service:

- Approximately three-quarters of hearing-impaired adults never obtain a hearing aid, and among them there are people whose hearing impairment is worse than a mild hearing loss. These people either do not seek help, or they are not referred for a hearing aid fitting because of the prevalent misconception among a proportion of health professionals (such as GPs) that hearing aids are unnecessary or useless.
- Those people who obtain aids do so with a delay. They persevere with declining hearing for approximately 15 years before they seek help and are fitted, on average, around the age of 70.

Thus, help-seeking behaviour in the population, and misconceptions among some categories of professionals, prevent people who could benefit from hearing aids from receiving them.

Population screening has been proposed as one possible solution to this problem. Screening would aim:

- to increase the proportion of the hearing-disabled population who make use of the available services
- to increase the benefit derived from the available rehabilitative means by applying this rehabilitation early rather than late.

TABLE 39 *Possession of hearing aids in target population before and after intervention*

Location	Before intervention	After intervention
Cardiff (Roath)	3 (21/662)	9 (61/662)
Glyncorrwg (1st part of Afan Valley study)	7 (19/266)	24 (64/266)
Blaengwynfi (2nd part of Afan Valley study)	8 (24/322)	22 (71/322)
Llantrisant	7 (36/530)	15 (80/530)

Values are percentages. The values in parentheses show the number of aid candidates identified out of the total number of people in the target populations.

Literature to date has shown that the first of these aims is feasible in the short term; that is, screening increases the prevalence of hearing aid ownership in the population. There is also literature that suggests that early hearing aid fitting may be more beneficial than late. However, this remained to be proven.

Studies in strand 3 added to the knowledge base relating to the two aims of screening mentioned above. The three main research questions that this strand aimed to answer were:

- Do those who become possessors of hearing aids after screening use hearing aids in the long term?
- Are there any predictors of long-term hearing aid use? This would help to identify people who need extra postfitting support.
- Do those who are fitted after screening at a younger age after early adult hearing screening experience more benefit than if they were fitted at a more advanced age (as is typical for those who present to hearing aid clinics)?

For the purposes of strand 3, people who had taken part in three earlier studies on adult hearing screening were followed up approximately 12 years later. The main group of participants in the follow-up studies comprised people who had taken part earlier, in three initial screening studies. They are described in the next sections. These were three separate studies set up in Wales to assess the effectiveness of an adult hearing screening programme.

The studies were conducted in 1982–1983 (in Cardiff), 1987–1989 (in the Afan Valley) and 1990–1992 (in Llantrisant). In these three initial studies, all people aged 50–65 years in four general practices were sent a screening questionnaire on hearing difficulties. Those who reported hearing problems were examined and tested audiometrically. If their hearing level exceeded 30 dB in their worse hearing ear, they were offered a hearing aid fitting. Early results from two of the three studies have been reported previously.[13,14,63–65] As a result of the intervention, hearing aid possession in these population groups increased three-fold (*Table 39*).

These studies showed that this intervention was effective in increasing the take-up of hearing aids in the population in the short term. It remained to be seen whether those who were fitted in the three initial studies would continue to use their hearing aids in the long term. Between March 1999 and April 2000 those patients from the initial screening studies who were still traceable were followed up. This follow-up came 8–16 years after their initial screening and fitting (average 12 years).

Study 1 of strand 3 investigated the long-term use rate of hearing aids among those who were fitted for the first time at the initial screening studies.

There has not been any published work in this area, yet this is an important subject. Early screening aims at increasing the number of hearing aid users in the population and, most importantly, among the elderly population of the future, as it is the elderly who suffer the most disability in terms of prevalence and severity.

Study 1 also investigated whether it is possible to identify predictors of long-term use of aids among those who were fitted with aids after screening. Knowledge of such predictors of use could help to improve the method of screening that was used in the initial screening studies, by minimising waste of resources (caused by fitting aids to people who may later reject them). Predictor variables would be useful for:

- selective fitting of those who are likely to continue using their hearing aids (assuming that the research community reaches a consensus as to whether this is ethical)

- offering those more at risk of rejecting their hearing aids priority access to postfitting support and counselling services, thus increasing the cost-effectiveness of these services.

Study 2 of strand 3 investigated the amount of benefit experienced by those who were fitted at the initial screening studies and who continued using their hearing aids in the long term.

In the literature there was some existing evidence suggesting that people fitted at a younger age may experience more benefit from their aids than those fitted at an older age, such as those people who postpone seeking help until they become older and their hearing deteriorates. This evidence was based on the fact that younger people have better handling skills and better adaptation capabilities. It was also based on the notion that early fitting might 'preserve' auditory ability, which otherwise would be lost if the 'auditory brain' were deprived of acoustical input through the years that pass until the person seeks help. However, people fitted at screening have not asked for their aids on their own initiative. Even though they accept an aid when it is offered, they may lack motivation and may perceive their aids as unnecessary or not beneficial. Thus, it remained to be proved whether early screening would result in more benefit than fitting under a responsive system, which typically happens at an older age. This was the aim of study 2.

Ethical committee approval for the studies in strand 3 was granted by the ethical committees of the Bro Tâf and the Iechyd Morgannwg health authorities.

Study 1: long-term use rate and predictors of use

Objectives

The objectives of this study were to determine the long-term use of hearing aids among people fitted after adult population screening at the age of 50–65 years and to identify predictors of use.

Methods

The names and birth dates of the participants in the initial screening studies were retrieved from the initial databases. Based on this information, the four general practices that had taken part in the initial screening studies searched their current register and provided up-to-date addresses and telephone numbers of those patients who were still registered with them. Some patients had changed GP since the initial studies. A few of them were traced from data kept at the outpatient department at the University Hospital of Wales, and also by searching the local telephone directories.

All those whose addresses were traced were sent, via the post, an invitation letter signed by the GP, a consent form with relevant information written in lay terms and a prepaid reply envelope for returning the consent form.

Those who had not returned their forms after 2 months were contacted again by a second mailing. If there was no response they were contacted by telephone. All interviews and tests at follow-up were performed by one of the authors of this report (IG). The venue was the Welsh Hearing Institute for the patients from Cardiff, the general practices for those who lived outside Cardiff, in the Afan Valley and in Llantrisant.

The follow-up took place between March 1999 and April 2000, 8–16 years after the initial screening and fitting. The average time from the intervention (screening and fitting) until the follow-up was 12 years (mean and median: 12 years, range 8–16 years).

Participants

Not one patient refused to take part in the follow-up. The reason for this outstanding response rate reflects not only the persistence of the researcher (Dr Gianopoulos), but also the population under investigation and the nature of the study. In the initial preintervention survey, a response rate of over 97 was achieved in Glyncorrwg and Blaengwynfi. There are several factors underlying this. This population had experienced a number of earlier medical studies under the aegis of Dr Julian Tudor Hart, one of the GPs involved. Patients did not have to travel far, but just to visit their GP, from whom they had received the recruitment letter. Finally, the study was perceived in the villages as being for the benefit of the population after public meetings were held to inform them about the research.

People who did not take part were dead or uncontactable. The latter had either moved away and changed GP, or they had died and the GP's register was not informed of this. In total, 116 people (74 men and 42 women) were traced for follow-up out of the original 176 who had accepted to be fitted with a hearing aid in the initial studies. Of those who were untraceable for

follow-up, at least 27 had died, and for the remaining 33 no contact details were available. So, 66% of all those who accepted a hearing aid in the initial studies were traced, or 78%, if those who were known to be dead are disregarded.

Tests

Open interview questions

Participants were asked about the amount of use of hearing aids since the initial fitting. They were categorised as hearing aid users even if they only used an aid for a limited length of time, as long as they used it at least once a week. This decision was based on the notion that successful hearing aid users may use their aids selectively for situations when an aid is needed and helpful.[66] For example, a person who only used the aid for attending a weekly meeting lasting for 1 hour was considered a hearing aid user.

There were few participants who owned a (reportedly) working aid and who used it in rare situations separated by long intervals of non-use lasting for several months; these were considered non-users. These participants seemed to have overreported even these small amounts of use, possibly out of courtesy to the researchers who had fitted them with the aid. They had, at the beginning of the interview, reported more use. However, after having been assured by the interviewer that the objective of the study was to determine their real amount of use, and that no offence would be taken if they reported that an aid was useless to them, they reconsidered and reported lower and irregular amounts of use.

All of the following data used for this study were available from the initial screening studies.

Demographic data

These data comprised age at the time of fitting, gender and socio-economic group (in terms of manual or non-manual occupation according to the guidelines of the Registrar General).[67]

Audiological tests

- Average pure tone hearing levels were measured at 0.5, 1, 2 and 4 kHz, by air conduction, for the better hearing ear (BEHL) and for the worse hearing ear (WEHL).
- Speech tests: AB(S) lists of monosyllabic words[68] were presented in the quiet, at the most comfortable hearing level, separately in each ear by earphones. This test was conducted only in the Afan Valley studies (i.e. in Glyncorrwg and Blaengwynfi).

Questionnaires

Screening questionnaire devised by the MRC (IHR)

This questionnaire asks about a variety of issues, such as perceived auditory ability, hearing difficulties in life situations, aspects of tinnitus, history of exposure to noise, previous ear problems, previous use of hearing-related services, and general demographic data. It comprises a list of individual questions with no total or subscale scores. The questionnaire[14] had been used previously in the NSH[2] and in several other places, including a *BMJ* paper by the present group.[13]

Social Hearing Handicap Index (SHHI)[69]

This is a questionnaire on difficulties in understanding speech in life situations. Scores range between 0 and 42, with higher scores suggesting more difficulties.

Emotional Response Scale (ERS)

This is a questionnaire on the emotional effects of hearing loss. It consists of five questions taken from the Hearing Measurement Scale.[70] Scores range from 0 to 10, with higher scores suggesting more serious effects.

Invitations

The number of invitations required in the initial screening studies before the subject responded was recorded. The Cardiff study did not provide data for this variable as only one invitation was sent. In the Afan Valley study, if the participants did not respond, they received up to three mailings and finally were contacted by telephone. In Llantrisant, only two mailings were sent. This variable is used as a gauge of attitudes towards hearing rehabilitation before intervention.

Availability of data

Data on the demographic features and the pure tone audiograms were recorded in all three initial studies (Cardiff, Afan Valley and Llantrisant studies). The speech tests were only conducted in the Afan Valley study. None of the questionnaires was used in all three initial studies. The IHR screening questionnaire was used in half of the Cardiff sample and half of the Afan Valley sample (i.e. in Glyncorrwg). The SHHI and the ERS were used in the Afan Valley studies.

Questionnaire data on tinnitus

In the analyses that follow in this study, data on tinnitus have been grouped together from across all the initial studies into the following four variables: presence of tinnitus, sidedness of

tinnitus, annoyance from tinnitus and pattern of tinnitus (continuous versus intermittent).

Data on these variables were collected as follows. In Cardiff, the participants were administered the IHR screening questionnaire, which contains a section on tinnitus (questions C1–7). In the Afan Valley the same questionnaire was used. They were asked similar questions on tinnitus at interview, during their first visit. Questions on tinnitus were included in the screening questionnaire used in Blaengwynfi. In Llantrisant, participants were asked a single question as to the presence of tinnitus in the screening recruitment questionnaire, and more detailed questions during their interview.

Analysis: results

Overall, 50 patients (43%, 95% CI 34 to 52) were using their aids at follow-up, and 66 were not. When the 116 patients interviewed were compared with the 33 who could not be traced, no significant differences were found in gender, occupation (manual versus non-manual), age, hearing levels at fitting, or answers on the two questionnaires used in the initial screening studies (the SHHI, a measure of difficulties in understanding speech and the ERS, a measure of emotional effects of hearing loss extracted from the hearing measurement scale). This suggests that the patients who were missing at follow-up were not different from those who were available for follow-up; therefore, the follow-up attendance rate is unlikely to have caused a bias in the results of this study.

The following analysis concentrates on finding factors that could be used as predictors of long-term hearing aid use among those who were fitted at the initial screening and who were available for follow-up.

Tables 40 and *41* show a list of demographic and audiological variables with data recorded in the initial screening studies. These were used for comparison of those who at follow-up were using aids (50 cases) versus those who were not (66 cases).

All 116 cases had available data for the comparisons in terms of the demographic variables of *Table 40*. However, not all tests and questionnaires were part of the protocol in all the initial studies. *Table 41* shows the number of cases that provide data for each of the audiological variables for comparisons between users and non-users.

There were some missing data from the initial databases because the respective questions were left unanswered by the participants or because the data were not recorded in the initial databases. *Table 41* shows the number of cases with recorded and missing data. There was no indication that there was any bias in the collection and recording of data in the initial databases, and as the tables show, the proportion of missing data was low. The main source of unavailability of data for comparison is due to some variables not having been sought as part of the protocol in one or some of the initial screening studies. However, as mentioned earlier, the important demographic and pure tone audiometry variables were sought in all studies.

For the comparisons in *Tables 40* and *41* parametric or non-parametric tests were used,

TABLE 40 *Demographic data from initial screening studies for comparisons between people using aids at follow-up versus people not using aids at follow-up, among people who accepted to be fitted in the initial studies and who were available for follow-up*

Variable for comparison	Using aid (n = 50)	Not using aid (n = 66)	Statistical comparison
Male/female	M: 37 (74%) F: 13 (26%)	M: 37 (56%) F: 29 (44%)	$\chi^2 = 3.96$, df = 1, $p = 0.05$
Manual/non-manual occupation	M: 34 (68%) NM: 16 (32%)	M: 47 (71%) NM: 19 (29%)	$\chi^2 = 0.54$, df = 1, $p = 0.5$
Location (Cardiff/Afan/Llantrisant)	C: 11 (22%) A: 24 (48%) L: 15 (30%)	C: 8 (12%) A: 41 (62%) L: 17 (26%)	$\chi^2 = 2.89$, df = 2, $p = 0.2$
Age at fitting, median (25th and 75th quartiles)	58 (54, 62) years	56 (53, 60) years	$z = 1.29$, $p = 0.2$

Comparisons were based on the Pearson χ^2 test statistic (χ^2), except for the last row, where the Mann–Whitney U-test (z) was used. * $p \leq 0.05$.

TABLE 41 *Audiological data from initial screening studies for comparisons between people using aids at follow-up versus people not using aids at follow-up among people who accepted to be fitted in the initial studies and who were available for follow-up*

Variable for comparison	Using aid	Not using aid	Statistical comparison	Availability of data from initial studies per variable for comparison		
				No. of cases with recorded data	No. of cases with missing data	No. of cases with data not sought
BEHL	32 (26, 41)	26 (19, 32)	$t = 4.13$ df = 114 $p < 0.001$***	50 users 66 non-users	0	0
WEHL	45 (36, 53)	38 (32, 48)	$z = 2.32$ $p = 0.021$*	50 users 66 non-users	0	0
AB(S) speech test better ear	100 (96, 100)	100 (97, 100)	$z = 0.26$ $p = 0.79$	22 users 40 non-users	2 users 1 non-user	51 cases
AB(S) speech test worse ear	93 (87, 98)	93 (90, 99)	$z = 0.64$ $p = 0.52$	22 users 40 non-users	2 users 1 non-user	51 cases
Tinnitus presence	'Yes': 30 'No': 15	'Yes': 39 'No': 22	$\chi^2 = 0.08$ df = 1 $p = 0.84$	45 users 61 non-users	0	10 cases
Tinnitus pattern (continuous/intermittent/ no tinnitus)	10/20/15	14/25/22	$\chi^2 = 0.13$ df = 2 $p = 0.93$ $z = 0.22$ $P = 0.83$	45 users 61 non-users	0	10 cases
Tinnitus sidedness (bilateral/unilateral/ no tinnitus)	16/14/15	17/22/22	$\chi^2 = 0.73$ df = 2 $p = 0.69$ $z = 0.79$ $P = 0.42$	45 users 61 non-users	0	10 cases
Tinnitus severity (severely/moderately/ slightly/not annoying/ no tinnitus	2/5/21/2/15	8/19/9/3/22	$\chi^2 = 16.04$ df = 4 $p = 0.003$** $z = 3.20$ $P = 0.001$	45 users 61 non-users	0	10 cases
Tinnitus severity (severely or moderately versus all other categories)	7/38	27/34	$\chi^2 = 9.80$ df = 1 $p = 0.002$** $z = 3.75$ $P = <0.001$	45 users 61 non-users	0	10 cases
IHR questionnaire	[a]	[a]	[a] ns at 95% level	19 users 20 non-users	0 users 2 non-users	75 cases
SHHI	27.5 (16, 34)	23 (18, 28)	$z = 0.86$ $p = 0.39$	24 users 41 non-users	0	51 cases
ERS	5 (2, 7)	3 (1, 5.5)	$z = 1.34$ $p = 0.18$	24 users 41 non-users	0	51 cases
Invitations (one/two/three mailings or telephone)	28/9/2	45/12/1	$\chi^2 = 1.73$ df = 3 $p = 0.63$	39 users 58 non-users	0	19 cases

Unless otherwise stated, values are medians with quartiles in parentheses. In the column showing statistical comparisons, where a *t*-value is presented a *t*-test was performed. Where a *z*-value is presented, a Mann–Whitney U test was performed. Where χ^2 is presented, a Pearson χ^2 test was performed. *** $p \leq 0.001$, ** $p \leq 0.01$, * $p < 0.05$.

[a] No cumulative score is produced by this questionnaire. χ^2 test was performed for each item, except for items D1 and D2, which are meaningless in the context of these comparisons. Also, the questions on tinnitus (section C) were analysed with the tinnitus-related variables in this table.

depending on whether the data fulfilled the criteria of normal distribution and equal variances between users and non-users. The variable 'tinnitus annoyance' was analysed initially by a Pearson's χ^2 test on a 5×2 table. There were five categories of tinnitus annoyance coded as 'severely annoying', 'moderately annoying', 'slightly annoying', 'not annoying' or 'no tinnitus at all', cross-tabulated with the status of 'use' or 'non-use' of a hearing aid at follow-up. The *p*-value of this (as shown in *Table 41*) was 0.003, indicating that one or some of these tinnitus categories had different distribution between the users and the non-users. A bar-chart was produced to help to group together tinnitus severity categories that did not differ between users and non-users. This suggested that the variable tinnitus severity could become simpler: a binary variable distinguishing those who reported severely or moderately annoying tinnitus, from those who reported slightly or not annoying tinnitus or no tinnitus. A χ^2 test based on a cross-tabulation of this binary variable with the status of use or non-use of aids was significant too. Both analyses are displayed in *Table 41*.

Among the demographic variables only gender showed marginal significant difference, with men using their aids more than women. This is investigated further later in the analysis. Among the audiological variables, non-users had significantly better hearing at fitting in both the better and the worse hearing ear, and were more likely to report moderately or severely annoying tinnitus than those who used aids.

The following stage of the analysis describes an effort to obtain a measure, based on the information that was available at the time of screening, of how precisely it would be possible to predict whether a subject would be likely to discontinue using their aids in the long term.

The first step in this effort was an attempt to identify which variables, of those that showed significant differences in *Tables 40* and *41*, were the best predictors of use or non-use of aids at follow-up.

For this purpose, a regression analysis was used. A backward stepwise logistic regression approach was used, where the outcome variable was the status of use or non-use of a hearing aid at follow-up. Variables where significant differences were found between users and non-users in *Tables 40* and *41*. were entered as predictor variables. The cut-off probability level for exclusion of a variable from the model was set at 0.05. The analysis was performed on the 116 patients who had accepted a hearing aid in the initial screening studies and were available for follow-up. In the first analysis the variables entered in the list of predictor variables were:

- gender
- better ear average hearing level
- worse ear average hearing level
- tinnitus annoyance (the binary variable).

In total, 106 cases were included in this analysis. In the final step of the analysis only two variables remained. They were:

- the BEHL (odds ratio based on 10-dB HL increments in hearing level 2.35, 95% CI 1.45 to 3.81)
- the presence (or not) of at least moderately severe tinnitus (odds ratio 4.57, 95% CI 1.63 to 12.81).

Therefore, this analysis created a model (i.e. an equation based on the BEHL at the time of fitting and the presence or not of at least moderate severity tinnitus) aiming to predict whether a patient would or would not be a user of a hearing aid at the time of follow-up. This model was correct on 72% of the cases in this sample.

The analysis then focused on how accurately the variable 'better ear hearing level' could predict the long-term use of aids. In a more tangible interpretation of the results of the logistic regression analysis presented above, an odds ratio of 2.35 means that for every 10-dB HL difference (in this case better hearing) the risk of hearing aid rejection increases by 135% (or that the risk becomes more than twice as high every 10 dB HL).

The calculation of odds ratios, presented above, gives the impression that BEHL has a very strong influence on whether a person would continue using his or her hearing aid. However, the odds ratio is a statistical term that is not easily interpretable in terms of clinical importance. So another measure was sought to establish whether the BEHL can accurately discriminate between people who would continue using their aids and those who would not.

Table 42 is more clinically relevant than the odds ratios presented above. It shows how the proportion of long-term users would have increased if the criterion for fitting a hearing aid

TABLE 42 *Effect of a fitting criterion based on severity of hearing loss in the better ear on long-term use of the aids*

Criterion for fitting	Users	Non-users	Proportion of users (95% CI)
⩾15 dB[a]	47	60	44% (35 to 53%)
⩾20 dB[a]	45	46	50% (39 to 60%)
⩾25 dB[a]	41	36	53% (42 to 64%)
⩾30 dB[a]	33	21	61% (48 to 73%)
⩾35 dB	22	13	63% (46 to 77%)
⩾40 dB	15	5	75% (53 to 89%)
⩾45 dB	6	1	86% (49 to 97%)
⩾50 dB	5	1	83% (44 to 97%)
⩾55 dB	2	0	100% (34 to 100%)

[a] A hearing aid is offered if the worse ear hearing level is equal to or worse than 30 dB HL.

TABLE 43 *Hearing levels (averaged over 0.5, 1, 2 and 4 kHz) of the 74 men and 42 women who in the initial screening studies were fitted with hearing aids, and were available for follow-up*

	Men	Women	Statistical comparison
BEHL	Mean: 30 Median: 30 Quartiles: 28, 38	Mean: 26 Median: 26 Quartiles: 19, 33	$z = 2.06$, $p = 0.04$
WEHL	Mean: 42 Median: 39 Quartiles: 34, 49	Mean: 46 Median: 40 Quartiles: 34, 56	$z = 0.81$, $p = 0.42$

was based not only on the WEHL, but also on the BEHL, and the cut-off level of the BEHL for offering an aid was increased in 5-dB HL increments.

It should be noted that the first level in *Table 42* (which is set at 15 dB HL) excludes a number of the participants who were fitted in the initial studies: those who were unilaterally impaired. It is obvious from *Table 42* that even though the proportion of long-term users increases with increasing hearing loss, one cannot accurately discriminate individuals who will reject their aids, on the basis of their hearing impairment in their better ear at fitting. However, it is possible to discriminate groups of people who are more likely than others (those with lesser impairment) to reject their aids.

The χ^2 test of gender versus use in *Table 40* shows that women are marginally less likely than men to become long-term users. The 74 men and 42 women who were available for follow-up were compared in terms of their better and worse ear hearing levels. These comparisons are shown in *Table 43*.

The assumptions of normality and equal variances were only met in terms of the BEHLs so a *t*-test statistic was used for the comparison of the better ear levels, and a Mann–Whitney *U*-test for the comparison of the worse ear levels. Significant differences were found in terms of the better ear levels, but not in terms of the worse ear levels. Men had worse hearing levels in their better ear (but not in the worse ear) than women. In the logistic regression analysis, gender was not among the variables in the final model. This suggests that the reason why more men use hearing aids is that they have worse hearing levels.

Discussion

Compliance with aids

The analysis in this study showed that the proportion of hearing aid users at follow-up among those people who were the target of screening in the initial studies is only 43%, which is lower than hoped for. The importance of this finding is that it highlights that a national screening programme would require additional measures that would increase the proportion of those who comply with the recommended intervention, namely hearing aids, to justify its cost-effectiveness.

Two courses of action may provide ways to improve the effectiveness of screening. The first is to combine screening and fitting with aids with

postfitting support, counselling and other compliance-improving policies. The studies by Brooks[71–73] have shown the effectiveness of counselling on compliance with aids among people who present to a hearing aid clinic. It seems reasonable that this would also happen among those fitted after screening, and certainly it looks like an issue that could be investigated in future research.

The second course of action may be for the intervention programme to be more selective in terms of people who are fitted with hearing aids. Avoiding fitting people who are likely to discontinue using their aids would reduce the amount of wasted resources. This is a complicated issue involving ethical and managerial considerations. A decision to propose selective fitting of hearing aid candidates cannot be based solely on the evidence of this study.

Hearing tests as predictors of long-term use

This study has shown that the hearing level in the better hearing ear is a more reliable predictor of long-term use than the worse hearing ear. The precision of this variable as a predictor for long-term use may not be good enough to allow selective fitting of individuals who will continue using their aids, but it is useful in terms of predicting groups that are likely or unlikely to continue using their aids. The study highlights that, with increasing hearing loss in the better hearing ear, the chance that people will reject their aids in the long-term diminishes. In *Table 42*, at the fitting criterion of at least 40 dB the lower end of the 95% CI of the proportion of users is above 50%. Thus, people who had bilateral impairment and their hearing level in the better ear was of at least moderate severity were more likely than not to continue using their aids, even without postfitting support and counselling.

This is quite an encouraging finding considering that these people had not asked for the hearing aid on their own initiative. It is also useful for cost-effectiveness considerations because it may allow postfitting support services to concentrate on those with milder or unilateral hearing losses, who are at higher risk of discontinuing using their aids.

Even though speech tests have an advantage over pure tone tests in assessing higher functions of the auditory pathways and real-life ability to understand speech, the specific tests used in the Afan Valley sample did not have any value as predictors of long-term use. This, however, may be due to the fact that the paradigm used was too easy for the participants (i.e. presented in the quiet and at the most comfortable level). This resulted in a ceiling effect, and the test could not discriminate those people who had difficulties in understanding speech in real-life circumstances, where there is often noise in the background or speech is presented at a quiet level.

Self-reported severity of tinnitus as predictor of long-term use

This study showed that among those who failed screening and accepted to be fitted with aids, individuals who, at the time of fitting, had reported moderately or severely annoying tinnitus were more likely to discontinue using their hearing aids in the long-term. This is in accordance with the findings of Schumacher and Carruth,[74] who reported that 19% of their sample stopped using their hearing aids because "they had tinnitus". Also, Stephens and Meredith[75] found that 8% of their sample of people who were fitted with hearing aids reported that tinnitus made their hearing worse. The authors highlight that this is rather unexpected, as hearing aids are generally regarded as an effective means of suppressing tinnitus.

It is interesting to note here that in the initial screening studies, presence of tinnitus was found to be a predictor of hearing aid acceptance in the screened population. Humphrey and colleagues[76] also found that presence of tinnitus was associated with increased likelihood to seek help and accept hearing aids.

So, whether a hearing aid is used or not seems to depend largely on the balance between hearing loss (need) and tinnitus (limiting acceptability). It was worth investigating the interrelationship of these two variables. The crude odds ratio (i.e. odds of hearing aid use) for those with moderate/severe tinnitus versus those with slight/not annoying/no tinnitus was 4.31 (based on data in *Table 41*, product of 27/34 divided by the product of 7/38 gives 4.31). This is only slightly altered to 4.57 on adjustment for BEHL on the logistic regression analysis. This suggests that the two variables are not strongly related. Next, the BEHL among those with severe/moderate tinnitus was compared with those with slight/not annoying/no tinnitus and the two groups were not found to have any statistical difference (Mann–Whitney U-test, $z = 1.04$, $p = 0.3$). The same applied when the same comparisons were made within the subgroups of those who used hearing aids ($z = 0.14$, $p = 0.89$) and those who did not use hearing aids at follow-up ($z = 0.06$,

$p = 0.95$). This suggests that the variability in the sample in terms of tinnitus annoyance was not related to the variability in terms of BEHL.

To summarise, it seems that presence of tinnitus makes people more likely to seek and accept hearing aids (perhaps by increasing their awareness of hearing problems), but among those who are fitted, annoyance of tinnitus has a negative effect on hearing aid use. It is not known whether this is due to the hearing aid causing the tinnitus to become worse, or whether there is a feature of those who report annoying tinnitus that makes them less likely to tolerate their hearing aids.

Questionnaires as predictors of long-term use

This study also highlights that the contemporary questionnaires cannot be used in the context of screening for the purpose of identifying people who are at risk of rejecting their aids, among those who accept hearing aids after screening; at least not the questionnaires used in this study. This calls for further research into the subject, by exploring questions that tap into attitudes and perceptions in the general population [i.e. contextual factors, in terms of the International Classification of Function, Disability and Health (ICF)], not solely into activity, participation and emotional effects, which could be used at a secondary stage with screening audiometry.

Attention should be drawn to the fact that the participants fitted with aids in the initial screening studies were recruited on the basis of their answers to questionnaires, as well as pure tone audiometry. People who did not perceive themselves as hearing impaired were excluded from being fitted. Thus, the discussion about the predictive ability of questionnaires in relation to long-term use of aids applies to samples that were drawn in this particular fashion. It would not apply to attitudes in the general population and to samples recruited from the general population solely on the basis of audiometric criteria, for example.

Is screening effective in terms of increasing hearing aid use in the hearing-impaired population?

The question arises as to whether those who continued using their hearing aids in the long term are those people who would seek help on their own initiative at some point in their life, even if they were left to themselves (i.e. not contacted via screening). The validity of this question was reinforced by the evidence produced in this study that those who continued using their hearing aids after screening were mostly those who had worse hearing at the time of screening.

This study has shown that the long-term use of hearing aids was low, but significant. Thus, unless research or good practice shows that compliance-improving strategies could be combined with the screening programme and they would increase the proportion of those who continue using their aids, it seems that screening would not be effective in terms of increasing the prevalence of hearing aid users in those with mild hearing loss. In fact, only an RCT could prove whether screening (combined with compliance-improving strategies) would actually result in increasing hearing aid use.

The contribution of this study to the knowledge about screening effectiveness is that it highlighted the need for compliance-improving strategies and an RCT. The existing evidence in the literature seemed to be rather too optimistic about increasing prevalence dramatically, for example, 50 or 100% more use.

Study 2: benefit from aids fitted after early screening

Objective

The objective of this study was to determine how beneficial hearing aid users fitted after early adult screening perceive their aids to be, compared with people who are fitted at a hearing aid clinic.

Background

People who are fitted under a responsive system of service have demonstrated that they want help with their hearing, or at least their relatives want them to obtain help. So there is some motivation, on their part or on their relative's part, to seek help and try a hearing aid prior to fitting. However, people who are fitted under a proactive system of service have not demonstrated the initiative to seek help. Those fitted after screening may be more likely to underappreciate their hearing aids, and their perceived benefit from their aids may be less than among people who are fitted at a clinic.

However, the notion that attitudes before fitting are likely to result in less benefit among those fitted after screening is an intuitive assumption. It is possible that all those who do not find their aids adequately beneficial as a result of their preconceptions and attitudes (such as lack of motivation or stigma) eventually reject their aids. Thus, it might be that those who continue using

their aids find them equally beneficial, independently of whether they were fitted at a clinic or at screening. Long-term non-compliance with fitted aids may be a factor that filters out people with such attitudes and perceived hearing needs that make them less likely to perceive their aids as beneficial. Whether this is what happens in reality is something that can only be proven by research that specifically addresses participants fitted after adult hearing screening.

There is another factor closely related to screening which influences the amount of benefit derived from an aid: the age of the person when fitted. In the initial screening studies in Wales the target of screening was the age group 50–65 years. Thus, those fitted with aids received rehabilitation early. This early intervention was intentional and the following is a summary of the rationale of early fitting.

Under the current responsive system of services, those who seek help from a hearing aid clinic do so with a significant delay. People who attend a hearing aid clinic admit to having had hearing difficulties for approximately 8–15 years. The average patient presenting at a hearing aid clinic for the first time is aged about 70 years and has a hearing threshold in excess of 45 dB. (The average for England is 42 dB.) There is evidence that this delay in hearing aid fitting could result in reduction of the benefit that can be derived from amplification, in that age has been shown to affect the ability of the person to handle their hearing aid, and age affects generally the individual's behavioural adaptation, and this could affect their ability to adjust to the new auditory and social experience associated with hearing aids.

Finally, there is the phenomenon of 'auditory acclimatisation', which is a kind of physical conditioning of the auditory system to aided listening that results in better hearing function and appears after consistent use of an aid for a few months. In view of these factors, it is not unreasonable to expect that early fitting after screening may result in more benefit from hearing aid fitting than fitting at a hearing aid clinic, because the latter typically happens at a more advanced age.

One of the criteria for screening set by the NSC is that there should be evidence that early treatment is more beneficial than late. This is most relevant to life-threatening diseases where the benefit of screening is measured by increase in survival due to early treatment. In such health conditions, if early diagnosis does not result in longer life, then screening causes only harm, as it takes away from the patient's years of apparent health.

Evidence that early fitting results in more benefit than late fitting is not an absolute prerequisite for adult hearing screening. Even if such an advantage of early screening does not exist, screening (early or late) would be worthwhile, as long as it increases the prevalence of hearing aid use. Early fitting would also be worthwhile on the basis of quality-adjusted life-years (QALYs), as it would give those fitted with aids more years with better hearing. The important point is that, although a potential advantage of early fitting at screening over late fitting at a clinic is not an absolute criterion for adult hearing screening, it would add to the argument for it. If there is such an advantage in early screening, the current responsive system of services does not help aid users to obtain the maximum potential benefit from their aids.

Methods

The method used for this study aimed to obtain measures of hearing aid benefit among people who were fitted after screening, and compare them with hearing aid benefit measured among two control groups. These two control groups differed from those fitted after screening in that they were fitted at a hearing aid clinic at an older age (as is typically the case in hearing aid clinics). However, the control participants were matched with those fitted after screening in terms of gender, socio-economic group, current age and hearing levels. Details of the method of subject recruitment and matching are described are the following sections.

Participants

Screening group

This consisted of the 50 people who were fitted after proactive screening in the initial screening studies in Wales, and who were using a hearing aid at the follow-up that was conducted in 1999–2000. Earlier, in study 1, details were presented as to how these people were recruited for the follow-up. At follow-up they underwent pure tone audiometry and they were administered the questionnaires described in the appropriate sections below.

Control group 1

This was a sample of 50 hearing aid users drawn from a pool of participants from the database of the MRC IHR Scottish Section in Glasgow. A few years before this study, these people had been referred to a Glasgow NHS hearing aid clinic,

through the standard NHS channels. After their referral they accepted to take part in various research studies on hearing aids, none of which was related to this study. In these studies, carried out at the MRC IHR, many of these participants were fitted with digital hearing aids. Some other participants, however, were using standard NHS hearing aids. From the participants in these studies a control group was formed that was called for follow-up, for the purpose of this study. The follow-up was conducted by one researcher (IG), in a similar fashion to the follow-up of the participants of the screening group.

The aim was that each subject of control group 1 would be matched to a specific individual from the screening group as follows. They should be:

- of the same gender
- of the same SEG (manual or non-manual occupation)
- of as similar levels as possible in terms of their hearing thresholds in the better and in the worse hearing ears at the time of follow-up
- of as similar age as possible at the time of follow-up
- different in terms of their age at the time of fitting. It was desirable to identify control participants who were fitted at approximately 10 years more advanced age than the age of fitting of their counterparts from the screening group.

A final criterion for recruiting this control group was that:

- participants were fitted at least 1 year before the follow-up.

The purpose of this was to obtain controls who would be experienced hearing aid users. In the 'Analysis: results' section (p. 108), the closeness of the matching that was achieved between participants of control group 1 and the screening group is discussed.

Control group 2

This sample also was drawn from another database of MRC IHR, and consisted of people who in 1996 had been referred by their GP to standard NHS clinics (one in Glasgow and one in Manchester) and who were fitted there with standard NHS hearing aids (BE series). Twelve weeks after their discharge from the clinic, they attended a follow-up session where data were collected about the outcome of their fitting. (The researchers who had conducted the follow-ups were different from the professionals who fitted the participants at the NHS clinics.) This follow-up was conducted in the context of a study unrelated to the screening studies described earlier, by researchers who were unaware that the data they collected would be used later for the comparison with participants who were fitted after screening. It was thought useful to draw a suitable control sample from these patients, since some of the tests and questionnaires used for measuring hearing aid outcome among them were the same as those used among the participants in the screening group.

The database that was created in 1996 was searched again to identify 50 suitable pairs to the participants of the screening group. Each subject from this control group, compared to their individual pair from the screening group was aimed to be

- of the same gender
- of as similar hearing level as possible in the ear with which they were fitted with a hearing aid
- of as similar an age as possible at the time of follow-up.

Also, an effort was made to obtain as close a match as possible in terms of

- their socio-economic group (manual or non-manual occupation)
- their hearing levels in the better and in the worse ear.

These last two criteria were given second priority, because the participants who had taken part in the study conducted in 1996 were too few to provide close matches in terms of all five criteria.

Thus, the criteria used for matching of control group 2 were somewhat different from the criteria used for matching of control group 1. In addition, the participants of control group 2 were reviewed only 12 weeks after their discharge from the hearing aid clinic, thus they had only been using aids for a few months (as opposed to those of control group 1, who had been using aids for at least a year).

Tests

Audiological tests

Pure tone hearing levels were measured, by air conduction, averaged over 0.5, 1, 2 and 4 kHz.

Questionnaires

Instruction was given to the respondents to answer hearing-related questions so that their

answers would reflect their situation in the aided condition. If they were not using the aid in the particular circumstance to which the question was referring, they were asked to answer the question with the unaided condition in mind.

SHHI[69]
This is a questionnaire on difficulties in understanding speech in life situations. Scores range between 0 and 42, with higher scores suggesting more difficulties.

ERS
This is a questionnaire on the emotional effects of hearing loss. It consists of five questions taken from the Hearing Measurement Scale.[70] Scores range from 0 to 10, with higher scores indicating more serious effects.

Glasgow Health Status Inventory (GHSI)[77,78]
This is an 18-item questionnaire, that is designed to be all-purpose, that is, it can be adapted to focus on different health problems. For the purposes of this study, the questionnaire was adapted to address hearing difficulties, by replacing the words 'health problem' with the words 'hearing problem'. This questionnaire produces three subscales:

- The general subscale (12 items) asks questions about experiences that result from the respondent's hearing impairment. These questions mostly tap into the area of participation restrictions (some ask generally about effects of hearing loss on one's life and some others are more specific) and emotional effects of hearing loss.
- The social support subscale (three items) does not refer to hearing specifically; rather, it asks general questions about the amount of support the respondent has from family and friends.
- The physical health subscale (three items) enquires about general health, not specifically for hearing-related problems.

There is also a total score where each subscale contributes in proportion to the number of questions it contains. Scores in all subscales and the total score range from 0 to 100, with higher scores reflecting better and lower scores worse situations.

GHABP[23]
This is a measure of outcome of hearing aid fitting. This multifaceted instrument has a number of qualities, described below.

The instrument measures various dimensions that relate to hearing aid outcome. So, instead of providing a single total score, six subscale scores are produced:

- The initial disability subscale taps into hearing activity; that is, ability to hear in specific listening circumstances, without a hearing aid.
- The initial handicap subscale enquires about emotional effects that result from the respective activity limitations of the initial disability subscale.
- The use subscale is a self-assessed measure of the amount of use of a hearing aid in specific listening circumstances, in terms of the proportion of the time that a particular circumstance happens in the person's life, during which he or she uses a hearing aid.

The GHABP adopts the philosophy of measuring use in terms of duration of use within specific listening contexts, rather than the approach based on number of hours of use during a day or week. This is based on the notion that some successful hearing aid users choose to use their aid selectively in situations where the aid is most needed or most beneficial.

- The benefit subscale measures the self-perceived benefit derived from the hearing aid in specific listening circumstances. Thus, this subscale adopts the direct differential approach to measuring benefit, which has been shown to be more sensitive than the subtractive approach.[78]
- The residual disability subscale enquires about activity limitation that the person experiences, despite wearing their hearing aid(s) in specific listening circumstances. It is thus a measure of performance.
- The satisfaction subscale is a measure of the person's overall satisfaction with the performance of the hearing aid in the respective listening circumstances.

Arguably, obtaining information on all the above dimensions can draw attention to aspects of the respondent's rehabilitation that need special attention.[78] For example, low satisfaction in association with good performance and use may indicate unrealistic expectations and the need for counselling.

All subscales (dimensions) are scored on a scale from 0 to 100. Zero represents lowest reported levels of each subscale and 100 the highest. Thus, 100 represents the worst situation in terms of

TABLE 44 *Closeness of matching achieved between the screening and the control participants, as depicted by group data*

Matching-related variables	Screening group	Control group 1	Control group 2
Age at follow-up	70 years (61, 66, 74, 82)	72.5 years (62, 68, 77, 83)	69 years (62, 66, 75, 83)
Age at fitting	58 years (50, 54, 62, 66)	69 years (59, 64, 72, 79)	69 years (62, 66, 75, 83)
Duration of aid ownership	12 years (9, 10, 13, 16)	4 years (1, 3, 6, 8)	All seen approx. at 3-months postfitting
BEHL[a]	43.5 dB (20, 36, 54, 72)	45 dB (24, 37, 53, 75)	45.5 dB (20, 36, 57, 89)
WEHL[a]	55 dB (32, 42, 68, 130)	55 dB (31, 45, 70, 130)	51 dB (29, 42, 64, 93)
Fitted ear hearing level[a]	51.5 dB (32, 40, 63, 88)	51.5 dB (30, 43, 66, 84)	51 dB (29, 42, 64, 89)
Gender	Male: 37 Female: 13	Male: 37 Female: 13	Male: 37 Female: 13
SEG	Non-manual: 16 Manual: 34	Non-manual: 16 Manual: 34	Non-manual: 18 Manual: 32

Unless otherwise stated, medians are shown, and in parentheses, minimum value, 25th percentile, 75th percentile and maximum value, in that order.
[a] Averaged over 0.5, 1, 2 and 4 kHz, as this was at follow-up.

initial disability, initial handicap and residual disability, and the best situation in terms of the remaining subscales, namely more use, more benefit and more satisfaction.

EuroQol 'thermometer'[79]
Using a visual analogue scale, the respondent is asked to rate on a scale of 0 to 100 how they perceive their general health status at the time of completion (see Appendix 5, section D). On this scale, 100 corresponds to the best and 0 to the worst health status the respondent can imagine. This scale is different from the EuroQol score, which is a single score also ranging from 0 to 100 that is derived with an appropriate formula from the answers to five questions concerning various aspects of general health.

Analysis: results

Tables 44 and *45* show how closely matched the participants chosen to form the two control groups were to the participants of the screening group.

The variables listed in *Tables 44* and *45* provided the basis for matching either one or both of the control groups to the screening group. These variables delineate important features of the participants in the three groups; all these features comprise factors that could influence the amount of benefit derived from hearing aids, if they were not properly controlled for by the matching procedure. It is thus very important to determine how closely the control groups were matched to the screening group, in terms of these variables. Each table presents data related to the closeness of matching, from a slightly different perspective. *Table 44* shows measures of the distributions of variable values in each group, and thus depicts how the groups compare with one another in terms of cumulative data within each group. *Table 45* shows the differences of each individual control subject, from their respective pair from the screening group. In other words, *Table 44* depicts group data, whereas *Table 45* refers to individual pairs.

Statistical comparisons were performed between each of the control groups and the screening group in terms of the variables listed in *Tables 44* and *45*. Normality tests and tests of equality of distributions showed that non-parametric tests were more suitable for the comparisons. *Table 46* shows the values of the statistical comparisons that were conducted. These are discussed further in the following two paragraphs.

The participants of control group 1 were found to be significantly different from the screening group in terms of the age at the time of follow-up, if a paired test (Wilcoxon sign rank test) was used, whereas if an independent samples test (Mann–

TABLE 45 *Closeness of matching achieved between the screening and the control participants, in terms of differences within individually matched pairs*

Matching variable	Difference between screening and control group 1 participants	Difference between screening and control group 2 participants
Age at follow-up	–3 (–5, –3, –1, 5)	0 (–3, –1, 1, 3)
Age at fitting	–10 (–18, –12, –9, –8)	–12 (–19, –14, –11, –7)
Duration of time using aids	8 (5, 6, 9, 14)	12 (9, 10, 13, 16)
BEHL at follow-up[a]	–2.5 (–7, –4, 2, 6)	2 (–63, –9, 7, 17)
WEHL at follow-up[a]	–1 (–7, –4, 1, 6)	1 (–13, –3, 4, 80)
Fitted ear hearing level at follow-up[a]	–0.5 (–6, –3, 3, 6)	0.5 (–4, –2, 2, 4)
Gender	All pairs matched	All pairs matched
SEG	32 pairs: manual 14 pairs: non-manual 2 pairs: manual screening subject and non-manual control subject 2 pairs: non-manual screening subject and manual control subject	28 pairs: manual 12 pairs: non-manual 6 pairs: manual screening subject and non-manual control subject 4 pairs: non-manual screening subject and manual control subject

Unless otherwise stated, the values result from the subtraction: variable value for screening subject minus variable value for control subject. Medians of the differences are shown, and in parentheses, the minimum, 25th percentile, 75th percentile and maximum values of the differences, in that order.
[a] Averaged over 0.5, 1, 2 and 4 kHz, as this was at follow-up.

Whitney *U*-test) was used there was no significant difference at the 95% level. However, as *Table 44* shows, the participants of control group 1 were only slightly older than the screening group (median difference 3 years). It is probably not worth arguing whether the Wilcoxon or the Mann–Whitney test is more suitable for this comparison as this small age difference is clinically not important. It seems unlikely that such a small difference in age would influence self-reported hearing aid outcome.

Differences in terms of age at fitting were also significant, but this was intentional. There was a difference in terms of duration of hearing aid ownership, but this too was a direct effect of the recruitment method; the screening group was fitted at a younger age and followed up at approximately the same age as the control group 1. There were no differences found in terms of hearing levels in the better, worse and the fitted ear. Finally, the χ^2 test did not show significant differences in terms of gender and (manual or non-manual) SEG. To summarise, it seems that a good match was achieved between the screening group and control group 1, in that they were similar in terms of gender, SEG and hearing levels, and they differed in terms of age at follow-up, only minimally. The screening group was fitted at a younger age, by approximately 10 years.

The participants in control group 2 were not significantly different from the screening group in terms of gender, SEG, age at follow-up or hearing levels in the better, worse and fitted ear. As it was the intention of the recruitment procedure, they were fitted at a significantly younger age. They had also been using their aids for a significantly shorter length of time, as a result of the fact that they were followed up at 12 weeks after their discharge. To summarise, a good match was achieved between control group 2 and the screening group, in that they were similar in terms of gender, SEG, hearing levels and age at follow-up. The screening group was fitted when they were approximately 12 years younger than the age when the participants from control group 2 were fitted.

The next analysis compares the screening group against the control groups in terms of a list of variables. A variety of such variables was chosen so

TABLE 46 *Statistical comparisons between screening and control groups in terms of the variables used for matching*

Matching-related variables	Comparisons between screening and control group 1		Comparisons between screening and control group 2	
	Paired test	Independent samples test	Paired test	Independent samples test
Age at follow-up	$z = 4.52$, $p < 0.01$	$z = 1.80$, $p = 0.07$	$z = 0.50$, $p = 0.62$	$z = 0.28$, $p = 0.78$
Age at fitting	$z = 6.18$, $p < 0.01$	$z = 7.40$, $p < 0.01$	$z = 6.19$, $p < 0.01$	$z = 8.13$, $p < 0.01$
Duration of aid ownership	$z = 6.19$, $p < 0.01$	$z = 8.67$, $p < 0.01$	$z = 6.19$, $p < 0.01$	$z = 9.25$, $p < 0.01$
BEHL[a]	$z = 1.79$, $p = 0.07$	$z = 0.42$, $p = 0.68$	$z = 0.06$, $p = 0.95$	$z = 0.57$, $p = 0.57$
WEHL[a]	$z = 1.46$, $p = 0.15$	$z = 0.24$, $p = 0.82$	$z = 0.78$, $p = 0.43$	$z = 0.75$, $p = 0.45$
Fitted ear hearing level[a]	$z = 0.60$, $p = 0.55$	$z = 0.28$, $p = 0.78$	$z = 0.66$, $p = 0.51$	$z = 0.00$, $p = 1.00$
	Pearson's chi-squared test		**Pearson's chi-squared test**	
Gender	$\chi^2 = 0.00$, df = 1, $p = 1.00$		$\chi^2 = 0.00$, df = 1, $p = 1.00$	
SEG	$\chi^2 = 0.00$, df = 1, $p = 1.00$		$\chi^2 = 0.18$, df = 1, $p = 0.83$	

Paired test: Wilcoxon sign rank test. Independent samples test: Mann–Whitney *U*-test. Where a χ^2 value is presented, a Pearson's χ^2 test was conducted.
[a] Averaged over 0.5, 1, 2 and 4 kHz, as this was at follow-up.

that they would explore a potential advantage of the screening group in terms of various aspects of hearing aid outcome. Thus, the questionnaires that were used explore issues such as:

- self-reported acoustical benefit of hearing aids
- amount of use of aids
- satisfaction
- hearing-related activity limitations and participation restrictions
- emotional effects of hearing loss when wearing an aid
- general health-related quality of life.

Table 47 shows the medians and other quartile values of the variables that were used in this study for comparison of hearing outcome between the screening group and each one of the control groups.

Where the variables under comparison were categorical (nominal or ordinal), a χ^2 test was performed. Where the variable of comparison was continuous, tests of normality and equality of variances were conducted. Depending on whether the assumptions of normal distribution and equal variances between groups were met or not, non-parametric or parametric tests were used for the corresponding comparison. Independent samples tests were used for these comparisons.

Tables 47 and *48* show that the screening group fared better than the control groups in terms of the following variables:

- The SHHI: this indicates that their perception of their ability to understand speech in life situations was better than that of control group 1. The questionnaire was not administered to control group 2.
- The general subscale of the GHSI: they reported fewer adverse effects of hearing loss on their lives than did both control groups. The screening group also reported more support from their family and friends on the social support subscale, compared with control group 2. However, this was not corroborated by a similar difference from control group 1. The differences in the subscales were also reflected in the total score of the GHSI.
- In the GHABP the screening group reported more use, more self-perceived acoustical benefit and more satisfaction with their aids, than did both control groups. Also, in comparison with control group 2 (but not with control group 1) they fared better on the initial handicap subscale (i.e. they were less bothered, worried or upset by inability to hear in the unaided condition) and on the residual disability subscale (i.e. they had less difficulty hearing in situations where they wore a hearing aid).

Variables where there were no differences between the screening and control groups were the ERS, which measures emotional effects of hearing loss, and the EuroQol thermometer scale, which measures general health quality of life.

TABLE 47 *Outcome variables for comparison of screening and control groups*

Variable for comparison	Screening group		Control group 1		Control group 2	
	Value	No. of valid cases	Value	No. of valid cases	Value	No. of valid cases
SHHI	22 (19, 28)	49	26.5 (21, 31)	50		0
ERS	3 (1, 6)	49	4 (1, 8)	50		0
GHSI total	54 (45, 63.5)	50	48 (35, 59)	50	42 (32, 51)	50
GHSI general	57 (41, 68)	50	46.5 (24.5, 59)	50	42 (30.5, 52.5)	50
GHSI social support	67 (58, 83)	50	67 (58, 83)	50	44 (31, 51.5)	50
GHSI physical health	33 (25, 50)	50	33 (25, 42)	50	38 (25, 50)	50
GHABP initial disability	67 (50, 81)	49	57 (50, 75)	50	67.5 (51, 85)	50
GHABP initial handicap	50 (28, 69)	49	47 (23.5, 69)	50	58.5 (43, 73.5)	50
GHABP use	67 (35.5, 100)	49	38 (19, 64)	50	48.5 (34, 61.5)	50
GHABP benefit	56 (38, 75)	49	38 (25, 51.5)	50	42.5 (24, 47)	50
GHABP residual disability	25 (13, 38)	49	28 (13, 39.5)	50	34.5 (21, 45)	50
GHABP satisfaction	63 (44, 75)	49	40 (25, 50)	50	39 (28, 50)	50
EuroQol thermometer	67.5 (50, 80)	50	70 (50, 80)	50	60 (50, 70)	50

Unless otherwise stated, medians are shown, and in parentheses the 25th and 75th percentiles, in that order. The numbers of available cases with valid data for each variable are also shown.

TABLE 48 *Statistical comparisons between screening and the control groups, in terms of the variables of outcome of hearing aids*

Variable for comparison	Screening group vs control group 1	Screening group vs control group 2
SHHI	$t = 2.52$, df = 97, $p = 0.01$**	
ERS	$z = 1.01$, $p = 0.31$	
GHSI total	$t = 2.99$, df = 98, $p < 0.01$**	$z = 4.35$, $p < 0.01$**
GHSI general	$z = 2.7$, $p = 0.01$**	$z = 3.61$, $p < 0.00$***
GHSI social support	$z = 0.19$, $p = 0.85$	$z = 6.39$, $p < 0.01$**
GHSI physical health	$z = 0.15$, $p = 0.88$	$z = 0.53$, $p = 0.60$
GHABP initial disability	$z = 1.30$, $p = 0.19$	$z = 0.87$, $p = 0.39$
GHABP initial handicap	$z = 0.59$, $p = 0.56$	$t = 2.21$, df = 86, $p = 0.029$*
GHABP use	$z = 2.57$, $p = 0.01$**	$z = 2.78$, $p = 0.01$**
GHABP benefit	$z = 3.80$, $p < 0.01$**	$z = 4.15$, $p < 0.01$**
GHABP residual disability	$t = 0.842$, df = 97, $p = 0.40$	$t = 2.34$, df = 97, $p = 0.02$*
GHABP satisfaction	$z = 4.69$, $p < 0.01$**	$z = 4.88$, $p < 0.01$**
EuroQol thermometer	$z = 0.10$, $p = 0.92$	$z = 1.49$, $p = 0.14$

Where a *t*-value is presented, a *t*-test was conducted. Where a *z*-value is presented, a Mann–Whitney *U*-test was conducted. Where a x^2 value is presented, a χ^2 test was conducted. ***$p \leq 0.001$, ** $p \leq 0.01$, * $p < 0.05$.

Discussion

Findings

In this study, people who were fitted at an early age, under a proactive system, showed an advantage in self-report measures of hearing aid outcome over people who were fitted under a responsive system of services, at an older age. This advantage was present after controlling for age, hearing level, gender and socio-economic group. The advantage related to:

- better ability to understand speech
- fewer adverse effects of hearing loss in the person's life
- more use of hearing aids
- more self-perceived acoustical benefit
- more satisfaction.

These findings were confirmed by comparisons of the study group with both control groups. The study also showed some evidence that early proactive fitting was linked to more support from family and friends. This evidence, however, only derives from comparisons involving one control group. As the investigation of the other control group did not corroborate the link between proactive fitting and social support, this evidence seems less robust than the other findings.

Age, gender, socio-economic group and hearing levels are factors that could influence self-reported hearing ability and self-reported hearing aid outcome. By recruiting appropriate controls, this study has shown that there is an advantage in early proactive fitting even after controlling for these variables.

Another feature of this study was that it showed that the early screening group had an advantage over two, not just one, control groups; this reduces the chance that this advantage is due to some unpredictable bias. The two control groups were dissimilar in various ways and it is reasonable to expect that none of these differences has introduced a bias; otherwise the comparisons of the screening group with the two control groups would have given conflicting results.

It is useful here to summarise the features of the groups investigated in this study:

- Participants in control group 1 were followed up a few years after they were fitted, whereas those in control group 2 were followed up 12 weeks after their discharge from the NHS clinic. Thus, the two control groups represent two separate points along the time-course of hearing aid outcome.
- Participants in control group 1 were followed up by the same investigator as those in the screening group, whereas those in control group 2 were followed up by different researchers, who were unaware that their data would be used in the context of adult hearing screening.
- Control group 2 was more representative of the standard NHS hearing aid services, as it comprised people referred through the standard NHS channels, fitted with standard NHS hearing aids, at a standard NHS hearing aid clinic. Control group 1 consisted of people referred to an NHS hearing aid clinic through the standard NHS channels, but whose course of management was more diverse. Many of them were routed to the MRC IHR and were fitted with digital hearing aids. All, even those who were using NHS hearing aids at follow-up, had been involved in the research activities of the MRC IHR. It is possible that those who take part in research become more attentive to the details in their management and perhaps more astute and critical as to the performance of hearing aids. The screening group bears similarities with both control groups. They were, like control group 1, fitted in a research environment but, like control group 2, fitted by NHS clinicians and audiologists, in an NHS clinic or in their own GP's practice.
- Many of those in control group 1 were fitted with digital hearing aids that were newer and of better quality than those used in the screening group and control group 2.

It is unlikely that the results of this study were influenced by biases due to differences in quality of fitting, as participants in control group 1 were fitted with better quality hearing aids, but their hearing aid outcome was lacking in comparison to that of the screening group. Nor is it likely that confounding was introduced by the setting of the fitting: the screening group was fitted in a semi-research environment, control group 1 in a purely research environment and control group 2 in a purely NHS environment.

As hearing loss progresses with time, hearing aid fittings that are appropriate at the time of fitting are likely to become suboptimal a few years later. The fact that those in the screening group were fitted several years before those in the two control groups makes it more likely that their fittings would be suboptimal. The results are probably not researcher dependent, as different researchers saw the participants of control groups 1 and 2.

Including participants fitted in Manchester among those in control group 2 has hopefully controlled for geographical differences in terms of mind-set and attitudes that could have influenced self-report measures of outcome. It also seems reasonable to expect that controlling for gender, age and socio-economic group has, at least partially, evened out such geographical differences in attitudes.

It is important to discuss the findings of this study in relation to the changes that occur in hearing aid outcome over time. This study has shown advantages of early proactive fitting over two separate points along the timeline of the hearing aid outcome experienced by people fitted in a responsive system of services. Control group 1 consisted of people who were followed up between 1 and 8 years postfitting (average 4 years) and control group 2 of people followed up 3 months after their discharge from the hearing aid clinic (thus, they only had their hearing aid for a few months since fitting). One could argue that the screening group reported more benefit than control group 2 just because the latter were inexperienced users and they did not have enough time to adjust to using their aids. Even if this were true, it does not relate to control group 1, who had enough time to adjust.

Another issue that relates to time-related changes of hearing aid outcome is the fact that a number of people reject the aids they are fitted with. This poses a question as to whether this attrition in use of aids could have caused a bias in the findings of this study. One could argue that the screening group reported better outcome because those who were dissatisfied with their aids rejected their aids during the years since fitting; whereas dissatisfied individuals in the control groups have not yet rejected their aids. This is a reasonable argument, but the evidence in the literature suggests that those in control group 1 had their hearing aid for a sufficiently long time to ensure that virtually all those among them who were likely to reject their aids had already done so before the time of follow-up.

Schumacher and Carruth[74] showed that all those who stopped using their hearing aids in their sample, did so within the first year after fitting. In Brooks' sample,[80] those who were using a hearing aid at 1 year postfitting were all using their aids at 10 years after fitting. Henrichsen and colleagues[81] showed that there was no evidence of change in hearing aid use of and benefit from ITE aids between 6 months and 4 years, among those participants who continued using the same aid for 4 years; those who used their aids at 4 years used and benefited from them equally as much as at 6 months postfitting. Kyle and Wood,[66] in a sample of 25–55 year olds showed that those who were fitted for less than 2 years used their aids more (both at work and at home) than those who were fitted between 2 and 10 years earlier.

Limitations of this study related to general literature on screening

The literature on screening in general (not specifically hearing screening) argues that it is imperative that an RCT study is organised, to ensure that early treatment is more beneficial than late, before a screening programme is implemented. The reason for this is that there are potential sources of error in the effort to investigate whether early treatment is advantageous, errors that are not detectable with any other study design, including controlled studies such as this one.

One potential source of bias merits discussion. Is it possible that the screening group consists of people who would benefit from a responsive system anyway, even if screening were not applied, because their shorter natural history of hearing loss would make them use the responsive services at a younger age?

Study 1 has shown that those who continued using their hearing aids, among those who were fitted at the initial screening studies, were those with worse hearing levels at the time of screening. This raises the possibility that those who continued using their hearing aids were those who would have sought help on their own initiative (i.e. even if they were not contacted via screening). Furthermore, it is possible that, because they were the ones with worse hearing loss, they would seek a hearing aid at a younger age than the average age of those who present to a hearing aid clinic on their own initiative. If this scenario is true, then screening has only resulted in fitting with aids those who, after only a short time, would seek an aid of their own accord. In this case, the advantage of early screening that was shown in this study would be misleading, as these people would also be likely to receive this benefit under a responsive system of service.

An argument against this notion could be based on the fact that the screening and the control groups were matched for hearing levels at the time of follow-up. So, it is reasonable to expect that

because they had the same amount of hearing loss at follow up, the screening and the control groups would be people with the same natural history of hearing loss (same length of time with hearing loss and same rate of deterioration). If they had the same natural history before their follow-up, then this study has successfully controlled for the possibility of inadvertently including in the screening group people who would have obtained a hearing aid at a young age under a responsive system. There is not much evidence in the literature as to the natural history of individuals with age-related hearing loss, so one cannot argue with certainty that this route of bias can be excluded.

An RCT is the only methodology that could safeguard against this potential bias. However, it is not entirely clear what such an RCT would assess in terms of outcomes; for example, would it be 10-year take-up of hearing aids compared with screening in the same population?

Final notes

This study has shown an advantage for people who were fitted with aids after early screening and continued using their aids in the long term, over people who were fitted at an older age at a hearing aid clinic. This advantage related to better speech hearing activity, better participation in life, more use of the aids, more self-reported acoustical benefit and more satisfaction with aids.

Age, gender, socio-economic group and hearing levels have been controlled for and, in the section 'Discussion' (p. 112), it has been argued why several other potential causes of bias have been avoided. It seems that the evidence provided by this study is sufficiently reliable and encouraging. Accordingly, it argues for a future RCT that would deal conclusively with some limitations inherent to non-randomised controlled studies, such as this one.

The advantage of early proactive fitting over late responsive fitting shown in this study could be due to either or both of the following reasons:

- Those fitted in an early proactive system of services have the chance to use their aids for longer than those fitted in a responsive system of services because the latter typically happens at an older age. In this case, if those fitted at a hearing aid clinic survive for several more years they may eventually reach the same amount of benefit as those fitted early at screening.
- Those fitted at early screening were fitted at a younger age. It may be that because they were younger they had the chance to adapt better to hearing aids in a way that those fitted at an older age will never be able to. This adaptation could be due to either behavioural adjustment (i.e. ability to handle hearing aids, and adjusting to the physical and social experience associated with hearing aid use) or biological changes in the auditory system (such as the phenomenon of acclimatisation), or both.

If this is the case, early proactive fitting has offered a benefit that those fitted later at a hearing aid clinic would never be able to experience, however many years pass after their fitting. The participants of control group 1 had used their aids for a length of time that varied between 1 and 8 years (average 4 years). This is a considerable duration of hearing aid use. There is no conclusive literature as to how long it takes for the various aspects of hearing aid outcome to reach a plateau, but it seems that control group 1 had enough time to adapt. Even if their self-reported hearing aid outcome were to continue to improve in the years following the follow-up of this study, eventually to equal the outcome among the participants of the screening group, it seems that the screening group enjoys the worthwhile advantage of being several years ahead in terms of their cumulative experienced benefit.

Finally, putting these findings into the context of the NSC strategy concerning appropriate use of diagnostic tests (www.18weeks.nhs.uk/public/), even people who rejected their aids after being fitted at screening have had a benefit of an appropriate hearing assessment. This benefit empowers the patient through appropriate diagnostic and prognostic information to make a choice about whether to proceed with fitting of a hearing aid, and then using or not using that hearing aid.

Chapter 5

Performance of different options for screening for the ability to benefit from intervention for hearing problems

Introduction

The aim of this whole study was to show that

- hearing loss has a high prevalence in the older population and a real impact on the people who are impaired to justify screening, if effective and acceptable methods are available
- take-up and benefit can be shown to make a measurable outcome difference in domain specific measures and in quality of life.

(The cost of hearing loss to Europe's economy is likely to amount to over €200 billion annually, accounting for at least 1.4% of its GDP. Hearing loss affects one in six of the European population and this is projected to increase to one in four by 2050. Hearing loss is age related and affects three out of four adults over the age of 70 years, thus constraining their autonomy and capacity to live independently. A recent study reports that hearing loss ranks with asthma, diabetes and musculoskeletal diseases in terms of burden of disability, and should be considered as a national health priority.[82])

Strand 1, the population study, examined:

- prevalence of reported hearing impairment in the population for the age group 55–74 years
- views on and ways of offering screening
- take-up of screening offers
- screening methods
- hearing assessment methods
- measures that achieved good case-finding without high false-positive rates
- take-up of hearing aids following assessment
- use of hearing aids once fitted and reported benefit.

At all stages the study was within the framework of a patient journey [see Do Once and Share (DOAS): www.mrchear.info/doas], and measuring acceptability to the patient was central. The information from the population study, strand 1, was then used to look at models for screening programmes, which is the focus of this chapter. Potential costs of screening models are also outlined, along with a discussion in the light of the results on which approach to screening for hearing impairment seems to maximise benefit for the population and the individual.

Population studies are intrinsically complex. Studies involving general practice at a time of considerable organisational uncertainty in the NHS are also complex. At the time when the studies were proposed we had reasonable expectations of recruiting a large enough sample to give good statistical power and a robust ability to generalise from the research. In the event it was not possible to recruit for screening as many centres for screening as had been hoped, or to progress from screen to treatment as many patients in different subgroups as hoped. However, based on the population study, a power of effect required was calculated in terms of the outcome measures that meant that the results are strong enough as a basis for making screening recommendations (even though one site did not recruit as many patients as had been hoped at the outset). The critical power of the study was calculated on those who needed to be screened to measure the primary outcome of acceptability of the intervention, not the quality of life outcomes for those who were aided. However, in the event, both specific and generic outcomes were capable of showing a difference with the sample sizes used.

Hearing impairment too is complex. Losing hearing is not life threatening, although it does diminish quality of life (for the individual and their family) and can lead to loss of employment in some cases. Because hearing loss nearly always develops gradually, patients do not see it as a dramatic health problem requiring urgent intervention. Many people are not aware of their own mild to moderate hearing loss; for example, it is quite common to hear it said that "people don't speak so clearly these days". Hearing loss is a condition that has to be managed rather than cured, so some of the incentives for other screens

do not apply; screening for early identification and treatment will not save lives, although it may be argued that it will gain years of higher quality life and increase an individual's ability to take part in everyday and other personal activities.

This study tried to find out which were the most important factors that predicted ability to benefit (the whole patient journey: acceptance, use and benefit). The conclusion was reached that, contrary to the initial hypothesis in the proposal, the most consistent and predictive factor is the level of hearing impairment. It is the level of this factor at which intervention or providing a hearing aid is most likely to be effective and acceptable that is the most important parameter (even above motivational and other factors in this age group).

This chapter will focus on the performance of different options for screening and ability to benefit from intervention. In addition, the cost-effectiveness, implications for policy and practice, in the context of the NSC criteria (see Appendix 8), and recommendations for future work are discussed.

Establishing the 'best' screening programme is not an exact science. 'Best' will vary for a number of reasons: the balance between specificity, false alarm rates, true-positive rates, positive predictive value and cost, acceptability and risk will all vary according to patient needs, the treatment outcomes, costs per screen and case found, the nature of the intervention, and so on. This chapter extracts key dimensions and determines how they can be combined to give an acceptable, efficient and affordable screening programme with measurable worthwhile benefits and for which population the screen would be most effective in detecting unmet need.

Prevalence

Prevalence of reported concerns about hearing impairment

The population study showed that reported hearing problems that severely worry, annoy or upset people increase substantially with age. Four per cent of the 55–74-year-old population report such serious concerns. This increases rapidly with age after 50 years of age and over 8% in the 75 and over age group report serious concerns. Almost one in four (22.6%) people aged 75 and older have a moderate or severe worry because of hearing problems. People under 75 who report concerns are less likely than those over 75 to have sought and obtained help or intervention for this problem in the form of a referral or hearing aids.

Population study sample selection and possible bias

As noted in Chapter 2, the sample selection and possible bias produced by a 30% non-response merits discussion, since it could be more likely that respondents will have hearing impairment than non-respondents.

This study showed that people with lower levels of hearing loss are less likely to express concern and seek help. The non-responders may therefore differ from the responders in a way that led to overestimation. The sample weights were adjusted to take into account the gender and age distribution in the population, although this may not have eliminated all of the bias.

Self-reported hearing loss is a poor indicator of prevalence and this would affect the whole sample, leading to underestimation. It often takes 10 years for an individual to recognise that they have a hearing problem (but a shorter time for significant others). So this may mean that the current estimate of the population prevalence of more severe levels of hearing loss may be lower than the actual prevalence in the population. No adjustment was made for this, so the estimates of prevalence are likely to be underestimates rather than overestimates.

The methods may overestimate the prevalences of the rare and severe symptoms related to hearing and balance problems. Davis[2,83] has shown that using similar methods the prevalences for mild and moderate hearing impairment are not overestimated, when non-responders are vigorously followed up. The response rates in the present study are less than in the previous study and so there may be bias; in the extreme there might be no people in the non-respondents who have the particular symptom. However, this is unlikely. If the responses in this study are examined as a function of questionnaire reminder, for instance, on the question 'Do you have great difficulty hearing in a background of noise?' the overall responses were 24, 19, 19 and 21% for mailings 1, 2, 3 and 4, with a mean of 22%. For the question related to great hearing difficulty in the right ear they were 2.4, 1,4, 1.5, and 2.1%, respectively, with a mean of 2.0%, and for hearing aid use 4.0, 2.5, 2.8 and 3.2%, respectively, with a mean of 3.5%. The estimates may therefore be slightly biased in favour of apparent greater

prevalence, but there is no strong evidence of large systematic response bias for non-responders.

Prevalence of assessed levels of hearing impairment

The study found that the level of assessed hearing impairment is the primary predictor of both ability to benefit from intervention and compliance with using the hearing aid. The idea was to look at the best level of impairment to set as the cut-off point in the screen. Setting too low a level would result in too many people passing on to the next stage, and if their hearing loss was relatively mild, they might be less motivated to proceed to treatment or having and using an aid, so there might be less benefit. Looking at the different degrees of hearing impairment from minimal (say 15–24 dB HL) to mild (say 25–39 dB HL) there is a sharp increase in prevalence with every 10-dB difference. In the age group 55–74 years, 44% have a hearing loss of at least 25 dB HL (0.5, 1, 2 and 4 kHz average) in either ear, with 30% having such a loss bilaterally, in both ears. This decreases to 14% (i.e. it halves) for 35 dB HL.

Figures 56 and *57* show the prevalence of the degree of hearing impairment for the age group 55–74 years with a 35-dB criterion in the worse ear and better ear, by gender and age group, and whether they are using a hearing aid or not.

Data from strand 1, the population study, show that 26% of people have a 35-dB HL hearing impairment in the worse ear, of whom 23% do not have a hearing aid. On the better ear criterion there are 14% reducing to 11% who do not have a hearing aid. The percentages are greater in men and in the older age group (≥65 years). In the younger age group, 6% of the 60–64 year olds have this degree of impairment, of whom five out of six who are hearing impaired at the 35-dB HL level do not use hearing aids.

Therefore, the proportion of people with a hearing loss that is unmanaged by provision of hearing aids is very high. Would these people benefit from amplification? One of the main aims of amplification through fitting hearing aids is to improve the ability to hear speech in noise, in particular. If this ability is improved then this could and should lead to an increase in taking part in social communication.

The data in strand 1, stage 3, concerning the ability to benefit from amplification are shown in *Figure 58*. For each subject an analysis was conducted on the speech in noise data from the FAAF test, which performed 80 independent four-alternative auditory feature trials, to yield two scores, one for aided performance and the other for unaided performance. Using a GLM, with a logistic error term, the parameter for the difference between aided and unaided performance was derived and if there was a significant difference at the 0.05 level in the direction of better performance with amplification then this was counted as significant benefit.

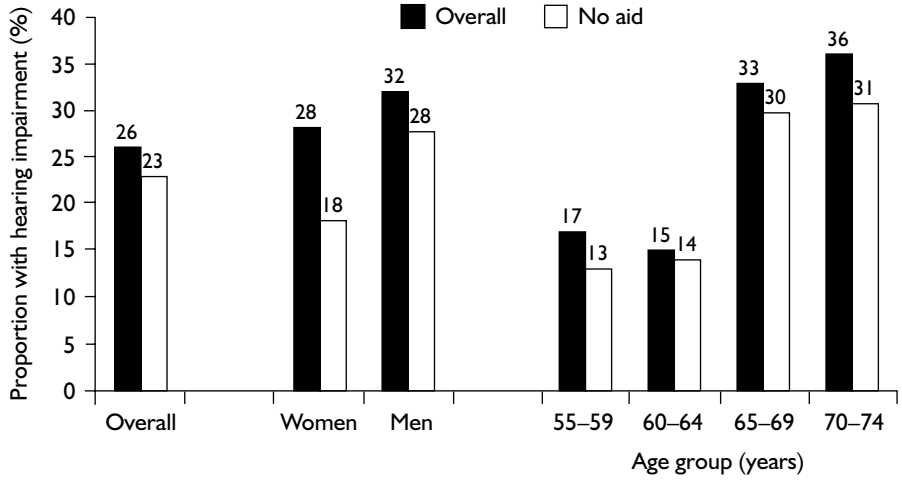

FIGURE 56 *Percentage of population with a significant hearing impairment at 0.5, 1, 2 and 4 kHz in any ear using a criterion of 35 dB HL or greater as a function of gender, age and aided status (aid or no aid), projected from the strand 1 population study*

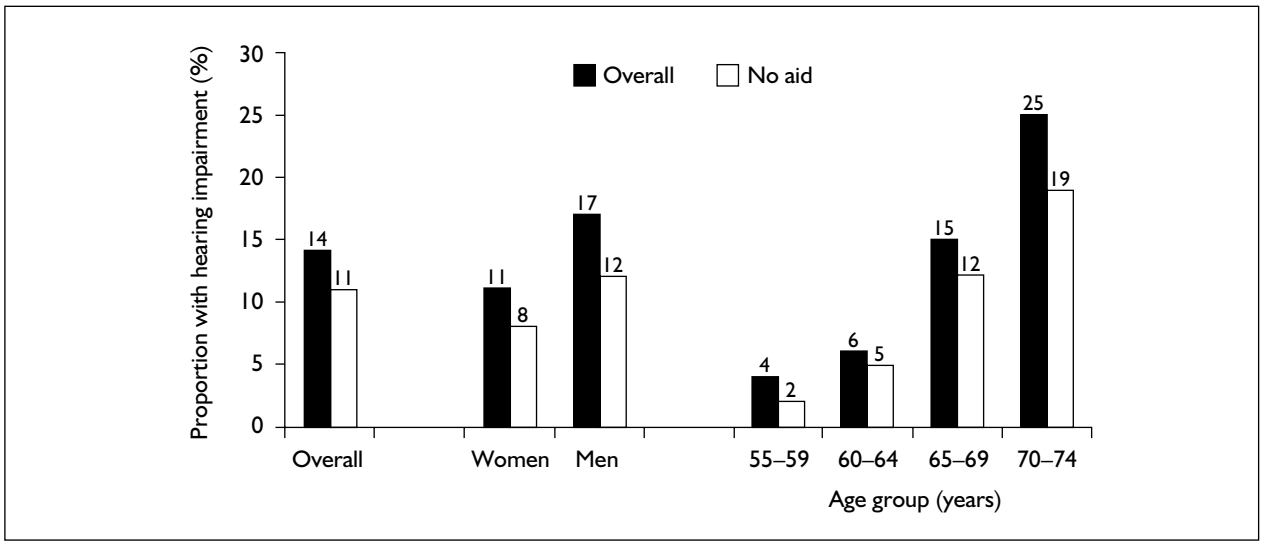

FIGURE 57 *Percentage of population with a significant hearing impairment at 0.5, 1, 2 and 4 kHz in both ears using a criterion of 35 dB HL or greater as a function of gender, age and aided status (aid or no aid), projected from the strand 1 population study*

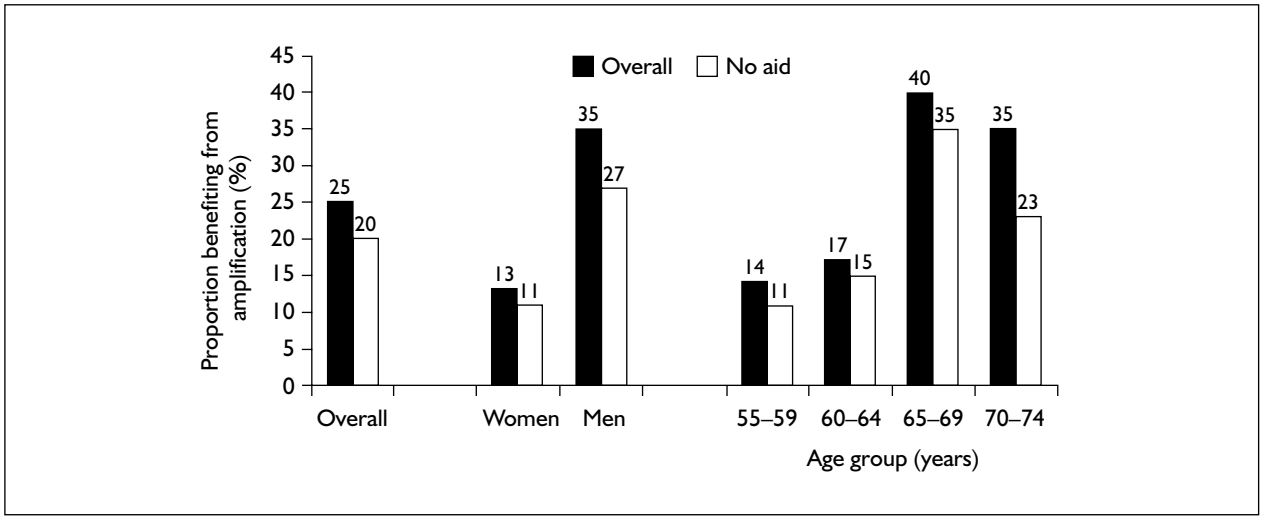

FIGURE 58 *Percentage with performance that is significantly better with amplification, calculated using an appropriate within-subject logistic model from the data in strand 1, stage 3. The benefit parameter (aided performance – unaided performance) was estimated for each subject and estimated as being significant at the 95% significance level or not. Performance in this study for each case was a score of correctly identified target words out of 80 trials.*

Figure 58 shows that over 65 years of age there is a much greater prevalence of ability to benefit statistically in terms of speech in noise performance when given appropriate amplification. These population-weighted data show the great potential of amplification in enabling better speech recognition in noisy environments.

In the 60–64 year age group 17% of people benefit from amplification, but 2% already have hearing aids, so that the 'need' for amplification in the population is 15% of 60–64 year olds because they benefit from amplification, and as seen above when they do benefit statistically, that benefit translates into significantly better recognition (e.g. 12–15% better).

This study is unique because it has sought to gain interventions for as many people as possible across a wide range of hearing impairments (minimal, mild and moderate) precisely to measure and titrate the benefits (at about 3–6 months postintervention) against degree of hearing impairment. This will enable evaluation of the benefits of triaging (or targeting) particular

degrees of hearing impairment, rather than all those who report hearing problems.

Screening models

Screening and intervention based on targeting people whose hearing impairment is at least 35 dB HL: best outcomes for available resources?

In deciding on a particular approach to screening we were guided by the NSC criteria, especially those concerning ability to benefit from interventions. They have made a series of judgements on the basis of evidence, some of which is presented in previous chapters and some of which will be reviewed here in secondary analyses of the primary data collected in this research.

The evidence suggests that resources should be targeted towards those

- with greater disability and need, which is associated with higher levels of hearing impairment in this study
- who have at least 35 dB HL, which this study has shown is the best level that could be targeted with current technology and within current service models
- who are also most likely to benefit most (again those who are more impaired)
- who are more likely to make use of hearing aids once supplied
- who are less likely to self-refer or be referred without screening.

A range of results from these studies supports this:

Strand 1, the population study, stage 4 (which aimed to identify the most efficient tool to screen for ability to benefit from aiding), showed that the benefit from hearing aids is linearly related to benefit from amplification and is also related to hearing level, supporting the case for targeting those with higher levels of impairment, in the first instance.

Strand 3, study 2, showed that long-term use (after 12 years) gives about two-thirds still using their hearing aids and benefiting, for those with at least 35 dB HL (better ear average), using analogue, BTE hearing aids. The two-thirds figure for those still using hearing aids could probably be raised if additional and more effective support was given (in the population study normal or current support was given). This supports the case for targeting those with higher levels of impairment, knowing that many will have years of use and benefit following the fitting of an aid.

Strand 2 data show that reported quality of life improves following fitting of hearing aids for all groups, but greater domain-specific benefit follows for those with at least 35 dB HL loss. The data supporting this are set out in *Tables 49* and *50*.

Does reported quality of life improve following fitting of hearing aids?

Table 49 shows the major outcome characteristics for those who were screened and accepted fitting of hearing aids, and includes those who had a hearing loss of 35 dB HL or more, and those who had a hearing loss of less than 35 dB HL in strand 2, the clinical effectiveness study. The table shows that there is overall benefit on a number of generic and domain-specific outcome measures. Similar benefits were also seen in the population study reported in strand 1, Stage 4.

The cut-off point for screening that gives the best outcomes in relation to amplification and hearing aid benefit positive predictive value and costs is 35 dB HL or more (averaged over 0.5, 1, 2 and 4 kHz).

In *Table 49* the major outcome characteristics shown are:

- the two quality of life measures used (HUI and SF-6D), which both show a positive gain in utility, with the HUI being substantially better after 3 months of using hearing aids
- the two hearing aid benefit measures: GHABP and APHAB
- the speech in noise performance benefits.

The table also shows key characteristics of the sample:

- age and duration of hearing impairment
- better and worse ear hearing impairment at 0.5, 1, 2 and 4 kHz
- a percentage estimate of those who would refer to audiological assessment with a two-stage screen with Q1 or Q2 and steady 3-kHz tone at 35 dB HL
- a percentage estimate of those who would refer to audiological assessment with a one-stage screen with a steady 3-kHz tone at 35 dB HL
- a percentage estimate of those with bilateral sensorineural hearing impairment (criteria used were <10 dB asymmetry or <10 dB air–bone gap over 0.5, 1 and 2-kHz thresholds averaged).

TABLE 49 *Major outcome and demographic variables for strand 2 patients who accept and use their amplification*

Measure	Mean	95% CI	Number
Quality of life measures increase			
HUI benefit	0.074	0.043 to 0.105	116
SF-6D benefit	0.016	0.001 to 0.031	96
QoFL benefit	0.015	0.002 to 0.027	106
GHABP			
Use	67	63 to 71	129
Benefit	58	55 to 61	129
Residual disability	13	12 to 15	129
Satisfaction	63	60 to 66	129
Disability 'benefit'	31	28 to 35	129
Overall	68	66 to 71	129
APHAB measures of benefit			
EC benefit	28	24 to 31	132
BN benefit	34	31 to 38	129
RV benefit	36	32 to 40	123
AV benefit	–19	–23 to –16	132
Global benefit	17	15 to 20	133
Speech in noise (WN or ICRA noise) FAAF measure of benefit (aided – unaided)			
WN 55/55	7.7	6.0 to 9.4	135
ICRA 55/60	8.8	6.5 to 11.3	131
ICRA 55/55	7.1	4.6 to 9.6	131
ICRA 65/70	6.4	4.1 to 8.7	131
ICRA 65/65	6.2	3.6 to 8.7	131
Key characteristics			
Age and duration of hearing impairment (years)			
Age	65	65 to 66	157
Duration	12	10 to 14	154
Better and worse ear hearing impairment at 0.5, 1, 2 and 4 kHz			
B5124	31	29 to 32	158
W5124	40	38 to 42	158
Percentage who would refer to audiological assessment with two-stage screen with Q1 or Q2 and steady 3-kHz tone at 35 dB HL			
% Refer	0.49	0.41 to 0.57	158
Percentage with bilateral sensorineural hearing impairment (criteria used were <10 dB asymmetry or <10 dB air–bone gap over 0.5, 1 and 2 kHz thresholds averaged)			
Select10	0.75	0.68 to 0.82	158

Developing the approach developed in reporting strand 2, the clinical effectiveness study, *Table 50* compares those whose better ear average thresholds are 35 dB HL or more with those who had a lower level of hearing impairment (under 35 dB HL).

Table 50 shows that within the overall benefit found for providing amplification through hearing aids there is greater benefit in targeting intervention and fitting to those with a hearing loss of 35 dB HL or more, using the same outcome measures. There are substantial differences for the hearing outcome measures: this shows significant benefit for those of at least 35 dB HL both in the reported outcomes and in the speech in noise measures. There is a tendency for a greater benefit on the quality of life measure (HUI), but no difference between the different hearing loss categories for the SF-6D (but the SF-6D is fairly insensitive to hearing[84]) or the QoFL.

The more impaired people are older (by 2 years) on average and remember having difficulty hearing for an average of 13 years. The proportion who would be referred by an

TABLE 50 *Selection of outcome and demographic variables for the two groups in strand 2, who accepted amplification, one of whom had at least 35 dB HL (over 0.5, 1, 2 and 4 kHz) and the other whose hearing impairment was 'better' than 35 dB HL*

Variable	Group	*n*	Estimate	SD	*t*	*p*
Quality of life measures						
HUI benefit	<35 dB	79	0.063	0.176	–0.794	0.431
	35+ dB	37	0.099	0.249		
SF-6D	<35 dB	67	0.016	0.076	0.383	0.702
	35+ dB	30	0.015	0.081		
QoFL	<35 dB	69	1.90	6.2	0.87	0.38
	35+ dB	37	0.73	7.1		
GHABP						
Use	<35 dB	86	60.0	30.7	–4.9	<0.001
	35+ dB	43	82.1	20.5		
Benefit	<35 dB	86	52.6	23.6	–5.1	<0.001
	35+ dB	43	69.6	14.3		
Residual disability	<35 dB	86	15.3	13.2	1.6	0.104
	35+ dB	43	11.5	10.6		
Satisfaction	<35 dB	86	58.8	24.0	–4.3	<0.001
	35+ dB	43	72.8	13.6		
Disability 'benefit'	<35 dB	86	25.5	17.7	–5.6	<0.001
	35+ dB	43	43.9	17.2		
Overall	<35 dB	86	64.0	19.4	–5.2	<0.001
	35+ dB	43	78.3	11.9		
APHAB measure of benefit						
EC benefit	<35 dB	86	22.1	20.3	–3.8	<0.001
	35+ dB	46	39.3	26.8		
BN benefit	<35 dB	83	29.9	24.2	–3.1	0.002
RV benefit	<35 dB	80	33.3	26.4	–2.0	0.045
	35+ dB	43	43.6	27.6		
AV benefit	<35 dB	86	–20.5	25.3	–0.6	0.559
	35+ dB	46	–18.0	20.0		
Global benefit	<35 dB	87	13.9	18.8	–3.6	<0.001
	35+ dB	46	25.7	16.2		
Speech in noise benefit (aided – unaided scores)						
SN 55/55	<35 dB	91	5.6	11.6	–3.0	0.003
	35+ dB	44	12.1	12.0		
ICRA 55/60	<35 dB	88	7.8	16.8	–1.1	0.275
	35+ dB	43	11.2	16.6		
ICRA 55/55	<35 dB	88	5.1	17.3	–1.9	0.066
	35+ dB	4	3	11.04	7	16.958
ICRA 60/65	<35 dB	88	3.7	15.8	–2.9	0.005
	35+ dB	43	12.0	14.5		
ICRA 60/60	<35 dB	88	4.0	18.5	–2.0	0.048
	35+ dB	43	10.6	15.5		
Key characteristics						
Age in years and duration of perceived hearing loss (years)						
Age	<35 dB	106	65.3	5.7	–2.2	0.03
	35+ dB	51	67.3	5.0		
Duration	<35 dB	105	11.9	13.9	–0.5	0.638
	35+ dB	49	13.0	14.7		

continued

TABLE 50 *Selection of outcome and demographic variables for the two groups in strand 2, who accepted amplification, one of whom had at least 35 dB HL (over 0.5, 1, 2 and 4 kHz) and the other whose hearing impairment was 'better' than 35 dB HL (cont'd)*

Variable	Group	*n*	Estimate	SD	*t*	*p*
Average hearing impairment across 0.5, 1, 2 and 4 kHz for better and worse ears						
B5124	<35 dB	107	24.9	6.0	−14.9	<0.001
	35+ dB		51	44	8.1	
W5124	<35 dB	107	35.3	14.9	−7.1	<0.001
	35+ dB	51	50	11.1		
Percentage of the population in each hearing impairment band who would be referred by a two-stage screen using Q1 or Q2 plus a 3-kHz 35 dB HL steady-state pure tone screen test						
% Refer	<35 dB	107	29.9	0.46	$\chi^2 = 47$	<0.001
By two-stage screen	35+ dB	51	88.2	0.325	df = 1	
Percentage of the population in each hearing impairment band who would be referred by a one-stage screen using Q1 or Q2 plus a 3-kHz 35 dB HL steady-state pure tone screen test						
% Refer	<35 dB	107	28.6	0.46	$\chi^2 = 58$	<0.001
By one-stage screen	35+ dB	51	98.3	0.325	df = 1	
Percentage of the groups who would not have asymmetric HL or conductive hearing loss in each category						
Proportion SNHL	<35 dB	107	0.729	0.447	$\chi^2 = 0.87$	0.34
	35+ dB	51	0.804	0.401	df = 1	

SNHL, sensorineural hearing loss.

audiometric screen at 3 kHz 35 dB HL with a steady-state pure tone is about 98% and this drops by about 10% if the first stage screen is added as the first two questions on the screening questionnaire. So, if a cheap, easy to use and reliable screening instrument were available it would be much more sensitive to use rather than filter on the questionnaire. A measure of the benefit from intervention can be taken as the initial disability minus the residual disability in the GHABP. It is clear that on this reliable benefit measure there is a substantial difference of 18% between the two groups, owing to the lower initial disability in the 35 dB HL or greater group. The majority of the people (80%) detected by any screen who are in the 35 dB HL or greater group will have bilateral SNHL.

Deciding to offer a hearing aid with a screen cut-off of 35 dB HL or more: what are the implications?

Although there is evidence that significant numbers would benefit from intervention, there are practical and long-term implications, as well as the trade-off between sensitivity and FARs, which need to be taken into account in any screening programme. The results suggest that a screen with an intention of intervening and offering an aid for those who have at least 35 dB HL would be very worthwhile indeed as the domain-specific benefits are very large (e.g. +1 SD for the speech in noise, >1.5 SD in the APHAB, 1 SD in the GHABP and 0.4 SD in the generic HUI). What implications would this decision have for current activity?

At present, 24% of new hearing aid fittings in NHS clinics are fitted for people who have less than 35 dB HL hearing impairment (Davis A: personal communication from MHAS data set, 2006). However, it is reasonable to assume that if a person with less than 35 dB HL is fitted with hearing aids it is because they have reported concerns and have been committed to seeking and receiving help without being prompted by a screening programme. The aim of this study is to focus on the benefits of screening for people who do not receive help with hearing problems that they are concerned about, or who have hearing loss and are not aware that they should seek help. The results show that the NSC criteria for introducing and maintaining a comprehensive screening programme are met if the cut-off point is 35 dB HL or higher: the hearing impairment is substantial, the impact is great (there is evidence that patients equate moderate hearing loss to chronic pain resulting from a slipped disc[82]), the numbers are large, and this study shows that the intervention is acceptable and provides significant benefit. The follow-up study, strand 3, showed that there was measurable benefit at 3 months, and we know that long-term use (after 12 years) is about two-thirds still using hearing aids and benefiting,

for those with 35 dB HL (better ear average), using analogue, BTE hearing aids. In a quality-assured service using DSP hearing aids one would expect the benefits and compliance to be higher.

Based on this evidence, what are the benefits and potential costs of taking forward a hearing screening programme?

Comparing screening programme elements

Methodology for comparing measurable outcomes and screening performance: a signal detection theory approach

The comparison used a signal detection theory approach to balancing the trade-offs involved in screening programme decisions. The major variables of interest in screening performance are those that are derived from classic signal detection theory.[85,86] A central concept in signal detection theory is the ROC curve.

ROC curves enable one to look at the effect of choosing different cut-off levels, which is why they are so useful in thinking about screening programmes. By moving along an ROC curve (i.e. choosing different cut-off levels) one can look at the consequences (in terms of, for instance, increased or decreased proportions of false positives) of choosing different cut-off points. If a high cut-off point is set there would be almost no false positives, but there would not be very many true positives either; this would be the case if the threshold was 50 dB HL, for example. Too low a threshold will give too many false positives along with a good number of true positives. Moving along ROC curves allows the cut-off point that will give the best balance between false and true positives to be plotted.

In general, the closer an ROC curve is to a diagonal, the less useful the test is at discriminating between the two populations. The more steeply the curve moves up and then across, the better the test. A precise way of characterising this 'closeness to the diagonal' is to look at the area under the ROC curve. The closer the area is to 0.5, the less good the test, and the closer it is to 1.0, the better the test. The area under the curve is non-parametric; this means that the area under the ROC curve is not significantly affected by the shapes of the underlying populations. This is most useful, as there is no need to worry about non-normality or other curve shape problems, and a single parameter of great meaning – the area under the ROC curve – can be derived (for more detailed information see: http://www.anaesthetist.com/mnm/stats/roc/).

Whether or not parametric assumptions are strictly met, a measure called d′ is conventionally used as an alternative to the area under curve to summarise how discriminating and useful a test is. This use tends to assume that with the test there is some option to trade false positives for false negatives.

Measurable outcomes and benefits that the results indicate may follow from interventions after screening

The benefits discussed fall into two categories:

- the real long-term (and short-term) benefits of intervention
- those that can act as a proxy for long-term benefits.

We looked at a number of parameters and their interactions and calculated the d′ for each one to indicate how useful each would be as a test. These are summarised in *Table 51*.

Therefore, the benefits of intervention with a number of variables could be considered: average hearing impairment of either 30 or 35 dB HL, and one or two ears impaired (taking the better and worse ear).

These were not the criteria that we set out to use when proposing these studies. However, for the reasons outlined above and in the long-term follow-up (Chapter 4), a decision was made to use these measures. It was felt they had value and they are easier to assess without any additional equipment being required. The more 'valid' outcomes used the benefit obtained in speech in noise (quiet voice, moderately difficult signal SNR), whether this was significantly beneficial (usually >7%) or any benefit at all (>0%).

The measurable outcomes and benefits used were:

- the benefit obtained in speech in noise (quiet voice, moderately difficult SNR), whether this was significantly beneficial (usually >7%) or any benefit at all (>0%)
- two operational points taken from the GHABP
  - whether the aid was used more than 69% or
  - whether there was at least 60% self-reported benefit using the GHABP

TABLE 51 *Ten criteria to screen for the target groups which were analysed to obtain the signal detection theory parameters and screen costs and their populations' weighted proportion in the target group (D+) and not (D–)*

Description of criterion for screen	Target group (D+)	Not target group (D–)
Better ear 30+ dB HL	0.208	0.792
Better ear 35+ dB HL	0.125	0.875
Worse ear 30+ dB HL	0.346	0.654
Worse ear 35+ dB HL	0.244	0.756
Significant benefit FAAF (SiN)	0.129	0.871
Any benefit FAAF (SiN)	0.206	0.794
Offered aid	0.525	0.475
Accept and use aid	0.356	0.644
GHABP benefit >59%	0.259	0.741
GHABP use aid >69%	0.235	0.765

TABLE 52 *First stage questionnaire criteria from strand 2 used in analysis*

Questionnaire abbreviation	Question (see questionnaire[a] for precise definition)
q1	Have a hearing problem (Yes/No)
q2	Great difficulty hearing in noise (Yes/No)
q3q4	No difficulty hearing in quiet on left or right
2q3q4	Q1 = yes, Q2 = yes, slight problem on left or right
maxq34	Worse ear problem in quiet
2maxq34	Worse ear moderate or worse problem in quiet
hear	Any problem on index over the three questions
2hear	Moderate problem
q12	Q1 and Q2 = yes
q1or2	Q1 or Q2 = yes

[a] Appendix 6.

- whether a hearing aid was offered and whether a hearing aid was offered and accepted by the person.

In addition to these performance criteria, the wider definition was also used: whether a hearing aid was offered and whether a hearing aid was offered and accepted by the person. The hearing levels and aid offer/acceptance can be weighted to reflect the non-hearing aided population of respondents to the screen. We are reasonably confident that these reflect the population too, as there was a similar distribution of hearing impairment and hearing aid use imputed for strand 1 and 2 populations. The other measures were only used on the population who accepted the hearing aids. In these populations inferences can be made based on the assumption that those who accepted the intervention were on an ordinal distribution; those who did not accept or were not offered an intervention were very unlikely to benefit and by default would be assigned to 'not in the target group'.

Comparing items of the questionnaire to see which are the best indicators: constructing HEAR, a graded index of hearing impairment

For each of the outcome criteria outlined in *Table 51*, the questions that could be used as a one-stage screen or as part of a two-stage screen are shown in *Table 52*.

We analysed how well the questions discriminated singly and in combination as indicators of actual hearing impairment, so that they could judge the most effective questionnaire – effective either as the single screen, or as part of a two-stage screen with simple audiometry as the second stage.

The single questions and combinations are derived essentially from the three questions used in Q1–4 in the screening questionnaire:

- Question 1 essentially asks whether the individual thinks that they have a hearing problem/concern.
- Question 2 asks about hearing in noise.

TABLE 53 *Audiometric screening parameters used in strand 2*

Abbreviation	Frequency	Level (dB HL)
S4K45	Steady 4 kHz	45
S4K40		40
S4K35		35
S3K40	Steady 3 kHz	40
S3K35		35
S3K30		30
cwarble	Average all warbles	
csteady	Average all steady state	
r3540	Average of 35/40 steady	
W4K45	Warble 4 kHz	45
W4K40		40
W4K35		35
W3K40	Warble 3 kHz	40
W3K35		35
W3K30		30

- Questions 3 and 4 ask about hearing in quiet, with a graded response (slight to no hearing at all on each ear).
- Question 5 essentially eliminates those who already have a hearing aid.

Questionnaires 12 and Questionnaires 1 or 2 show whether there was a positive screening response to both Q1 and Q2 or just one positive response to these questions.

An index of hearing difficulty, 'HEAR', was developed, which combined scores on Q1–4 in a systematic way. This index enables the reported hearing problem to be given a grade, depending on the priorities for screening and its costs. Different grades or cut-off points can be decided which will admit more or fewer people to the next stage after initial screen by questionnaire.

The questionnaire is simple to fill out and is one page in length, so it is simple and short, which helps with the further trade-off involved in deciding on cost against predictive value, in terms of staff time and patient acceptability of questionnaires of different length and complexity.

Comparing audiometric screens: are steady-state tones better than warble tones?

The next aspect of possible screening approaches investigated was the comparison between audiometric screening methods.

Steady-state tones and warble tones were compared. The accuracy of the two methods is important, and their resistance to external noise is also important. It means that the tests can be given in a range of environments without the problem that people who take the tests in noisy environments will appear to have greater impairment, leading to people being referred on to the next stage who may not need to be; as would happen if, for example, vision tests were carried out in poorly lit rooms.

Table 53 shows the different screening parameters used for the audiometric screens.

For two-stage screens the two sets of abbreviations are combined, and where the abbreviation is too long some characters from the stage 1 abbreviation are left out.

Steady-state tones and warble tones at 3 and 4 kHz were used; the two frequencies chosen are relatively resistant to external noise of considerable intensity. Three levels were used:

- 30, 35 and 40 dB HL at 3 kHz
- 35, 40 and 45 dB HL at 4 kHz.

In addition, all warbles and all steady-state tones were combined, and an average was taken at 35 and 40 dB HL (the intensities in common at 3 and 4 kHz). For all the single tone screens the absence of response on both ears was taken as the criterion. For all other screens one tone or none heard was taken as the referral criterion.

What combination of questions and audiometric criteria gives the best screening performance?

All first stage questions can be combined with each of the audiometric criteria. For each one-stage screen or two-stage combination the gold-standard

(i.e. how does it compare as a predictor of hearing impairment compared with an audiometric assessment?) criterion from the outcome measures shown in *Table 51* can be applied. This leads to a large number of outcome meta-data (see Appendix 9), which are summarised here.

Sensitivity and FAR

Screening programmes have to have a good balance between sensitivity and FAR. The sensitivities and FARs were calculated using appropriate population weighting and 90% CIs (derived from logistic model CIs) to give an indication of the extreme 5% of each tail of the distribution.

The comparisons needed to give the best trade-off between sensitivity and FAR can be difficult. Because of this the d′ (d prime) statistic has been calculated together with its counterpart, the criterion on the normalised distribution. The d′ value can be thought of as the distance between the two distributions (those with hearing impairment one wishes to target, and those one does not). The criterion can be thought of as how biased the selection is from the target group (this may be adjusted, but for single binary categorical questions is fixed).

The major elements of the data have been abstracted to enable the impact on sensitivity and FARs to be investigated, and to identify the screening elements that will give the best value. *Figure 59* shows the effectiveness of using the single questionnaire screen for identifying an audiometrically measured hearing loss of the better ear average at 35 dB HL or above. (The logistic derived confidence interval is given for the two dimensions.)

The effectiveness of this screen for this audiometric criterion is that there is a high FAR if only Q1 or Q1 and Q2 is asked, but sensitivity is high. If the more specific questions are asked the FAR goes down, but sensitivity is also lower.

Figure 60 shows the effectiveness of using only a simple, low-cost audiometric screen for identifying the same audiometrically measured hearing loss of the better ear average at 35 dB HL or above.

The sensitivity is reasonably good and the FAR is an acceptable 10–20%. For example, picking out one point on the graph, the steady-state 3-kHz 35 dB HL tone has about 88% sensitivity and 10% FAR. The equivalent warble tone is about 6% less in sensitivity and a few per cent more in FAR.

Costing screening programmes

The best value screening programme will be one that combines good sensitivity with a low FAR and a reasonable screening cost with good outcome benefits after treatment. However, the cost of treating cases found through screening which are in addition to cases currently treated are also part of the costing of any new screening programme.

The parameters in this study enable the approximate cost of a particular screening programme to be estimated. A formula is shown in *Box 1* that gives the assumptions used here and the values used in these equations (using *Table 51* to give the prevalence of the target group).

Outcome benefits of the screening approaches in the study

The study looked at different ways of screening [single (questionnaire only) or two-stage (questionnaire plus audiometry)] and different ways of case-finding (systematically writing to all in the target population or offering screening opportunistically to patients when they attended a GP's surgery).

Findings on cost and effectiveness of the screening programmes in the study

Methods for costing

The aim of this study was to show that

- hearing loss has a high enough prevalence in the older population to justify screening if effective and acceptable methods are available
- screening take-up and benefit can be shown to make a measurable outcome difference in quality of life.

The results show that it is possible, by screening for hearing loss in the targeted population, to increase uptake and use of hearing aids and improve quality of life. The cost and benefit of different screening programmes need to be assessed to see whether they indicate that further work on developing a national screening programme is justified.

Costing services in the NHS is complex. There are several ways of modelling services and costs, and different views on what should be included (for example, whether patient costs such as time and travel should be included). In the current climate of almost continuous reorganisation within the NHS, costing has become even more complex and

Average cost of screening = Base cost + TPF * P(D+) * { $C_{TP} - C_{FN}$ }
+ FPF * P(D–) * { $C_{FP} - C$TN }
+ C_{TN}*P(D–) + C_{FN}*P(D+)

where C = cost, TPF = true positive found (i.e. sensitivity), D+ = in the target group on criterion, D– = not in the target group, FPF = false alarm rate, TP = true positive, FN = false negative, FP = false positive, TN = true negative, P(D+) probability of being in target group, and Base cost = administrative and technological central charge per person.

Base cost assumptions: £2 administration; £2 equipment (based on £140 per screening audiometer)

C_{TP} = £3 questionnaire (reducing to £1.80 for opportunistic) + £6 per audiometric screen + £20 per audiogram assessment + optional £853 for 10-year treatment costs depending on costing basis

C_{FN} = £3 questionnaire (reducing to £1.80 for opportunistic) + £6 per audiometric screen

C_{FP} = £3 questionnaire (reducing to £1.80 for opportunistic) + £6 per audiometric screen + £20 per audiogram assessment

C_{TN} = £3 questionnaire (reducing to £1.80 for opportunistic)

Based on 2004/05 national (England) average unit costs declared by hospital trusts to the Department of Health for hearing aid assessment (£55, SD £69), fitting (£68, SD £68) and follow-up (£44, SD £47), assuming that 80% of patients opt for two hearing aids (£116 tender cost) and using average unit costs of staff carrying out the screen and associated tasks from www.pssru.ac.uk

BOX 1 *Estimating the cost of a screening programme: formula showing the assumptions used and the values used in these equations*

open to debate. (The difficulties of costing accurate estimates for future screening programmes are well set out in the report 'Improving outcomes for people with skin tumours including melanoma'.[87]) There are wide variations in service patterns and costs. Costings based on service patterns when this study was carried out will no longer apply, because patterns and costs of service delivery in primary and acute health services have changed and continue to change (e.g. components of the National Tariff, costs of GPs with Special Interests).

We have taken a pragmatic approach, within the limitations of their sample and budget. The aim was to see whether this study could arrive at a guide cost for the screen which this research found to be the 'best'. These guide costs were then used to see whether the QALY benefit calculation was within the accepted £30,000 per QALY gained. If costs were so high that the QALY benefit cost was above £30,000 there would not have been a strong case to be made for further work on a national screening programme.

This economic evaluation is only preliminary, but the guide costings are within the range that indicate that it would be worthwhile proceeding to pilot screening programmes that would collect detailed cost and benefit information. It would then be worthwhile to model this in more detail to inform decisions about extending the programme to a national one. Even if it is not possible at this stage to quantify formally the level of uncertainty that surrounds the cost estimates, the results still indicate that it is worthwhile to proceed to a pilot screening programme with costing methodologies agreed. In this way cost–benefit can be assessed in the light of the actual costs of the components of the service pathways currently in place.

Detailed technical discussions follow, outlining the way in which cost estimation and benefit calculations were approached.

Calculating the cost per person screened and cost per QALY: issues to be considered

Cost estimates

When estimating all additional costs associated with the costs of screening, all people, even those who it transpires do not have a hearing impairment, are included within the analysis. If these patients had not been involved in this study they would have received no intervention. So, when analysing the data an ITT methodology is adopted and the cost-effectiveness for all people is included, regardless of outcome. The cost per QALY estimates are thereby the mean cost and mean QALY estimates for all presenting patients, rather than just for those who go on to receive a hearing aid.

Cost components

In terms of staff time (both direct contact time and non-contact time), staff cost per hour (i.e. staff grade for each task), equipment, overheads, and so on, costs were assessed from the perspective of the UK NHS. Bottom–up costing methods were used to estimate both the level of resource use and associated unit cost associated with all hearing aid appointments (including both contact and non-contact time). Thus, the incremental costs associated with hearing aid provision, staffing, equipment and accommodation (including cleaning, electricity, etc.) were estimated. Costs to the NHS were estimated at 2004/05 cost levels as indicated above, and future costs discounted at 3% per annum.[88] These costs may change in line with the procurement of hearing aids and any tariff [payment by results (PbR)] that is agreed for hearing aid services in the future.

Utility gains

In line with previous analyses,[89] it was assumed that utility changed linearly over the first 3 months after hearing aid fitting (from the preintervention value to the value measured at 3 months postfitting) and that, thereafter, the gain associated with hearing aid provision would remain constant (relative to the assumed alternative of no intervention). The appropriate period for which these gains are assumed to be sustained is the period for which early screening is assumed to provide benefits, beyond those benefits that an individual would have received had the screening programme not existed. A conservative estimate is that a screening programme could result in patients being provided with hearing aids, on average, 9 years earlier than would have been with case if the screening programme had not been set up. Thus, QALY scores are calculated based on the assumption that the utility gain (3 months postfitting) will be applicable for a period of 8 years and 9 months postfitting. It was assumed that hearing aids last for 3 years and there is a fixed charge for repairs. In reality, the costs are much lower than the ones included here, as replacement aids and reassessments may be on a longer basis (e.g. every 5 years; however, this is offset by the cost of repairs which average £22 and may be needed two to four times over the same period, which is effectively cost neutral).

Estimating patient-specific levels of resource use

For probabilistic sensitivity analysis to be undertaken, it is generally necessary for patient-specific levels of resource use and changes in utility to have been measured. Individual patients completed quality of life measures both before and after intervention, and thus it is possible to estimate the change in utility for patients (who provided such data) in this study. However, after discussion with healthcare professionals, the decision was made not to estimate individual patient-specific levels of resource use, for two reasons.

The first reason was that it was relatively easy to estimate the average level of resource use for each patient, associated with each type of patient contact, using top–down methods [e.g. average staff time per patient was calculated by dividing total staff time (for all patients) by the number of patients]. The second reason for not estimating patient-specific levels of resource use was that in a pilot study, where healthcare professionals were asked to report the duration of each patient contact, most healthcare professionals simply reported the booking time of the appointment, which may, or may not, have been equivalent to the exact contact time spent with each individual patient. In this study, therefore, top–down methods were used to estimate the average level of resource use associated with each type of patient contact, but resource levels for individual patients were not estimated. As such, it is not possible formally to quantify the level of uncertainty that surrounds the cost estimates at the patient level.

Cost-effectiveness for the NHS

The likelihood that the intervention is cost-effective for the NHS was estimated. O'Brien and colleagues[90] advocated the use of 95% CIs, surrounding both mean cost and QALY estimates, to estimate the level of uncertainty surrounding the mean cost per QALY estimate. Given the limitations of the data set, it was necessary to adapt such methods to estimate how likely it is that the mean cost per QALY associated with this intervention is below £20,000 per QALY. It should be noted that although it has been suggested that a £20,000–30,000 criterion is used by the National Institute for Health and Clinical Excellence (NICE) (e.g. Raftery[91]), more recent interpretations have concluded that cost-effectiveness is only one of several variables that predict whether an intervention will be approved[92] and that the cost-effectiveness boundary is gradual rather than abrupt.

Utility scores were measured both before and after intervention in this study and, based on the HUI3, where a difference of 0.074 was found, the mean QALY gain over a 9-year period was estimated to be 0.56 (95% CI 0.33 to 0.80). These upper and lower bound 95% CI estimates can be used to

estimate the maximum cost levels that would still permit the intervention to be deemed cost-effective (i.e. mean cost per QALY <£20,000). If it transpired that the mean QALY gain was actually 0.33, then so long as the mean per person cost of the intervention was less than £6592 (6592/0.33=20,000) the mean cost per QALY estimate would still be below the threshold of £20,000. Thus, based on the lower 95% CI utility gain estimate of the HUI3, only if the actual costs were more than seven times greater than the mean cost estimate would the cost per QALY estimate be above the £20,000 threshold. Over a 6- rather than a 9-year period, the QALY gain was 0.3 (95 CI 0.23 to 0.56) and the mean per-person cost of the intervention to be below the threshold of £20,000 at the lower CI was £4554, which is still over seven times greater than the mean cost.

When similar analyses are conducted for the SF-6D scores, the mean QALY gain is estimated to be 0.12 (95% CI 0.01 to 0.24). Thus, based on the lower 95% CI gain derived from the SF-6D, only if the mean cost was over £153 per person would the cost per QALY estimate be above the £20,000 threshold (153/0.01 ⩽20,000). This is because the CI for the SF-6D benefit is wide and approaches 0 at the lower end. If the 95% CI is used then only if the mean cost was in excess of £1053 would the cost per QALY exceed the threshold. However, another interpretation would be that the SF-6D was not sensitive to changes in hearing and communication at the activity level.

A major assumption is that the benefit seen at 3 months postintervention is maintained over the 6 or 9 years used in the model. Using the current assessment tools it can be assumed that the benefit will remain, as the questions in the HUI3, for instance, which are responsible for the change are rather robust, and changes in hearing loss are slow to present (e.g. 5–10 dB per decade), but they do and over 20 years this can be a problem, if an appropriate reassessment protocol is in place. It can be assumed that the overall QALY will decrease with age and that the contributory benefit from intervention for hearing problems will grow provided that the hearing aids are maintained properly, as referred to in the follow-up study in Chapter 4. The two other studies (strand 1, stage 4, and Barton[84]) also show similar results relating to the HUI and the SF-6D using a random sample of people and a clinical sample of first time direct referral patients fitted with hearing aids.

The above analysis shows that, even under what might be deemed worst-case scenarios, it is still estimated that the mean cost per QALY is well below £20,000 using the HUI and is somewhat less clear-cut at the lower end of the CI for the SF-6D model. This beneficial situation arises because the per-person incremental healthcare costs associated with hearing aid provision are relatively low compared with many other healthcare interventions.

Cost-effectiveness of a screening programme

The minimum cost of a screening programme can be derived from the first differential of the equation in *Box 1*. The slope of the ROC curve at which cost is minimised for the parameters used can be estimated. This will depend heavily on whether the costs of intervention are included in the estimation or not. If the treatment costs are included, the slope of minimal cost will be more on the left of the ROC, so that fewer cases are identified. If the cost of the treatment or intervention is outside the domain of the screening programme (e.g. two independent cost centres: public screen, private treatment; private screen, private treatment, etc.) then the cost is minimised by finding relatively more cases at the cost of more false alarms. In this case the slope is lower and the best point on the ROC to minimise cost is to the upper right.

Sensitivity, FAR, criterion used and average cost over 10 years

Tables in Appendix 9 show for each outcome criterion the screen performance for each of the possible single-stage screens and two-stage screens. The parameters shown in the tables are:

- sensitivity of the screen (sen)
- false alarm rate (fa)
- d′ (dprime)
- estimated criterion used (crit)
- overall average cost including treatment over 10 years (cost.avg)
- slope of the ROC curve at which the costs are minimised (cost.slope)
- cost of the screening component alone (cost.sc.avg)
- slope of the ROC curve at which the screening costs are minimised (cost.sc.slope).

The major elements of the data are abstracted and presented as figures so that general messages can be seen.

In *Figure 59* the one-stage screen performance of the questions without an audiometric test is shown

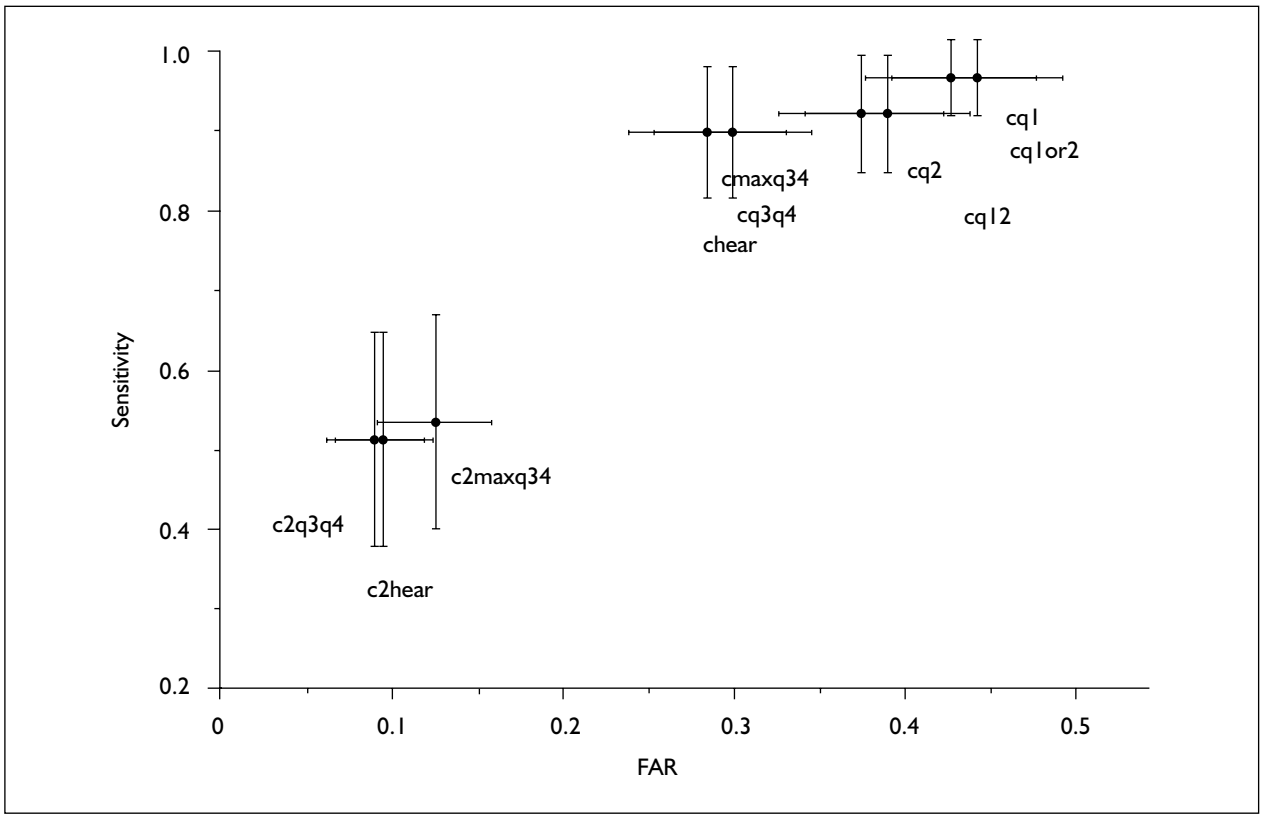

FIGURE 59 *Sensitivity and FARs, with 90% CI, for all age groups for a one-stage screen with different first questionnaire stage shown. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more. Note large FAR.*

using, for example, the better ear average of at least 35 dB HL criterion. Each point shows the CI for its two dimensions. Two major features are readily apparent:

- there is a high FAR for the simple criteria associated with Q1 or with the combinations (e.g. Q1 or Q2), but high sensitivity
- for the more stringent questions there is a lower FAR but lower sensitivity (i.e. the yield of actual hearing impairment cases will be lower).

Sensitivity has a CI of about 10% and FAR slightly less, so only gross differences are significantly different.

Figure 60 shows the same data for a single-stage screen using a simple audiometric screen (costing about £6 with low-cost equipment). Using the same criterion, the range of sensitivity (or yield) is more compressed, which is much better, and the FARs are in the range 10–20%, which is much more acceptable. Picking out one point on the graph, the steady-state 3 kHz 35-dB HL tone has about 88% sensitivity and 10% FAR. The equivalent warble tone is about 6% lower in sensitivity and a few per cent higher in FAR.

Considering the average costs of screening alone with no treatment costs for the single-stage audiometric screen, *Figure 61* shows the plot of screen cost versus sensitivity (or yield). This shows that for those screens in the region of 90% sensitivity for the 35-dB HL hearing loss criterion, the steady-state 3-kHz, 35-dB HL tone has a minimum cost at about £13 per person screened (per respondent of the systematic screen).

This approach and these results indicate that the best fit screening programme would use:

- patient-reported concern (Q1 or Q2)
- and a 3-kHz 35-dB HL steady-state audiometric screen on both ears (no responses on either ear).

(Note that this is not equivalent to a hearing threshold of 35 dB HL, but is more equivalent to 40 dB HL at 3 kHz, owing to the protocol used to determine hearing thresholds.)

This screening programme can be typified as an ROC plot, shown in *Figure 62*, where each point represents a different outcome. It is clear from this figure the point where there is a significant difference between the criteria, with the criterion

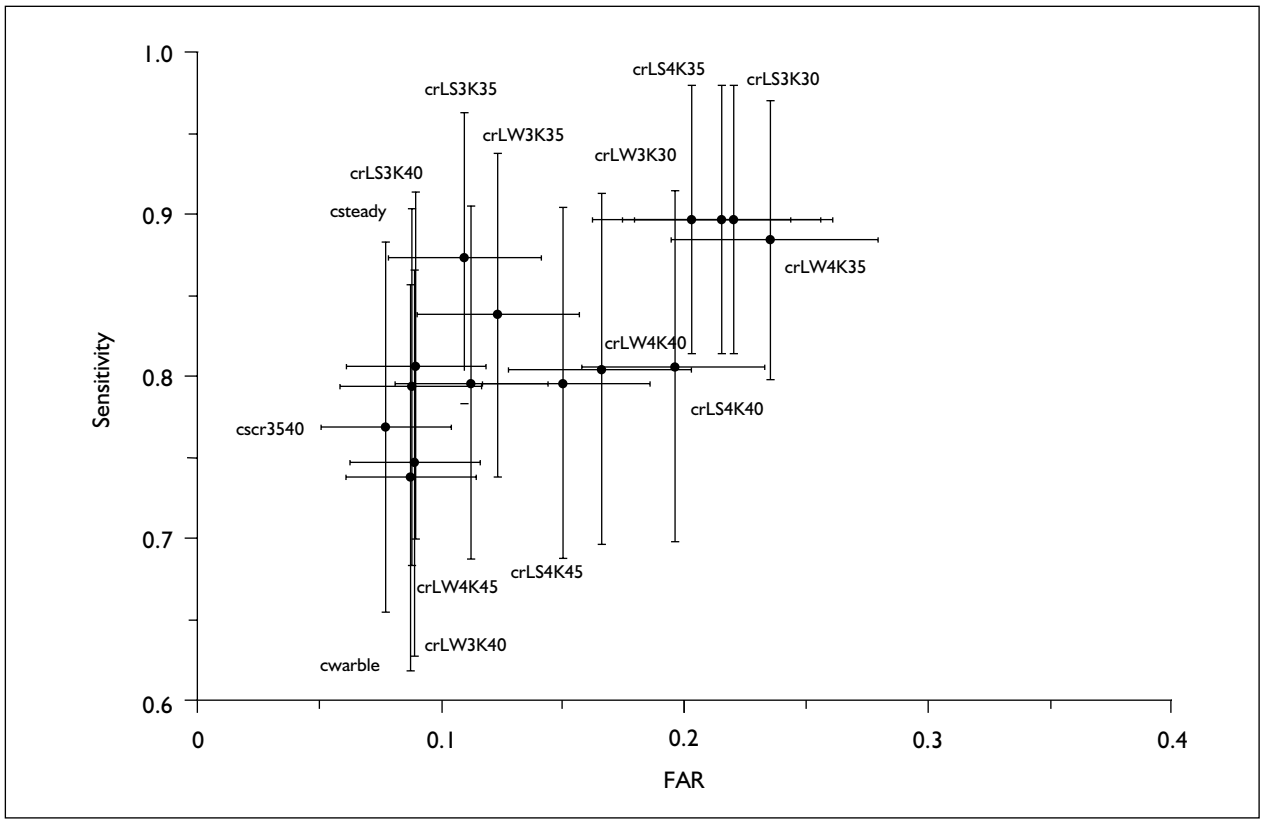

FIGURE 60 *Sensitivity and FARs, with 90% CI, for all age groups for a one-stage screen with different audiometric screen as first stage shown. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

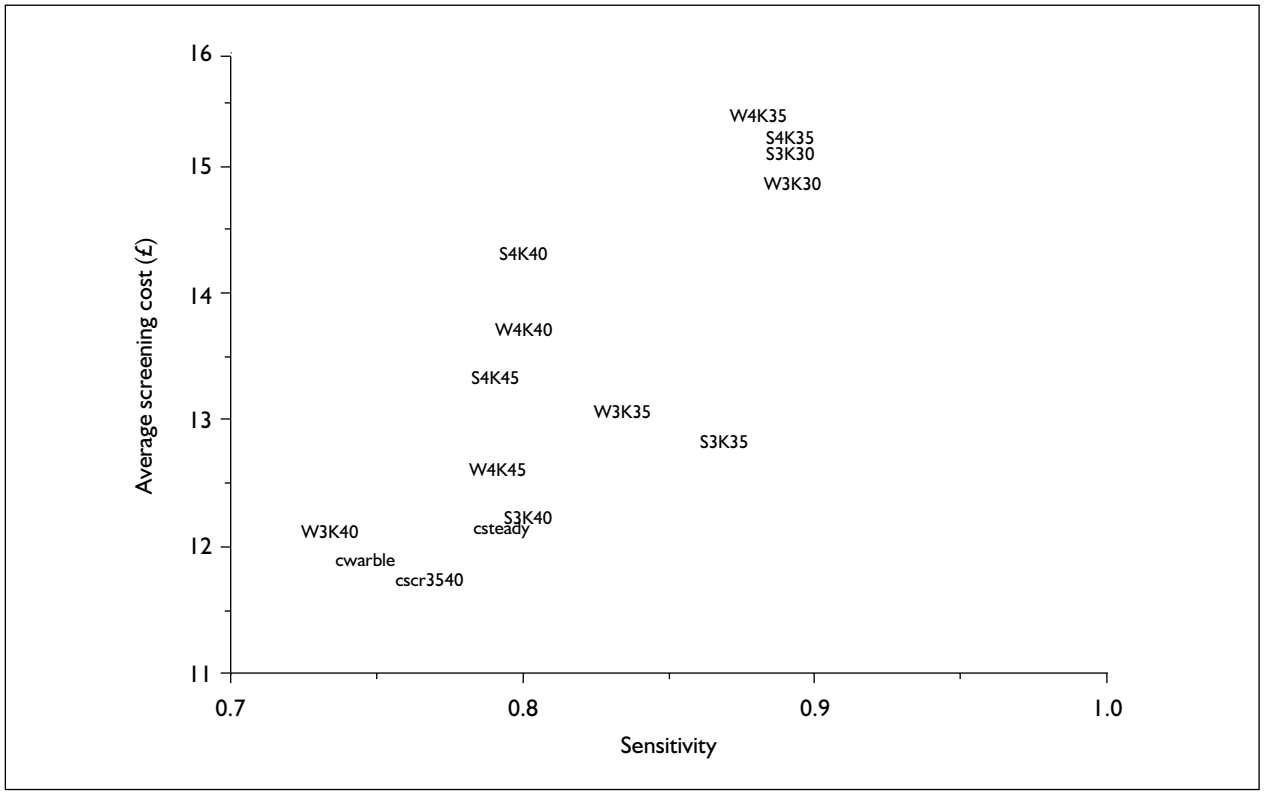

FIGURE 61 *Average screening cost (excluding 10-year treatment costs) as a function of sensitivity for all age groups for a one-stage audiometric screen with different first stage shown. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

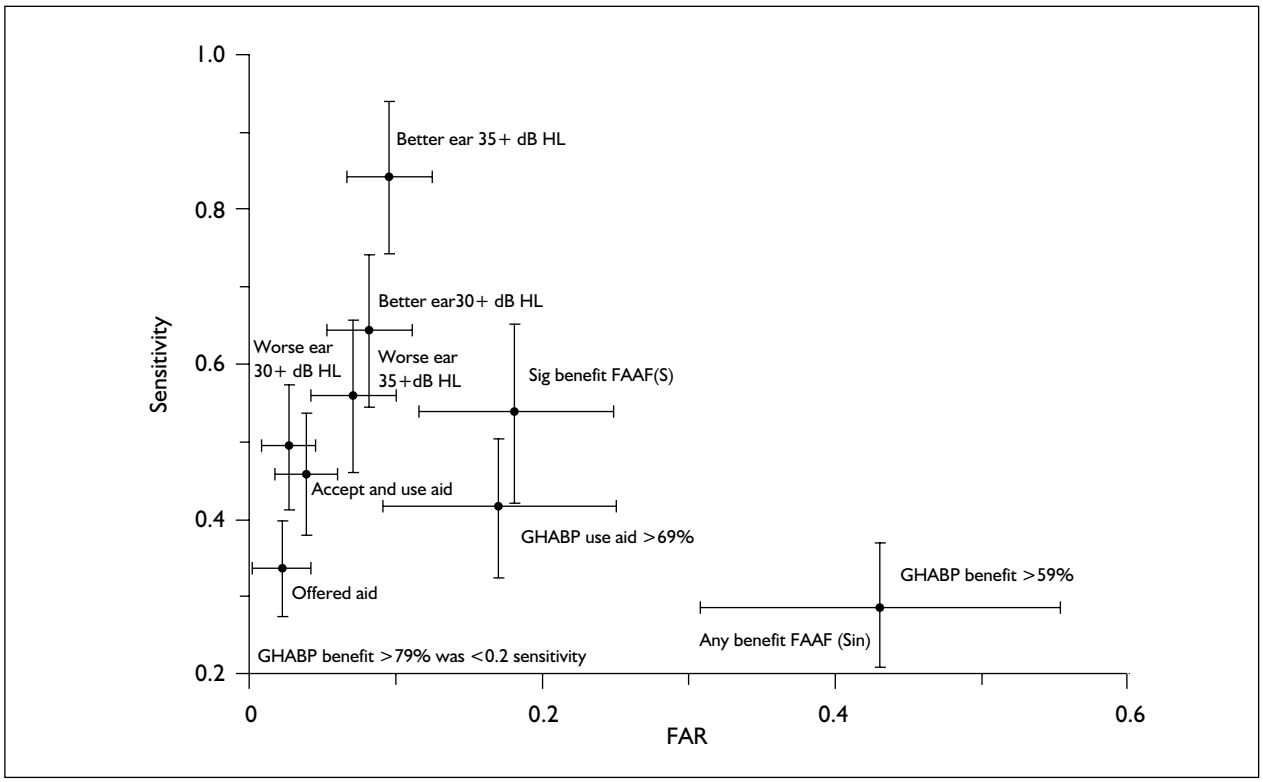

FIGURE 62 *Sensitivity against FAR, with 90% CI, for all age groups for a two-stage screen with Q1 or Q2 as the first criterion and screening audiometry as the second stage using a steady pure tone at 3 kHz, at 35 dB HL. Each point is for a different criterion.*

at 35 dB HL or more being different from the other outcomes. This gives a sensitivity around 85% and an FAR below 10%.

Screening with this two-stage screen for significant benefit for speech in noise gives 50–60% sensitivity, but about a 20% FAR. Using such a gold standard might be thought to be valid, as the main intention is to improve speech in noise performance. The data here indicate that some form of speech in noise test should be done at assessment, which may be useful in demonstrating benefit. This would add at least 20 minutes to the assessment and follow-up if done thoroughly. However, using an indirect outcome measure such as hearing level is something that is a necessary part of every hearing assessment (using the MHAS patient journey), does not add to the cost and seems to be a robust indicator of ability to benefit from hearing aids when listening to speech in noise.

Comparing the cost of the screen as a function of d′, as shown in *Figure 63*, it is clear that, using the two-stage screen above, the best d′ is easily given by the 35 dB HL or greater criterion at a d′ of about 2.3, with all other d′ below 2. This gives the second best cost of around £13 per person screened. The slope of the ROC curve was estimated for each of the outcome criteria at the place where they fall on *Figure 61* and compared with the slope that minimises the cost when treatment costs are excluded. If the aim is to minimise the cost of the screen then the plot should fall on the diagonal line in *Figure 64*. It is clear that the one criterion that is close to the diagonal is 35 dB HL or greater average.

To compare the screen strategy discussed above with other question combinations and a fixed 35-dB HL 3-kHz steady pure tone, *Figure 65* shows the ROC plot for each of the questions as part of a two-stage programme. It also shows the audiometric screen itself. From this figure it can be seen that Q1 or Q2 combination has the best sensitivity and a reasonable FAR. However, there are no clear statistical significant differences within the two groups of questions shown and there is a lot of overlap.

Costs of screening, cost per case found and treated

Figure 66 shows the time-discounted 9-year cost for screen plus treatment for each of the different questionnaire first stages as a function of sensitivity. The 9-year cost includes three sets of hearing aids, such as those used in the MHAS programme, and assumes a good, quality-assured

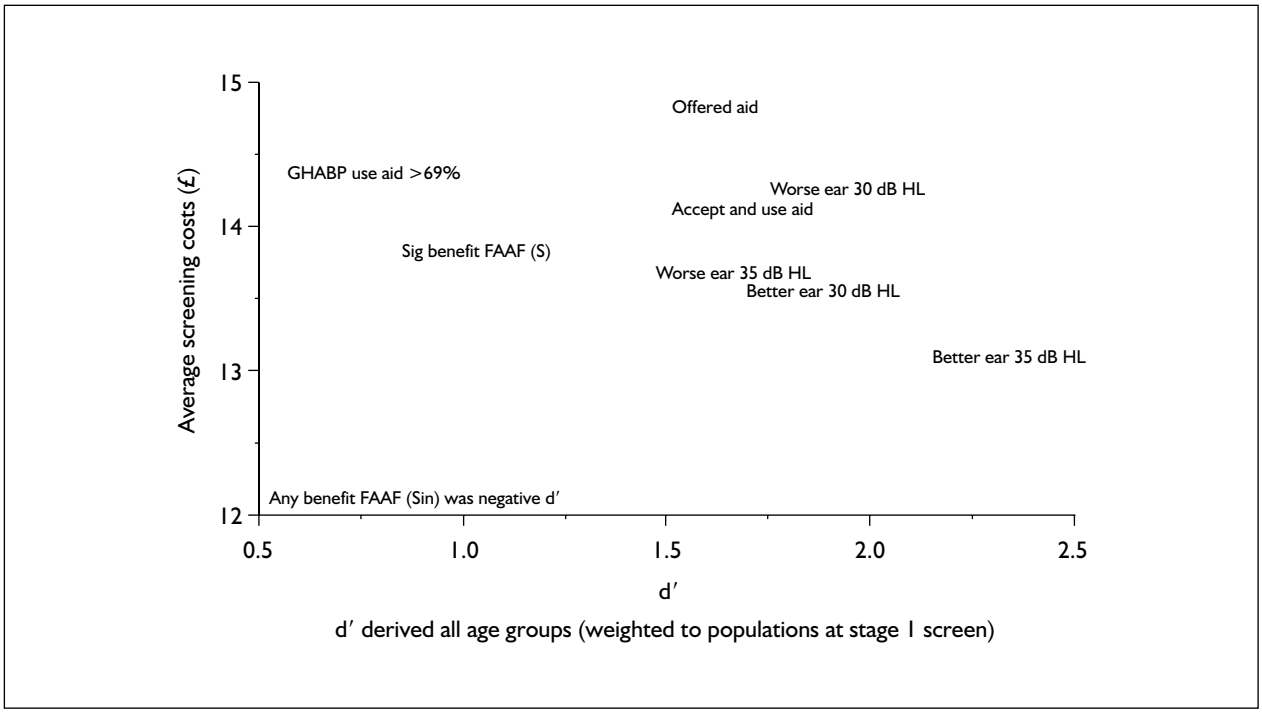

FIGURE 63 *Average screen cost as a function of d′ for all age group (55–74 years) for a two-stage screen with Q1 or Q2 as the first criterion and screening audiometry as the second stage using a steady pure tone at 3 kHz, at 35 dB HL. Each point is for a different criterion (see text).*

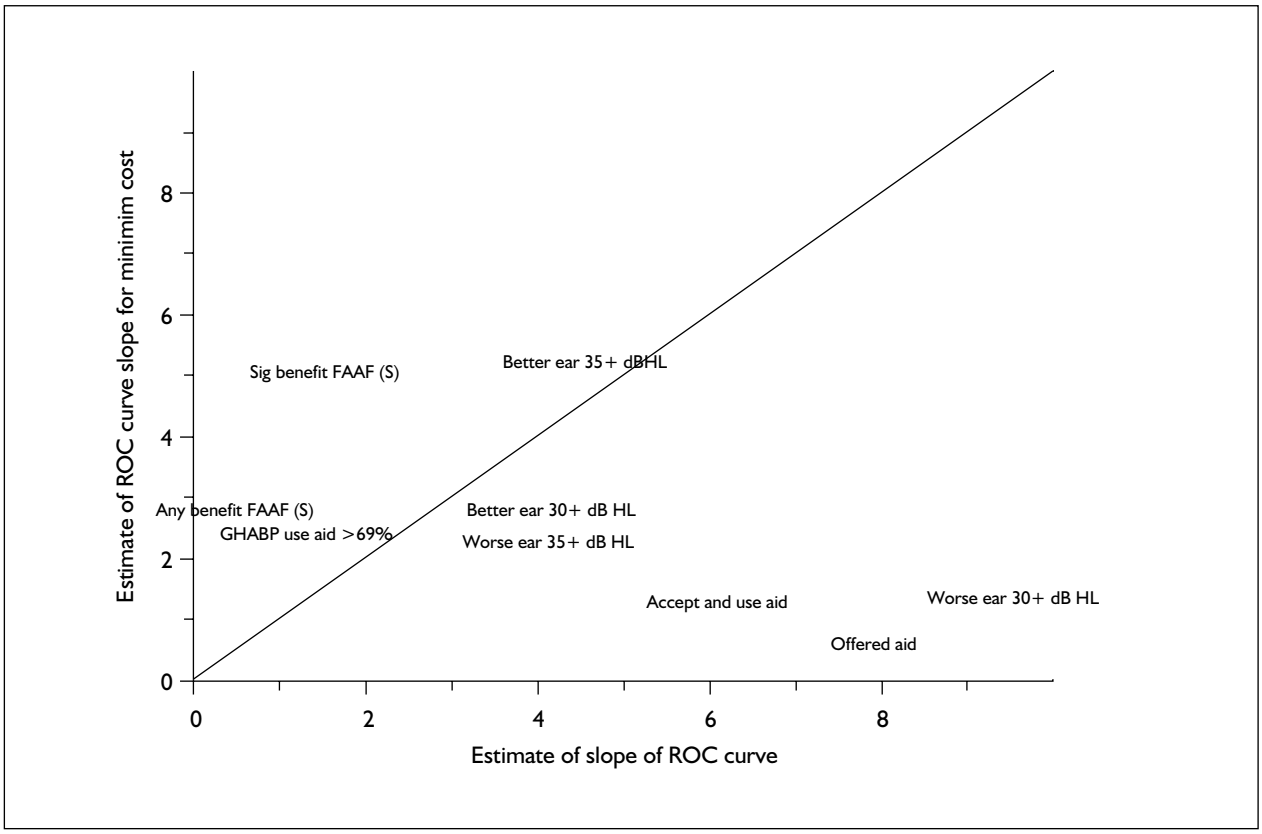

FIGURE 64 *Estimate of slope for minimising cost on the ROC as a function of the actual values obtained for a two-stage screen with Q1 or Q2 as the first criterion and screening audiometry as the second stage using a steady pure tone at 3 and 4 kHz and levels of 30, 35, 40 or 45 dB HL. Average warble and steady pure tone are also given. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

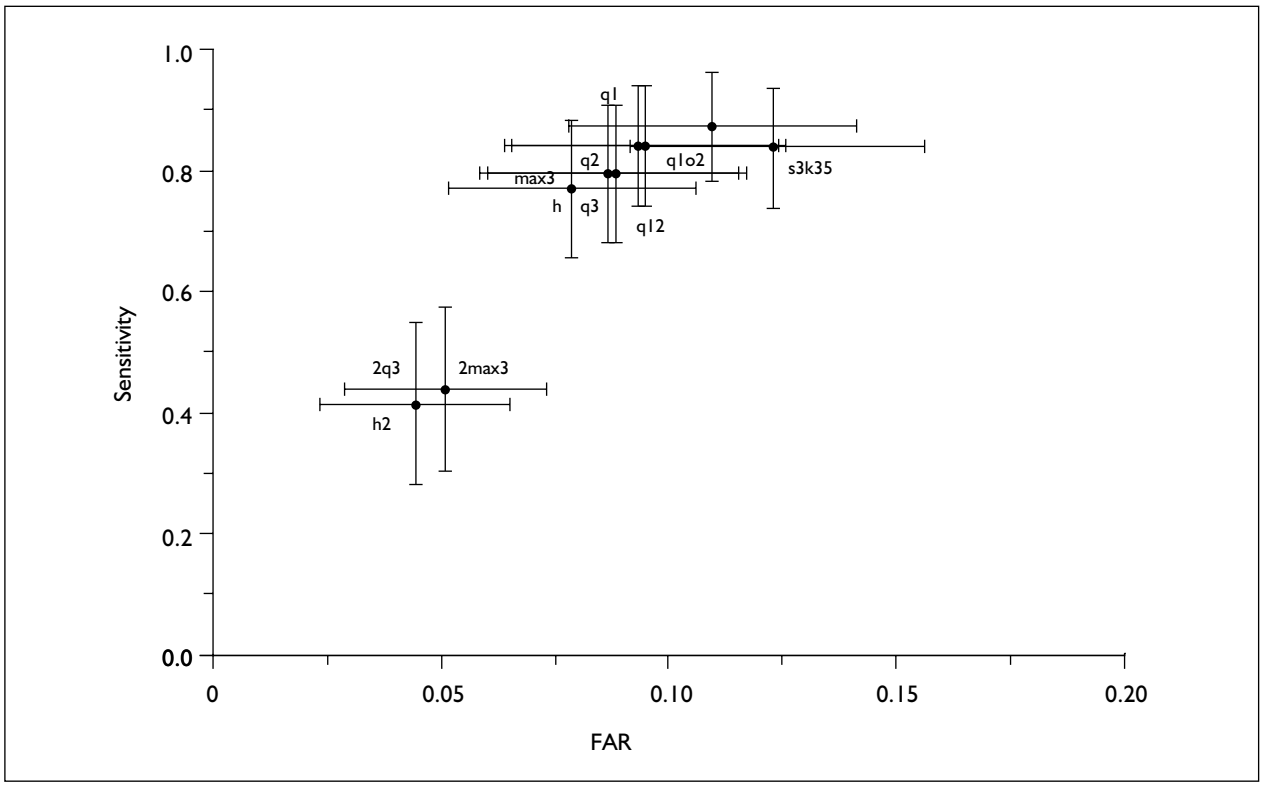

FIGURE 65 *Sensitivity against FAR, with 90% CI, for all age groups for a two-stage screen with different first stage shown and a fixed second stage screen using a steady pure tone at 3 kHz, at 35 dB HL. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

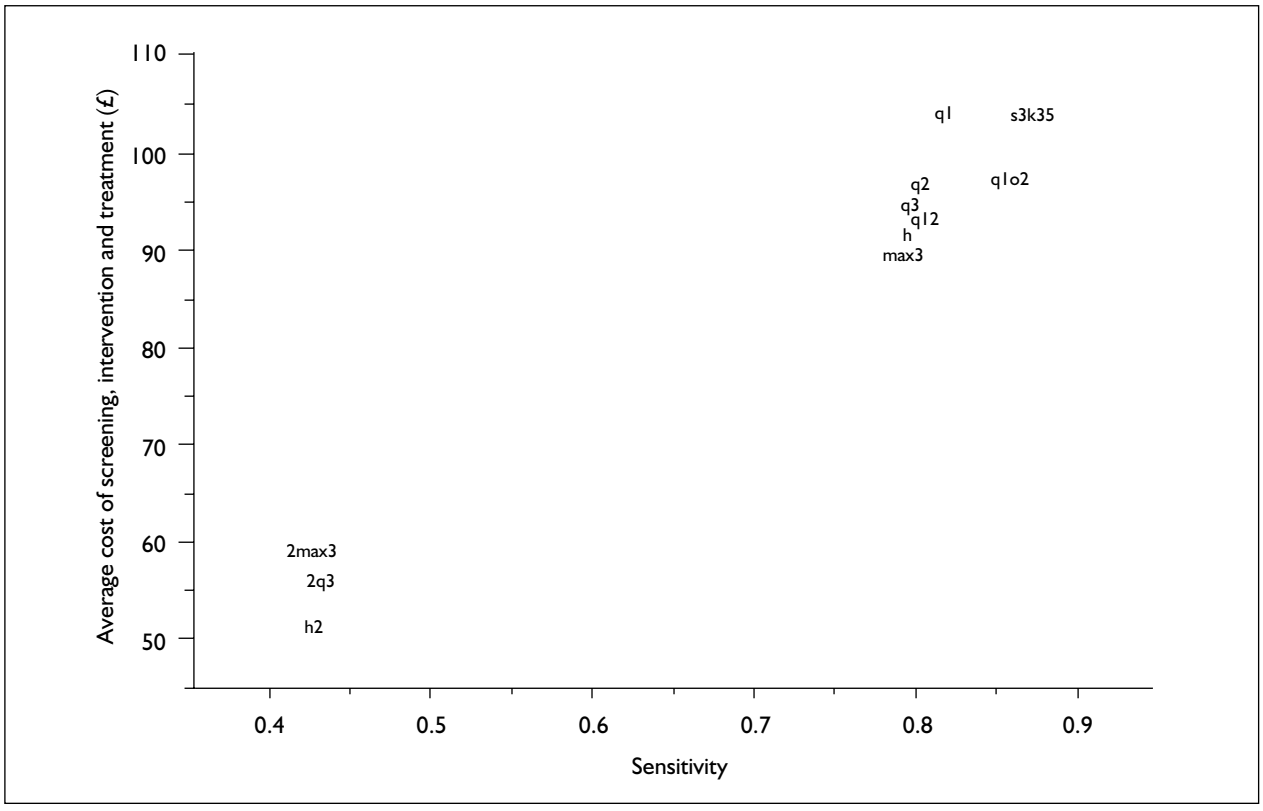

FIGURE 66 *Full cost (including 10-year treatment costs) as a function of sensitivity for all age groups for a two-stage screen with different first stage shown and a fixed second stage screen using a steady pure tone at 3 kHz, at 35 dB HL. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

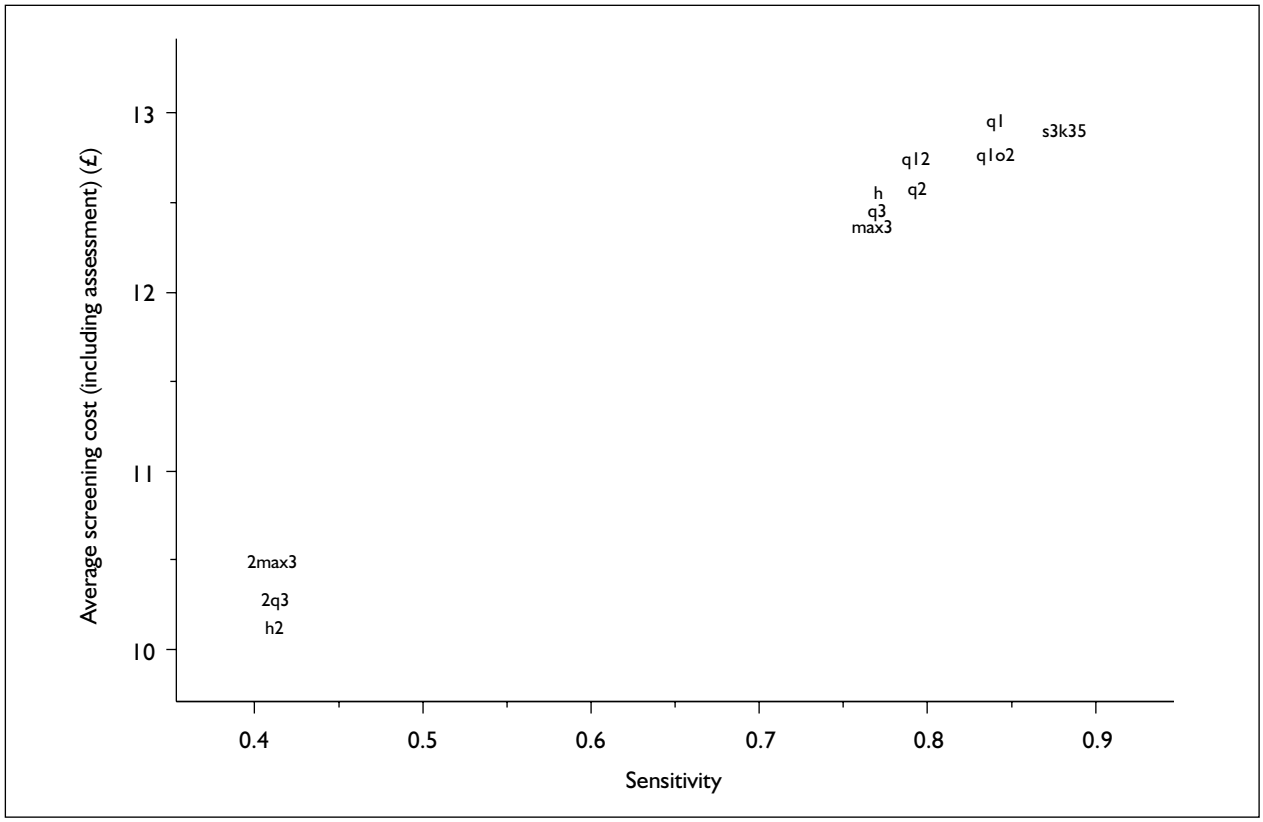

FIGURE 67 *Screening cost (excluding 10-year treatment costs) as a function of sensitivity for all age groups for a two-stage screen with different first stage shown and a fixed second stage screen using a steady pure tone at 3 kHz, at 35 dB HL. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

patient journey. This cost is close to £900. So, the higher the yield and the better the sensitivity, the greater the overall cost. If screening was done with only Q1 or Q2, which has the best sensitivity, the cost of the screen would be about £100 per case found.

The cost of screening is dominated by the treatment costs, which are 90–100 times greater than the screening costs. So, for a cohort of 436,000 people aged 60 years, if there was a take-up of 60% for the screen then potential costs are in the order of £25 million over 9–10 years, or an annual discounted cost of £2.8 million per annual cohort screened, compared with an annual budget for adult audiological services (hearing aid services) in England of about £108 million in 2004. If screening were extended beyond a single cohort then it would incur greater costs.

Figure 67 shows the screening costs where the treatment costs are paid outside of the screening services and this gives an approximate cost comparison. It shows a cost per person screened of about £13.12 which, with a take-up of 60%, gives an annual screening cost of £3.59 million per typical cohort based on the whole age range.

A similar plot for cost against d′ is shown in *Figure 68*.

All three of these figures (*Figures 66–68*) also show the costs of a one-stage audiometric screen. This seems to give a competitive cost compared with the two-stage screen. However, because this study encouraged compliance and take-up of the audiometric screen with payment of travel costs, take-up of an audiometric screen in the real world is likely to be lower. No incentives were offered for completing the questionnaire, so take-up in the study will reflect real-world take-up. However, if the audiometric screen was as easy as the questionnaire to administer (availability of high-quality, low-cost instruments, easy to use, with good information and back-up) and interpret then this would be a good option.

Figure 69 shows the average cost of the screen when adjusted for the population compliance found in strand 2. It shows that for the two-stage

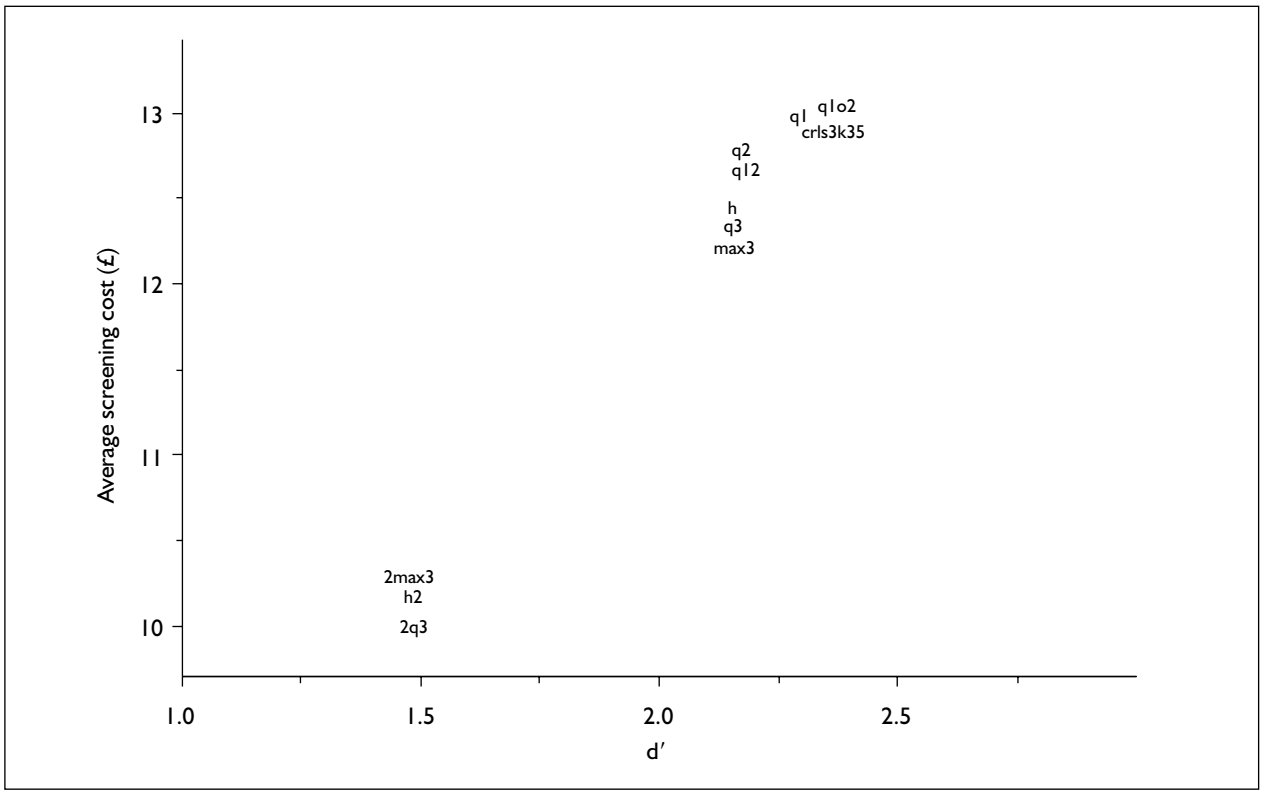

FIGURE 68 *Average screening cost (excluding 10-year treatment costs) as a function of sensitivity for all age groups for a two-stage screen with different first questionnaire stage shown and a fixed second stage screen using a steady pure tone at 3 kHz, at 35 dB HL. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

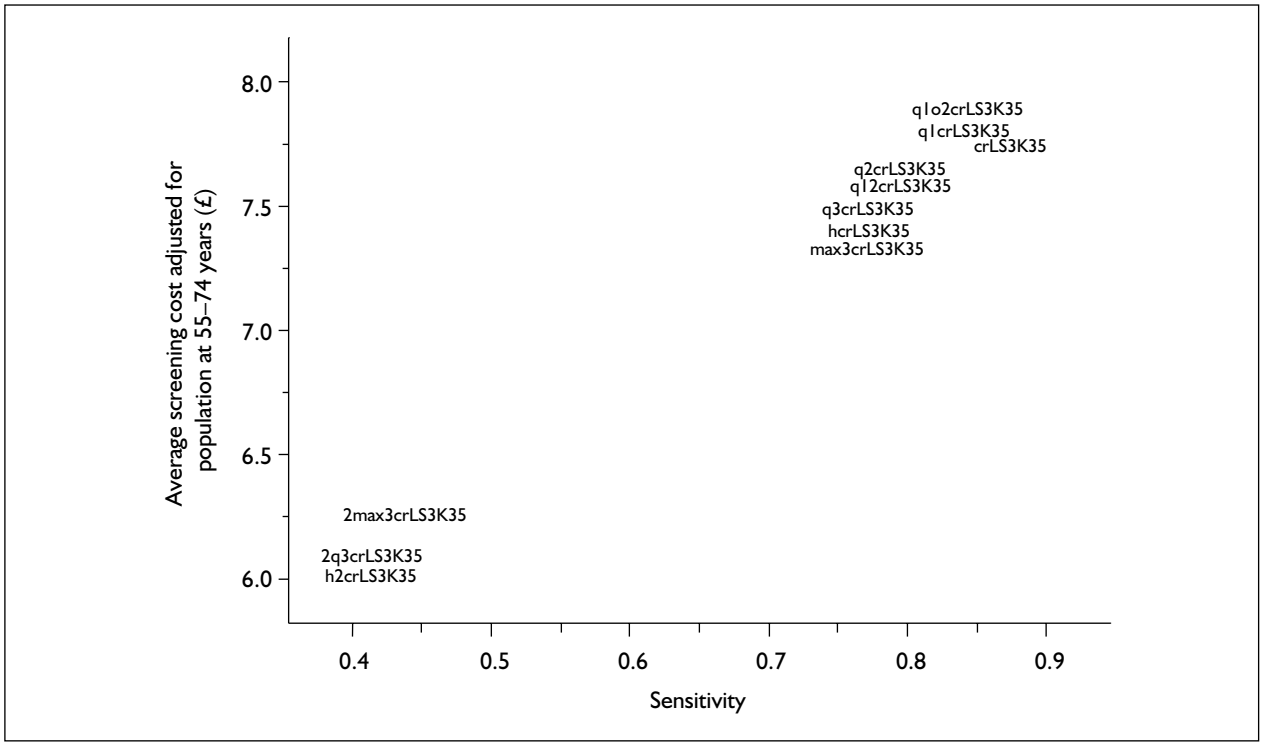

FIGURE 69 *Population screening cost (excluding 10-year treatment costs) as a function of sensitivity for all age groups for a two-stage screen with different first stage shown and a fixed second stage screen using a steady pure tone at 3 kHz, at 35 dB HL. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

screening programme, the average cost is somewhere in the range of £8 per person responding in the cohort, that is, adjusting for the rate of population compliance with the screen programme.

Accepting hearing aids as the criterion: costing

If accepting hearing aids is taken as the criterion, then *Figure 70* shows that there is a lower d′ but lower cost for the 35-dB HL screen compared with the 30-dB HL screen. This confirms that the 35-dB HL screen would be more cost-effective against the important criterion of acceptance of a hearing aid.

Age of identification of hearing impairment: costs and benefits

The range of ages used in the study represented people younger than a typical hearing aid user. There are potentially more years of ability to benefit from amplification through hearing aids for younger people in the sample, provided they are going to use their hearing aids. *Figure 71* shows two populations taken from the overall group: one centred at 60 years and the other at 70 years.

At 60 years of age it is probable that someone could have 10–12 more years with better hearing, whereas at 70 years, there will be fewer years of additional benefit. There is a higher FAR for the older group, but a higher sensitivity. The steady-state 3-kHz 35-dB HL tone has an FAR close to 5% for the average 60 year old, and about 12% for the older group. The sensitivity (yield) is close to 77% and 92%, respectively.

The average cost of the screen is given in *Figures 72* and *73* as a function of sensitivity and d′. The costs of screening are greater in the older group, but d′ is better (i.e. the screen is more accurate). Using the 3-kHz 35-dB HL screen the costs are in the region of £12–13 for the younger group and £14–15 for the older group. The overall cost including treatment is substantially greater for the older group because the numbers with hearing impairment are greater and so, therefore, is the yield.

Figure 74 is similar to *Figures 56–58*. It shows estimates of the performance of the steady-state 3-kHz 35-dB HL audiometric screen, but is based on strand 1 population data, allowing extrapolation from the operating characteristics explored for the specific populations seen in strand 2 to the population as a whole.

In the 'younger' UK population (57–63 years) the estimate is that 15% have 35 dB HL in the better

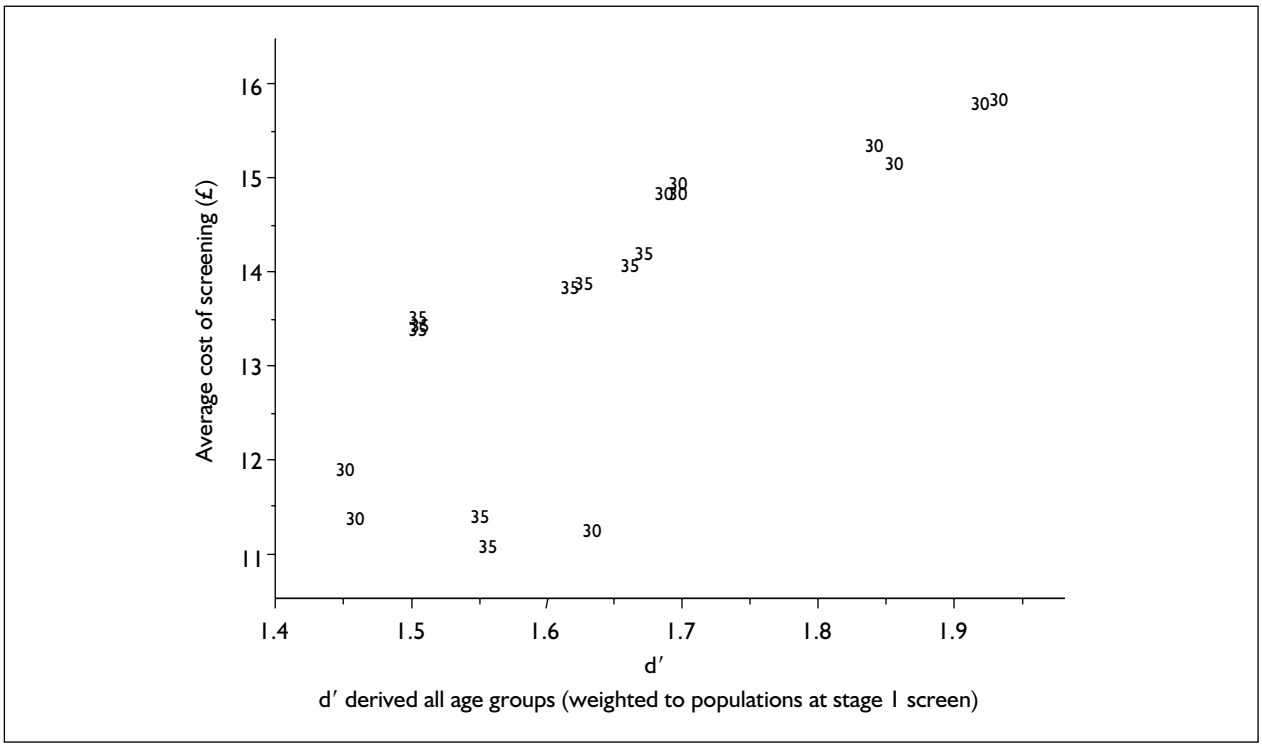

FIGURE 70 *Average cost of screening per person as a function of d′ for criterion of accepting hearing aids as a function of screening audiometry at 30 or 35 dB HL following a questionnaire sieve (different points represent different questions)*

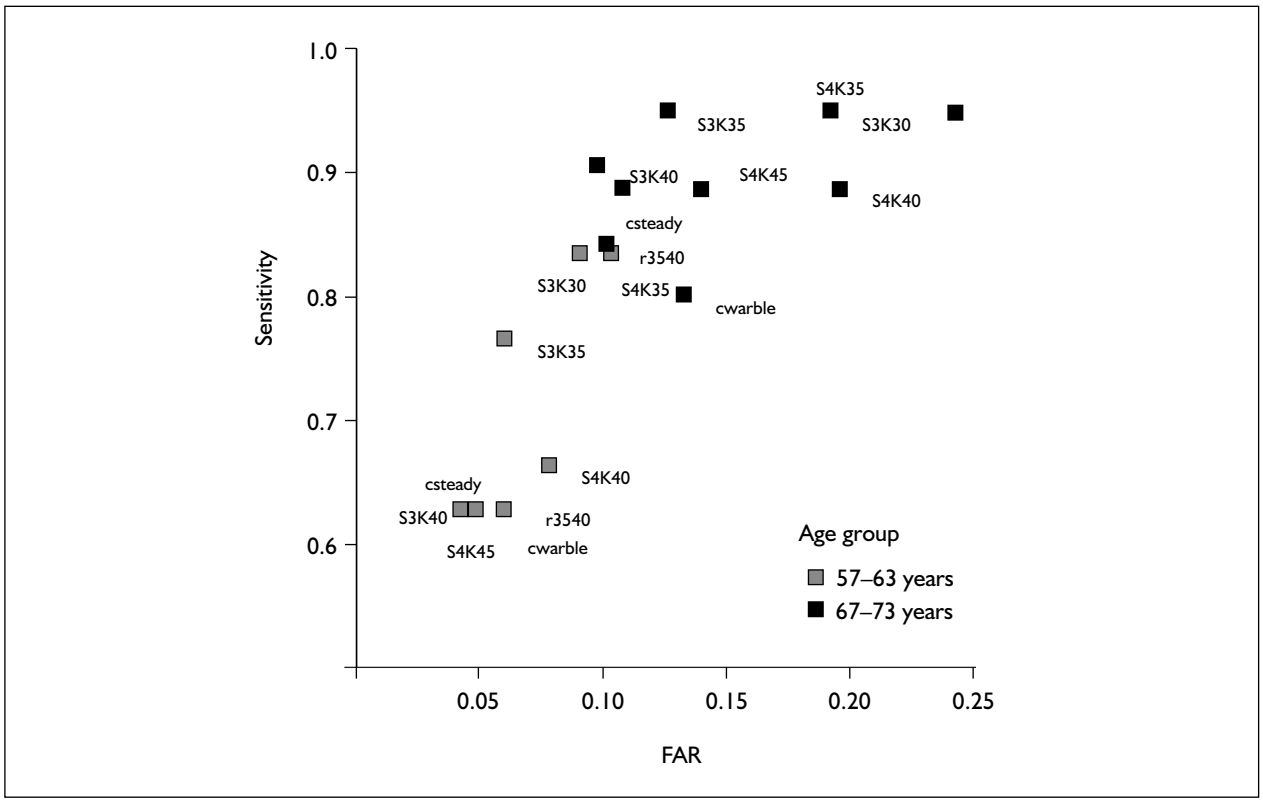

FIGURE 71 *Sensitivity against FAR for the 57–63 and 67–73-year age groups only for a two-stage screen with Q1 or Q2 as the first criterion and screening audiometry as the second stage using a steady pure tone at 3 and 4 kHz and levels of 30, 35, 40 or 45 dB HL. Average warble and steady pure tone are also given. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

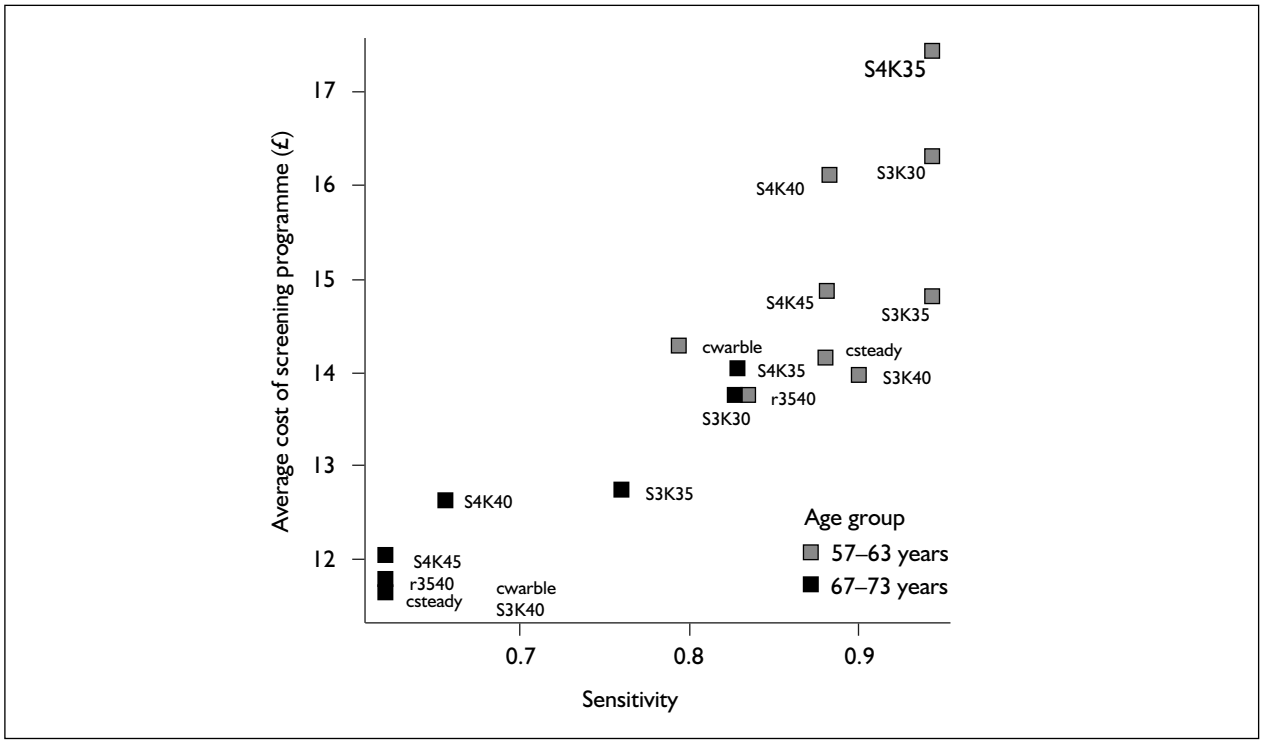

FIGURE 72 *Average screen cost as a function of sensitivity for the 57–63-year age group only for a two-stage screen with Q1 or Q2 as the first criterion and screening audiometry as the second stage using a steady pure tone at 3 and 4 kHz and levels of 30, 35, 40 or 45 dB HL. Average warble and steady pure tone are also given. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

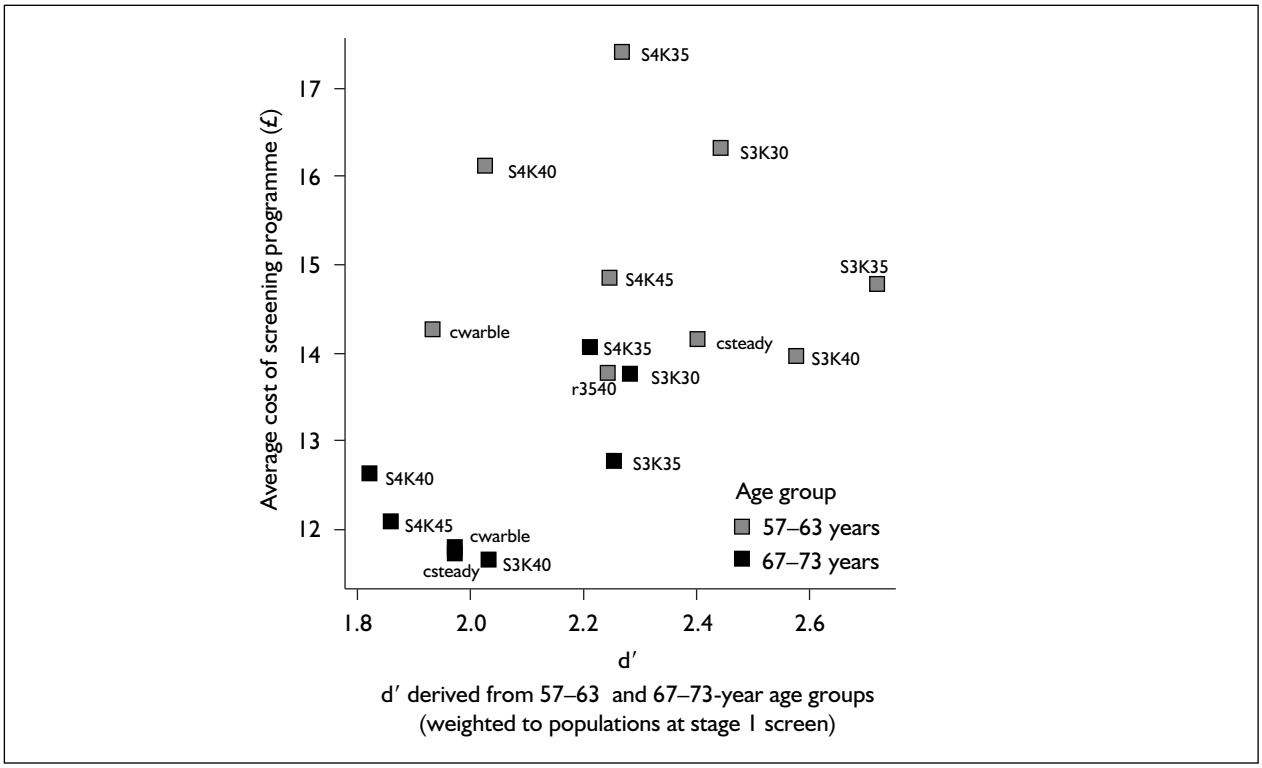

FIGURE 73 *Average screen cost as a function of d′ for the 57–63-year age group only for a two-stage screen with Q1 or Q2 as the first criterion and screening audiometry as the second stage using a steady pure tone at 3 and 4kHz and levels of 30, 35, 40 or 45 dB HL. Average warble and steady pure tone are also given. Criterion is BEA threshold at 0.5, 1, 2 and 4 kHz of 35 dB HL or more.*

ear, of whom 13% do not have a hearing aid. A hearing level of 35 dB is a significant loss, and if more of this group could be identified through screening and accepted the offer of a hearing aid and used it this would be an important benefit and improvement on the current situation. What would be the cost of screening targeted on this age group and this cut-off of 35 dB HL?

Figure 74 shows that 27% of the whole age group 57–73 years would reach the criterion of 35 dB HL in the better ear. Of this 27%, 24% do not already have hearing aids (i.e. one in four of the population aged 57–73 who reach the criterion of having 35 dB HL hearing impairment does not have a hearing aid). More men than women have 35 dB HL and do not have a hearing aid.

A screen that achieved 80% sensitivity in this younger group of 57–73 year olds would equate to about 10% of the 13% who are in the target group of 35 dB HL being identified by the screen; that is, one in ten of the age group.

Table 52(a) shows that 13% of the population to be screened in the age group 55–74 years would be in the category 35 dB HL or above.

Assuming a 60% uniform take-up, about 7% of the age group with 35 dB HL would be found by screening. A two-stage screen using Q1 or Q2 with the steady pure tone at 3 kHz 35 dB HL would potentially yield 6% of the 7% in the population accepting hearing aids. Of these acceptances, 10% would be at least 35 dB HL in both ears and 6% would have hearing loss less than 35 dB HL in the better ear, but all would be greater than 35 dB HL in the worse ear.

These figures are calculated given the actual take-up in strand 2 and therefore may be optimistic because of payment of taxi fares to attend the assessment sessions (which has added about 10% to the costs of service provision). For costs to be estimated accurately, the protocol following the screen would need to be clear about who should be offered the intervention of hearing aids. As *Table 52(b)* shows, in the age range 55–74 years from strand 2, the upper estimate of those aided is 8.9% but the lower estimate is 4.6%, and the actual take-up and acceptance within this range will have a large impact on costs.

The NSH and the postal survey in strand 1 both estimate 5.7% as the proportion aided in the

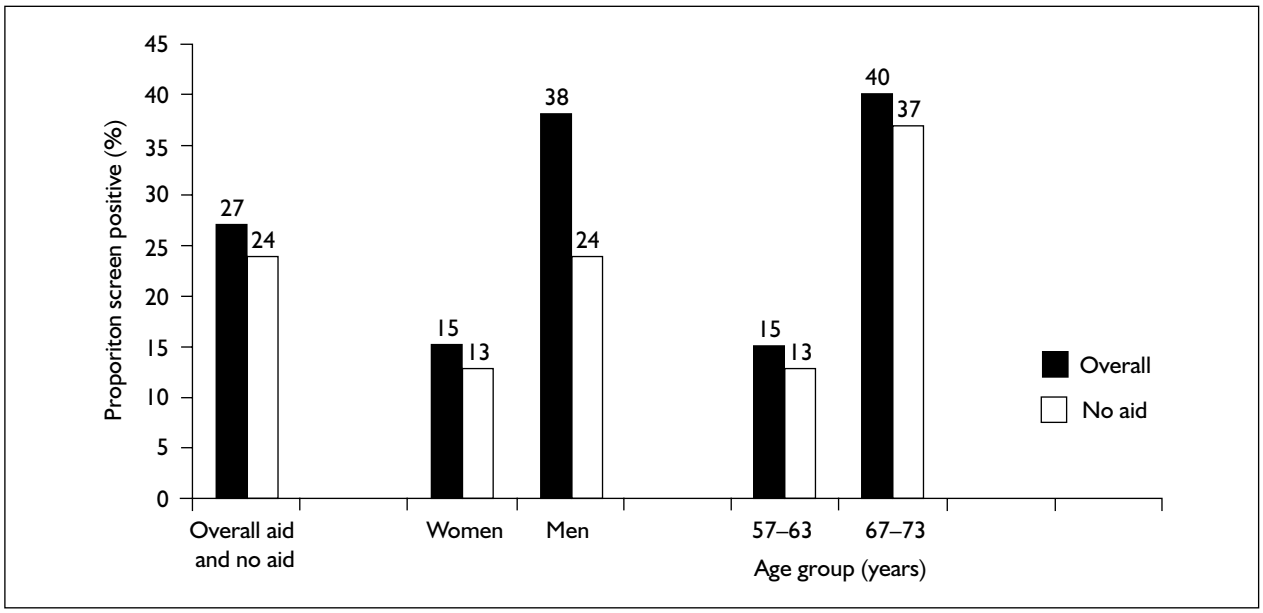

FIGURE 74 *Percentage of people who would be screen positive for a 35-dB HL steady pure tone for the whole population (black) and those without a hearing aid (white), as a function of age and gender*

TABLE 52 *(a) Percentage of people aged 55–74 years who would be identified by different criteria and the estimate of achievable aid use in the population if take-up of the screen is 60%;[a] (b) estimated percentage aided in this study and the NHS; (c) estimated percentage of the population who have hearing in excess of 35 dB HL and who are not already in possession of hearing aids*

	% of those who took up screen	90% CI	% in population if 60% take-up	*n*
(a) Criterion (better ear)				
20+ dB HL	29	25 to 34	18	306
25+ dB HL	23	19 to 27	14	306
30+ dB HL	17	13 to 21	10	306
35+ dB HL	13	9 to 15	7	306
40+ dB HL	8	6 to 11	5	306
45+ dB HL	4	2 to 5	2	306
Two-stage screen 35 dB 3 kHz	19	15 to 22	11	305
Accept aid after two-stage screen	16	13 to 20	10	305
Accept aid after two-stage screen and 35+ dB HL	10	7 to 12	6	305
Accept aid after two-stage screen and <35 dB HL but worse ear 35+ dB HL	6	4 to 8	4	305

	% aided
(b) Percentage aided	
% aided in age category who responded	8.9
% aided in age category who responded who were sent questionnaires	4.6
Postal, strand 1, stage 1	5.7
NSH	5.7

	35+ dB HL	No aid and 35+ dB HL	Population estimate of no aid and 35+ dB HL
(c) Percentage with no aid			
NSH	16.7	12.2	11.5
Strand 1, stage 3	14.0	10.5	10.0
Strand 2		12.5	11.25

[a] This table combines data from strand 1 for the population prevalence and strand 2 for take-up and the performance of the two-stage screen.

population of this age. Thus, if the estimate of aiding was 16% (10% were ≥35 dB HL) then the aided population in this age range would at least double if a screening programme had this yield. The provision of hearing aids would be more equitable in this age range with respect to need that can be readily met, as shown in *Table 50*. *Table 52(c)* shows the degree of unmet need derived from three independent studies, estimated at 10–11.5%.

Table 53 shows the costs and utility for eight different scenarios.

The cost per QALY gained was calculated for those patients in strand 2 who accepted and used hearing aids after a questionnaire stage 1 screen and audiological assessment. The overall group is shown, along with a proposed target group who would have an average better ear hearing threshold in excess of 35 dB HL (0.5, 1, 2 and 4 kHz). Assumptions are made as to whether costs are incurred over a 6- or 9-year period before intervention as if there had been no screen. The data show current national average unit costs for NHS hearing aids (two assumed in 80% of patients) and service provision. Maintenance is assumed to cost the same as initial provision every 3 years. The costs of screening are either not accounted for or accounted for in relation to the cost of screening to find one case (assumed to be different for the two different criteria at

TABLE 53 *Cost per QALY gained for those patients in strand 2 who accepted and use hearing aids after a questionnaire stage 1 screen and audiological assessment; the overall group is shown along with a group who would have an average better ear hearing threshold in excess of 35 dB HL (0.5, 1, 2 and 4 kHz)*

(a) Compared with no intervention, and assumption of being picked up 9 years later
Nine-year health cost and cost per QALY for all who accepted amplification and a target subset of those whose better ear hearing impairment was 35 dB HL or greater

	9 years (all)		9 years (35+ dB HL)	
QALY measure	**HUI**	**SF-6D**	**HUI**	**SF-6D**
Healthcare costs of amplification	£733	£733	£733	£733
QALY gain	0.56	0.12	0.79	0.12
Cost per QALY	£1308	£6208	£931	£6208
Healthcare costs of amplification and screening (including not aided group)	807	807	850	850
QALY gain	0.56	0.12	0.79	0.12
Cost per QALY	£1441	£6724	£1076	£7085

(b) Compared with no intervention, and assumption of being picked up 6 years later
Six-year health cost and cost per QALY for all who had amplification and those whose better ear hearing impairment was 35 dB HL or greater

	6 years (all)		6 years (35+ dB HL)	
QALY measure	**HUI**	**SF-6D**	**HUI**	**SF6D**
Healthcare costs of amplification	£513	£513	£513	£513
QALY gain	0.39	0.08	0.55	0.08
Cost per QALY	£1315	£6413	£933	£6413
Healthcare costs of amplification and screening (included not aided group)	£587	£587	£630	£630
QALY gain	0.39	0.08	0.55	0.08
Cost per QALY	£1504	£7333	£1145	£7875

Assumptions are made as to whether costs are incurred over (a) a 9-year or (b) a 6-year period before intervention if there had been no screen. The data show 2005 average national unit costs for NHS hearing aids (two assumed in 80% of patients) and service provision. Maintenance is assumed to be equal to the cost of replacement aids every 3 years. The costs of screening are either not accounted for or accounted for in relation to the cost of screening to find one case (assumed to be different for the two different criteria at ~£73 or ~£117 per case), at a cost equivalent to a two-stage screen using a steady-state tone at 35 dB HL 3 kHz and Q1 or Q2 criteria for the first stage of the screen.

appropriately £73 or £117 per case), at a cost equivalent to a two-stage screen using a steady-state tone at 35 dB HL 3 kHz and Q1 or Q2 criteria for the first stage of the screen. The costs of a one-stage screen using a simple steady-state 3-kHz pure tone at 35 dB HL would be similar, if the assumptions made above are true concerning the cost of equipment and cost of time for screening.

Two different utility measures are derived, one from the HUI and one for the SF-6D.

- HUI showed a statistically significant benefit for the patients, which was greater for those who met the 35-dB HL criterion.
- SF-6D showed a benefit that was small and on the margins of statistical significance and was not statistically significantly different between hearing level groups.

The answers given by the two measures differ substantially, but both appear to be well within the region of acceptability. Discounting was performed at the standard rate for the costs and benefits. It was considered that the benefits could have accumulated for 9 years (e.g. at the age of 63 years) or 6 years (e.g. at the age 66 years) before the individual may have had the intervention without screening (with probability <0.3). This is not an unreasonable assumption. If one considers the whole group then the cost per QALY was about £1441, including all screening costs, using the HUI estimates and £6724 using the SF-6D. If one considers someone who has a BEA threshold of at least 35 dB HL then these costs are reduced to approximately 75% of the original level. If one considers a 6- as opposed to a 9-year period the cost per QALY only increases by about 4% (as treatment cost now only contributes for one reassessment rather than two, etc.).

If one only considers 3 years, the cost per QALY as indicated by the HUI is £2046 (i.e. only one set of hearing aids in 3 years) and at the limit of 1 year the cost per QALY would be £6522 (similar costs, less cumulative utility). Comparable figures using the SF-6D are £9465 and £25,625. Even at these short-term levels the intervention for hearing impairment would appear to be well within the region of acceptability. The SF-6D outcome measure does not appear to be very sensitive to hearing problems or interventions, but this measure can be used to calculate that if the intervention is accepted and used, and benefit gained at the average rate, then even use for 17–18 months will give a cost per QALY below £20,000. The great variation obtained with different instruments was shown by Barton and colleagues.[84] Hearing and communication were not the driving forces behind constructing these instruments. However, hearing and communication are central to maintaining a quality family life and a productive work life. It should be a priority to develop appropriately validated measures to ensure that no undue discrimination in provision of hearing healthcare occurs on the basis of poor quality of life instruments. Clearly, in this respect the HUI is to be preferred, but it is still relatively crude in reflecting the quality of spoken communication compared with the HEAR instruments used in this study. The great variation between the two measure counsels against detailed sensitivity analysis, given the major variations in screening parameters, are shown here and instead the CI advocated by O'Brien and colleagues[90] has been adopted, as explained above.

Combining the analyses: extent to which the hearing-impaired population may benefit from amplification and hearing aid provision

In this section, the analyses conducted so far are combined to understand the extent to which the hearing-impaired population can benefit from screening and provision of hearing aids. The previous sections have come to the conclusion that a screening programme that targeted substantial hearing problems, where the benefits are absolutely indisputable in the hearing domain, would aim to identify people who were bilaterally impaired at around 35 dB HL averaged over the mid-frequencies of hearing. This sort of screen will mainly identify those with a moderate or worse hearing impairment at the high frequencies. This is a substantial burden.

To illustrate how the underlying distribution of hearing impairment may vary in different subpopulations relevant to screening, the distribution of the BEA threshold (0.5, 1, 2 and 4 kHz) is shown in *Figure 75*. This shows that those who were already aided in the NSH and already aided in the NHS (post-MHAS) are similar, with the new patients having a distribution showing milder hearing impairment with a median at around 40 dB HL (these are people who may have had 12 or more years of hearing impairment without intervention). Those who would have been identified by a two-stage screen show close agreement to current new patients, as do those who got material and statistical individual benefit

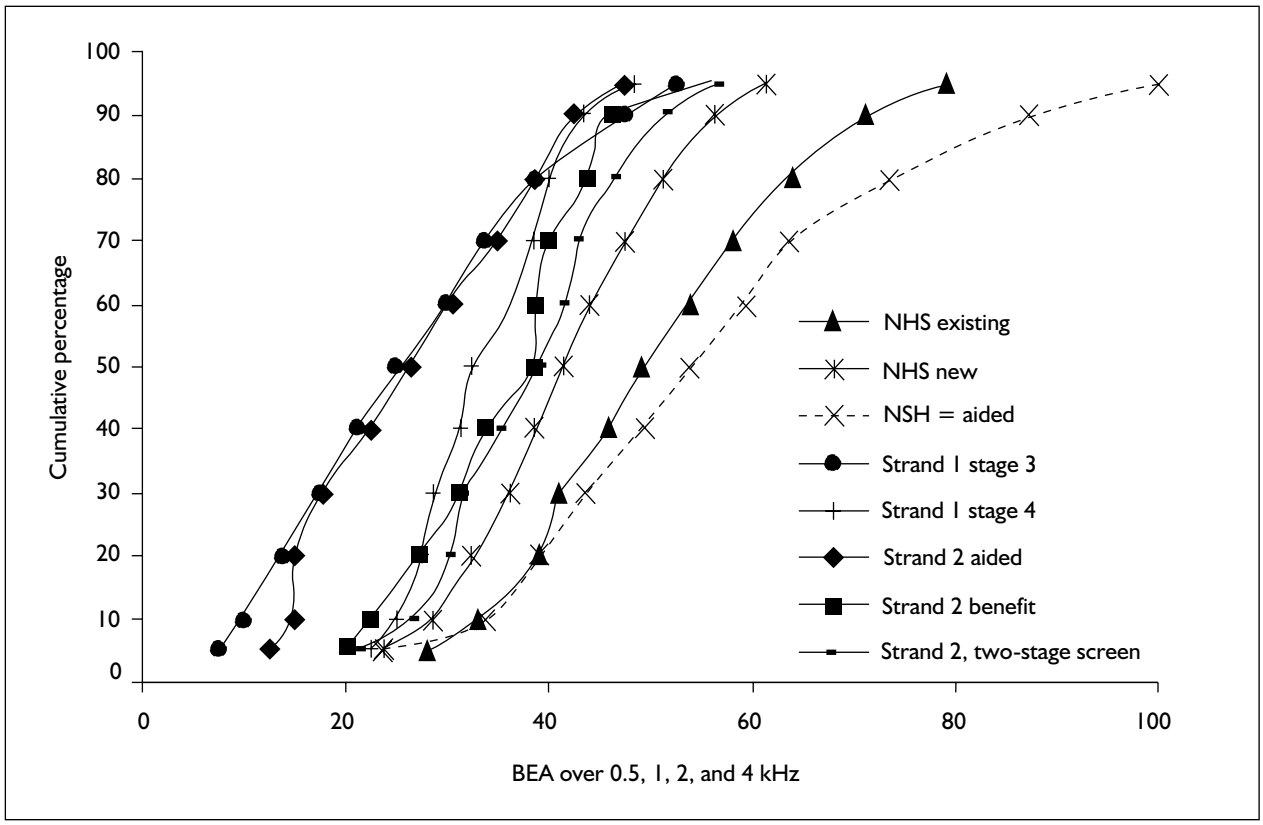

FIGURE 75 *Distribution of better ear threshold averaged over 0.5, 1, 2 and 4 kHz for NHS (MHAS) new and existing patients, for the NSH hearing aid users, and for various strand 1 and 2 populations in the current study*

in strand 2 for the FAAF test using SN. The samples used in the strand 1 and strand 2 studies are shown to be less impaired and were therefore good samples in which to examine the extent to which the population might benefit from amplification and hearing aid provision in general, and where the best criterion might be to identify a specific target group to benefit from intervention following screening.

From this, it is clear that the proposal for a two-stage screen (or a single-stage screen) will yield a group that has the appropriate characteristics. These people would gain significant benefit, use their aids, and gain many added years of amplification through being fitted with hearing aids several years before they may have otherwise done so, because the increase in prevalence of 35 dB HL or greater by age group far outweighs the incident referral rate for first time patients who would benefit from hearing aids.

Strand 1, the population study, stage 2, shows that the increase in prevalence for 5-year age bands for at least 35 dB HL is 4, 7, 15, 25% (similar to the NSH), while that for the use of hearing aids is 5, 2, 6, 9%. Therefore, there does not seem to be compelling evidence from this source that those identified by the screen would have been picked up by the hearing aid service earlier anyway. Indeed, there seems to be compelling evidence that there is considerable need for a screen to meet unmet need. The model shown here is therefore highly conservative in showing the benefits overall, as it assumes that all hearing-impaired people are identified and would be fitted with hearing aids at about 72 years of age.

Summary

Current unmet need resulting from hearing impairment is substantial in the 55–74-year age group, probably around 15% of the population. The numbers affected will increase until at least 2015 because of the ageing demographic profile of the population. This study and other work[82] show the large impact of hearing impairment on the individual and the family.

The performance (operating characteristics) of different screen combinations, one-stage and two-

stage, were calculated on the basis of strand 1 and 2 data, with some input from strand 3 addressing issues of compliance. A two-stage systematic screen using Q1 or Q2 as the first stage, and screening audiometry at 35 dB HL at 3 kHz with a steady-state pure tone is potentially the most cost-effective and acceptable screening programme, with the criterion being set at 35 dB HL or above for the target group. The operating characteristics are estimated at about 88% sensitivity, 8% FAR and 36% positive predictive value. If a one-stage audiometric screen were practicable it would have better sensitivity, slightly higher FAR and lower positive predictive value (28%).

The present 5–6% take-up and use of hearing aids would be increased substantially by possibly 10% to 15–20% through a screening programme to meet the current unmet need. The intervention for the unmet need gives great benefit to the individuals and substantially increases their quality of life in a cost-effective manner; the cost per QALY could easily be around £1000 for 9 added years of hearing aid use. (This is conservative because with only one in three of the hearing impaired having their hearing assessed ever currently, for three typical 65 year olds with hearing problems for whom the Treasury predict 16 years' life expectancy, the additional expected gain could be 9 + 16 + 16 = 41 years of enhanced quality of life through screening = 2.55 QALY at a cumulative cost over 16 years of about £1000 per QALY.)

The screen would be best (i.e. would minimise cost per QALY) targeted at the younger age groups, for example 60–62 years of age, where the potential benefit from screening is greatest because of the added number of years gained with amplification. For an annual cohort of people such a screen would cost in the region of £3–4 million per year, but would probably result in activity reductions in 10–20 years' time while giving significant benefit to the individuals concerned.

Targeting a screen at younger people would minimise costs and would have the best long-term effects in terms of activity, participation and independence. This does not mean that it does not impart substantial clinical benefits to have a screening programme and intervene at any age. As derived above, even 18 months use of a hearing aid falls below the £20,000 per QALY threshold and the expense is equivalent to less than a week in sheltered care. Therefore, if even a few such days are avoided this may give a return on investment. However, there is need to collect the appropriate data to substantiate this proposal (i.e. that hearing aid use protects against need for sheltered care).

Considering a screen at 60 years of age, as hearing changes by about 5–10 dB per decade in the 3-kHz region of the cochlea, it may be worth screening at intervals of 10 years after an initial programme has proved to be successful.

Chapter 6

Overall summary and conclusions

About 12% of people aged 55–74 years have a hearing problem that causes moderate or severe worry, annoyance or upset. Fourteen per cent have a bilateral hearing impairment of at least 35 dB HL, with only 3% currently receiving intervention, through the use of hearing aids. This level of hearing impairment has been shown to be equivalent to chronic pain such as that from a slipped disc in terms of how patients would rank their symptoms and effects on their life. These hearing problems, which mainly affect ability to hear speech in noise, have a mean reported duration of about 10 years in those who have not received hearing aids. Over 90% of people interviewed felt that hearing screening was acceptable, especially if associated with the GP's practice.

Good amplification was shown to benefit about one in four of this 55–74-year-old population and the degree of hearing loss predicted benefit accurately. In a population intervention trial with a single hearing aid, less benefit was received on this test when measured in real-world situations than in the laboratory. However, there was a strong correlation between benefit from amplification and that from using hearing aids.

Questionnaires and audiometric screens gave good performance ROC curves, whereas otoacoustic emissions and speech in noise tests were not as good. Sensitivity for a two-stage questionnaire and audiometric screen was close to 90%, with an FAR close to 10% and a PPV at about 30%.

One- and two-stage screening programmes were examined in the context of systematic and opportunistic screening programmes. The systematic screening programme was more acceptable and gave a better response. The offer of two hearing aids was accepted by about 70% of those who were offered an aid, which increased to 95% for those with at least 35 dB HL. There were significant and substantial benefits in terms of hearing in noise (>1 SD benefit), domain-specific questionnaire outcomes (>1 SD benefit) and health utility (HUI3, 0.4 SD benefit) from amplification for this target group (≥35 dB HL).

The case–control study showed that long-term hearing aid use was low, unless hearing impairment was quite high (e.g. ≥35 dB HL). Those identified early had greater benefit than those of the same age and hearing impairment who were fitted with hearing aids later.

The best screen judged in terms of d′ and cost for this target group was two questions and a hearing screen using a pure tone at 3 kHz 35 dB HL. The average cost of the screening programme was estimated as £13 per person screened or about £100 if treatment costs were included.

The benefits and costs were assessed using the HUI and SF-6D. With identification giving 9 additional years using hearing aids (average gain if identified earlier, i.e. 63 rather than 72 years of age), the 9-year costs of screening and intervention were in the range of £800–1000 per QALY. However, at any age in these groups there would be substantial benefits of screening and providing hearing aids, which would be cost-effective if use exceeded 18 months.

Conclusions

Hearing impairment in adults is a highly prevalent major public health problem which is often left too late before access to services is achieved.

One in ten people aged 55–74 years is substantially impaired (≥35 dB HL) but has not received help and would greatly benefit from referral for assessment of hearing and possible intervention using hearing aids. Lack of intervention impacts on activity and causes substantial handicap in older people. Amplification gives significant benefit to these people. This benefit can be realised by provision of good-quality, acceptable hearing aids to people with this high degree of need.

A simple systematic screen has been shown to be acceptable to people in the age range 55–74 years and provides measurable and lasting benefits (at reasonable costs) for those in the target group who proceed to the Do Once and Share

(DOAS: www.mrchear.info/doas) patient journey. This study used small ITE hearing aids in a service development and research setting. New developments in open-ear DSP hearing aids, which are targeted at this age group in particular, would probably be equally acceptable to patients.

Such a screening programme meets the NSC's screening criteria in almost all respects, provided screening is targeted at those with at least 35 dB HL better ear average (0.5, 1, 2 and 4 kHz). All age ranges may benefit, but concentrating on the younger age range would give greater benefit and cost-effectiveness. This is where the additional benefits (e.g. from 10 years' earlier identification) are more likely to be found and will potentially be compounded in later life.

Recommendations for research

Prospective RCT study of one and two-stage hearing screen to identify bilateral 35 dB HL hearing impairment, or poorer, in 60–70-year-old people and intervene in a PCT setting using current NSH hearing aids (BTE)

The current study examined a wide range of hearing screening technologies and a large number of one- and two-stage screen programmes. It was found that the best potential screen is a two-stage screen using a five-question questionnaire (Appendix 6) and a simple audiological screen at 35 dB HL with a 3-kHz pure tone. The experimental screening programme was used in a number of GPs' surgeries in a clinical effectiveness study for research purposes using people aged 55–74 years. This was a good way to look at a large number of alternatives and their benefits and costs. The next stage in the 'research into practice' loop is to use the best one- and two-stage screen without incentives for participants to attend the clinic and across a wider setting.

Modelling of different screening programmes, their cost-effectiveness and budget impact

The current research has found a range of hearing impairments that can be detected by one- and two-stage screening programmes. Domain-specific benefit is clearly related to hearing impairment, but it is not clear how that translates into quality of life benefit or indeed financial benefit. There is a need to model the societal, healthcare and personal impact as a function of different forms of hearing impairment and different age groups for a variety of screening and service programmes.

Development and trial of simple, low-cost audiometric screen device

At the outset of the research project the device used for audiometric screening turned out not to be a very good device for the task. However, there may soon be better devices on the market that will be cheap and can easily be configured to use the protocol developed herein. If such devices can be developed in the near future they will need to be trialled to see how well they work in the intended primary care context. It could be that a single-stage audiometric screen could be used if the devices were accurate, reliable and valid, as well as cheap enough to buy for many thousands of primary care workers. (The 18-week wait programme and physiological measurement development sites are currently assessing different ways of evidence-based best practice in meeting the need within the population by using a screening test technique on those who present with hearing difficulties, to explore whether more uniform referral patterns can be maintained, so any trial proposed here should be done in the light of other work in this area.)

Prospective pilot of hearing screen triage to identify people who should be referred for and could benefit from audiological assessment and provision of hearing aids in a PCT setting

The current work has shown a large range of referral practices across the country for a given level of reported disability or for a given level of hearing impairment on the better hearing ear. It has also shown that those who do not respond to a 35-dB HL 3-kHz steady pure tone do accept intervention and benefit substantially in the short and long term. Such intervention is highly cost-effective. The current methods were developed primarily for the 55–74-year-old age group, but should be piloted for use in primary care settings to enable better opportunistic (and systematic) referral for audiological assessment. As audiology has one of the longest waiting lists for assessments, uniform referral, as well as more appropriate local assessment, needs to be piloted as a matter of urgency. A further logical step would be an evaluated trial of commissioning a screen or triage with audiological assessment, which could be done in people's homes, at other local facilities, such as libraries, or in public sector accommodation, depending on local arrangements. This study provides the rationale and some of the tools to put such pilot schemes into place.

Trial of a Hearing Direct, telemedicine, alternative to the questionnaire and low-cost audiometric screening device

The MHAS programme showed that quality audiological services for hearing-impaired people could be delivered and give substantial benefits to patients. One of the major contributors to the increased benefits was the introduction of the national patient journey. However, using the patient journey created a capacity gap in some services. Hearing Direct reduced that gap by providing a central service to follow up patients and pinpoint their continuing needs, and to evaluate the outcome for those patients. Hearing Direct is run through NHS Direct and also runs a help service for patients who use hearing aids.

The evaluation of these services shows that they deliver improved services as well as help to meet the capacity gap. Hearing Direct could run a screening service in systematic or opportunistic mode. If in the former, it could schedule to telephone on behalf of the PCT, people aged 60, for example, to ask the five screening questions, undertake a hearing screen over the telephone or schedule a hearing screen at a local GP's surgery. Such a method could be feasible. A proposed trial would look at the scale and type of input that Hearing Direct or a local equivalent may have for a PCT that wanted to contract out the hearing screening function.

Workforce review

Introducing a screen for early identification of hearing impairments would certainly change the character of the referrals from GPs over time. An organisational research review is needed to estimate the impact of introducing the screen on the audiological workforce in general and to look at the workforce requirements for different levels of staff to assist patients through the patient journey (e.g. for all components of the patient journey) if the screen became widespread across PCTs. Such a review could be carried out alongside an RCT or evaluated screening pilot programme.

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Contribution of authors

Adrian Davis (Director of MRC Hearing and Communication Group) was lead investigator throughout the study. He was responsible for the design, overall management, analysis and writing of the project. Pauline Smith [Clinical Scientist (Audiology)] project managed all stages of strand 1 (population study) and liaised with staff at NCSR and ISVR. She took a major role in writing and coordinating the draft final report. Melanie Ferguson [Clinical Scientist (Audiology)] project managed strand 2 (clinical effectiveness trial), liaised with staff at Bath, and wrote Chapter 3. She took a major role in coordinating the draft final report. Dafydd Stephens (Honorary Professor of Audiological Medicine) and Ioanis Gianopoulos (Specialist Registrar in Otolaryngology) carried out strand 3 (retrospective study) and wrote Chapter 4.

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Appendix 1

Strand 1 – stage 1: postal questionnaire ENT survey

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LONDON EC1V 0AX
Tel: 0171 250 1866 Fax 0171 250 1524

SOCIAL & COMMUNITY PLANNING RESEARCH SCPR

Field and DP Office: 100 KINGS ROAD
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August 1998

O.U.O
Serial no :101-105
Card :106-107
Batch no:108-112

P1768

MEDICAL RESEARCH COUNCIL

NATIONAL STUDY OF EAR, NOSE AND THROAT PROBLEMS

CONFIDENTIAL QUESTIONNAIRE

INSTRUCTIONS

This questionnaire should be completed by **every person in your household aged 14 years or over.**

The questionnaire should be completed by **each person himself or herself.** (However, if someone is absent, another person should complete the questionnaire on their behalf, and indicate who answered at the end.)

Please complete one column for each person (see next page), starting with the column headed "Person 1". (For example, if there are 3 people aged 14 or over, you should complete the columns for "Person 1", "Person 2" and "Person 3". Put at the top of each column the initials for that person).

If there are more than 5 people in your household aged 14 or over, complete the questionnaire for the five oldest.

To reduce costs in this publicly funded research, the replies will be read by computer, so please tick clearly inside one box using a **blue or black pen** like this example question.

Did this questionnaire come through the post?	
Yes	
No	

BEFORE STARTING THE QUESTIONNAIRE OVERLEAF, PLEASE ANSWER THE FOLLOWING QUESTION:

Q1. Including yourself, how many people living in your household are aged 14 or over? → ☐ 113-114

MRC NATIONAL STUDY OF EAR, NOSE AND THROAT PROBLEMS

BEFORE YOU START →

NOTE: For persons who normally use a hearing aid, questions 2-8 should be answered as if they were NOT using an aid.

	Card 1	Card 2	Card 3	Card 4	Card 5	
	Person 1	**Person 2**	**Person 3**	**Person 4**	**Person 5**	
Q2. PLEASE WRITE IN YOUR INITIALS →						
Q3. Do you have any difficulty with your hearing?	(✓)	(✓)	(✓)	(✓)	(✓)	08
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
Q4. Do you find it very difficult to follow a conversation if there is background noise (such as TV, radio, children playing)?						09
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
Q5. How well do you hear someone talking to you when that person is sitting…						
a) …on your <u>RIGHT SIDE</u> in a quiet room?						10
With no difficulty	☐	☐	☐	☐	☐	1
With slight difficulty	☐	☐	☐	☐	☐	2
With moderate difficulty	☐	☐	☐	☐	☐	3
With great difficulty	☐	☐	☐	☐	☐	4
Cannot hear at all	☐	☐	☐	☐	☐	5
b) …on your <u>LEFT SIDE</u> in a quiet room?						11
With no difficulty	☐	☐	☐	☐	☐	1
With slight difficulty	☐	☐	☐	☐	☐	2
With moderate difficulty	☐	☐	☐	☐	☐	3
With great difficulty	☐	☐	☐	☐	☐	4
Cannot hear at all	☐	☐	☐	☐	☐	5
Q6. Do you have difficulty...						
a) ...following TV programmes at a volume others find acceptable, without any aid to hearing?						12
No	☐	☐	☐	☐	☐	1
Yes, slight difficulty	☐	☐	☐	☐	☐	2
Yes, moderate difficulty	☐	☐	☐	☐	☐	3
Yes, great difficulty	☐	☐	☐	☐	☐	4
b) ...having a conversation with several people in a group?						13
No	☐	☐	☐	☐	☐	1
Yes, slight difficulty	☐	☐	☐	☐	☐	2
Yes, moderate difficulty	☐	☐	☐	☐	☐	3
Yes, great difficulty	☐	☐	☐	☐	☐	4

AA

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
Q7. Do very loud sounds annoy you?	(✓)	(✓)	(✓)	(✓)	(✓)	14
Not at all	☐	☐	☐	☐	☐	1
Slightly	☐	☐	☐	☐	☐	2
Moderately	☐	☐	☐	☐	☐	3
Severely	☐	☐	☐	☐	☐	4
Q8. <u>Nowadays</u>, how much does any difficulty in hearing worry, annoy or upset you?						15
Do not have hearing difficulty	☐	☐	☐	☐	☐	1
Not at all annoying	☐	☐	☐	☐	☐	2
Slightly annoying	☐	☐	☐	☐	☐	3
Moderately annoying	☐	☐	☐	☐	☐	4
Severely annoying	☐	☐	☐	☐	☐	5
Q9a) <u>Nowadays</u>, do you usually wear a hearing aid? No	☐	☐	☐	☐	☐	16 1
No, but have tried one	☐	☐	☐	☐	☐	2
Yes, some of the time	☐	☐	☐	☐	☐	3
Yes, most of the time	☐	☐	☐	☐	☐	4
b) Did you get your hearing aid…						17-18
TICK ALL THAT APPLY Not applicable	☐	☐	☐	☐	☐	1
Free through the NHS	☐	☐	☐	☐	☐	2
Privately, paying for it	☐	☐	☐	☐	☐	3
Q10. Have you ever had an ear operation?						19-20
TICK ALL No	☐	☐	☐	☐	☐	
Yes - as a child (under 16 years)	☐	☐	☐	☐	☐	1
Yes - as an adult (16 years or older)	☐	☐	☐	☐	☐	2 3
Q11. <u>In the last 12 months</u> have you had discharge of blood or pus, or smelly discharge (not wax) from either ear?						21
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
Q12. Did any of your parents, children, brothers or sisters have <u>great difficulty in hearing</u> before the age of 55 years?						22
No or Don't know	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2

BB

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
Q13. Nowadays, do you ever get noises in your a) head or ears (tinnitus) which usually last longer than five minutes?	(✓)	(✓)	(✓)	(✓)	(✓)	23
No, never	☐	☐	☐	☐	☐	1
Some of the time	☐	☐	☐	☐	☐	2
Most or all of the time	☐	☐	☐	☐	☐	3
b) Nowadays, how much do these noises worry, annoy or upset you when they are at their worst?						24
Do not get noises in head or ears	☐	☐	☐	☐	☐	1
Not at all annoying	☐	☐	☐	☐	☐	2
Slightly annoying	☐	☐	☐	☐	☐	3
Moderately annoying	☐	☐	☐	☐	☐	4
Severely annoying	☐	☐	☐	☐	☐	5
c) Nowadays, how much do these noises affect your ability to lead a normal life?						25
Do not get noises in head or ears	☐	☐	☐	☐	☐	1
Not at all	☐	☐	☐	☐	☐	2
Slightly	☐	☐	☐	☐	☐	3
Moderately	☐	☐	☐	☐	☐	4
Severely	☐	☐	☐	☐	☐	5
Q14. In the last 12 months have you had…						26
a) … a spell where you have had a blocked nose every day for more than 14 days in a row?						
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
b) … a spell where you have had a runny nose or mucus running down the back of your nose for more than 14 days in a row?						27
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
c) … sneezing bouts (with at least 6 sneezes together) every day for more than 14 days in a row?						28
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
d) …hayfever?						29
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2

CC

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
Q15. In the last 12 months, how much have ANY problems with your nose worried, annoyed or upset you?	(✓)	(✓)	(✓)	(✓)	(✓)	30
Do not have any nose problems	☐	☐	☐	☐	☐	1
Not at all annoying	☐	☐	☐	☐	☐	2
Slightly annoying	☐	☐	☐	☐	☐	3
Moderately annoying	☐	☐	☐	☐	☐	4
Severely annoying	☐	☐	☐	☐	☐	5
Q16. Have you ever had a nose operation?						31
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
Q17. In the last 12 months, have you had any of these problems with your speaking or singing voice that lasted for more than 14 days in a row?						32
a) … hoarseness or croakiness of the voice?						
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
b) … loss or weakness of the voice?						33
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
c) … any other abnormal change in the sound of the voice such as deepening or unstable pitch (tone of the voice)?						34
No	☐	☐	☐	☐	☐	1
Yes	☐	☐	☐	☐	☐	2
Q18. In the last 12 months, how much has ANY voice problem worried, annoyed or upset you?						35
Do not have any voice problems	☐	☐	☐	☐	☐	1
Not at all annoying	☐	☐	☐	☐	☐	2
Slightly annoying	☐	☐	☐	☐	☐	3
Moderately annoying	☐	☐	☐	☐	☐	4
Severely annoying	☐	☐	☐	☐	☐	5
Q19. In the last 12 months how many times have you had tonsillitis or a severe sore throat?						36
None	☐	☐	☐	☐	☐	1
1-4 times	☐	☐	☐	☐	☐	2
5 times or more	☐	☐	☐	☐	☐	3

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
Q20. In the last 12 months, has tonsillitis or a severe sore throat stopped you from working or carrying out your normal activities for more than one day?	(✓)	(✓)	(✓)	(✓)	(✓)	37
No	☐	☐	☐	☐	☐	1
Yes, 1-4 times	☐	☐	☐	☐	☐	2
Yes, 5 times or more	☐	☐	☐	☐	☐	3
Q21. In the last 12 months, how much has ANY throat problem worried, annoyed or upset you?						38
Do not have any throat problems	☐	☐	☐	☐	☐	1
Not at all annoying	☐	☐	☐	☐	☐	2
Slightly annoying	☐	☐	☐	☐	☐	3
Moderately annoying	☐	☐	☐	☐	☐	4
Severely annoying	☐	☐	☐	☐	☐	5
Q22. Have you ever had an operation to remove your tonsils?						39
No	☐	☐	☐	☐	☐	1
Yes - as a child (under 16 years)	☐	☐	☐	☐	☐	2
Yes - as an adult (16 years or older)	☐	☐	☐	☐	☐	3
Q23. Have you ever suffered from. ..						40-41
a) .... attacks of dizziness in which things seem to spin around you?						
TICK ALL THAT APPLY No	☐	☐	☐	☐	☐	1
Yes, within the last year	☐	☐	☐	☐	☐	2
Yes, more than 1 year ago	☐	☐	☐	☐	☐	3
b) ... unsteadiness, lightheadedness or feeling faint?						42-43
TICK ALL THAT APPLY No	☐	☐	☐	☐	☐	1
Yes, within the last year	☐	☐	☐	☐	☐	2
Yes, more than 1 year ago	☐	☐	☐	☐	☐	3
c) ... attacks of dizziness in which you seem to move?						44-45
TICK ALL THAT APPLY No	☐	☐	☐	☐	☐	1
Yes, within the last year	☐	☐	☐	☐	☐	2
Yes, more than 1 year ago	☐	☐	☐	☐	☐	3

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
Q24. Nowadays, how much does the dizziness or unsteadiness worry, annoy or upset you?	(✓)	(✓)	(✓)	(✓)	(✓)	46
Do not have problems with dizziness or unsteadiness	☐	☐	☐	☐	☐	1
Not at all annoying	☐	☐	☐	☐	☐	2
Slightly annoying	☐	☐	☐	☐	☐	3
Moderately annoying	☐	☐	☐	☐	☐	4
Severely annoying	☐	☐	☐	☐	☐	5
Q25. Has dizziness or unsteadiness ever stopped you working or carrying out your normal activities for more than one day? TICK ALL THAT APPLY						47-49
No	☐	☐	☐	☐	☐	1
Yes, for 1 day or more, but less than 1 week	☐	☐	☐	☐	☐	2
Yes, for 1 week or more, but less than 1 month	☐	☐	☐	☐	☐	3
Yes, for 1 month or more	☐	☐	☐	☐	☐	4
Q26. In the last 12 months, have you been to your own doctor (GP) or referred to a hospital about problems with …						50-51
a) …your hearing? TICK ALL THAT APPLY — No	☐	☐	☐	☐	☐	1
Yes, visited doctor (GP)	☐	☐	☐	☐	☐	2
Yes, referred to hospital	☐	☐	☐	☐	☐	3
b) …noises in your head or ears? TICK ALL THAT APPLY						52-53
No	☐	☐	☐	☐	☐	1
Yes, visited doctor (GP)	☐	☐	☐	☐	☐	2
Yes, referred to hospital	☐	☐	☐	☐	☐	3
c) …your nose? TICK ALL THAT APPLY						54-55
No	☐	☐	☐	☐	☐	1
Yes, visited doctor (GP)	☐	☐	☐	☐	☐	2
Yes, referred to hospital	☐	☐	☐	☐	☐	3
d) …your voice? TICK ALL THAT APPLY						56-57
No	☐	☐	☐	☐	☐	1
Yes, visited doctor (GP)	☐	☐	☐	☐	☐	2
Yes, referred to hospital	☐	☐	☐	☐	☐	3

GG

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
e) …tonsillitis or a severe sore throat?	(✓)	(✓)	(✓)	(✓)	(✓)	58-59
TICK ALL THAT APPLY No	☐	☐	☐	☐	☐	1
Yes, visited doctor (GP) 1 or 2 times	☐	☐	☐	☐	☐	2
Yes, visited doctor 3 times or more	☐	☐	☐	☐	☐	3
Yes, referred to hospital	☐	☐	☐	☐	☐	4
f) …balance, dizziness or unsteadiness?						61-62
TICK ALL THAT APPLY No	☐	☐	☐	☐	☐	1
Yes, visited doctor (GP)	☐	☐	☐	☐	☐	2
Yes, referred to hospital	☐	☐	☐	☐	☐	3
Q27. What best describes your main occupation throughout most of your life?						62
Professional or managerial	☐	☐	☐	☐	☐	1
Non-manual or clerical	☐	☐	☐	☐	☐	2
Manual	☐	☐	☐	☐	☐	3
Housewife	☐	☐	☐	☐	☐	4
Student	☐	☐	☐	☐	☐	5
None	☐	☐	☐	☐	☐	6
Q28. Have you <u>ever</u> worked in a place… …with a lot of dust?						63-64
TICK ALL THAT APPLY No	☐	☐	☐	☐	☐	1
Yes, in last 2 years	☐	☐	☐	☐	☐	2
Yes, more than 2 years ago	☐	☐	☐	☐	☐	3
b) …that was so noisy you had to shout to be heard?						65-67
TICK ALL THAT APPLY No, never	☐	☐	☐	☐	☐	1
Yes, for less than 1 year	☐	☐	☐	☐	☐	2
Yes, for 1-5 years	☐	☐	☐	☐	☐	3
Yes, for over 5 years	☐	☐	☐	☐	☐	4
Q29. How many brothers and sisters did you live with during most of your childhood?						68
None	☐	☐	☐	☐	☐	1
One	☐	☐	☐	☐	☐	2
Two	☐	☐	☐	☐	☐	3
Three or more	☐	☐	☐	☐	☐	4

HH

	Card 2 Person 1	Card 3 Person 2	Card 4 Person 3	Card 5 Person 4	Card 6 Person 5	
PLEASE WRITE IN YOUR INITIALS →						
Q30. What is your sex? Male	☐	☐	☐	☐	☐	69 1
Female	☐	☐	☐	☐	☐	2
Q31. And what is your year of birth?	19☐	19☐	19☐	19☐	19☐	70-73
Q32. Please write in your full name and tel. no. **(This information will only be made available to researchers at SCPR and researchers working on behalf of the Medical Research Council).** First name **(PLEASE USE BLOCK CAPITALS)** Surname	_____ _____	_____ _____	_____ _____	_____ _____	_____ _____	
Telephone number (including area code)	_____	_____	_____	_____	_____	
Q33. **a) Was this column completed by the person named above?** Yes	☐	☐	☐	☐	☐	74 1
No	☐	☐	☐	☐	☐	2
b) If no, was the person filling it in.... **TICK ONE ONLY** a male relative	☐	☐	☐	☐	☐	75 1
a female relative	☐	☐	☐	☐	☐	2
a male friend	☐	☐	☐	☐	☐	3
a female friend	☐	☐	☐	☐	☐	4

PLEASE CHECK YOU HAVE ANSWERED ALL THE QUESTIONS. THANK YOU VERY MUCH FOR YOUR HELP
Please post this questionnaire back in the envelope provided. (No stamp is needed)
Return to : SCPR, 100 Kings Road, Brentwood, Essex CM14 4LX

HH

Appendix 2

Strand 1 – stage 2: interview schedule

P1889 **March 1999**

MEDICAL RESEARCH COUNCIL
SURVEY OF HEARING

Card 3
Serial
301-305

SERIAL NUMBER: ☐☐☐☐☐ ☐
CLK

Card
306-307
Batch
308-312
313-316

TIME AT START OF INTERVIEW: ☐☐ : ☐☐
(use 24 hour clock)

INTRODUCTION

IF NECESSARY: (Thank you for filling in our questionnaire last year. We are now following up some of the people who took part in that study, to ask a few more questions about hearing problems and hearing services. Even if you have no problems with your hearing, we are still interested in your views).

SECTION A: YOUR HEARING

I am going to start by asking you a few questions about your hearing. If you have a hearing aid, please answer these questions by thinking about the situation as if you were **not** wearing your hearing aid.

1. Do you have any difficulty with your hearing?

Yes 1 317
No 2

2. SHOW CARD A. Imagine that a normal young adult has a hearing ability of 100 and someone who is totally deaf has a hearing ability of 0. I would like you to say which number best indicates the state of your own hearing, taking your answer from the card.

WRITE IN: ☐☐☐ 318-320

3. Do you find it **very** difficult to follow a conversation if there is background noise such as TV, radio or children playing?

Yes 1 321
No 2

4. **SHOW CARD B.** How well do you hear someone talking to you when that person is sitting on your right side in a quiet room?
Would you say you had … **READ OUT**

… no difficulty,	1	322
slight difficulty,	2	
moderate difficulty,	3	
great difficulty,	4	
or would you say you cannot hear at all on that side?	5	
(Can't say)	8	

5. **SHOW CARD B AGAIN.** How well do you hear someone talking to you when that person is sitting on your left side in a quiet room?
IF NECESSARY READ OUT: Would you say you had…

… no difficulty,	1	323
slight difficulty,	2	
moderate difficulty,	3	
great difficulty,	4	
or would you say you cannot hear at all on that side?	5	
(Can't say)	8	

6. **INTERVIEWER CHECK Q1, Q3, Q4 AND Q5 AND RECORD**

Difficulty reported at Q1 (**code 1**), Q3 (**code 1**), Q4 (**code 2-8**), or Q5 (code **2-8**)	1 **ASK Q7**	324
No difficulty reported at Q1 (**code 2**), Q3 (**code 2**), Q4 (**code 1**) or Q5 (**code 1**)	2 **GO TO Q8a**	

IF HAS DIFFICULTY (CODE 1 AT Q6)

7. Nowadays, how much does any difficulty in hearing worry, annoy or upset you? Does it worry, annoy or upset you …
READ OUT

… severely,	1	325
moderately,	2	
slightly,	3	
or not at all?	4	
(Varies/Can't say)	8	

ALL

8a. I would now like to ask you about specific situations where some people find hearing more difficult than usual. Please think about any difficulties you may have in these situations due to your hearing.

SHOW CARD C. Do you have difficulty listening to the television with other family or friends when the volume is adjusted to suit other people, without any aid to hearing? Please take your answer from the set at the **top** of the card.

No difficulty	1 **GO TO Q9a**	326
Only slight difficulty	2 **ASK Q8b**	
Moderate difficulty	3 **ASK Q8b**	
Great difficulty	4 **ASK Q8b**	
Cannot manage at all	5 **ASK Q8b**	
(Can't say)	8 **GO TO Q9a**	

IF HAS DIFFICULTY (CODE 2-5 AT Q8a)

8b. **SHOW CARD C.** How much does any difficulty in this situation worry, annoy or upset you? Please take your answer from the set at the **bottom** of the card.

Not at all	1	327
Only a little	2	
A moderate amount	3	
Quite a lot	4	
Very much indeed	5	
(Can't say)	8	

ALL

9a. **SHOW CARD C.** Do you have difficulty having a conversation with one other person when there is no background noise, without any aid to hearing? Please take your answer from the set at the **top** of the card.

No difficulty	1	**GO TO Q10a**	328
Only slight difficulty	2	**ASK Q9b**	
Moderate difficulty	3	**ASK Q9b**	
Great difficulty	4	**ASK Q9b**	
Cannot manage at all	5	**ASK Q9b**	
(Can't say)	8	**GO TO Q10a**	

IF HAS DIFFICULTY (CODE 2-5 AT Q9a)

9b. **SHOW CARD C.** How much does any difficulty in this situation worry, annoy or upset you? Please take your answer from the set at the **bottom** of the card.

Not at all	1	329
Only a little	2	
A moderate amount	3	
Quite a lot	4	
Very much indeed	5	
(Can't say)	8	

ALL

10a. **SHOW CARD C.** Do you have difficulty carrying on a conversation in a busy street or shop, without any aid to hearing? (Please take your answer from the set at the **top** of the card).

No difficulty	1	**GO TO Q11a**	330
Only slight difficulty	2	**ASK Q10b**	
Moderate difficulty	3	**ASK Q10b**	
Great difficulty	4	**ASK Q10b**	
Cannot manage at all	5	**ASK Q10b**	
(Can't say)	8	**GO TO Q11a**	

IF HAS DIFFICULTY (CODE 2-5 AT Q10a)

10b. **SHOW CARD C.** How much does any difficulty in this situation worry, annoy or upset you? (Please take your answer from the set at the **bottom** of the card).

Not at all	1	331
Only a little	2	
A moderate amount	3	
Quite a lot	4	
Very much indeed	5	
(Can't say)	8	

ALL

11a. **SHOW CARD C.** Do you have difficulty having a conversation with several people in a group, without any aid to hearing? (Please take your answer from the set at the **top** of the card).

No difficulty	1 **GO TO Q12**	332
Only slight difficulty	2 **ASK Q11b**	
Moderate difficulty	3 **ASK Q11b**	
Great difficulty	4 **ASK Q11b**	
Cannot manage at all	5 **ASK Q11b**	
(Can't say)	8 **GO TO Q12**	

IF HAS DIFFICULTY (CODE 2-5 AT Q11a)

11b. **SHOW CARD C.** How much does any difficulty in this situation worry, annoy or upset you? (Please take your answer from the set at the **bottom** of the card).

Not at all	1	333
Only a little	2	
A moderate amount	3	
Quite a lot	4	
Very much indeed	5	
(Can't say)	8	

Spare
334-350

SECTION B: SEEKING HELP AND USING SERVICES

ALL

12. **INTERVIEWER CHECK Q6 AND RECORD**

Hearing difficulties reported (code 1)	1 **GO TO Q14**	351
No hearing difficulties reported (code 2)	2 **ASK Q13**	

IF NO DIFFICULTY (CODE 1 AT Q12)

13. Have you ever thought you had a difficulty with your hearing?

Yes	1 **ASK Q14**	352
No	2 **GO TO Q28**	

IF HAS/HAD DIFFICULTY (CODE 1 AT Q12 OR CODE 1 AT Q13)

14. Please think back to when you first thought you had a difficulty with your hearing. Were you …

IF RESP. SAYS NO DIFFICULTY, CHECK Q6 AND REMIND THEM OF REPORTED DIFFICULTY. IF STILL INSISTS NO DIFFICULTY, CODE AS 3.

… under 18,	1 **GO TO Q31**	353
or 18 or over?	2 **ASK Q15**	
(Resp. insists no difficulty)	3 **GO TO Q31**	

IF DIFFICULTY BEGAN AT 18 OR OVER (CODE 2 AT Q14)

15. What was the <u>first</u> thing that made you think you had a difficulty with your hearing?
CODE ONE ONLY

Difficulty hearing people talking	01	354-355
Difficulty when people didn't talk clearly or loudly enough	02	
Difficulty in noisy places (e.g. at work, in pubs)	03	
Difficulty holding a conversation (e.g. mishearing words, giving wrong answers)	04	
People saying I was ignoring them	05	
Difficulty hearing TV	06	
(Hearing loss was result of illness/accident)	07	
Other (**WRITE IN**)	08	

IF RESP. GIVES ANSWER 07, PROBE: 'WHEN YOU HAD THE ILLNESS/ACCIDENT, WHAT WAS THE 1ST THING …'

16a. Have you ever been given any advice by anyone about your difficulty with your hearing?

Yes	1 **ASK Q16b**	356
No	2 **GO TO Q29**	

IF HAS HAD ADVICE (CODE 1 AT Q16a)

16b. **SHOW CARD D.** Who did you **<u>first</u>** get advice from about your difficulty with your hearing?
CODE ONE ONLY

Family or friends	01	357-358
GP/Nurse/Other health professional	02	
An organisation for people with hearing problems (e.g. RNID, Hearing Concern, a helpline)	03	
A private hearing aid supplier	04	
Other (**WRITE IN**)	05	
Can't remember	98	

17. Most people have a hearing problem for a long time before they get advice about it.
What made you get advice about your hearing problem at the time you did?
PROBE FULLY AND RECORD VERBATIM

359-364

18. Have you ever mentioned your hearing problem to your GP?

Yes	1 **ASK Q19**	365
No	2 **GO TO Q23**	

IF HAS MENTIONED IT TO GP (CODE 1 AT Q18)

19. On how many occasions since you were 50 years old have you been to your GP for help or advice about your hearing problem …
Have you gone… **READ OUT**

… more than once,	1	366
once,	2	
or have you not gone at all?	3	

20. Thinking about all your visits to your GP, how long ago was the visit which you considered to be most helpful in doing something about your hearing problem?

Less than 6 months ago	1	367
6 months, less than 1 year ago	2	
1 year, less than 3 years ago	3	
3 years, less than 5 years ago	4	
5 years ago or longer	5	
Can't remember	8	

21. And on that visit, what recommendations did your GP make concerning your hearing problem? Card 4
PROBE FULLY AND CODE ALL THAT APPLY

Prescribed course of drugs (e.g. antibiotics or ear drops)	01	408-417
Referral to consult a private hearing aid supplier	02	
Referral to an Ear, Nose and Throat (ENT) Clinic	03	
Referral to hospital Audiology Dept or NHS hearing clinic to get a hearing aid	04	
Wax removed at GP surgery	05	
Referral to get wax removed	06	
Further tests/action at GP surgery	07	
GP to monitor situation	08	
No recommendations/Nothing could be done	09	
Other (**WRITE IN**)	10	
Don't know/Can't remember	98	

EXCLUDE WAX-SOFTENING EAR DROPS FROM CODE 1

22. **SHOW CARD E.** Overall, how satisfied were you with the GP's approach to your hearing problem? Please take your answer from the card.

Very satisfied	1	418
Fairly satisfied	2	
Neither satisfied nor dissatisfied	3	
Fairly dissatisfied	4	
Very dissatisfied	5	
(Can't say)	8	

IF HAS BEEN GIVEN ADVICE (CODE 1 AT Q16a)

23. Have you been given any help or advice about your hearing problem by an Ear Nose and Throat (ENT) clinic or an NHS hearing clinic?

Yes	1	**ASK Q24**	419
No	2	**GO TO Q31a PAGE 10, SECTION C)**	

IF HAS HAD ADVICE FROM ENT/HEARING CLINIC (CODE 1 AT Q23)

24. On how many occasions since you were 50 years old have you been to an Ear Nose and Throat (ENT) clinic or an NHS hearing clinic for help or advice about your hearing problem … Have you gone … **READ OUT**

… more than once,	1	420
once,	2	
or have you not gone at all?	3	

25. Thinking about all your visits to the clinic, how long ago was the visit which you considered to be most helpful in doing something about your hearing problem?

Less than 6 months ago	1	421
6 months, less than 1 year ago	2	
1 year, less than 3 years ago	3	
3 years, less than 5 years ago	4	
5 years ago or longer	5	
Can't remember	8	

26. And on that visit, what recommendations did the clinic make concerning your hearing problem? **PROBE FULLY AND CODE ALL THAT APPLY**

Prescribed course of drugs e.g. antibiotics or ear drops	01	422-431
ENT operation	02	
NHS hearing aid (a first one)	03	
Replacement hearing aid	04	
Repair to current hearing aid	05	
Consultation with private hearing aid supplier	06	
General advice on listening	07	
Hearing test	08	
Clinic to monitor situation	09	
No recommendations/Nothing could be done	10	
Other (**WRITE IN**)	11	

EXCLUDE WAX-SOFTENING EAR DROPS FROM CODE 1

_____

_____

Don't know/Can't remember	98	

27. **SHOW CARD E AGAIN** Overall, how satisfied were you with the clinic's approach to your hearing problem? Please take your answer from the card.

Very satisfied	1		432
Fairly satisfied	2	**GO TO Q31**	
Neither satisfied nor dissatisfied	3	**(PAGE 10,**	
Fairly dissatisfied	4	**SECTION C)**	
Very dissatisfied	5		
(Can't say)	8		

IF NEVER HAD DIFFICULTY IN HEARING (CODE 2 AT Q13)

28. If you found that you had a difficulty with your hearing, who would you go to <u>first</u> for advice? **CODE ONE ONLY**

Family or friends	01		433-434
GP/Nurse/Other health professional	02		
An organisation for people with hearing problems (e.g. RNID, Hearing Concern, a helpline)	03	**GO TO Q31a**	
A private hearing aid supplier	04	**(PAGE 10,**	
Other (**WRITE IN**)	05	**SECTION C)**	
_____			
I wouldn't seek advice from anyone	06		
Don't know/Can't say	08		

IF NEVER HAD ADVICE (CODE 2 AT Q16a)

29. Why have you not chosen to ask anyone for advice about your difficulty in hearing? **PROBE FULLY AND RECORD VERBATIM** 435-440

30. What would make you seek advice about your difficulty in hearing? **PROBE FULLY AND CODE ALL THAT APPLY**

Difficulty communicating	01	441-446
Difficulty doing work or everyday tasks	02	
If my family or friends persuaded me	03	
If the hearing problem got worse	04	
Other symptoms involving the ear such as tinnitus or dizziness	05	
Other (**WRITE IN**)	06	

_____

_____

I wouldn't seek advice	07	
Don't know/Can't say	98	

<u>Spare</u>
447-460

SECTION C: VIEWS ON THE NHS HEARING SERVICES

31a. I am now going to ask you a few questions about NHS hearing services. By NHS hearing services, I mean services at an NHS hospital or clinic, where people can get hearing tests and other help or advice about hearing problems.
INTERVIEWER CHECK Q12 AND RECORD

Hearing difficulties reported (code 1)	1 **GO TO Q32**	461
No hearing difficulties reported (code 2)	2 **GO TO Q31b**	

IF NO DIFFICULTIES NOW (CODE 2 AT Q31a)
31b. **INTERVIEWER CHECK Q13 AND RECORD**

Has had difficulty (code 1)	1 **ASK Q32**	462
Has never had difficulty (code 2)	2 **GO TO Q32**	

32. **IF DIFFICULTIES NOW OR IN PAST (CODE 1 AT Q31a OR Q31b)**
Can I check, have you ever used any NHS hearing services?

Yes	1	463
No	2	

ALL
33. **SHOW CARD F.** I am going to read out a list of statements about NHS hearing services. For each statement, please say how often in general you think it is true, thinking about your own experiences, or about what you have heard. Please take your answers from the card. **READ OUT a) TO g) AND CODE FOR EACH**

	All of the time	**Most of the time**	**Some of the time**	**None of the time**	**Can't say/ Don't know**	
a) The staff at the NHS hearing services are experts in their job.	1	2	3	4	8	464
b) Staff in the NHS hearing services are sympathetic to patients.	1	2	3	4	8	465
c) There are problems with transport to get to the NHS hearing clinic.	1	2	3	4	8	466
d) The staff treat you with courtesy and respect.	1	2	3	4	8	467
And how often do you think these statements are true …						
e) You have to wait a long time for an appointment with NHS hearing services.	1	2	3	4	8	468
f) The staff take time to explain things to you.	1	2	3	4	8	469
g) The staff give good advice on coping with everyday life with a hearing problem.	1	2	3	4	8	470

34. **SHOW CARD G.** Please say how much you agree or disagree with the following statement, taking your answer from the card. It is embarrassing to use the NHS hearing services. Card 5

Strongly agree	1	508
Agree	2	
Neither agree nor disagree	3	
Disagree	4	
Strongly disagree	5	
(Can't say/Don't know)	8	

35a. I**NTERVIEWER CHECK Q31a AND RECORD**

Hearing difficulties reported (code 1)	1 **GO TO Q35c**	509
No hearing difficulties reported (code 2)	2 **GO TO Q35b**	

IF NO DIFFICULTIES NOW (CODE 2 AT Q35a)

35b. **INTERVIEWER CHECK Q31b AND RECORD**

Has had difficulty (code 1)	1 **GO TO Q35c**	510
Has never had difficulty (code 2)	2 **GO TO Q39a (PAGE 13, SECTION D)**	

IF DIFFICULTIES NOW OR IN PAST (CODE 1 AT Q35a OR Q35b)

35c. **INTERVIEWER CHECK Q32 AND RECORD**

Has used NHS hearing service (code 1)	1 **GO TO Q36**	511
Has not used NHS hearing service (code 2)	2 **GO TO Q39a (PAGE 13, SECTION D)**	

IF USED NHS HEARING SERVICES (CODE 1 AT Q35c)

36. If you were given the choice, would you prefer to use NHS hearing services at a hospital or at your GP surgery?

Hospital	1 **ASK Q37**	512
GP surgery	2 **GO TO Q38**	
No preference	**3 GO TO Q39a (PAGE 13, SECTION D)**	

IF WOULD PREFER HOSPITAL (CODE 1 AT Q36)

37. Why would you prefer to go to the hospital?
PROBE FULLY AND CODE ALL THAT APPLY

Expert advice/knowledge of staff	1	513-520
Better equipped	2 **GO O Q39a**	
More efficient	3 **(PAGE 13,**	
Other reason (**WRITE IN**)	4 **SECTION D)**	

IF WOULD PREFER GP SURGERY (CODE 2 AT Q36)

38. Why would you prefer to go to the GP surgery?
PROBE FULLY AND CODE ALL THAT APPLY 521-532

Nearer/More convenient	01
Cheaper to get there/Cheaper to park there	02
Easier to find somewhere to park	03
They know me/my records	04
More friendly	05
Other reason (**WRITE IN**)	06

Spare
533-550

SECTION D: HEARING AIDS AND HEARING AID SERVICES

ALL

39a. **INTERVIEWER CHECK Q12 AND RECORD** Card 5

Hearing difficulties reported (code 1)	1 **GO TO Q40**	551
No hearing difficulties reported (code 2)	2 **GO TO Q39b**	

IF NO DIFFICULTIES NOW (CODE 2 AT Q39a)

39b. **INTERVIEWER CHECK Q13 AND RECORD**

Has had difficulty (code 1)	1 **ASK Q40**	552
Has never had difficulty (code 2)	2 **GO TO Q57**	

IF DIFFICULTIES NOW OR IN PAST (CODE 1 AT Q39a OR Q39b)

40. Can I check, do you have, or have you ever had, a hearing aid?

Yes, has one now	1 **GO TO Q41**	553
Doesn't have one now, but has had one in the past	2 **GO TO Q51**	
No, has never had one	3 **GO TO Q56**	

IF HAS HEARING AID (CODE 1 AT Q40)

41. Do you have a hearing aid for one ear only, or do you have a pair, that is, one for each ear?

For one ear only	1	554
A pair, one for each ear	2	

42. How often do you use your hearing aid(s)? Do you use it (them)…
READ OUT

IF 'EVERY DAY BUT SOMETIMES FORGET', CODE AS 1

… every day,	1	555
most days,	2	
some days,	3 **ASK Q43**	
only occasionally,	4	
or never?	5 **GO TO Q44**	

IF USES HEARING AID(S) AT LEAST OCCASIONALLY

43. On the days you use your hearing aid(s), how many hours a day on average do you use it/them? Do you use it (them) … **READ OUT**

… less than 2 hours a day,	1	556
more than 2 but less than 4 hours a day,	2	
more than 4 but less than 8 hours a day,	3	
or 8 hours a day or more?	4	
(It varies)	5	

44. Do you have a spare (pair of) hearing aid(s)?

Yes	1	557
No	2	

45a. I would like you to tell me about the hearing aid(s) you have at the moment.

IF RESPONDENT HAS SPARE HEARING AID – CODE 1 AT Q44:
(Please tell me about the hearing aid(s) you wear most often).

First, could you tell me the name of the company that makes your hearing aid?
RECORD VERBATIM

45b. Now, could you tell me the name or the number of the model of hearing aid you have?
RECORD VERBATIM

45c. How much did you pay for the (pair of) hearing aid(s) you have at the moment?

WRITE IN: £ ☐☐☐☐ **.00** 558-561

46. **INTERVIEWER CHECK Q44 AND RECORD:**

Respondent has spare hearing aid (code 1)	1 **ASK Q47a**	562
Respondent does not have spare hearing aid (code 2)	2 **GO TO Q48**	

IF HAS SPARE HEARING AID (CODE 1 AT Q46)

47a. Now please tell me about the hearing aid you wear less often.

First, could you tell me the name of the company that makes this hearing aid?
RECORD VERBATIM

47b. Now, could you tell me the name or the number of the model of this hearing aid?
RECORD VERBATIM

47c. How much did you pay for this (pair of) hearing aid(s)?

WRITE IN: £ ☐☐☐☐ **.00** 563-566

IF HAS HEARING AID (CODE 1 AT Q40)

48. **SHOW CARD H.** How satisfied are you with the hearing aid(s) you have at the moment? Please take your answer from the card.

IF RESPONDENT HAS SPARE HEARING AID – CODE 1 AT Q44:
(Please tell me about the hearing aid(s) you wear most often).

Very satisfied	1	567
Fairly satisfied	2	
Neither satisfied nor dissatisfied	3	
Fairly dissatisfied	4	
Very dissatisfied	5	

49. Looking back, do you think you should have got your first hearing aid earlier than you did?

Yes	1	568
No	2	
Don't know	8	

IF HAS/HAD HEARING AID NOW OR IN PAST (CODE 1–2 AT Q40)

50. How old were you when you got your first hearing aid?

WRITE IN: ☐☐ **YEARS OLD** 569-570

51. Have you had more than one hearing aid in your life? Card 6

INCLUDE REPLACEMENTS

Yes, more than one	1 **GO TO Q53**	608
No, just one	2 **ASK Q52**	

IF HAS ONLY HAD ONE HEARING AID (CODE 2 AT Q51)

52. Can I just check, was your hearing aid supplied by the NHS?

Yes	1 **GO TO Q57**	609
No	2 **GO TO Q56**	

IF HAS HAD MORE THAN ONE HEARING AID (CODE 1 AT Q51)

53. I would like you to tell me the total number of hearing aids you have had in your life.
Please include spare hearing aids and replacement hearing aids.
Please count a pair of hearing aids as two hearing aids.
If you can't remember the exact number, please give us your best estimate.

WRITE IN: ☐☐ **HEARING AIDS** 610-611

54. Can I just check, have you ever had a hearing aid supplied by the NHS?

Yes	1 **ASK Q55**	612
No	2 **GO TO Q56**	

IF HAS HAD NHS HEARING AID (CODE 1 AT Q54)

55. Thinking again about all the hearing aids you have had in your life, how many of your hearing aids were supplied by the NHS?
If you can't remember exactly how many were supplied by the NHS, please give us your best estimate.

WRITE IN: ☐☐ **HEARING AIDS AND GO TO Q57** 613-614

IF HAS NOT HAD NHS HEARING AID (CODE 2 AT Q40, Q52 OR Q54)

56. Have you ever been given any help or advice about hearing aids by your GP or by other NHS hearing services?

Yes	1	615
No	2	

ALL

57. **SHOW CARD J.** I am going to read out a list of statements about NHS hearing aid services. For each statement, please say how much you agree or disagree in general, thinking about your own experiences, or about what you have heard. Please take your answers from the card.
READ OUT a) TO g) AND CODE FOR EACH

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree	Can't remember/ can't say	
a) NHS hearing aids break down often.	1	2	3	4	5	8	616
b) The hearing aids provided by the NHS give a good quality of sound.	1	2	3	4	5	8	617
c) Once you have been tested for an NHS hearing aid, there is a long wait before you get your hearing aid.	1	2	3	4	5	8	618
d) The hearing aids provided by the NHS are too large. And how much do you agree or disagree with these statements?	1	2	3	4	5	8	619
e) The NHS uses up-to-date technology in its hearing aid clinics.	1	2	3	4	5	8	620
f) I don't trust the NHS hearing aid services.	1	2	3	4	5	8	621
g) The NHS should always offer hearing aid patients a hearing aid for each ear, if this would help them.	1	2	3	4	5	8	622

58. Do you think the NHS could improve its hearing aid services?

Yes	1	623
No	2	
Don't know/Can't say	8	

ALL

59a. **INTERVIEWER CHECK Q12 AND RECORD**

Hearing difficulties reported (code 1)	1 **GO TO Q60**	624
No hearing difficulties reported (code 2)	2 **GO TO Q59b**	

IF NO DIFFICULTIES NOW (CODE 2 AT Q59a)

59b. **INTERVIEWER CHECK Q13 AND RECORD**

Has had difficulty (code 1)	1 **ASK Q60**	625
Has never had difficulty (code 2)	2 **GO TO Q63**	

IF HAS/HAD DIFFICULTY NOW OR IN PAST (CODE 1 AT Q59a OR 59b)

60. Have you ever been given any help or advice about hearing aids by a private hearing aid supplier?

Yes	1	626
No	2	

61. **INTERVIEWER CHECK Q40 (PAGE 13) AND RECORD**

Has hearing aid or had one in past (code 1–2)	1 **ASK Q62**	627
Has never had hearing aid (code 3)	2 **GO TO Q63**	

IF HAS/HAD HEARING AID NOW OR IN PAST (CODE 1 AT Q61)

62. Have you ever bought a hearing aid from a private hearing aid supplier?

Yes	1	628
No	2	

ALL

63. **SHOW CARD J AGAIN.** I am going to read out a list of statements about private hearing aid suppliers. For each statement, please say how much you agree or disagree, in general, thinking about your own experiences, or about what you have heard. Please take your answers from the card. **READ OUT a) TO h) AND CODE FOR EACH**

	Strongly agree	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly Disagree**	**Can't remember/ can't say**	
a) Hearing aids from private suppliers break down often.	1	2	3	4	5	8	629
b) The hearing aids provided by the private supplier give a good quality of sound.	1	2	3	4	5	8	630
c) Once you have been tested for a hearing aid by a private hearing aid supplier, there is a long wait before you get your hearing aid.	1	2	3	4	5	8	631
d) The hearing aids provided by private suppliers are too large.	1	2	3	4	5	8	632
e) Private hearing aid suppliers use up-to-date technology.	1	2	3	4	5	8	633
f) The cost of hearing aids from a private supplier is reasonable.	1	2	3	4	5	8	634
g) I don't trust the private hearing aid suppliers.	1	2	3	4	5	8	635
h) Private suppliers should always offer hearing aid patients a hearing aid for each ear, if this would help them.	1	2	3	4	5	8	636

Spare
637-650

SECTION E:
EXPERIENCE AND EXPECTATIONS OF HEARING AIDS

ALL

64. Do you think hearing aids help people with hearing problems …
READ OUT

…all of the time,	1	651
most of the time,	2	
some of the time,	3	
or none of the time?	4	
(Depends)	5	
(Don't know/Can't say)	8	

65. And do you think having a hearing aid for a long time can damage a person's hearing ?

Yes	1	652
No	2	
Sometimes/Depends	3	
Don't know	8	

66. Do you think having a hearing aid for a long time can result in better hearing when the hearing aid is <u>not</u> being worn?

Yes	1	653
No	2	
Sometimes/Depends	3	
Don't know	8	

67. And do you think hearing aids make sounds clearer?

Yes	1	654
No	2	
Sometimes/Depends	3	
Don't know	8	

68. Do you think hearing aids can help people to hear more of what is said?

Yes	1	655
No	2	
Sometimes/Depends	3	
Don't know	8	

69. And do you think hearing aids help people locate where sounds are coming from?

Yes	1	656
No	2	
Sometimes/Depends	3	
Don't know	8	

70. Can you think of any problems or disadvantages there might be for someone who wears a hearing aid?
PROBE FULLY AND RECORD VERBATIM 657-666

71. Can you think of any benefits there might be for someone who wears a hearing aid? Card 7
PROBE FULLY AND CODE ALL THAT APPLY

Hearing better generally	01	708-717
Locating sounds	02	
Communicating more easily	03	
Not missing so much	04	
Joining in more social activities	05	
Watching TV	06	
Doing work or everyday tasks more easily	07	
Less embarrassment	08	
Other (**WRITE IN**)	09	

_____

_____

Don't know/Can't think of any 98

72. I am going to read out a list of different situations. For each one, I would like you to tell me whether you think hearing aids can help people at all in that situation.
READ OUT AND CODE FOR EACH

	Yes, can help	**No, can't help**	**Don't know/ Can't say**	
a) Watching television	1	2	8	718
b) Having a conversation on the telephone	1	2	8	719
c) Having a face-to-face conversation with <u>one</u> person	1	2	8	720
d) Having a face-to-face conversation with <u>more</u> than one person And do you think hearing aids can help people at all in <u>these</u> situations?	1	2	8	721
e) Having a conversation in a noisy place	1	2	8	722
f) Hearing sounds around the home	1	2	8	723
g) At a concert or at the theatre	1	2	8	724
h) At the cinema	1	2	8	725

73a. **SHOW CARD K.** Please look at the photograph on the first photo card, card K. Were you aware that this sort of hearing aid existed?

Yes	1	726
No	2	

73b. Still looking at the first photo card. How easy do you think <u>you</u> would find it to put this kind of hearing aid on?
Do you think it would be … **READ OUT**

IF RESP. ASKS, QN IS ABOUT 'WHEN YOU ARE USED TO IT'

… very easy,	1	727
easy,	2	
difficult,	3	
or very difficult?	4	
(Don't know/Can't say)	8	

73c. And how acceptable would you find the appearance of the hearing aid if you were to wear it?
Would you find it… **READ OUT**

… very acceptable,	1	728
acceptable,	2	
unacceptable,	3	
or very unacceptable?	4	
(Don't know/Can't say)	8	

74a. **SHOW CARD L.** Please look at the photograph on the second photo card, card L.
Were you aware that this sort of hearing aid existed?

Yes	1	729
No	2	

74b. Still looking at the second photo card. How easy do you think you would find it to put this kind of hearing aid on?
Do you think it would be … **READ OUT**

… very easy,	1	730
easy,	2	
difficult,	3	
or very difficult?	4	
(Don't know/Can't say)	8	

74c. And how acceptable would you find the appearance of the hearing aid if you were to wear it?
Would you find it … **READ OUT**

… very acceptable,	1	731
acceptable,	2	
unacceptable,	3	
or very unacceptable?	4	
(Don't know/Can't say)	8	

75a. **SHOW CARD M.** Looking now at the photograph on the third photo card, card M.
Were you aware that this sort of hearing aid existed?

Yes	1	732
No	2	

75b. Still looking at the third photo card. How easy do you think you would find it to put this kind of hearing aid in your ear?
Do you think it would be … **READ OUT**

… very easy,	1	733
easy,	2	
difficult,	3	
or very difficult?	4	
(Don't know/Can't say)	8	

75c. And how acceptable would you find the appearance of the hearing aid if you were to wear it?
Would you find it … **READ OUT**

… very acceptable,	1	734
acceptable,	2	
unacceptable,	3	
or very unacceptable?	4	
(Don't know/Can't say)	8	

76a. **SHOW CARD N.** Please look at the photograph on the fourth photo card, card N.
Were you aware that this sort of hearing aid existed?

Yes	1	735
No	2	

76b. Still looking at the fourth photo card. How easy do you think you would find it to put this kind of hearing aid in your ear?
Do you think it would be … **READ OUT**

… very easy,	1	736
easy,	2	
difficult,	3	
or very difficult?	4	
(Don't know/Can't say)	8	

76c. And how acceptable would you find the appearance of the hearing aid if you were to wear it?
Would you find it … **READ OUT**

… very acceptable,	1	737
acceptable,	2	
unacceptable,	3	
or very unacceptable?	4	
(Don't know/Can't say)	8	

77a. **SHOW CARD P.** Looking now at the photograph on the final photo card, card P.
Were you aware that this sort of hearing aid existed?

Yes	1	738
No	2	

77b. Still looking at the final photo card. How easy do you think you would find it to put this kind of hearing aid in your ear?
Do you think it would be … **READ OUT**

… very easy,	1	739
easy,	2	
difficult,	3	
or very difficult?	4	
(Don't know/Can't say)	8	

77c. And how acceptable would you find the appearance of the hearing aid if you were to wear it?
Would you find it … **READ OUT**

… very acceptable,	1	740
acceptable,	2	
unacceptable,	3	
or very unacceptable?	4	
(Don't know/Can't say)	8	

78. INTERVIEWER CHECK Q40 AND RECORD

Has or has had a hearing aid (code 1–2)	1 **ASK Q79**	741
Has never had a hearing aid (code 3)	2 **GO TO Q84**	

HAS/HAD A HEARING AID (CODE 1 AT Q78)

79. Which of the five sorts is/was your hearing aid?
ASK RESPONDENT TO SHOW YOU CARD WITH THEIR HEARING AID ON IT.

CODE ONE ONLY

IF HAS MORE THAN ONE SORT, CODE SORT WORN MOST OFTEN.

IF USED TO WEAR ONE BUT DOESN'T NOW, CODE MOST RECENT SORT.

Card K – Body worn	1	742
Card L – Behind the ear	2	
Card M – In the ear	3	
Card N – In the canal	4	
Card P – Smaller canal aid	5	
Other sort (**WRITE IN**)	6	

---

80. When you first got a hearing aid, how long did it take you to get used to wearing it?

Got used to it straight away	1	743
Less than 1 week	2	
1 week, less than 1 month	3	
1 month, less than 3 months	4	
3 months, less than 6 months	5	
6 months or more	6	

81. Do you think the general public knows enough about hearing loss and hearing aids?

Yes	1	744
No	2	
Don't know/Can't say	8	

82. Thinking about your own experiences, or about what you have heard, how much do you think GPs know about hearing loss and hearing aids? In general, do you think they know … **READ OUT**

… a great deal,	1	745
a fair amount,	2	
a little,	3	
or nothing at all about hearing loss and hearing aids?	4	
(Don't know/Can't say)	8	

83. Now thinking about practice nurses and district nurses. In general, do you think they know … **READ OUT**

… a great deal,	1	746
a fair amount,	2	
a little,	3	
or nothing at all about hearing loss and hearing aids?	4 **GO TO Q87**	
(Don't know/Can't say)	8	

NEVER HAD HEARING AID (CODE 2 AT Q78)

84. How long do you think it would take to get used to wearing a hearing aid?

Straight away	1	747
Less than 1 week	2	
1 week, less than 1 month	3	
1 month, less than 3 months	4	
3 months, less than 6 months	5	
6 months or more	6	
(Depends/Don't know)	8	

85. If it could be shown that you would benefit from having a hearing aid, would you agree to try out the most appropriate sort for free?

IF WOULD ONLY TRY SMALLEST ONE, CODE AS 'YES'	Yes	1	748
	No	2	

86. Would you feel nervous about trying out a hearing aid?

Yes, would feel nervous	1	749
No, wouldn't feel nervous	2	

ALL

87. **SHOW CARD Q.** Here is a list of devices and services which people with hearing problems can use in the home. Please look all the way down the list, and tell me all the ones you have heard of.
PROBE FULLY AND CODE ALL THAT APPLY

Extra-loud doorbells	01	750-771
Flashing lights to show the doorbell is ringing	02	
Extra-loud telephones	03	
Flashing lights to show the telephone is ringing	04	
Typetalk/Textphone/Minicom	05	
TV amplifiers	06	
TV subtitles available through Teletext	07	
Vibrating alarms (e.g. vibrating alarm clocks)	08	
Ear trumpet	09	
Other things heard of (**WRITE IN**)	10	

_____

_____

Haven't heard of any of these	11

88. **SHOW CARD R.** Here are some other devices and services which can help people with hearing problems in their everyday lives. Please look all the way down the list, and tell me all the ones you have heard of. Card 8
PROBE FULLY AND CODE ALL THAT APPLY

Other devices		
Induction loops (in theatres/cinemas etc.)	01	808-823
Earphones which pick up sound through an infra-red transmitter	02	
Earphones which pick up sound through an FM transmitter	03	
Visual alarm systems (e.g. flashing fire alarms)	04	
Other services		
Sign language services offered in public places (e.g. theatres, GP surgeries)	05	
Hearing dogs for the deaf	06	
Other things heard of (**WRITE IN**)	07	
Haven't heard of any of these	10	

ALL

89. **SHOW CARD S.** Many people who experience problems with hearing don't come forward to have their hearing tested. Please look all the way down the list and tell me which things you think would be most likely to encourage people to have their hearing tested.
CODE UP TO THREE ONLY. IF RESPONDENT MENTIONS MORE THAN THREE, ASK FOR THE THREE MOST LIKELY TO ENCOURAGE PEOPLE.

Better services for those with hearing problems	01	824-829
If hearing aids gave better sound quality	02	
If hearing aids were smaller	03	
If people were told they could have a test for free	04	
More information and publicity about hearing tests (e.g. in GP surgeries, or on TV)	05	
If there were hearing advice centres	06	
If more people wore hearing aids	07	
If people had hearing tests or check-ups on a routine basis	08	
Being able to attend a hearing clinic without being referred by a GP	09	
Being able to have a test at the GP surgery	10	
Being able to get results immediately	11	
Other (**WRITE IN**)	12	
None of these	13	
Don't know	98	

90. Do you think that NHS hearing aids are … **READ OUT**

… free for everyone,	1	830
free for some groups of people,	2	
or not free for anyone?	3	
(Don't know/Can't say)	8	

91. Do you think that NHS hearing aids ought to be …
READ OUT

…free for everyone,	1 **GO TO Q93 (section F)**	831
free for some people,	2 **GO TO Q 93 (section F)**	
or not free for anyone?	3 **ASK Q92**	
(Don't know/Can't say)	8 **GO TO Q93 (section F)**	

IF THINKS EVERYONE OUGHT TO PAY (CODE 3 AT Q91)

92. How much do you think a basic NHS hearing aid ought to cost?
Do you think they ought to be…READ OUT

… less than £50,	1	832
between £50 and £100,	2	
or more than £100?	3	
(Don't know/Can't say)	8	

Spare
833-850

SECTION F: GENERAL HEALTH

93a. **SHOW CARD T.** I would now like you to think about your general health, not just your hearing. Please look at the card and tell me whether you have any of the health problems listed on the card. Just tell me the number next to any health problems you have.
PROBE AND CODE ALL THAT APPLY

EXCLUDE VISION PROBLEMS CORRECTABLE BY GLASSES

1 (Vision)	1	851-866
2 (Mobility)	2	
3 (Dexterity)	3	
4 (Emotional problems)	4	
5 (Speech problems)	5	
6 (Remembering, thinking clearly)	6	
7 (Pain)	7	
8 (Self care)	8	
None of these	9	

93b. **SHOW CARD U.** I would like you to give an overall estimate of the quality of life for your family. If 100 is the best quality of life imaginable, and 0 is the worst, please think about all the things that are important to you and your family in your everyday lives and choose the number from the card which best fits your family.

WRITE IN: ☐☐☐ 867-869

Spare
870-899

SECTION G: SCREENING

ALL

94a. For some health problems it is possible to have a quick test or check-up to find out whether you need to have more detailed tests. This is called a screening test. Card 9

Have you heard of screening tests?

Yes	1	908
No	2	

94b. I am going to read out a list of different screening tests. For each one, I would like you to say whether you have heard of that screening test.
READ OUT EACH ONE AND CODE WHETHER HEARD OF

	Yes	No	DK	
breast screening?	1	2	8	909
cervical screening?	1	2	8	910
children's hearing screening?	1	2	8	911
old age screening, or the 75 year screen?	1	2	8	912
colorectal cancer screening?	1	2	8	913
glaucoma screening?	1	2	8	914
well man or well woman checks?	1	2	8	915
occupational screening?	1	2	8	916

94c. Do you think that screening tests are a good idea?

Yes	1	917
No	2	
Some screens/Sometimes	3	
Don't know/Can't say	8	

95a. **INTERVIEWER CHECK Q12 AND RECORD**

Hearing difficulties reported (code 1)	1 **GO TO Q95b**	918
No hearing difficulties reported (code 2)	2 **GO TO Q96**	

IF HAS DIFFICULTY (CODE 1 AT Q95a)

95b. **INTERVIEWER CHECK Q40 (PAGE 13) AND RECORD**

Has hearing aid now (code 1)	1 **GO TO Q100**	919
Does not have hearing aid now (code 2-3)	2 **ASK Q96**	

96. Would you have a screening test for your hearing, even if you didn't feel you had a hearing problem?

CODE 'ONLY AS PART OF MORE GENERAL CHECKUP' AS 'NO'

Yes	1 **GO TO Q98**	920
No	2 **ASK Q97**	
Don't know/Can't say	2 **GO TO Q98**	

IF WOULDN'T HAVE SCREEN (CODE 2 AT Q96)

97. Why wouldn't you have a screening test for your hearing?
PROBE AND CODE ALL THAT APPLY

I know I haven't got a problem	1		921-923
Don't want to know if I've got a problem	2		
I wouldn't want a hearing aid	3		
I don't have time	4		
I don't like hospitals/clinics/doctors	5		
The thought makes me nervous	6	**GO TO Q100**	
Other (**WRITE IN**)	7		
_____			
_____			
Don't know/Can't say	8		

IF WOULD HAVE SCREEN OR DON'T KNOW (CODE 1 OR 8 AT Q96)

98. Would you feel nervous about having a screening test for your hearing?

Yes	1	924
No	2	
Don't know	8	

99. I am going to read out a list of places where you could go to have a screening test for your hearing. For each place, I would like you to say whether you would be prepared to go there for a screening test for your hearing. Would you be prepared to have a screening test for your hearing…
READ OUT AND CODE FOR EACH

	Yes	**No**	**Can't say/ Doesn't apply**	
a) … at your GP surgery?	1	2	8	925
b) … at another local health centre?	1	2	8	926
c) … at hospital?	1	2	8	927
d) … at the premises of a private hearing aid supplier?	1	2	8	928
e) … at work?	1	2	8	929
f) … in your own home?	1	2	8	930

ALL

100. Would you be prepared to fill in a short screening questionnaire about your hearing and return it to your GP?

Yes	1	**GO TO Q5**	931
No	2	**ON PAGE 2 OF ARF**	

101. Thank you very much for helping us with this valuable study. The Medical Research Council would like to follow up this interview by inviting you to visit their Hearing Clinic, at ……

IF IN SOUTHAMPTON:
… the Hearing and Balance Centre, University of Southampton.

IF IN NOTTINGHAM:
… the Institute of Hearing Research, University of Nottingham.

They would like to see people with good hearing as well as people with hearing problems. If you agreed to visit the clinic, you would have several accurate hearing tests. The visit would last about 2½ to 3 hours, and would take place at your convenience some time in the next few months.

The Institute would pay for your travel to the clinic, and if necessary they would book and pay for a taxi for you. You would also be given £25 for attending the clinic.

Would you be willing for the clinic to contact you?

Yes	01		932-937
No – given enough time to survey already/expecting too much	02		
No – too busy/can't spare time (if code 2 doesn't apply)	03	**(GIVE**	
No – disabled/ill/housebound	04	**CLINIC**	
No – travel too inconvenient	05	**LEAFLET**	
No – childcare/other care responsibilities	06	**AND …)**	
No – moved/about to move	07	**GO TO Q7**	
No – had enough of tests/medical profession at present time	08	**ON PAGE 4**	
No – worried about what might find out/'might tempt fate'	09	**OF ARF**	
No – scared/nervous about medical tests	10		
No – don't want people to look in my ears	11		
No – cannot see point/already knows about hearing	12		
No – refused to give reason	13		
No – other reason (**WRITE IN**)	14		

102. Finally, there is a short self-completion booklet about your general health which I would like to leave with you to complete in your own time. It normally takes about ten minutes to fill in.

Can I give you the booklet to complete?

Yes	01	**GO TO Q103**	938-943
No – given enough time to survey already/expecting too much	02		
No – too busy/can't spare time (if code 2 doesn't apply)	03		
No – too ill	04		
No – cannot see point	05		
No – eyesight problems	06	**GO TO Q104**	
No – language problems	07		
No – reading difficulties	08		
No – refused to give reason	09		
No – other reason (WRITE IN)	10		

SELF-COMP ACCEPTED (CODE 01 AT Q102)

103. **WRITE IN SERIAL NUMBER ON FRONT OF BOOKLET AND GIVE TO RESPONDENT WITH PRE-PAID ENVELOPE.**
Thank you for helping us with the self-completion booklet. When you have completed the booklet, please put it in the pre-paid envelope and post it back to us as soon as you can.

RING CODE 1 AT Q6 ON PAGE 3 OF ARF

SELF-COMP REFUSED (CODE 2 AT Q107 OR Q108)

104. **RING CODE 2 AT Q6 ON PAGE 3 OF ARF**

105. That is the end of the interview. Thank you very much for your help.

106. **INTERVIEWER COMPLETE:**

TIME AT END OF INTERVIEW ☐☐ : ☐☐ 944-947
(use 24 hour clock)

DURATION OF INTERVIEW ☐☐☐ **mins** 948-950

DATE OF INTERVIEW ☐☐☐☐☐☐ 951-956
Day Month Year

INTERVIEWER NUMBER ☐☐☐☐☐☐ 957-962

INTERVIEWER SIGNATURE _____

Spare
963-999

Appendix 3

Strand 1 – screening questionnaire

Screening questions

If you normally wear a hearing aid, please answer the following questions as if **NOT** wearing a hearing aid. Please put a (✓) in the relevant box along with any further comments.

		(✓)
Q1.	**Do you have any difficulty with your hearing? If YES please write down the most troublesome problem you have.**	
	No	☐
	Yes	☐
Q2.	**Do you find it very difficult to follow a conversation if there is background noise (such as TV, radio, children playing)?**	
	No	☐
	Yes	☐
Q3.	**a) How well do you hear someone talking to you when that person is sitting … on your <u>RIGHT SIDE</u> in a quiet room?**	
	With no difficulty	☐
	With slight difficulty	☐
	With moderate difficulty	☐
	With great difficulty	☐
	Cannot hear at all	☐
	b) **… on your <u>LEFT SIDE</u> in a quiet room?**	
	With no difficulty	☐
	With slight difficulty	☐
	With moderate difficulty	☐
	With great difficulty	☐
	Cannot hear at all	☐

Does this situation happen in your life? **LISTENING TO THE TELEVISION WITH OTHER FAMILY OR FRIENDS WHEN THE VOLUME IS ADJUSTED TO SUIT OTHER PEOPLE** 0 ____ No 1 ____ Yes	
How much difficulty do you have in this situation? **How much does any difficulty in this situation worry, annoy or upset you?**	
0 ____ N/A 1 ____ No difficulty 2 ____ Only slight difficulty 3 ____ Moderate difficulty 4 ____ Great difficulty 5 ____ Cannot manage at all	0 ____ N/A 1 ____ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 ____ Very much indeed
Does this situation happen in your life? **HAVING A CONVERSATION WITH ONE OTHER PERSON WHEN THERE IS NO BACKGROUND NOISE** 0 ____ No 1 ____ Yes	
How much difficulty do you have in this situation?	How much does any difficulty in this situation worry, annoy or upset you?
0 ____ N/A 1 ____ No difficulty 2 ____ Only slight difficulty 3 ____ Moderate difficulty 4 ____ Great difficulty 5 ____ Cannot manage at all	0 ____ N/A 1 ____ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 ____ Very much indeed
Does this situation happen in your life? **CARRYING ON A CONVERSATION IN A BUSY STREET OR SHOP** 0 ____ No 1 ____ Yes	
How much difficulty do you have in this situation?	How much does any difficulty in this situation worry, annoy or upset you?
0 ____ N/A 1 ____ No difficulty 2 ____ Only slight difficulty 3 ____ Moderate difficulty 4 ____ Great difficulty 5 ____ Cannot manage at all	0 ____ N/A 1 ____ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 ____ Very much indeed
Does this situation happen in your life? **HAVING A CONVERSATION WITH SEVERAL PEOPLE IN A GROUP** 0 ____ No 1 ____ Yes	
How much difficulty do you have in this situation? **How much does any difficulty in this situation worry, annoy or upset you?**	
0 ____ N/A 1 ____ No difficulty 2 ____ Only slight difficulty 3 ____ Moderate difficulty 4 ____ Great difficulty 5 ____ Cannot manage at all	0 ____ N/A 1 ____ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 ____ Very much indeed

Appendix 4

Strand 1 – Auditory Lifestyle and Demand Questionnaire

In this questionnaire we are interested in what sort of listening situations you find yourself, and how important they are to you.

We have included a list of 25 different listening situations. For each situation we would like you to tell us:

1. How often **YOU** find yourself in the situation, and also
2. How important listening in this situation is to **YOU**.

For each of the 25 situations, please tick the answer that is closest to what YOU think.

Example 1:	**How often do you find yourself in this situation?**	**How important a factor is this in your everyday life?**
Listening to your boss in a quiet office	1 ____ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 __✓__ Quite a lot 5 ____ Very much indeed	1 ____ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 __✓__ Very much indeed

This person listens to his boss in a quiet office quite a lot of the time and rates its importance as very much indeed.

Example 2:	**How often do you find yourself in this situation?**	**How important a factor is this in your everyday life?**
Listening to your boss in a quiet office	1 __✓__ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 ____ Very much indeed	1 __✓__ Not at all 2 ____ Only a little 3 ____ A moderate amount 4 ____ Quite a lot 5 ____ Very much indeed

This person does not have a boss, so he describes the situation as one where he finds himself not at all, and it is not at all an important factor in his everyday life.

We would now like you to answer all the following questions. Please do not leave any blank.

Auditory Lifestyle and Demand Questionnaire	**How often do you find yourself in this situation?**	**How important a factor is this in your everyday life?**
1. Listening in a background of noise	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
2. Listening to sounds that are quiet and difficult to hear	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
3. Listening to sounds that are consistently loud	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
4. Listening to sounds that are close by you	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
5. Listening to sounds that are far away	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
6. Listening when there are lots of echoes	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
7. Listening when two or more people are talking at once	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
8. Having to listen to sounds that vary a lot in loudness	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
9. Listening to sounds that vary quickly in loudness	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed

Auditory Lifestyle and Demand Questionnaire	**How often do you find yourself in this situation?**	**How important a factor is this in your everyday life?**
10. Talking on the telephone	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
11. Listening to music at home	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
12. Listening to music at a concert	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
13. Listening to the radio	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
14. Listening to the television	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
15. Listening to sounds or voices that are moving around	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
16. Listening when you have no control or influence over the speaker	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
17. Listening when not being able to understand could be embarrassing	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
18. Listening when not being able to understand could cause an accident	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed

Auditory Lifestyle and Demand Questionnaire	**How often do you find yourself in this situation?**	**How important a factor is this in your everyday life?**
19. Listening when not being able to understand could cause you to lose money	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
20. Listening to a speaker who is in another room	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
21. Listening to a speaker whose voice is not familiar to you	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
22. Listening to the sounds of nature	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
23. Having to understand what is happening around you	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
24. Listening to people with unfamiliar accents or dialects	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed
25. Being in a situation where you actually do not want to hear what is happening	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed	1 ___ Not at all 2 ___ Only a little 3 ___ A moderate amount 4 ___ Quite a lot 5 ___ Very much indeed

Thank you very much for filling in this questionnaire.

Appendix 5

Strand 1 – Quality of Family Life Questionnaire

Participant Label

QUALITY OF FAMILY LIFE

We would like to find out how your family member's hearing affects your family.

We would like you to tell us how you think your family feels. Please answer the questions for your family as a whole.

You may want to talk to other members of your family before answering.

Everything you say will be treated confidentially.

The questions in Section A are about who is in your family

Section C asks about how your family feels about things now

Section D asks you to estimate how good your family's quality of life is overall

Thank you for taking the time to fill in this questionnaire.

DATE OF 3 MONTH REVIEW: _____

SECTION A

Not all families are the same. Please could you tell us who is in your immediate family. Usually, these will be the people who live with you.

We don't want to know their names, just how they are related to you and how old they are.

The example shows a family of four, a woman, her husband, their son and the husband's mother.

EXAMPLE:

MYSELF	**Age** ..50..
My ..Husband..	**Age** ..52..
My ..Son..	**Age** ..20..
My ..Mother-in-law..	**Age** ..74..

Now please fill in the box below for yourself and your family.

YOUR FAMILY:

MYSELF	**Age** .....
My	**Age** .....
My	**Age** .....
My	**Age** .....
My	**Age** .....
My	**Age** .....
My	**Age** .....
My	**Age**.....

SECTION C

Taking into account your family member's hearing, please answer the following questions about how your family feels about things now.

Please answer the questions for your family as a whole

Taking into account your family member's hearing …

1 … how much enjoyment does your family get from going out together?

A great deal of enjoyment	Quite a lot of enjoyment	Some enjoyment	Not much enjoyment	No enjoyment or very little enjoyment
( )	( )	( )	( )	( )

2- … is your family restricted in going out together?

Not at all restricted	Slightly restricted	Moderately restricted	Severely restricted	Very severely restricted
( )	( )	( )	( )	( )

3- … how much effort from your family is needed to help your family member to communicate with others?

A great deal of effort	Quite a lot of effort	Some effort	Only a little effort	No effort at all
( )	( )	( )	( )	( )

4- … how much of an effort is it for your family to get ready in the morning?

No effort at all	Only a little effort	Some effort	Quite a lot of effort	A great deal of effort
( )	( )	( )	( )	( )

5- … how confident is your family that it has enough time to do all the household activities it has to do (e.g. chores, odd jobs)?

Not confident at all	Not very confident	Somewhat confident	Quite confident	Very confident
( )	( )	( )	( )	( )

6- … how satisfied is your family with the support it receives from people around it (e.g. from friends, family and others)?

Very satisfied	Quite satisfied	Somewhat satisfied	Not very satisfied	Not satisfied at all
( )	( )	( )	( )	( )

7 … how confident is your family that it is coping with life in general?

Not confident at all	Not very confident	Somewhat confident	Quite confident	Very confident
( )	( )	( )	( )	( )

Taking into account your family member's hearing …

8- … how confident is your family that it will be able to cope with life in general in the future?

Not confident at all	Not very confident	Somewhat confident	Quite confident	Very confident
( )	( )	( )	( )	( )

9- … how much enjoyment does your family get from watching TV together?

A great deal of enjoyment	Quite a lot of enjoyment	Some enjoyment	Not much enjoyment	No enjoyment or very little enjoyment
( )	( )	( )	( )	( )

10- …how confident is your family that it has enough time to do all the social and leisure activities it would like to do (e.g. entertaining, visiting friends, hobbies, sport)?

Not confident at all	Not very confident	Somewhat confident	Quite confident	Very confident
( )	( )	( )	( )	( )

11- … how much enjoyment does your family get from having meals together at home?

No enjoyment or very little enjoyment	Not much enjoyment	Some enjoyment	Quite a lot of enjoyment	A great deal of enjoyment
( )	( )	( )	( )	( )

12- … how worried is your family that your family member cannot communicate with others when on his own?

Not worried at all	Just a little worried	Somewhat worried	Worried quite a lot	Very worried
( )	( )	( )	( )	( )

13- … how easy or difficult is it for your family to come to an agreement?

Very easy	Easy	Neither easy nor difficult	Difficult	Very difficult
( )	( )	( )	( )	( )

14- … how much do other people interfere in your family's life?

Don't interfere at all	Interfere just a little	Interfere somewhat	Interfere quite a lot	Interfere a great deal
( )	( )	( )	( )	( )

15- … how much enjoyment does your family get from going away on holiday together?

No enjoyment or very little enjoyment	Only a little enjoyment	Some enjoyment	Quite a lot of enjoyment	A great deal of enjoyment
( )	( )	( )	( )	( )

16- … is your family restricted in its choice of holidays?

Very severely restricted	Severely restricted	Moderately restricted	Slightly restricted	Not at all restricted
( )	( )	( )	( )	( )

Taking into account your family member's hearing …

17- … how much does your family feel under pressure?				
Under no pressure ( )	**Under very little pressure** ( )	**Under some pressure** ( )	**Under quite a lot of pressure** ( )	**Under a great deal of pressure** ( )

18- … how worried is your family about the well-being of your family member when you are not together?				
Not worried at all ( )	**Just a little worried** ( )	**Somewhat worried** ( )	**Worried quite a lot** ( )	**Very worried** ( )

19- … is your family satisfied with its achievements (e.g. in work, school, sports or hobbies)?				
Not satisfied at all ( )	**Not very satisfied** ( )	**Somewhat satisfied** ( )	**Quite satisfied** ( )	**Very satisfied** ( )

20- … how difficult is it for your family to enjoy the television together?				
Impossible ( )	**Very difficult** ( )	**Somewhat difficult** ( )	**A little difficult** ( )	**Not difficult at all** ( )

21- … is any stress caused when including your family member in family activities?				
No stress at all ( )	**Only a little stress** ( )	**Some stress** ( )	**Quite a lot of stress** ( )	**A great deal of stress** ( )

22- … which of the following statements best describes your family's view of the future?				
Not confident at all ( )	**Not very confident** ( )	**Somewhat confident** ( )	**Quite confident** ( )	**Very confident** ( )

23- … is your family confident that it has enough money to keep up its standard of living?				
Not confident at all ( )	**Not very confident** ( )	**Somewhat confident** ( )	**Quite confident** ( )	**Very confident** ( )

24- … how satisfied is your family that its needs are being met?				
Not satisfied at all ( )	**Not very satisfied** ( )	**Somewhat satisfied** ( )	**Quite satisfied** ( )	**Very satisfied** ( )

25- … is any embarrassment caused when including your family member in family activities?				
No embarrassment at all ( )	**Only a little embarrassment** ( )	**Some embarrassment** ( )	**Quite a lot of embarrassment** ( )	**A great deal of embarrassment** ( )

Taking into account your family member's hearing …

26- … how much does your family understand about your family member's hearing?				
As much as we would like ( )	Not quite as much as we would like ( )	Less than we would like ( )	Much less than we would like ( )	Very much less than we would like ( )

27- … how much control does your family have over the way it lives its life?				
No control or very little control ( )	Not much control ( )	Some control ( )	Quite a lot of of control ( )	Complete or nearly complete control ( )

28- … how worried is your family that your family member is in danger because of his hearing?				
Not worried at all ( )	Just a little worried ( )	Somewhat worried ( )	Worried quite a lot ( )	Very worried ( )

29- … how much enjoyment does your family get from spending time together at home (e.g. talking, playing games)?				
No enjoyment or very little enjoyment ( )	Not much enjoyment ( )	Some enjoyment ( )	Quite a lot of enjoyment ( )	A great deal of enjoyment ( )

30- … how happy is your family?				
Very happy ( )	Happy ( )	Somewhat happy ( )	Not very happy ( )	Not happy at all ( )

We have dealt with some of the aspects of family life and activities which may be affected by someone having hearing difficulties. We would now like you to think of any other aspects or activities, which are important to your family, which might be affected. Please write them in the shaded boxes and then tick the answer which best describes how much your family is affected.

31-				
Cannot manage to do at all ( )	Affected very much ( )	Affected quite a lot ( )	Affected somewhat ( )	Affected only slightly ( )

32-				
Cannot manage to do at all ( )	Affected very much ( )	Affected quite a lot ( )	Affected somewhat ( )	Affected only slightly ( )

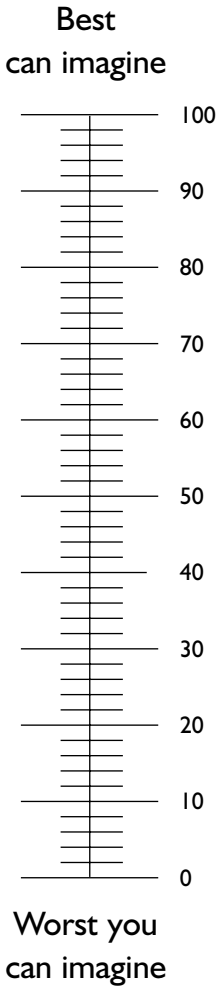
SECTION D

We would like you to give **an overall estimate** of the quality of life of your family.

To help you make an estimate we have drawn a scale (rather like a thermometer) on which the best quality of life you could imagine is marked by 100 at the top, and the worst quality of life you could imagine is marked by 0 at the bottom.

Please think about all the things which are important to you and your family in your everyday lives and then draw a line from the box marked "the quality of life of your family today" to whichever point on the scale you feel is right for your family.

The Quality of Life of your family today



Appendix 6

Strand 2 – screening questionnaire

Q1. Do you have any difficulty with your hearing? No/Yes

Q2. Do you find it very difficult to follow a conversation if there is background noise (such as TV, radio, children playing)? No/Yes

Q3. How well do you hear someone talking to you when that person is sitting on your <u>RIGHT SIDE</u> in a quiet room?

With no difficulty
With slight difficulty
With moderate difficulty
With great difficulty
Cannot hear at all

Q4. How well do you hear someone talking to you when that person is sitting on your <u>LEFT SIDE</u> in a quiet room?

With no difficulty
With slight difficulty
With moderate difficulty
With great difficulty
Cannot hear at all

Q5. Do you use a hearing aid nowadays? No/Yes

Appendix 7

Strand 2 – focus group report: 2-year follow-up

Acceptability, benefit and costs of early screening for hearing disability: focus group of patients

Introduction

A focus group of nine young elderly people (55–74 years of age), who had in the last 2 years been fitted with either one or two ITE hearing aid(s) following the completion of an early screening for hearing disability questionnaire at their GP's surgery, was held at the Ear Foundation, Nottingham. The purpose of the focus group was to seek the group's views and experiences of hearing loss, the early screening programme and the effectiveness of their new hearing aids.

Background

Purpose of the study

In the UK 1.9 million people aged 55–74 years would benefit greatly from a hearing aid. However, only one in five of these people actually uses a hearing aid. The average age of individuals who consult their GP with concerns about their hearing is 75 years and in many cases these hearing difficulties have been present for an average of 15–20 years. Research has shown that if hearing aids are fitted earlier, they provide each individual with more help with their hearing and the fewer problems they have later in life if hearing deteriorates even further. A screening questionnaire has been developed by the MRC IHR, Nottingham, that aims to identify which 55–74 year olds will benefit from early fitting of a hearing aid.

Questionnaires were distributed to general practices in the Nottingham area and patients were either asked or self-selected to fill in the questionnaire. Those who completed the questionnaire indicating possible problems with their hearing were asked to visit the IHRCS for some hearing tests.

Those identified with hearing loss were fitted with ITE hearing aids.

Current study

As well as the quantitative research that has been drawn together on the effectiveness of this intervention by the IHR, it was felt that this work could be supplemented and enriched by a qualitative study of a randomly selected focus group of patients who participated in the study. Fifty-three patients were randomly selected from the patient list and were written to. Forty-one patients had responded within a week of the invitation being sent, of whom 14 could attend. Many of those who declined did so due to other commitments but expressed an interest. Nine of the 14 patients were randomly selected to come to the Ear Foundation on 6 October 2004 and meet for 2 hours with an independent consultant to give their views about the research project and how they were getting on with their new hearing aid(s).

The focus group meeting followed the group's historical experience with hearing loss along the following lines:

- before contact with the audiological service and then the first contact
- the assessment, fitting and follow-up process
- how they had been with their aid(s) and how things were now
- what they thought of the idea of a hearing loss screen for all elderly people.

Executive summary

All patients in the focus group were supportive of the idea of an early screen for 55–74 year olds. They were enthusiastic about the service they had received and, in the main, were using their hearing aid(s) as a regular part of their lives.

The one major concern they expressed was the provision of an adequate after-care service for repairs and reassessments. Without this back-up service they felt that the screen would be less than fully effective, in terms of raising expectation of a new quality of life and then to be disappointed by the lack of continuity of care. In fairness, the provision of appropriate after-care was not a part of the early screening study, but would need to be addressed if the programme was implemented on a more widescale basis.

There is no doubt that this group of patients felt that their lives had been enriched by taking part

in the study and that they had been saved from many years of deafness and hard of hearing by this early intervention.

The detailed study

Before contact with the audiological service (patients, direct quotes)

"I had a test 15 years before which showed 50% loss in one ear and I knew there had been further deterioration because I was shouting on the phone."

"My friends kept mumbling!"

"I was aware of deterioration when listening to records; I knew the top end of my hearing was falling away."

"My television knob was getting further and further to the right!"

"You don't realise you are going deaf, you just think people are talking more softly."

"I refused to accept that I was going deaf, I didn't want a big aid on my ear – first your hair and then your ears!"

"It had never occurred to me – I thought it was wax, but the practice nurse said I had no wax. I thought she was wrong."

"I did not think it was as bad as it was."

"I knew it was going but I kept putting it off, but the wife kept going on at me, I was tired of saying 'sorry, what did you say?"

"People make a joke of it, so you don't like to admit it. You wouldn't treat a blind person the same."

First contact with the early detection of hearing loss questionnaire

Three of the group saw the questionnaire on the table in the waiting room at their GP's surgery; two received the questionnaire in the post from their surgery; the rest were asked by the receptionist to fill in the questionnaire. Their GP appointment was unrelated.

None had any reservations about filling in the questionnaire. They thought that it was straightforward and simple to complete. It was good to be offered the chance, they said; it might be a short cut, a good way of checking what the loss was.

The assessment, fitting and follow-up process

"Initially it was hard to take in, I didn't think I was deaf."

"It was a very good experience but even when I was being tested I felt a reluctance, found myself still trying to trick the system – guessing, hoping I got the right one."

"The noise tape was very interesting."

"Very professional, very supportive, treated you like a human being; didn't hurry you, left it open for you."

"They weren't pushy, said wear it for two weeks, see how it goes."

"Initially I was hearing things I had never heard before – tap running, water going down the drain, clock ticking, I didn't know there were so many everyday noises."

"The way you are treated really matters – I thought she fancied me!"

How has your hearing been since it was fitted? How has the aid worked?

Two of the group had been struggling with their aid(s). For one the left aid had packed up, it had been taken back for repair three times and now it did not work at all. This patient needed to take it back but hadn't got round to it. The other couldn't get the battery in or out. When this was checked she had put it in the wrong way. She said her daughter had been ill and this was rather more important than getting her aid sorted.

The rest of the group were generally getting along fine and were adamant that the aid(s) had greatly improved the quality of their lives.

They exchanged tips about how to get the best of different situations, for example, when going to a restaurant sit with a wall behind you to minimise the effect of conversations from behind.

There had been various problem situations. For example, if you hold the telephone too near, you get a big buzz. They shared ways of coping with the telephone; they talked of the need for good telephone technique! Several of the group went dancing regularly and they said that when dancing, if there are speakers only at one end, you tend to pick up the gossip close by rather than the music – there is a lot of unfocused chatter nearby. Also some said that their ear canal gets a bit sore. The ITE was creating too much moisture and they were getting through their wax busters very quickly. Again on windy days many of them had to take the aids out altogether because the sound of the wind was so bad.

However, they said that there were many new wonderful things in their lives: birds singing in the garden, for example. They talked of the mixed feelings about their first experiences with the new aid. On the one hand, the traffic noise as they left the Queen's Medical Centre was very scary. On the other, as many of them reached the park the sounds of the birds were wonderful; this was a very memorable experience.

Most of the group said that they would not like a BTE aid. They were concerned about what would happen if their ITE aid failed. Would they have to have a BTE? This was an issue of concern for many of them. When they were pressed later about the choice between BTE and no aid at all they all said, reluctantly, that they would choose a BTE rather than nothing.

Several of the group had been experiencing difficulties with reassessment. They felt that the after-service they were receiving from the local audiology service was poor. The repair service was OK but they felt that if the repair service did not correct any problems then you were on your own. One spoke of a 10–12-week wait becoming more like 10–12 months.

Patient responses to the idea of an early screening for hearing loss questionnaire for 55–74 year olds

The group were very supportive of an audiological screen for 55–74 year olds, as long as a comprehensive service could be provided. There was no point in building up expectations if the mainstream service could not deliver a good after-care service. They talked of the joy of hearing again only to be let down if there was no adequate back-up: it had to be a whole package.

Some of them had become real advocates for hearing. They spoke of the fact that things could only get worse for the population as a whole with so much loud music and sound around damaging young ears. There was the need for more hearing education. They spoke of the need for different attitudes in society to deafness. Deafness was often an area to be laughed at. Deaf people needed to be more assertive and needed training in assertiveness: 'I'm sorry, I do not hear very well, could you repeat that again and possibly speak a little more slowly'. People do not want to admit they are deaf and need permission to say that they cannot hear.

One of the group said that he praises his hearing aid to his friends; he has realised that many of them are hard of hearing and has become an advocate, a champion, explaining to friends and colleagues that many of them have a similar need and should do something about it.

They spoke of the raising of the age for retirement. If working to 70 was in any way to be a reality then there needed to be considerable investment to keep people in employment, and loss of hearing was one of the most important areas here. They returned to the theme of a sufficiently comprehensive service to meet this demand.

They universally said that their lives had improved with the new aid(s). They had not realised how badly they often felt in social and public situations, where they felt real pressure because they could not hear. It was very stressful to go out. Now they felt much more confident to converse with a number of people in a range of settings; the embarrassment factor had been taken away.

The group shared that many of them now feel that they can hear better than most other people. One spoke of a rattle in his car that nobody else could hear but when the mechanic checked there was something wrong! Although the new aid was not a replacement for young ears it was still a massive advantage.

Martin Evans
Independent Consultant
13 October 2004

Appendix 8

NSC criteria addressed

All of the following criteria should be met before screening for a condition is initiated: where evidence is cited it is part of the current report unless explicitly referenced.

The condition

1. The condition should be an important health problem

One in five of the adult UK population has a bilateral hearing impairment (25+ dB HL) which affects their hearing and communication. The condition is mainly associated with older adults:

- 30% aged 55–74 years have bilateral hearing impairment
- 14% of this age group have impairment of at least 35 dB HL, of whom only 3% have effective amplification through the use of hearing aids.

The impact of this degree of hearing impairment and reduced ability to communicate is substantial. There is a reduction in quality of life (depending on the quality of life instrument used to measure this):

- 4% of people aged 55-74 years are severely worried or upset about difficulties they have with hearing
- another 8% are moderately worried or upset
- 8% of people over 75 years are severely worried or upset and have considerable difficulty using hearing aids for the first time.

Communication difficulties associated with hearing impairment cross the whole health and social care spectrum. They can lead to depression, social withdrawal, problems with employment, and access to IT and information sources.

People with hearing impairment are highly likely to have other problems (40% co-morbidity), such as tinnitus and balance disorders, which contribute in part as risk factors for falls and other accidental injury. Imbalance and falls in older people are frequent causes of loss of independence, avoidable illness and mortality.

2. The epidemiology and natural history of the condition, including development from latent to declared disease, should be adequately understood and there should be a detectable risk factor or disease marker, and a latent period or early symptomatic stage

The epidemiology of hearing impairment is well understood. There are two major risk factors:

- age
- noise exposure,

which are additive in terms of overall population impact. There is high co-morbidity with other age-related diseases. Hearing loss is often associated with other systemic problems such as diabetes, and can be a by-product of treatments for cancer.

The prevalence of hearing impairment in the over-50s increases rapidly with age. One in two people aged over 80 has a substantial hearing impairment which greatly restricts communication and participation in activities where communication is important. Recent work[93] suggests that the onset of hearing problems is one of four factors that predicts major incident disability in the over 65-year-old population.

Cross-sectional and longitudinal studies show that hearing impairment is shown to progress from

- about 5 dB per decade of life at about 50 years of age

and increase with increasing age to

- about 7 dB per decade in 60–65 year olds.

Typically, it takes 10 years for an individual to recognise that they have a hearing problem (and a shorter time for significant others). Over the next 15 years hearing impairment will be an increasing population problem, because of the ageing population profile. It is likely to increase by 10–15% in population terms, without any shift in the prevalence of hearing impairment.

The degree of hearing impairment can be readily assessed and is a major factor that predicts ability

to benefit from hearing aids. It is proposed that a 'disease marker' of an impairment is used of 35 dB HL (averaged over 0.5, 1, 2 and 4 kHz) or over in the better hearing ear (prevalence 14%). About 11% of the 55–74-year-old age group have this level of impairment without receiving any intervention. This reduces to 4% at the age of 60 years.

3. All the cost-effective primary prevention interventions should have been implemented as far as practicable

The primary risk factors are age and noise exposure. Hearing protectors are now prescribed for noisy occupations. However, the damage for those aged 55–74 years has already been done, and there is nothing else to do to prevent the hearing loss. For future generations education and legislation are the main factors that will reduce the impact of avoidable deafness. Much of the heavy industry in the UK has ceased to operate and this has reduced the overall population exposure to loud noise. Social noise is now one of the major risks for hearing impairment and tinnitus in younger people.

The test

4. There should be a simple, safe, precise and validated screening test

A simple two-stage screening programme is suggested, using

- a systematic questionnaire (this could be self-assessment/postal)
- an audiometric screen using a pure tone at 3 kHz with an intensity of 35 dB HL tested separately in each ear.

This screening programme is simple and accessible to all. It is safe, and has a good sensitivity (80% or more) and a low false alarm rate (10% or below). The current study shows the clinical and scientific validity of such a systematic screen and its relationship to many other potential screens. A one-stage audiometric screen might be feasible in the near future.

Screens using other techniques, such as otoacoustic emissions and speech tests, have been shown scientifically to be

- less effective
- more complex
- less flexible

in identifying the target population. It is suggested that the screen is carried out initially at 60 years of age, with potential for screening in the future at 10-yearly intervals.

5. The distribution of test values in the target population should be known and a suitable cut-off level defined and agreed

The operating characteristics of the two-stage screening programme and its single components have been determined and are reported. The proposed screening programme gives the best d′ and gives approximately minimum costs for screening. A cut-off target level of 35 dB HL has been defined and demonstrated to be most cost-effective. Agreement by clinicians needs to be tested.

6. The test should be acceptable to the population

The interview schedule with a randomly selected representative population aged 55–74 years shows that

- 96% think that screening for hearing problems is a good idea
- 94–96% say that they would be prepared to go to the GP's surgery for a hearing test compared with 83% prepared to go to the hospital.

The clinical trial shows that the screening programme and its two tests are acceptable to the population, with a reasonably high degree of participation (>60% response rate to the postal questionnaire) in the controlled trial of different screen methods.

7. There should be an agreed policy on the further diagnostic investigation of individuals with a positive test result and on the choices available to those individuals

Individuals with a positive test result will be referred for a routine audiological assessment, similar in all respects to those referred to hearing aid centres by the GP Direct Referral scheme. This is a 45-minute assessment session with an agreed patient journey that offers the patients clear choices before, during and after assessment, in line with Modernised Hearing Aid Services (MHAS) protocols (agreed by the professional and scientific organisations, British Academy of Audiology and BSA) and in line with RNID quality standards.

The treatment

8. There should be an effective treatment or intervention for patients identified through early detection, with evidence of early treatment leading to better outcomes than late treatment

The effective intervention for hearing impairment of 35 dB HL or over in both ears is addressed through

- an appropriate assessment of hearing function
- in most cases, offering appropriate intervention which will include tailored amplification provided by
  - hearing aids
  - appropriate rehabilitation.

This approach will be more readily accepted by the younger, potential hearing aid users if they are provided with the smaller in-the-ear (ITE) hearing aids than the standard behind-the-ear (BTE) hearing aids currently on contract to the NHS. The ITE hearing aids provide very substantial improvements in hearing both in quiet and in noise. They give better hearing outcome scores than for equivalently hearing-impaired people with BTE hearing aids. So there is a better outcome, both at any given age and at any hearing level. In addition, there are substantial cumulative benefits for the years where no hearing aids would have been provided.

The rate of change in hearing impairment at 60–70 years of age is such that the increase in prevalence of the target group outweighs by 2:1 the change in provision of services. Therefore, the current services do not meet the incident needs (let alone the prevalent needs), primarily owing to lack of identification and referral to hearing services. The benefit in quality of life measured by HUI (version 3) is substantial from 3 months following the outset of rehabilitation.

Screening can identify people currently not using hearing aids who would benefit. Following screening, not everyone who is suitable will accept the offer of a hearing aid, although this number would be expected to increase with improved design. Uptake of aids after screening in this study was 36%. There is a need for improved support for those who accept a hearing aid to ensure that aids are used effectively, and that the user is supported in the learning and adaptation period, to increase the number who experience significant benefit from the use of an aid (36% of those identified following screening and fitted with an aid reported significant benefit).

9. There should be agreed evidence-based policies covering which individuals should be offered treatment and the appropriate treatment to be offered

There is agreement that those who are in the target group identified by audiological assessment should be offered rehabilitation that will include

- amplification through hearing aids
- other devices, e.g. assistive listening devices, usually provided by social services.

Evidence from this study and others (e.g. MHAS) shows that this intervention provides measurable, substantial benefits for the target population, as well as for those who are assessed and found to have other clinical needs that can be addressed through amplification (e.g. tinnitus).

10. Clinical management of the condition and patient outcomes should be optimised by all healthcare providers prior to participation in a screening programme

The MHAS programme in England and equivalent work in Wales, Scotland and Northern Ireland has agreed a national patient journey for all types of referral. This has provided an optimised approach which, together with the quality standards being introduced by the profession, should ensure a high quality of service. The capacity gap is a major issue that is being resolved by a number of initiatives.

The screening programme

11. There must be evidence from high-quality randomised controlled trials that the screening programme is effective in reducing mortality or morbidity

Where screening is aimed solely at providing information to allow the person being screened to make an 'informed choice' (e.g. Down's syndrome, cystic fibrosis carrier screening), there must be evidence from high-quality trials that the test accurately measures risk. The information that is provided about the test and its outcome must be of value and readily understood by the individual being screened. The work undertaken for the HTA programme addressed these issues in three ways.

Population study

In the first instance, individuals were selected randomly in two cities for screening and assessment. It was shown that there was much untreated disability in the population aged 55–74 years. This was (greatly) reduced by screening and early intervention (average age of people undergoing intervention was 65 years of age, compared with 74 years of age for new NHS hearing aid referrals). This suggests that 9 additional years of better hearing and quality of life can be secured by the screening programme.

It is not clear when or whether those identified by the screen would, without the screen, actually seek and find an appropriate intervention. Therefore, any screening programme should aim to identify earlier rather than later and to identify more impaired people as a priority rather than less impaired people, as the former are more prepared to use their hearing aids.

Clinical effectiveness trial

Secondly, a controlled trial was conducted of two different approaches to screening (opportunistic case finding versus systematic screening). Within this, information was collected on single- and two-stage screening programmes and associated tests. People were offered a wide range of interventions that were randomly assigned so that compliance and benefits could be examined. Those identified by the proposed screening programme showed measurable benefits in terms of their hearing and quality of life, and those in the target group showed greater benefits. Again, the average age of intervention was about 65 years, and the distribution of hearing loss for those in the proposed target group was similar to that of new hearing aid candidates.

Retrospective case control–study

Thirdly, a high-quality case–control study was conducted that compared a group of early-identified hearing aid users in Cardiff 10 years ago, with controls matched for age, gender and occupation in Cardiff, Glasgow and Manchester.

There was additional benefit for those identified earlier. A long-term, e.g. 10 years in duration, randomised control trial would be needed to assess the incident services that those in the target group might receive without screening. However, it is clear from the cross-sectional data (and a 20-year longitudinal study by this group; unpublished data) that most of these people, especially those aged around 60 years, will not receive any services unless screened. For those that do receive services, it is more likely that those services will be received when they are in their seventies.

12. There should be evidence that the complete screening programme (test, diagnostic procedures, treatment/intervention) is clinically, socially and ethically acceptable to health professionals and the public

The complete screening programme is acceptable to the public and is clinically, socially and ethically acceptable. As part of the HTA Programme a wide range of stakeholders has been consulted about the research and screening programme. There has been uniformly general acceptance of the need for the programme and about what should happen thereafter. However, restricting screening to a target group and the age at which the screen might be introduced were not specifically discussed with all stakeholders.

13. The benefit from the screening programme should outweigh the physical and psychological harm (caused by the test, diagnostic procedures and treatment)

There are real benefits from intervention, discussed above. There are no known physical or psychological harms associated with the screen and intervention, apart from any stigma associated with wearing hearing aids. Stigma can be minimised, through counselling and using small hearing aids, where financially justifiable. In the long run, as screening becomes more commonly accepted in this age group and as aids are seen as more 'high tech', it should help to minimise the stigma associated with the thought of 'not wanting to be seen to be old' by wearing a hearing aid. Some people may feel nervous about a visit to the GP to have a hearing screen test (7%), but this is likely to be true of other tests and screens.

14. The opportunity cost of the screening programme (including testing, diagnosis, treatment, administration, training and quality assurance) should be economically balanced in relation to expenditure on medical care as a whole (i.e. value for money)

The cost-effectiveness analysis carried out within this study is exploratory and further work will be required on this aspect of the study. At this stage, the results of the analysis provide a good indicator that the proposed screening programme makes good economic sense in relation to a service

costing £100–120 million per year. In terms of value for money, the screening programme will cost in the region of £1000 per QALY gained for 9 years' incremental intervention (compared with no intervention) using the HUI3 or £6000 using the SF-6D.

15. There must be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards

The management and monitoring of the screening programme and quality assurance would be the next steps in service development. The screening programme could be managed locally through the patient management systems used by audiology in consultation with the NPfIT (National Programme for IT) programme. Synergy with other screening programmes and registers (e.g. the colon screening and diabetic screening programmes) would be explored.

16. Adequate staffing and facilities for testing, diagnosis, treatment and programme management should be made available prior to the commencement of the screening programme

As part of the MHAS programme in England all hearing aid departments have been trained, and a similar effort has been undertaken in Wales and Northern Ireland, with Scotland investing in infrastructure. So, good facilities exist for testing, diagnosis and intervention, including IT systems where appropriate. The authors are talking with Professor Sue Hill and the workforce review team about the staffing of hearing aid centres, which is of concern regarding the target waiting time of 18 weeks for treatment by 2008. Skill mix, telemedicine and private sector initiatives have been implemented to begin to meet the staffing gap. It would be expected and has been discussed that screening (and assessment) may be one pressure that can be applied to meet need in the population, and that this will be one part of the system that can be looked at in a similar light.

17. All other options for managing the condition should have been considered (e.g. improving treatment, providing other services), to ensure that no more cost-effective intervention could be introduced or current interventions increased within the resources available

Most other options have been explored to enable more people to have their hearing assessed and to use hearing aids. The advantage of systematic screening is that it can be targeted at those who really can benefit substantially. Other methods may lead to a huge demand that the system cannot justifiably meet and which would not deliver enough measurable benefit to sufficient numbers.

18. Evidence-based information, explaining the consequences of testing, investigation and treatment, should be made available to potential participants to assist them in making an informed choice

The RNID and other representative organisations have information developed for MHAS that explains the hearing assessment, the typical patient journey and the choices that are available in terms of amplification and rehabilitation.

Public pressure for widening the eligibility criteria for reducing the screening interval, and for increasing the sensitivity of the testing process, should be anticipated. Decisions about these parameters should be scientifically justifiable to the public.

Appendix 9

Outcome criterion: the screen performance for each of the possible single-stage screens and two-stage screens

Tables 54–64 show for each outcome criterion the screen performance for each of the possible single-stage screens and two-stage screens. The parameters shown in the tables are: sensitivity of the screen (sen), false alarm rate (fa), d′ (dprime), the estimated criterion used (crit), the overall average cost including treatment over 10 years (cost.avg), the slope of the ROC curve at which the costs are minimised (cost.slope), the cost of the screening component alone (cost.sc.avg) and the slope of the ROC curve at which the screening costs are minimised (cost.sc.slope).

TABLE 54

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 30+ dB HL		crLW4K45	1	0.597	0.092	1.573	0.540	117.727	0.100	12.911	2.574
Better ear 30+ dB HL		crLW4K40	1	0.629	0.144	1.389	0.366	124.375	0.100	14.079	2.574
Better ear 30+ dB HL		crLW4K35	1	0.843	0.179	1.926	–0.044	164.128	0.100	16.226	2.574
Better ear 30+ dB HL		crLW3K40	1	0.569	0.064	1.699	0.675	112.017	0.100	12.186	2.574
Better ear 30+ dB HL		crLW3K35	1	0.628	0.103	1.591	0.468	123.546	0.100	13.325	2.574
Better ear 30+ dB HL		crLW3K30	1	0.788	0.159	1.798	0.100	153.657	0.100	15.466	2.574
Better ear 30+ dB HL		crLS4K45	1	0.618	0.129	1.432	0.415	122.173	0.100	13.723	2.574
Better ear 30+ dB HL		crLS4K40	1	0.678	0.166	1.433	0.255	133.715	0.100	14.813	2.574
Better ear 30+ dB HL		crLS4K35	1	0.781	0.179	1.693	0.071	152.806	0.100	15.795	2.574
Better ear 30+ dB HL		crLS3K40	1	0.611	0.066	1.784	0.611	119.649	0.100	12.530	2.574
Better ear 30+ dB HL		crLS3K35	1	0.664	0.084	1.799	0.477	129.654	0.100	13.232	2.574
Better ear 30+ dB HL		crLS3K30	1	0.875	0.150	2.188	–0.059	169.520	0.100	15.932	2.574
Better ear 30+ dB HL		cwarble	1	0.573	0.065	1.700	0.666	112.771	0.100	12.234	2.574
Better ear 30+ dB HL		csteady	1	0.608	0.062	1.813	0.632	119.170	0.100	12.434	2.574
Better ear 30+ dB HL		cscr3540	1	0.587	0.052	1.843	0.702	115.019	0.100	12.102	2.574
Better ear 30+ dB HL	q1		0	0.852	0.401	1.298	–0.398	168.314	0.087	18.755	2.238
Better ear 30+ dB HL	q2		0	0.797	0.367	1.173	–0.246	157.733	0.087	17.826	2.238
Better ear 30+ dB HL	q3q4		0	0.756	0.274	1.294	–0.047	148.724	0.087	16.070	2.238
Better ear 30+ dB HL	2q3q4		0	0.453	0.067	1.383	0.809	90.163	0.087	10.640	2.238
Better ear 30+ dB HL	maxq34		0	0.756	0.276	1.290	–0.049	148.744	0.087	16.091	2.238
Better ear 30+ dB HL	2maxq34		0	0.474	0.097	1.232	0.680	94.492	0.087	11.275	2.238
Better ear 30+ dB HL	hear		0	0.749	0.260	1.316	–0.014	147.213	0.087	15.791	2.238
Better ear 30+ dB HL	2hear		0	0.453	0.062	1.423	0.829	90.084	0.087	10.560	2.238
Better ear 30+ dB HL	q12		0	0.797	0.350	1.217	–0.224	157.473	0.087	17.566	2.238
Better ear 30+ dB HL	q1or2		0	0.852	0.417	1.256	–0.419	168.574	0.087	19.015	2.238
Better ear 30+ dB HL	q1	crLW4K45	2	0.578	0.084	1.574	0.589	114.933	0.113	13.456	2.910
Better ear 30+ dB HL	q2	crLW4K45	2	0.551	0.083	1.515	0.630	109.876	0.113	13.225	2.910
Better ear 30+ dB HL	q3	crLW4K45	2	0.509	0.068	1.512	0.733	101.997	0.113	12.635	2.910
Better ear 30+ dB HL	2q3	crLW4K45	2	0.296	0.018	1.563	1.317	62.049	0.113	10.090	2.910
Better ear 30+ dB HL	max3	crLW4K45	2	0.509	0.068	1.513	0.733	101.994	0.113	12.632	2.910
Better ear 30+ dB HL	2max3	crLW4K45	2	0.310	0.025	1.464	1.227	64.756	0.113	10.335	2.910
Better ear 30+ dB HL	h	crLW4K45	2	0.509	0.068	1.512	0.733	101.997	0.113	12.635	2.910
Better ear 30+ dB HL	h2	crLW4K45	2	0.296	0.018	1.563	1.317	62.049	0.113	10.090	2.910
Better ear 30+ dB HL	q12	crLW4K45	2	0.551	0.083	1.515	0.630	109.876	0.113	13.225	2.910
Better ear 30+ dB HL	q1o2	crLW4K45	2	0.578	0.084	1.574	0.589	114.933	0.113	13.456	2.910
Better ear 30+ dB HL	q1	crLW4K40	2	0.610	0.113	1.489	0.466	121.197	0.113	14.263	2.910
Better ear 30+ dB HL	q2	crLW4K40	2	0.582	0.111	1.426	0.506	116.108	0.113	14.035	2.910

continued

TABLE 54 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 30+ dB HL	q3	crLW4K40	2	0.540	0.092	1.432	0.616	108.062	0.113	13.329	2.910
Better ear 30+ dB HL	2q3	crLW4K40	2	0.319	0.025	1.486	1.215	66.282	0.113	10.396	2.910
Better ear 30+ dB HL	max3	crLW4K40	2	0.540	0.091	1.433	0.616	108.059	0.113	13.326	2.910
Better ear 30+ dB HL	2max3	crLW4K40	2	0.333	0.036	1.369	1.117	69.081	0.113	10.715	2.910
Better ear 30+ dB HL	h	crLW4K40	2	0.540	0.092	1.432	0.616	108.062	0.113	13.329	2.910
Better ear 30+ dB HL	h2	crLW4K40	2	0.319	0.025	1.486	1.215	66.282	0.113	10.396	2.910
Better ear 30+ dB HL	q12	crLW4K40	2	0.582	0.108	1.445	0.516	116.032	0.113	13.959	2.910
Better ear 30+ dB HL	q1o2	crLW4K40	2	0.610	0.117	1.470	0.457	121.273	0.113	14.339	2.910
Better ear 30+ dB HL	q1	crLW4K35	2	0.748	0.133	1.781	0.222	146.880	0.113	15.652	2.910
Better ear 30+ dB HL	q2	crLW4K35	2	0.700	0.133	1.635	0.294	138.063	0.113	15.315	2.910
Better ear 30+ dB HL	q3	crLW4K35	2	0.651	0.111	1.607	0.416	128.727	0.113	14.524	2.910
Better ear 30+ dB HL	2q3	crLW4K35	2	0.381	0.027	1.623	1.116	77.649	0.113	10.873	2.910
Better ear 30+ dB HL	max3	crLW4K35	2	0.651	0.111	1.608	0.416	128.723	0.113	14.520	2.910
Better ear 30+ dB HL	2max3	crLW4K35	2	0.402	0.039	1.508	1.003	81.776	0.113	11.280	2.910
Better ear 30+ dB HL	h	crLW4K35	2	0.651	0.111	1.607	0.416	128.727	0.113	14.524	2.910
Better ear 30+ dB HL	h2	crLW4K35	2	0.381	0.027	1.623	1.116	77.649	0.113	10.873	2.910
Better ear 30+ dB HL	q12	crLW4K35	2	0.700	0.128	1.661	0.307	137.949	0.113	15.201	2.910
Better ear 30+ dB HL	q1o2	crLW4K35	2	0.748	0.138	1.756	0.210	146.994	0.113	15.766	2.910
Better ear 30+ dB HL	q1	crLW3K40	2	0.550	0.054	1.734	0.741	109.117	0.113	12.625	2.910
Better ear 30+ dB HL	q2	crLW3K40	2	0.509	0.054	1.630	0.792	101.639	0.113	12.337	2.910
Better ear 30+ dB HL	q3	crLW3K40	2	0.501	0.047	1.681	0.837	100.106	0.113	12.135	2.910
Better ear 30+ dB HL	2q3	crLW3K40	2	0.302	0.022	1.505	1.271	63.238	0.113	10.206	2.910
Better ear 30+ dB HL	max3	crLW3K40	2	0.501	0.047	1.682	0.837	100.105	0.113	12.133	2.910
Better ear 30+ dB HL	2max3	crLW3K40	2	0.316	0.025	1.479	1.218	65.875	0.113	10.381	2.910
Better ear 30+ dB HL	h	crLW3K40	2	0.501	0.047	1.681	0.837	100.106	0.113	12.135	2.910
Better ear 30+ dB HL	h2	crLW3K40	2	0.302	0.022	1.505	1.271	63.238	0.113	10.206	2.910
Better ear 30+ dB HL	q12	crLW3K40	2	0.509	0.052	1.647	0.801	101.601	0.113	12.299	2.910
Better ear 30+ dB HL	q1o2	crLW3K40	2	0.550	0.056	1.717	0.733	109.155	0.113	12.663	2.910
Better ear 30+ dB HL	q1	crLW3K35	2	0.609	0.074	1.727	0.586	120.308	0.113	13.449	2.910
Better ear 30+ dB HL	q2	crLW3K35	2	0.561	0.074	1.602	0.648	111.488	0.113	13.109	2.910
Better ear 30+ dB HL	q3	crLW3K35	2	0.560	0.059	1.712	0.705	111.088	0.113	12.809	2.910
Better ear 30+ dB HL	2q3	crLW3K35	2	0.332	0.020	1.626	1.248	68.609	0.113	10.378	2.910
Better ear 30+ dB HL	max3	crLW3K35	2	0.560	0.059	1.713	0.705	111.085	0.113	12.807	2.910
Better ear 30+ dB HL	2max3	crLW3K35	2	0.346	0.025	1.561	1.177	71.302	0.113	10.591	2.910
Better ear 30+ dB HL	h	crLW3K35	2	0.560	0.059	1.712	0.705	111.088	0.113	12.809	2.910
Better ear 30+ dB HL	h2	crLW3K35	2	0.332	0.020	1.626	1.248	68.609	0.113	10.378	2.910
Better ear 30+ dB HL	q12	crLW3K35	2	0.561	0.072	1.615	0.655	111.450	0.113	13.071	2.910

continued

TABLE 54 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 30+ dB HL	q1o2	crLW3K35	2	0.609	0.075	1.713	0.580	120.346	0.113	13.487	2.910
Better ear 30+ dB HL	q1	crLW3K30	2	0.693	0.110	1.732	0.363	136.298	0.113	14.780	2.910
Better ear 30+ dB HL	q2	crLW3K30	2	0.644	0.110	1.599	0.429	127.478	0.113	14.440	2.910
Better ear 30+ dB HL	q3	crLW3K30	2	0.623	0.095	1.625	0.499	123.305	0.113	13.987	2.910
Better ear 30+ dB HL	2q3	crLW3K30	2	0.346	0.027	1.538	1.165	71.330	0.113	10.619	2.910
Better ear 30+ dB HL	max3	crLW3K30	2	0.623	0.095	1.626	0.499	123.301	0.113	13.984	2.910
Better ear 30+ dB HL	2max3	crLW3K30	2	0.367	0.037	1.443	1.061	75.423	0.113	10.992	2.910
Better ear 30+ dB HL	h	crLW3K30	2	0.623	0.093	1.635	0.504	123.269	0.113	13.951	2.910
Better ear 30+ dB HL	h2	crLW3K30	2	0.346	0.022	1.627	1.210	71.227	0.113	10.516	2.910
Better ear 30+ dB HL	q12	crLW3K30	2	0.644	0.106	1.618	0.439	127.404	0.113	14.366	2.910
Better ear 30+ dB HL	q1o2	crLW3K30	2	0.693	0.113	1.713	0.353	136.373	0.113	14.854	2.910
Better ear 30+ dB HL	q1	crLS4K45	2	0.599	0.085	1.626	0.562	118.715	0.113	13.604	2.910
Better ear 30+ dB HL	q2	crLS4K45	2	0.572	0.083	1.566	0.603	113.661	0.113	13.377	2.910
Better ear 30+ dB HL	q3	crLS4K45	2	0.530	0.068	1.564	0.706	105.778	0.113	12.782	2.910
Better ear 30+ dB HL	2q3	crLS4K45	2	0.303	0.022	1.505	1.269	63.343	0.113	10.213	2.910
Better ear 30+ dB HL	max3	crLS4K45	2	0.530	0.068	1.564	0.707	105.776	0.113	12.780	2.910
Better ear 30+ dB HL	2max3	crLS4K45	2	0.324	0.029	1.443	1.178	67.332	0.113	10.508	2.910
Better ear 30+ dB HL	h	crLS4K45	2	0.530	0.068	1.564	0.706	105.778	0.113	12.782	2.910
Better ear 30+ dB HL	h2	crLS4K45	2	0.303	0.022	1.505	1.269	63.343	0.113	10.213	2.910
Better ear 30+ dB HL	q12	crLS4K45	2	0.572	0.079	1.591	0.615	113.585	0.113	13.301	2.910
Better ear 30+ dB HL	q1o2	crLS4K45	2	0.599	0.088	1.603	0.550	118.791	0.113	13.680	2.910
Better ear 30+ dB HL	q1	crLS4K40	2	0.659	0.113	1.618	0.400	130.155	0.113	14.616	2.910
Better ear 30+ dB HL	q2	crLS4K40	2	0.631	0.110	1.561	0.446	125.030	0.113	14.351	2.910
Better ear 30+ dB HL	q3	crLS4K40	2	0.589	0.097	1.523	0.537	117.130	0.113	13.792	2.910
Better ear 30+ dB HL	2q3	crLS4K40	2	0.346	0.025	1.561	1.177	71.302	0.113	10.591	2.910
Better ear 30+ dB HL	max3	crLS4K40	2	0.589	0.097	1.524	0.537	117.127	0.113	13.789	2.910
Better ear 30+ dB HL	2max3	crLS4K40	2	0.367	0.038	1.438	1.058	75.432	0.113	11.001	2.910
Better ear 30+ dB HL	h	crLS4K40	2	0.589	0.097	1.523	0.537	117.130	0.113	13.792	2.910
Better ear 30+ dB HL	h2	crLS4K40	2	0.346	0.025	1.561	1.177	71.302	0.113	10.591	2.910
Better ear 30+ dB HL	q12	crLS4K40	2	0.631	0.106	1.581	0.456	124.954	0.113	14.275	2.910
Better ear 30+ dB HL	q1o2	crLS4K40	2	0.659	0.117	1.599	0.391	130.231	0.113	14.692	2.910
Better ear 30+ dB HL	q1	crLS4K35	2	0.762	0.140	1.792	0.184	149.547	0.113	15.899	2.910
Better ear 30+ dB HL	q2	crLS4K35	2	0.713	0.139	1.650	0.262	140.694	0.113	15.527	2.910
Better ear 30+ dB HL	q3	crLS4K35	2	0.665	0.119	1.607	0.378	131.394	0.113	14.772	2.910
Better ear 30+ dB HL	2q3	crLS4K35	2	0.381	0.025	1.654	1.131	77.611	0.113	10.835	2.910
Better ear 30+ dB HL	max3	crLS4K35	2	0.665	0.118	1.608	0.379	131.390	0.113	14.767	2.910
Better ear 30+ dB HL	2max3	crLS4K35	2	0.402	0.040	1.507	1.002	81.778	0.113	11.282	2.910

continued

TABLE 54 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 30+ dB HL	h	crLS4K35	2	0.665	0.119	1.607	0.378	131.394	0.113	14.772	2.910
Better ear 30+ dB HL	h2	crLS4K35	2	0.381	0.025	1.654	1.131	77.611	0.113	10.835	2.910
Better ear 30+ dB HL	q12	crLS4K35	2	0.713	0.133	1.675	0.274	140.580	0.113	15.413	2.910
Better ear 30+ dB HL	q1o2	crLS4K35	2	0.762	0.146	1.767	0.172	149.661	0.113	16.013	2.910
Better ear 30+ dB HL	q1	crLS3K40	2	0.592	0.049	1.890	0.713	116.592	0.113	12.811	2.910
Better ear 30+ dB HL	q2	crLS3K40	2	0.551	0.049	1.785	0.765	109.114	0.113	12.523	2.910
Better ear 30+ dB HL	q3	crLS3K40	2	0.543	0.041	1.842	0.813	107.580	0.113	12.320	2.910
Better ear 30+ dB HL	2q3	crLS3K40	2	0.323	0.018	1.640	1.278	67.007	0.113	10.282	2.910
Better ear 30+ dB HL	max3	crLS3K40	2	0.543	0.041	1.843	0.814	107.579	0.113	12.318	2.910
Better ear 30+ dB HL	2max3	crLS3K40	2	0.337	0.022	1.602	1.221	69.644	0.113	10.456	2.910
Better ear 30+ dB HL	h	crLS3K40	2	0.543	0.041	1.842	0.813	107.580	0.113	12.320	2.910
Better ear 30+ dB HL	h2	crLS3K40	2	0.323	0.018	1.640	1.278	67.007	0.113	10.282	2.910
Better ear 30+ dB HL	q12	crLS3K40	2	0.551	0.047	1.803	0.775	109.076	0.113	12.485	2.910
Better ear 30+ dB HL	q1o2	crLS3K40	2	0.592	0.050	1.872	0.704	116.630	0.113	12.849	2.910
Better ear 30+ dB HL	q1	crLS3K35	2	0.644	0.067	1.872	0.566	126.614	0.113	13.555	2.910
Better ear 30+ dB HL	q2	crLS3K35	2	0.596	0.067	1.744	0.629	117.793	0.113	13.215	2.910
Better ear 30+ dB HL	q3	crLS3K35	2	0.596	0.052	1.865	0.691	117.393	0.113	12.914	2.910
Better ear 30+ dB HL	2q3	crLS3K35	2	0.346	0.023	1.594	1.193	71.264	0.113	10.553	2.910
Better ear 30+ dB HL	max3	crLS3K35	2	0.596	0.052	1.866	0.691	117.391	0.113	12.912	2.910
Better ear 30+ dB HL	2max3	crLS3K35	2	0.367	0.029	1.559	1.119	75.247	0.113	10.816	2.910
Better ear 30+ dB HL	h	crLS3K35	2	0.596	0.052	1.865	0.691	117.393	0.113	12.914	2.910
Better ear 30+ dB HL	h2	crLS3K35	2	0.346	0.023	1.594	1.193	71.264	0.113	10.553	2.910
Better ear 30+ dB HL	q12	crLS3K35	2	0.596	0.065	1.759	0.636	117.755	0.113	13.177	2.910
Better ear 30+ dB HL	q1o2	crLS3K35	2	0.644	0.068	1.858	0.559	126.652	0.113	13.593	2.910
Better ear 30+ dB HL	q1	crLS3K30	2	0.727	0.106	1.851	0.322	142.473	0.113	14.950	2.910
Better ear 30+ dB HL	q2	crLS3K30	2	0.679	0.103	1.731	0.402	133.579	0.113	14.538	2.910
Better ear 30+ dB HL	q3	crLS3K30	2	0.657	0.093	1.727	0.458	129.514	0.113	14.192	2.910
Better ear 30+ dB HL	2q3	crLS3K30	2	0.380	0.030	1.574	1.092	77.651	0.113	10.936	2.910
Better ear 30+ dB HL	max3	crLS3K30	2	0.657	0.093	1.728	0.459	129.510	0.113	14.188	2.910
Better ear 30+ dB HL	2max3	crLS3K30	2	0.401	0.041	1.490	0.995	81.744	0.113	11.309	2.910
Better ear 30+ dB HL	h	crLS3K30	2	0.657	0.091	1.738	0.464	129.477	0.113	14.156	2.910
Better ear 30+ dB HL	h2	crLS3K30	2	0.380	0.025	1.653	1.131	77.548	0.113	10.832	2.910
Better ear 30+ dB HL	q12	crLS3K30	2	0.679	0.099	1.751	0.412	133.505	0.113	14.464	2.910
Better ear 30+ dB HL	q1o2	crLS3K30	2	0.727	0.110	1.832	0.313	142.547	0.113	15.024	2.910
Better ear 30+ dB HL	q	cwarble	2	0.554	0.065	1.652	0.690	110.051	0.113	12.877	2.910
Better ear 30+ dB HL	q	cwarble	2	0.526	0.063	1.596	0.732	104.958	0.113	12.645	2.910
Better ear 30+ dB HL	q	cwarble	2	0.505	0.050	1.653	0.814	100.829	0.113	12.235	2.910

continued

TABLE 54 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 30+ dB HL	2q	cwarble	2	0.297	0.020	1.528	1.296	62.300	0.113	10.134	2.910
Better ear 30+ dB HL	max	cwarble	2	0.505	0.050	1.654	0.815	100.827	0.113	12.234	2.910
Better ear 30+ dB HL	2max	cwarble	2	0.311	0.023	1.497	1.240	64.956	0.113	10.310	2.910
Better ear 30+ dB HL	h	cwarble	2	0.505	0.050	1.653	0.814	100.829	0.113	12.235	2.910
Better ear 30+ dB HL	h	cwarble	2	0.297	0.020	1.528	1.296	62.300	0.113	10.134	2.910
Better ear 30+ dB HL	q1	cwarble	2	0.526	0.063	1.596	0.732	104.958	0.113	12.645	2.910
Better ear 30+ dB HL	q1o	cwarble	2	0.554	0.065	1.652	0.690	110.051	0.113	12.877	2.910
Better ear 30+ dB HL	q	csteady	2	0.589	0.052	1.850	0.699	116.241	0.113	12.868	2.910
Better ear 30+ dB HL	q	csteady	2	0.562	0.052	1.778	0.734	111.187	0.113	12.674	2.910
Better ear 30+ dB HL	q	csteady	2	0.540	0.038	1.878	0.838	107.019	0.113	12.226	2.910
Better ear 30+ dB HL	2q	csteady	2	0.319	0.020	1.588	1.266	66.170	0.113	10.284	2.910
Better ear 30+ dB HL	max	csteady	2	0.540	0.038	1.879	0.838	107.018	0.113	12.224	2.910
Better ear 30+ dB HL	2max	csteady	2	0.340	0.023	1.576	1.201	70.116	0.113	10.510	2.910
Better ear 30+ dB HL	h	csteady	2	0.540	0.038	1.878	0.838	107.019	0.113	12.226	2.910
Better ear 30+ dB HL	h	csteady	2	0.319	0.020	1.588	1.266	66.170	0.113	10.284	2.910
Better ear 30+ dB HL	q1	csteady	2	0.562	0.050	1.796	0.743	111.149	0.113	12.635	2.910
Better ear 30+ dB HL	q1o	csteady	2	0.589	0.054	1.833	0.691	116.279	0.113	12.906	2.910
Better ear 30+ dB HL	q1	cscr3540	2	0.567	0.050	1.811	0.736	112.231	0.113	12.677	2.910
Better ear 30+ dB HL	q2	cscr3540	2	0.526	0.050	1.706	0.787	104.700	0.113	12.387	2.910
Better ear 30+ dB HL	q3	cscr3540	2	0.519	0.043	1.761	0.834	103.157	0.113	12.183	2.910
Better ear 30+ dB HL	2q3	cscr3540	2	0.297	0.020	1.528	1.296	62.300	0.113	10.134	2.910
Better ear 30+ dB HL	max3	cscr3540	2	0.519	0.043	1.762	0.834	103.156	0.113	12.182	2.910
Better ear 30+ dB HL	2max3	cscr3540	2	0.311	0.023	1.497	1.240	64.956	0.113	10.310	2.910
Better ear 30+ dB HL	h	cscr3540	2	0.519	0.043	1.761	0.834	103.157	0.113	12.183	2.910
Better ear 30+ dB HL	h2	cscr3540	2	0.297	0.020	1.528	1.296	62.300	0.113	10.134	2.910
Better ear 30+ dB HL	q12	cscr3540	2	0.526	0.049	1.724	0.796	104.662	0.113	12.348	2.910
Better ear 30+ dB HL	q1o2	cscr3540	2	0.567	0.052	1.794	0.727	112.269	0.113	12.715	2.910

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 55

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 35+ dB HL		crLW4K45	1	0.796	0.112	2.046	0.195	96.859	0.183	12.643	4.716
Better ear 35+ dB HL		crLW4K40	1	0.805	0.165	1.833	0.057	98.904	0.183	13.756	4.716
Better ear 35+ dB HL		crLW4K35	1	0.885	0.236	1.922	–0.241	109.152	0.183	15.520	4.716
Better ear 35+ dB HL		crLW3K40	1	0.738	0.087	1.996	0.360	89.962	0.183	11.902	4.716
Better ear 35+ dB HL		crLW3K35	1	0.839	0.123	2.150	0.085	101.761	0.183	13.051	4.716
Better ear 35+ dB HL		crLW3K30	1	0.897	0.203	2.097	–0.217	109.783	0.183	14.905	4.716
Better ear 35+ dB HL		crLS4K45	1	0.796	0.150	1.866	0.105	97.624	0.183	13.408	4.716
Better ear 35+ dB HL		crLS4K40	1	0.806	0.196	1.718	–0.003	99.587	0.183	14.379	4.716
Better ear 35+ dB HL		crLS4K35	1	0.897	0.220	2.038	–0.246	110.127	0.183	15.249	4.716
Better ear 35+ dB HL		crLS3K40	1	0.807	0.090	2.210	0.238	97.595	0.183	12.246	4.716
Better ear 35+ dB HL		crLS3K35	1	0.874	0.109	2.376	0.042	105.375	0.183	12.927	4.716
Better ear 35+ dB HL		crLS3K30	1	0.897	0.216	2.052	–0.239	110.045	0.183	15.167	4.716
Better ear 35+ dB HL		cwarble	1	0.747	0.088	2.016	0.344	90.939	0.183	11.960	4.716
Better ear 35+ dB HL		csteady	1	0.794	0.087	2.177	0.269	96.106	0.183	12.144	4.716
Better ear 35+ dB HL		cscr3540	1	0.769	0.077	2.163	0.345	93.199	0.183	11.828	4.716
Better ear 35+ dB HL		cq1	0	0.968	0.427	2.043	–0.837	120.639	0.159	18.220	4.101
Better ear 35+ dB HL		cq2	0	0.923	0.389	1.705	–0.572	114.964	0.159	17.372	4.101
Better ear 35+ dB HL		cq3q4	0	0.900	0.299	1.805	–0.376	110.826	0.159	15.696	4.101
Better ear 35+ dB HL		c2q3q4	0	0.513	0.095	1.345	0.640	64.721	0.159	10.469	4.101
Better ear 35+ dB HL		cmaxq34	0	0.900	0.300	1.802	–0.378	110.846	0.159	15.715	4.101
Better ear 35+ dB HL		c2maxq34	0	0.536	0.124	1.245	0.532	67.798	0.159	11.083	4.101
Better ear 35+ dB HL		chear	0	0.900	0.285	1.848	–0.355	110.567	0.159	15.437	4.101
Better ear 35+ dB HL		c2hear	0	0.513	0.090	1.372	0.653	64.642	0.159	10.390	4.101
Better ear 35+ dB HL		cq12	0	0.923	0.375	1.744	–0.552	114.704	0.159	17.111	4.101
Better ear 35+ dB HL		cq1or2	0	0.968	0.442	2.005	–0.856	120.899	0.159	18.480	4.101
Better ear 35+ dB HL	zq1	crLW4K45	2	0.765	0.104	1.978	0.267	93.891	0.207	13.013	5.331
Better ear 35+ dB HL	zq2	crLW4K45	2	0.753	0.098	1.977	0.304	92.462	0.207	12.816	5.331
Better ear 35+ dB HL	zq3	crLW4K45	2	0.696	0.083	1.896	0.435	85.827	0.207	12.238	5.331
Better ear 35+ dB HL	z2q3	crLW4K45	2	0.377	0.033	1.530	1.078	49.607	0.207	9.728	5.331
Better ear 35+ dB HL	zmax3	crLW4K45	2	0.696	0.083	1.897	0.436	85.824	0.207	12.235	5.331
Better ear 35+ dB HL	z2max3	crLW4K45	2	0.400	0.039	1.509	1.007	52.315	0.207	9.973	5.331
Better ear 35+ dB HL	zh	crLW4K45	2	0.696	0.083	1.896	0.435	85.827	0.207	12.238	5.331
Better ear 35+ dB HL	zh2	crLW4K45	2	0.377	0.033	1.530	1.078	49.607	0.207	9.728	5.331
Better ear 35+ dB HL	zq12	crLW4K45	2	0.753	0.098	1.977	0.304	92.462	0.207	12.816	5.331
Better ear 35+ dB HL	zq1o2	crLW4K45	2	0.765	0.104	1.978	0.267	93.891	0.207	13.013	5.331
Better ear 35+ dB HL	zq1	crLW4K40	2	0.773	0.137	1.845	0.173	95.552	0.207	13.783	5.331
Better ear 35+ dB HL	zq2	crLW4K40	2	0.761	0.130	1.835	0.207	94.113	0.207	13.589	5.331

continued

TABLE 55 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 35+ dB HL	zq3	crLW4K40	2	0.703	0.111	1.757	0.344	87.290	0.207	12.895	5.331
Better ear 35+ dB HL	z2q3	crLW4K40	2	0.370	0.046	1.356	1.011	49.094	0.207	9.991	5.331
Better ear 35+ dB HL	zmax3	crLW4K40	2	0.703	0.111	1.758	0.345	87.286	0.207	12.891	5.331
Better ear 35+ dB HL	z2max3	crLW4K40	2	0.393	0.055	1.325	0.933	51.905	0.207	10.310	5.331
Better ear 35+ dB HL	zh	crLW4K40	2	0.703	0.111	1.757	0.344	87.290	0.207	12.895	5.331
Better ear 35+ dB HL	zh2	crLW4K40	2	0.370	0.046	1.356	1.011	49.094	0.207	9.991	5.331
Better ear 35+ dB HL	zq12	crLW4K40	2	0.761	0.127	1.851	0.215	94.037	0.207	13.513	5.331
Better ear 35+ dB HL	zq1o2	crLW4K40	2	0.773	0.140	1.829	0.165	95.628	0.207	13.859	5.331
Better ear 35+ dB HL	zq1	crLW4K35	2	0.853	0.176	1.982	–0.060	105.273	0.207	15.019	5.331
Better ear 35+ dB HL	zq2	crLW4K35	2	0.807	0.171	1.816	0.040	100.088	0.207	14.717	5.331
Better ear 35+ dB HL	zq3	crLW4K35	2	0.784	0.144	1.849	0.140	96.864	0.207	13.985	5.331
Better ear 35+ dB HL	z2q3	crLW4K35	2	0.416	0.055	1.381	0.904	54.361	0.207	10.411	5.331
Better ear 35+ dB HL	zmax3	crLW4K35	2	0.784	0.143	1.850	0.140	96.859	0.207	13.980	5.331
Better ear 35+ dB HL	z2max3	crLW4K35	2	0.439	0.068	1.334	0.820	57.248	0.207	10.806	5.331
Better ear 35+ dB HL	zh	crLW4K35	2	0.784	0.144	1.849	0.140	96.864	0.207	13.985	5.331
Better ear 35+ dB HL	zh2	crLW4K35	2	0.416	0.055	1.381	0.904	54.361	0.207	10.411	5.331
Better ear 35+ dB HL	zq12	crLW4K35	2	0.807	0.166	1.836	0.050	99.974	0.207	14.603	5.331
Better ear 35+ dB HL	zq1o2	crLW4K35	2	0.853	0.181	1.963	–0.070	105.387	0.207	15.133	5.331
Better ear 35+ dB HL	zq1	crLW3K40	2	0.707	0.078	1.960	0.437	86.892	0.207	12.171	5.331
Better ear 35+ dB HL	zq2	crLW3K40	2	0.673	0.074	1.897	0.502	83.043	0.207	11.917	5.331
Better ear 35+ dB HL	zq3	crLW3K40	2	0.638	0.070	1.826	0.561	79.125	0.207	11.693	5.331
Better ear 35+ dB HL	z2q3	crLW3K40	2	0.342	0.042	1.317	1.065	45.985	0.207	9.799	5.331
Better ear 35+ dB HL	zmax3	crLW3K40	2	0.638	0.070	1.827	0.561	79.122	0.207	11.690	5.331
Better ear 35+ dB HL	z2max3	crLW3K40	2	0.365	0.046	1.345	1.016	48.621	0.207	9.973	5.331
Better ear 35+ dB HL	zh	crLW3K40	2	0.638	0.070	1.826	0.561	79.125	0.207	11.693	5.331
Better ear 35+ dB HL	zh2	crLW3K40	2	0.342	0.042	1.317	1.065	45.985	0.207	9.799	5.331
Better ear 35+ dB HL	zq12	crLW3K40	2	0.673	0.072	1.909	0.508	83.005	0.207	11.879	5.331
Better ear 35+ dB HL	zq1o2	crLW3K40	2	0.707	0.080	1.948	0.431	86.930	0.207	12.209	5.331
Better ear 35+ dB HL	zq1	crLW3K35	2	0.807	0.096	2.170	0.219	98.336	0.207	13.004	5.331
Better ear 35+ dB HL	zq2	crLW3K35	2	0.761	0.091	2.041	0.312	93.147	0.207	12.699	5.331
Better ear 35+ dB HL	zq3	crLW3K35	2	0.737	0.082	2.029	0.380	90.332	0.207	12.375	5.331
Better ear 35+ dB HL	z2q3	crLW3K35	2	0.392	0.041	1.469	1.008	51.433	0.207	9.974	5.331
Better ear 35+ dB HL	zmax3	crLW3K35	2	0.737	0.081	2.030	0.380	90.330	0.207	12.372	5.331
Better ear 35+ dB HL	z2max3	crLW3K35	2	0.416	0.046	1.475	0.951	54.138	0.207	10.187	5.331
Better ear 35+ dB HL	zh	crLW3K35	2	0.737	0.082	2.029	0.380	90.332	0.207	12.375	5.331
Better ear 35+ dB HL	zh2	crLW3K35	2	0.392	0.041	1.469	1.008	51.433	0.207	9.974	5.331
Better ear 35+ dB HL	zq12	crLW3K35	2	0.761	0.090	2.051	0.317	93.109	0.207	12.661	5.331

continued

TABLE 55 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 35+ dB HL	zq1o2	crLW3K35	2	0.807	0.098	2.160	0.214	98.374	0.207	13.042	5.331
Better ear 35+ dB HL	zq1	crLW3K30	2	0.865	0.140	2.183	–0.012	105.754	0.207	14.254	5.331
Better ear 35+ dB HL	zq2	crLW3K30	2	0.819	0.135	2.013	0.095	100.565	0.207	13.948	5.331
Better ear 35+ dB HL	zq3	crLW3K30	2	0.795	0.120	1.998	0.174	97.633	0.207	13.508	5.331
Better ear 35+ dB HL	z2q3	crLW3K30	2	0.416	0.047	1.462	0.944	54.166	0.207	10.216	5.331
Better ear 35+ dB HL	zmax3	crLW3K30	2	0.795	0.120	1.999	0.174	97.628	0.207	13.503	5.331
Better ear 35+ dB HL	z2max3	crLW3K30	2	0.439	0.058	1.416	0.861	57.019	0.207	10.576	5.331
Better ear 35+ dB HL	zh	crLW3K30	2	0.795	0.119	2.006	0.178	97.597	0.207	13.471	5.331
Better ear 35+ dB HL	zh2	crLW3K30	2	0.416	0.042	1.511	0.969	54.063	0.207	10.112	5.331
Better ear 35+ dB HL	zq12	crLW3K30	2	0.819	0.132	2.028	0.102	100.491	0.207	13.874	5.331
Better ear 35+ dB HL	zq1o2	crLW3K30	2	0.865	0.143	2.169	–0.019	105.828	0.207	14.328	5.331
Better ear 35+ dB HL	zq1	crLS4K45	2	0.765	0.109	1.951	0.254	94.004	0.207	13.127	5.331
Better ear 35+ dB HL	zq2	crLS4K45	2	0.753	0.103	1.948	0.290	92.580	0.207	12.934	5.331
Better ear 35+ dB HL	zq3	crLS4K45	2	0.696	0.088	1.864	0.419	85.940	0.207	12.352	5.331
Better ear 35+ dB HL	z2q3	crLS4K45	2	0.377	0.038	1.466	1.046	49.720	0.207	9.840	5.331
Better ear 35+ dB HL	zmax3	crLS4K45	2	0.696	0.088	1.865	0.420	85.937	0.207	12.349	5.331
Better ear 35+ dB HL	z2max3	crLS4K45	2	0.400	0.046	1.436	0.970	52.465	0.207	10.123	5.331
Better ear 35+ dB HL	zh	crLS4K45	2	0.696	0.088	1.864	0.419	85.940	0.207	12.352	5.331
Better ear 35+ dB HL	zh2	crLS4K45	2	0.377	0.038	1.466	1.046	49.720	0.207	9.840	5.331
Better ear 35+ dB HL	zq12	crLS4K45	2	0.753	0.100	1.967	0.299	92.504	0.207	12.858	5.331
Better ear 35+ dB HL	zq1o2c	rLS4K45	2	0.765	0.113	1.933	0.245	94.080	0.207	13.203	5.331
Better ear 35+ dB HL	zq1	crLS4K40	2	0.774	0.149	1.794	0.146	95.884	0.207	14.054	5.331
Better ear 35+ dB HL	zq2	crLS4K40	2	0.762	0.141	1.790	0.182	94.408	0.207	13.824	5.331
Better ear 35+ dB HL	zq3	crLS4K40	2	0.704	0.127	1.675	0.301	87.732	0.207	13.277	5.331
Better ear 35+ dB HL	z2q3	crLS4K40	2	0.370	0.052	1.291	0.978	49.244	0.207	10.141	5.331
Better ear 35+ dB HL	zmax3	crLS4K40	2	0.704	0.127	1.676	0.302	87.727	0.207	13.272	5.331
Better ear 35+ dB HL	z2max3	crLS4K40	2	0.393	0.065	1.241	0.891	52.133	0.207	10.538	5.331
Better ear 35+ dB HL	zh	crLS4K40	2	0.704	0.127	1.675	0.301	87.732	0.207	13.277	5.331
Better ear 35+ dB HL	zh2	crLS4K40	2	0.370	0.052	1.291	0.978	49.244	0.207	10.141	5.331
Better ear 35+ dB HL	zq12	crLS4K40	2	0.762	0.137	1.805	0.190	94.332	0.207	13.748	5.331
Better ear 35+ dB HL	zq1o2	crLS4K40	2	0.774	0.152	1.780	0.139	95.960	0.207	14.130	5.331
Better ear 35+ dB HL	zq1	crLS4K35	2	0.865	0.184	2.003	–0.102	106.755	0.207	15.255	5.331
Better ear 35+ dB HL	zq2	crLS4K35	2	0.819	0.178	1.835	0.006	101.534	0.207	14.917	5.331
Better ear 35+ dB HL	zq3	crLS4K35	2	0.795	0.152	1.854	0.102	98.347	0.207	14.221	5.331
Better ear 35+ dB HL	z2q3	crLS4K35	2	0.416	0.054	1.396	0.911	54.323	0.207	10.373	5.331
Better ear 35+ dB HL	zmax3	crLS4K35	2	0.795	0.152	1.855	0.102	98.341	0.207	14.216	5.331
Better ear 35+ dB HL	z2max3	crLS4K35	2	0.439	0.069	1.334	0.820	57.250	0.207	10.807	5.331

continued

TABLE 55 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 35+ dB HL	zh	crLS4K35	2	0.795	0.152	1.854	0.102	98.347	0.207	14.221	5.331
Better ear 35+ dB HL	zh2	crLS4K35	2	0.416	0.054	1.396	0.911	54.323	0.207	10.373	5.331
Better ear 35+ dB HL	zq12	crLS4K35	2	0.819	0.173	1.854	0.015	101.420	0.207	14.803	5.331
Better ear 35+ dB HL	zq1o2	crLS4K35	2	0.865	0.189	1.985	–0.112	106.869	0.207	15.369	5.331
Better ear 35+ dB HL	zq1	crLS3K40	2	0.775	0.074	2.206	0.346	94.367	0.207	12.357	5.331
Better ear 35+ dB HL	zq2	crLS3K40	2	0.741	0.069	2.133	0.419	90.518	0.207	12.103	5.331
Better ear 35+ dB HL	zq3	crLS3K40	2	0.707	0.065	2.054	0.484	86.600	0.207	11.879	5.331
Better ear 35+ dB HL	z2q3	crLS3K40	2	0.377	0.039	1.447	1.037	49.755	0.207	9.875	5.331
Better ear 35+ dB HL	zmax3	crLS3K40	2	0.707	0.065	2.055	0.484	86.597	0.207	11.876	5.331
Better ear 35+ dB HL	z2max3	crLS3K40	2	0.400	0.042	1.470	0.988	52.391	0.207	10.049	5.331
Better ear 35+ dB HL	zh	crLS3K40	2	0.707	0.065	2.054	0.484	86.600	0.207	11.879	5.331
Better ear 35+ dB HL	zh2	crLS3K40	2	0.377	0.039	1.447	1.037	49.755	0.207	9.875	5.331
Better ear 35+ dB HL	zq12	crLS3K40	2	0.741	0.067	2.145	0.425	90.480	0.207	12.065	5.331
Better ear 35+ dB HL	zq1o2	crLS3K40	2	0.775	0.075	2.195	0.340	94.405	0.207	12.395	5.331
Better ear 35+ dB HL	zq1	crLS3K35	2	0.842	0.093	2.325	0.159	102.157	0.207	13.088	5.331
Better ear 35+ dB HL	zq2	crLS3K35	2	0.796	0.088	2.178	0.262	96.968	0.207	12.782	5.331
Better ear 35+ dB HL	zq3	crLS3K35	2	0.772	0.079	2.162	0.334	94.153	0.207	12.458	5.331
Better ear 35+ dB HL	z2q3	crLS3K35	2	0.416	0.044	1.492	0.959	54.101	0.207	10.150	5.331
Better ear 35+ dB HL	zmax3	crLS3K35	2	0.772	0.078	2.162	0.334	94.150	0.207	12.456	5.331
Better ear 35+ dB HL	z2max3	crLS3K35	2	0.439	0.051	1.485	0.896	56.844	0.207	10.401	5.331
Better ear 35+ dB HL	zh	crLS3K35	2	0.772	0.079	2.162	0.334	94.153	0.207	12.458	5.331
Better ear 35+ dB HL	zh2	crLS3K35	2	0.416	0.044	1.492	0.959	54.101	0.207	10.150	5.331
Better ear 35+ dB HL	zq12	crLS3K35	2	0.796	0.087	2.189	0.267	96.930	0.207	12.744	5.331
Better ear 35+ dB HL	zq1o2	crLS3K35	2	0.842	0.095	2.315	0.154	102.195	0.207	13.126	5.331
Better ear 35+ dB HL	zq1	crLS3K30	2	0.865	0.145	2.162	–0.023	105.865	0.207	14.365	5.331
Better ear 35+ dB HL	zq2	crLS3K30	2	0.819	0.137	2.005	0.091	100.604	0.207	13.987	5.331
Better ear 35+ dB HL	zq3	crLS3K30	2	0.795	0.127	1.967	0.158	97.779	0.207	13.654	5.331
Better ear 35+ dB HL	z2q3	crLS3K30	2	0.416	0.058	1.356	0.891	54.425	0.207	10.474	5.331
Better ear 35+ dB HL	zmax3	crLS3K30	2	0.795	0.127	1.968	0.158	97.775	0.207	13.650	5.331
Better ear 35+ dB HL	z2max3	crLS3K30	2	0.439	0.070	1.325	0.816	57.277	0.207	10.834	5.331
Better ear 35+ dB HL	zh	crLS3K30	2	0.795	0.125	1.974	0.162	97.743	0.207	13.618	5.331
Better ear 35+ dB HL	zh2	crLS3K30	2	0.416	0.054	1.396	0.911	54.322	0.207	10.371	5.331
Better ear 35+ dB HL	zq12	crLS3K30	2	0.819	0.134	2.020	0.098	100.530	0.207	13.913	5.331
Better ear 35+ dB HL	zq1o2	crLS3K30	2	0.865	0.148	2.147	–0.030	105.939	0.207	14.440	5.331
Better ear 35+ dB HL	zq1	cwarble	2	0.715	0.088	1.920	0.392	88.032	0.207	12.431	5.331
Better ear 35+ dB HL	zq2	cwarble	2	0.703	0.082	1.927	0.430	86.589	0.207	12.234	5.331
Better ear 35+ dB HL	zq3	cwarble	2	0.645	0.074	1.822	0.539	80.028	0.207	11.801	5.331

continued

TABLE 55 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Better ear 35+ dB HL	z2q3	cwarble	2	0.334	0.041	1.314	1.085	45.096	0.207	9.730	5.331
Better ear 35+ dB HL	zmax3	cwarble	2	0.645	0.073	1.823	0.539	80.025	0.207	11.798	5.331
Better ear 35+ dB HL	z2max3	cwarble	2	0.358	0.044	1.342	1.035	47.762	0.207	9.905	5.331
Better ear 35+ dB HL	zh	cwarble	2	0.645	0.074	1.822	0.539	80.028	0.207	11.801	5.331
Better ear 35+ dB HL	zh2	cwarble	2	0.334	0.041	1.314	1.085	45.096	0.207	9.730	5.331
Better ear 35+ dB HL	zq12	cwarble	2	0.703	0.082	1.927	0.430	86.589	0.207	12.234	5.331
Better ear 35+ dB HL	zq1o2	cwarble	2	0.715	0.088	1.920	0.392	88.032	0.207	12.431	5.331
Better ear 35+ dB HL	zq1	csteady	2	0.762	0.078	2.128	0.351	92.995	0.207	12.411	5.331
Better ear 35+ dB HL	zq2	csteady	2	0.750	0.074	2.124	0.387	91.590	0.207	12.252	5.331
Better ear 35+ dB HL	zq3	csteady	2	0.692	0.064	2.025	0.511	84.990	0.207	11.781	5.331
Better ear 35+ dB HL	z2q3	csteady	2	0.370	0.041	1.409	1.037	48.984	0.207	9.880	5.331
Better ear 35+ dB HL	zmax3	csteady	2	0.692	0.064	2.026	0.511	84.988	0.207	11.778	5.331
Better ear 35+ dB HL	z2max3	csteady	2	0.393	0.046	1.417	0.979	51.688	0.207	10.094	5.331
Better ear 35+ dB HL	zh	csteady	2	0.692	0.064	2.025	0.511	84.990	0.207	11.781	5.331
Better ear 35+ dB HL	zh2	csteady	2	0.370	0.041	1.409	1.037	48.984	0.207	9.880	5.331
Better ear 35+ dB HL	zq12	csteady	2	0.750	0.072	2.136	0.393	91.552	0.207	12.214	5.331
Better ear 35+ dB HL	zq1o2	csteady	2	0.762	0.080	2.117	0.346	93.033	0.207	12.449	5.331
Better ear 35+ dB HL	zq1	cscr3540	2	0.737	0.075	2.074	0.401	90.224	0.207	12.231	5.331
Better ear 35+ dB HL	zq2	cscr3540	2	0.703	0.070	2.006	0.470	86.331	0.207	11.976	5.331
Better ear 35+ dB HL	zq3	cscr3540	2	0.668	0.067	1.932	0.532	82.367	0.207	11.749	5.331
Better ear 35+ dB HL	z2q3	cscr3540	2	0.334	0.041	1.314	1.085	45.096	0.207	9.730	5.331
Better ear 35+ dB HL	zmax3	cscr3540	2	0.668	0.067	1.933	0.533	82.365	0.207	11.747	5.331
Better ear 35+ dB HL	z2max3	cscr3540	2	0.358	0.044	1.342	1.035	47.762	0.207	9.905	5.331
Better ear 35+ dB HL	zh	cscr3540	2	0.668	0.067	1.932	0.532	82.367	0.207	11.749	5.331
Better ear 35+ dB HL	zh2	cscr3540	2	0.334	0.041	1.314	1.085	45.096	0.207	9.730	5.331
Better ear 35+ dB HL	zq12	cscr3540	2	0.703	0.069	2.019	0.476	86.293	0.207	11.938	5.331
Better ear 35+ dB HL	zq1o2	cscr3540	2	0.737	0.077	2.062	0.396	90.262	0.207	12.270	5.331

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 56 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 30+ dB HL		crLW4K40	1	0.562	0.077	1.582	0.634	178.907	0.050	14.779	1.278
Worse ear 30+ dB HL		crLW4K35	1	0.712	0.108	1.794	0.339	224.652	0.050	17.002	1.278
Worse ear 30+ dB HL		crLW3K40	1	0.420	0.036	1.602	1.002	135.137	0.050	12.484	1.278
Worse ear 30+ dB HL		crLW3K35	1	0.525	0.047	1.742	0.808	167.150	0.050	13.883	1.278
Worse ear 30+ dB HL		crLW3K30	1	0.669	0.088	1.788	0.456	211.527	0.050	16.208	1.278
Worse ear 30+ dB HL		crLS4K45	1	0.536	0.069	1.575	0.697	170.856	0.050	14.348	1.278
Worse ear 30+ dB HL		crLS4K40	1	0.596	0.100	1.522	0.518	189.473	0.050	15.526	1.278
Worse ear 30+ dB HL		crLS4K35	1	0.625	0.135	1.422	0.393	198.723	0.050	16.381	1.278
Worse ear 30+ dB HL		crLS3K40	1	0.437	0.043	1.557	0.936	140.395	0.050	12.796	1.278
Worse ear 30+ dB HL		crLS3K35	1	0.505	0.046	1.703	0.839	161.043	0.050	13.630	1.278
Worse ear 30+ dB HL		crLS3K30	1	0.726	0.076	2.034	0.416	228.598	0.050	16.688	1.278
Worse ear 30+ dB HL		cwarble	1	0.439	0.028	1.753	1.031	140.571	0.050	12.587	1.278
Worse ear 30+ dB HL		csteady	1	0.460	0.025	1.861	1.032	146.952	0.050	12.785	1.278
Worse ear 30+ dB HL		cscr3540	1	0.430	0.022	1.843	1.097	137.937	0.050	12.391	1.278
Worse ear 30+ dB HL	q1		0	0.839	0.313	1.479	–0.251	264.757	0.043	19.923	1.111
Worse ear 30+ dB HL	q2		0	0.798	0.276	1.429	–0.119	251.733	0.043	18.954	1.111
Worse ear 30+ dB HL	q3q4		0	0.713	0.197	1.415	0.147	224.882	0.043	16.919	1.111
Worse ear 30+ dB HL	2q3q4		0	0.385	0.022	1.724	1.154	123.149	0.043	10.780	1.111
Worse ear 30+ dB HL	maxq34		0	0.714	0.197	1.418	0.145	225.233	0.043	16.933	1.111
Worse ear 30+ dB HL	2maxq34		0	0.429	0.042	1.553	0.955	136.842	0.043	11.560	1.111
Worse ear 30+ dB HL	hear		0	0.704	0.181	1.447	0.187	222.110	0.043	16.619	1.111
Worse ear 30+ dB HL	2hear		0	0.374	0.022	1.693	1.169	119.661	0.043	10.645	1.111
Worse ear 30+ dB HL	q12		0	0.793	0.258	1.468	–0.084	250.222	0.043	18.674	1.111
Worse ear 30+ dB HL	q1or2		0	0.843	0.330	1.447	–0.284	266.268	0.043	20.203	1.111
Worse ear 30+ dB HL	q1	crLW4K45	2	0.459	0.043	1.608	0.908	148.032	0.056	14.176	1.444
Worse ear 30+ dB HL	q2	crLW4K45	2	0.442	0.041	1.590	0.941	142.975	0.056	13.945	1.444
Worse ear 30+ dB HL	q3	crLW4K45	2	0.386	0.041	1.446	1.014	125.855	0.056	13.280	1.444
Worse ear 30+ dB HL	2q3	crLW4K45	2	0.212	0.004	1.830	1.716	72.407	0.056	10.604	1.444
Worse ear 30+ dB HL	max3	crLW4K45	2	0.384	0.041	1.442	1.016	125.385	0.056	13.261	1.444
Worse ear 30+ dB HL	2max3	crLW4K45	2	0.227	0.009	1.634	1.564	77.222	0.056	10.862	1.444
Worse ear 30+ dB HL	h	crLW4K45	2	0.386	0.041	1.446	1.014	125.855	0.056	13.280	1.444
Worse ear 30+ dB HL	h2	crLW4K45	2	0.212	0.004	1.830	1.716	72.407	0.056	10.604	1.444
Worse ear 30+ dB HL	q12	crLW4K45	2	0.442	0.041	1.590	0.941	142.975	0.056	13.945	1.444
Worse ear 30+ dB HL	q1o2	crLW4K45	2	0.459	0.043	1.608	0.908	148.032	0.056	14.176	1.444
Worse ear 30+ dB HL	q1	crLW4K40	2	0.501	0.065	1.515	0.755	161.313	0.056	15.047	1.444
Worse ear 30+ dB HL	q2	crLW4K40	2	0.485	0.063	1.490	0.783	156.299	0.056	14.819	1.444
Worse ear 30+ dB HL	q3	crLW4K40	2	0.428	0.056	1.404	0.883	138.983	0.056	14.038	1.444

continued

TABLE 56 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 30+ dB HL	2q3	crLW4K40	2	0.237	0.006	1.769	1.600	80.175	0.056	10.941	1.444
Worse ear 30+ dB HL	max3	crLW4K40	2	0.426	0.056	1.400	0.885	138.460	0.056	14.018	1.444
Worse ear 30+ dB HL	2max3	crLW4K40	2	0.257	0.013	1.571	1.439	86.240	0.056	11.284	1.444
Worse ear 30+ dB HL	h	crLW4K40	2	0.428	0.056	1.404	0.883	138.983	0.056	14.038	1.444
Worse ear 30+ dB HL	h2	crLW4K40	2	0.237	0.006	1.769	1.600	80.175	0.056	10.941	1.444
Worse ear 30+ dB HL	q12	crLW4K40	2	0.481	0.061	1.498	0.798	154.975	0.056	14.732	1.444
Worse ear 30+ dB HL	q1o2	crLW4K40	2	0.505	0.067	1.509	0.741	162.637	0.056	15.135	1.444
Worse ear 30+ dB HL	q1	crLW4K35	2	0.605	0.078	1.682	0.575	193.006	0.056	16.490	1.444
Worse ear 30+ dB HL	q2	crLW4K35	2	0.576	0.079	1.606	0.611	184.275	0.056	16.155	1.444
Worse ear 30+ dB HL	q3	crLW4K35	2	0.516	0.070	1.518	0.720	165.778	0.056	15.292	1.444
Worse ear 30+ dB HL	2q3	crLW4K35	2	0.279	0.006	1.898	1.535	92.809	0.056	11.431	1.444
Worse ear 30+ dB HL	max3	crLW4K35	2	0.514	0.070	1.513	0.722	165.147	0.056	15.267	1.444
Worse ear 30+ dB HL	2max3	crLW4K35	2	0.303	0.015	1.645	1.340	100.148	0.056	11.860	1.444
Worse ear 30+ dB HL	h	crLW4K35	2	0.516	0.070	1.518	0.720	165.778	0.056	15.292	1.444
Worse ear 30+ dB HL	h2	crLW4K35	2	0.279	0.006	1.898	1.535	92.809	0.056	11.431	1.444
Worse ear 30+ dB HL	q12	crLW4K35	2	0.572	0.074	1.627	0.632	182.912	0.056	16.030	1.444
Worse ear 30+ dB HL	q1o2	crLW4K35	2	0.609	0.083	1.663	0.555	194.368	0.056	16.616	1.444
Worse ear 30+ dB HL	q1	crLW3K40	2	0.409	0.024	1.749	1.105	132.570	0.056	13.256	1.444
Worse ear 30+ dB HL	q2	crLW3K40	2	0.384	0.024	1.684	1.136	125.092	0.056	12.968	1.444
Worse ear 30+ dB HL	q3	crLW3K40	2	0.365	0.024	1.634	1.163	119.130	0.056	12.735	1.444
Worse ear 30+ dB HL	2q3	crLW3K40	2	0.219	0.006	1.711	1.629	74.788	0.056	10.732	1.444
Worse ear 30+ dB HL	max3	crLW3K40	2	0.363	0.024	1.630	1.165	118.685	0.056	12.718	1.444
Worse ear 30+ dB HL	2max3	crLW3K40	2	0.227	0.011	1.543	1.520	77.158	0.056	10.897	1.444
Worse ear 30+ dB HL	h	crLW3K40	2	0.365	0.024	1.634	1.163	119.130	0.056	12.735	1.444
Worse ear 30+ dB HL	h2	crLW3K40	2	0.219	0.006	1.711	1.629	74.788	0.056	10.732	1.444
Worse ear 30+ dB HL	q12	crLW3K40	2	0.384	0.022	1.725	1.157	125.054	0.056	12.930	1.444
Worse ear 30+ dB HL	q1o2	crLW3K40	2	0.409	0.026	1.711	1.086	132.608	0.056	13.294	1.444
Worse ear 30+ dB HL	q1	crLW3K35	2	0.468	0.035	1.735	0.947	150.782	0.056	14.141	1.444
Worse ear 30+ dB HL	q2	crLW3K35	2	0.439	0.035	1.660	0.983	141.986	0.056	13.802	1.444
Worse ear 30+ dB HL	q3	crLW3K35	2	0.407	0.035	1.581	1.024	132.331	0.056	13.425	1.444
Worse ear 30+ dB HL	2q3	crLW3K35	2	0.237	0.004	1.915	1.674	80.059	0.056	10.900	1.444
Worse ear 30+ dB HL	max3	crLW3K35	2	0.406	0.035	1.576	1.027	131.833	0.056	13.406	1.444
Worse ear 30+ dB HL	2max3	crLW3K35	2	0.244	0.011	1.600	1.492	82.456	0.056	11.103	1.444
Worse ear 30+ dB HL	h	crLW3K35	2	0.407	0.035	1.581	1.024	132.331	0.056	13.425	1.444
Worse ear 30+ dB HL	h2	crLW3K35	2	0.237	0.004	1.915	1.674	80.059	0.056	10.900	1.444
Worse ear 30+ dB HL	q12	crLW3K35	2	0.439	0.033	1.690	0.998	141.948	0.056	13.764	1.444
Worse ear 30+ dB HL	q1o2	crLW3K35	2	0.468	0.037	1.707	0.933	150.820	0.056	14.179	1.444

continued

TABLE 56 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 30+ dB HL	q1	crLW3K30	2	0.555	0.059	1.704	0.713	177.642	0.056	15.574	1.444
Worse ear 30+ dB HL	q2	crLW3K30	2	0.526	0.059	1.630	0.749	168.846	0.056	15.235	1.444
Worse ear 30+ dB HL	q3	crLW3K30	2	0.494	0.052	1.608	0.819	158.920	0.056	14.742	1.444
Worse ear 30+ dB HL	2q3	crLW3K30	2	0.261	0.004	1.992	1.635	87.436	0.056	11.186	1.444
Worse ear 30+ dB HL	max3	crLW3K30	2	0.492	0.052	1.603	0.822	158.315	0.056	14.718	1.444
Worse ear 30+ dB HL	2max3	crLW3K30	2	0.281	0.013	1.641	1.400	93.575	0.056	11.570	1.444
Worse ear 30+ dB HL	h	crLW3K30	2	0.494	0.050	1.629	0.829	158.883	0.056	14.706	1.444
Worse ear 30+ dB HL	h2	crLW3K30	2	0.250	0.004	1.956	1.653	83.934	0.056	11.050	1.444
Worse ear 30+ dB HL	q12	crLW3K30	2	0.526	0.055	1.669	0.768	168.772	0.056	15.161	1.444
Worse ear 30+ dB HL	q1o2	crLW3K30	2	0.555	0.063	1.668	0.695	177.716	0.056	15.648	1.444
Worse ear 30+ dB HL	q1	crLS4K45	2	0.475	0.041	1.674	0.899	153.056	0.056	14.335	1.444
Worse ear 30+ dB HL	q2	crLS4K45	2	0.459	0.039	1.656	0.931	148.064	0.056	14.109	1.444
Worse ear 30+ dB HL	q3	crLS4K45	2	0.402	0.039	1.515	1.004	130.900	0.056	13.440	1.444
Worse ear 30+ dB HL	2q3	crLS4K45	2	0.220	0.006	1.712	1.628	74.954	0.056	10.739	1.444
Worse ear 30+ dB HL	max3	crLS4K45	2	0.401	0.039	1.511	1.006	130.410	0.056	13.421	1.444
Worse ear 30+ dB HL	2max3	crLS4K45	2	0.240	0.011	1.588	1.501	81.040	0.056	11.046	1.444
Worse ear 30+ dB HL	h	crLS4K45	2	0.402	0.039	1.515	1.004	130.900	0.056	13.440	1.444
Worse ear 30+ dB HL	h2	crLS4K45	2	0.220	0.006	1.712	1.628	74.954	0.056	10.739	1.444
Worse ear 30+ dB HL	q12	crLS4K45	2	0.455	0.037	1.673	0.950	146.745	0.056	14.021	1.444
Worse ear 30+ dB HL	q1o2	crLS4K45	2	0.480	0.044	1.660	0.881	154.375	0.056	14.423	1.444
Worse ear 30+ dB HL	q1	crLS4K40	2	0.535	0.063	1.616	0.720	171.492	0.056	15.408	1.444
Worse ear 30+ dB HL	q2	crLS4K40	2	0.518	0.059	1.609	0.758	166.442	0.056	15.145	1.444
Worse ear 30+ dB HL	q3	crLS4K40	2	0.462	0.061	1.451	0.821	149.315	0.056	14.512	1.444
Worse ear 30+ dB HL	2q3	crLS4K40	2	0.254	0.006	1.821	1.573	85.200	0.056	11.136	1.444
Worse ear 30+ dB HL	max3	crLS4K40	2	0.460	0.061	1.446	0.824	148.750	0.056	14.490	1.444
Worse ear 30+ dB HL	2max3	crLS4K40	2	0.278	0.015	1.572	1.375	92.633	0.056	11.569	1.444
Worse ear 30+ dB HL	h	crLS4K40	2	0.462	0.061	1.451	0.821	149.315	0.056	14.512	1.444
Worse ear 30+ dB HL	h2	crLS4K40	2	0.254	0.006	1.821	1.573	85.200	0.056	11.136	1.444
Worse ear 30+ dB HL	q12	crLS4K40	2	0.514	0.057	1.618	0.773	165.118	0.056	15.057	1.444
Worse ear 30+ dB HL	q1o2	crLS4K40	2	0.539	0.065	1.609	0.706	172.817	0.056	15.496	1.444
Worse ear 30+ dB HL	q1	crLS4K35	2	0.609	0.089	1.622	0.534	194.479	0.056	16.726	1.444
Worse ear 30+ dB HL	q2	crLS4K35	2	0.580	0.087	1.559	0.577	185.711	0.056	16.355	1.444
Worse ear 30+ dB HL	q3	crLS4K35	2	0.520	0.081	1.451	0.676	167.256	0.056	15.528	1.444
Worse ear 30+ dB HL	2q3	crLS4K35	2	0.275	0.006	1.886	1.542	91.517	0.056	11.381	1.444
Worse ear 30+ dB HL	max3	crLS4K35	2	0.518	0.081	1.446	0.678	166.620	0.056	15.503	1.444
Worse ear 30+ dB HL	2max3	crLS4K35	2	0.298	0.018	1.579	1.318	98.962	0.056	11.850	1.444
Worse ear 30+ dB HL	h	crLS4K35	2	0.520	0.081	1.451	0.676	167.256	0.056	15.528	1.444

continued

TABLE 56 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 30+ dB HL	h2	crLS4K35	2	0.275	0.006	1.886	1.542	91.517	0.056	11.381	1.444
Worse ear 30+ dB HL	q12	crLS4K35	2	0.576	0.083	1.577	0.597	184.349	0.056	16.230	1.444
Worse ear 30+ dB HL	q1o2	crLS4K35	2	0.613	0.094	1.606	0.515	195.841	0.056	16.852	1.444
Worse ear 30+ dB HL	q1	crLS3K40	2	0.426	0.022	1.833	1.104	137.679	0.056	13.419	1.444
Worse ear 30+ dB HL	q2	crLS3K40	2	0.401	0.022	1.768	1.134	130.201	0.056	13.130	1.444
Worse ear 30+ dB HL	q3	crLS3K40	2	0.382	0.022	1.719	1.161	124.259	0.056	12.898	1.444
Worse ear 30+ dB HL	2q3	crLS3K40	2	0.228	0.004	1.886	1.688	77.385	0.056	10.797	1.444
Worse ear 30+ dB HL	max3	crLS3K40	2	0.380	0.022	1.715	1.163	123.794	0.056	12.880	1.444
Worse ear 30+ dB HL	2max3	crLS3K40	2	0.236	0.009	1.656	1.548	79.745	0.056	10.961	1.444
Worse ear 30+ dB HL	h	crLS3K40	2	0.382	0.022	1.719	1.161	124.259	0.056	12.898	1.444
Worse ear 30+ dB HL	h2	crLS3K40	2	0.228	0.004	1.886	1.688	77.385	0.056	10.797	1.444
Worse ear 30+ dB HL	q12	crLS3K40	2	0.401	0.020	1.813	1.157	130.163	0.056	13.092	1.444
Worse ear 30+ dB HL	q1o2	crLS3K40	2	0.426	0.024	1.792	1.083	137.717	0.056	13.457	1.444
Worse ear 30+ dB HL	q1	crLS3K35	2	0.494	0.024	1.962	0.997	158.316	0.056	14.256	1.444
Worse ear 30+ dB HL	q2	crLS3K35	2	0.465	0.024	1.887	1.032	149.520	0.056	13.917	1.444
Worse ear 30+ dB HL	q3	crLS3K35	2	0.433	0.024	1.809	1.073	139.897	0.056	13.542	1.444
Worse ear 30+ dB HL	2q3	crLS3K35	2	0.254	0.004	1.968	1.647	85.162	0.056	11.098	1.444
Worse ear 30+ dB HL	max3	crLS3K35	2	0.431	0.024	1.805	1.076	139.367	0.056	13.522	1.444
Worse ear 30+ dB HL	2max3	crLS3K35	2	0.265	0.011	1.665	1.459	88.825	0.056	11.350	1.444
Worse ear 30+ dB HL	h	crLS3K35	2	0.433	0.024	1.809	1.073	139.897	0.056	13.542	1.444
Worse ear 30+ dB HL	h2	crLS3K35	2	0.254	0.004	1.968	1.647	85.162	0.056	11.098	1.444
Worse ear 30+ dB HL	q12	crLS3K35	2	0.465	0.022	1.928	1.053	149.482	0.056	13.879	1.444
Worse ear 30+ dB HL	q1o2	crLS3K35	2	0.494	0.026	1.924	0.978	158.354	0.056	14.294	1.444
Worse ear 30+ dB HL	q1	crLS3K30	2	0.580	0.052	1.825	0.711	185.047	0.056	15.755	1.444
Worse ear 30+ dB HL	q2	crLS3K30	2	0.551	0.048	1.792	0.767	176.179	0.056	15.344	1.444
Worse ear 30+ dB HL	q3	crLS3K30	2	0.515	0.050	1.681	0.804	165.136	0.056	14.947	1.444
Worse ear 30+ dB HL	2q3	crLS3K30	2	0.286	0.006	1.919	1.525	94.957	0.056	11.514	1.444
Worse ear 30+ dB HL	max3	crLS3K30	2	0.513	0.050	1.676	0.806	164.506	0.056	14.922	1.444
Worse ear 30+ dB HL	2max3	crLS3K30	2	0.302	0.018	1.587	1.314	99.878	0.056	11.886	1.444
Worse ear 30+ dB HL	h	crLS3K30	2	0.515	0.048	1.702	0.814	165.100	0.056	14.911	1.444
Worse ear 30+ dB HL	h2	crLS3K30	2	0.274	0.006	1.885	1.542	91.454	0.056	11.378	1.444
Worse ear 30+ dB HL	q12	crLS3K30	2	0.551	0.044	1.837	0.790	176.104	0.056	15.270	1.444
Worse ear 30+ dB HL	q1o2	crLS3K30	2	0.580	0.057	1.786	0.691	185.121	0.056	15.829	1.444
Worse ear 30+ dB HL	q	cwarble	2	0.427	0.028	1.723	1.046	138.176	0.056	13.545	1.444
Worse ear 30+ dB HL	q	cwarble	2	0.410	0.026	1.715	1.084	133.098	0.056	13.314	1.444
Worse ear 30+ dB HL	q	cwarble	2	0.366	0.028	1.565	1.125	119.675	0.056	12.828	1.444
Worse ear 30+ dB HL	2q	cwarble	2	0.216	0.004	1.846	1.708	73.742	0.056	10.655	1.444

continued

TABLE 56 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 30+ dB HL	max	cwarble	2	0.365	0.028	1.561	1.127	119.227	0.056	12.811	1.444
Worse ear 30+ dB HL	2max	cwarble	2	0.224	0.009	1.617	1.568	76.126	0.056	10.821	1.444
Worse ear 30+ dB HL	h	cwarble	2	0.366	0.028	1.565	1.125	119.675	0.056	12.828	1.444
Worse ear 30+ dB HL	h	cwarble	2	0.216	0.004	1.846	1.708	73.742	0.056	10.655	1.444
Worse ear 30+ dB HL	q1	cwarble	2	0.410	0.026	1.715	1.084	133.098	0.056	13.314	1.444
Worse ear 30+ dB HL	q1o	cwarble	2	0.427	0.028	1.723	1.046	138.176	0.056	13.545	1.444
Worse ear 30+ dB HL	q	csteady	2	0.448	0.013	2.096	1.178	144.349	0.056	13.535	1.444
Worse ear 30+ dB HL	q	csteady	2	0.432	0.013	2.051	1.198	139.308	0.056	13.342	1.444
Worse ear 30+ dB HL	q	csteady	2	0.387	0.013	1.940	1.256	125.874	0.056	12.819	1.444
Worse ear 30+ dB HL	2q	csteady	2	0.229	0.004	1.888	1.687	77.617	0.056	10.806	1.444
Worse ear 30+ dB HL	max	csteady	2	0.386	0.013	1.936	1.258	125.400	0.056	12.801	1.444
Worse ear 30+ dB HL	2max	csteady	2	0.241	0.009	1.673	1.540	81.272	0.056	11.020	1.444
Worse ear 30+ dB HL	h	csteady	2	0.387	0.013	1.940	1.256	125.874	0.056	12.819	1.444
Worse ear 30+ dB HL	h	csteady	2	0.229	0.004	1.888	1.687	77.617	0.056	10.806	1.444
Worse ear 30+ dB HL	q1	csteady	2	0.432	0.011	2.123	1.234	139.270	0.056	13.304	1.444
Worse ear 30+ dB HL	q1o	csteady	2	0.448	0.015	2.034	1.147	144.387	0.056	13.574	1.444
Worse ear 30+ dB HL	q1	cscr3540	2	0.419	0.020	1.858	1.134	135.492	0.056	13.299	1.444
Worse ear 30+ dB HL	q2	cscr3540	2	0.394	0.020	1.792	1.165	127.982	0.056	13.010	1.444
Worse ear 30+ dB HL	q3	cscr3540	2	0.374	0.020	1.743	1.192	122.007	0.056	12.776	1.444
Worse ear 30+ dB HL	2q3	cscr3540	2	0.216	0.004	1.846	1.708	73.742	0.056	10.655	1.444
Worse ear 30+ dB HL	max3	cscr3540	2	0.373	0.020	1.739	1.194	121.549	0.056	12.758	1.444
Worse ear 30+ dB HL	2max3	cscr3540	2	0.224	0.009	1.617	1.568	76.126	0.056	10.821	1.444
Worse ear 30+ dB HL	h	cscr3540	2	0.374	0.020	1.743	1.192	122.007	0.056	12.776	1.444
Worse ear 30+ dB HL	h2	cscr3540	2	0.216	0.004	1.846	1.708	73.742	0.056	10.655	1.444
Worse ear 30+ dB HL	q12	cscr3540	2	0.394	0.017	1.842	1.190	127.944	0.056	12.972	1.444
Worse ear 30+ dB HL	q1o2	cscr3540	2	0.419	0.022	1.813	1.112	135.530	0.056	13.337	1.444

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 57

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 35+ dB HL		crLW4K45	1	0.515	0.095	1.348	0.636	118.792	0.081	12.925	2.099
Worse ear 35+ dB HL		crLW4K40	1	0.571	0.140	1.257	0.451	131.419	0.081	14.168	2.099
Worse ear 35+ dB HL		crLW4K35	1	0.753	0.177	1.613	0.122	171.070	0.081	16.313	2.099
Worse ear 35+ dB HL		crLW3K40	1	0.485	0.067	1.463	0.768	111.895	0.081	12.184	2.099
Worse ear 35+ dB HL		crLW3K35	1	0.547	0.105	1.373	0.569	125.693	0.081	13.350	2.099
Worse ear 35+ dB HL		crLW3K30	1	0.705	0.156	1.550	0.237	160.371	0.081	15.550	2.099
Worse ear 35+ dB HL		crLS4K45	1	0.545	0.130	1.240	0.508	125.672	0.081	13.768	2.099
Worse ear 35+ dB HL		crLS4K40	1	0.612	0.163	1.269	0.350	140.688	0.081	14.901	2.099
Worse ear 35+ dB HL		crLS4K35	1	0.694	0.179	1.427	0.206	158.505	0.081	15.866	2.099
Worse ear 35+ dB HL		crLS3K40	1	0.515	0.072	1.502	0.713	118.341	0.081	12.513	2.099
Worse ear 35+ dB HL		crLS3K35	1	0.577	0.085	1.568	0.590	131.855	0.081	13.258	2.099
Worse ear 35+ dB HL		crLS3K30	1	0.740	0.160	1.640	0.177	167.965	0.081	15.907	2.099
Worse ear 35+ dB HL		cwarble	1	0.488	0.068	1.461	0.760	112.540	0.081	12.229	2.099
Worse ear 35+ dB HL		csteady	1	0.518	0.065	1.559	0.734	118.933	0.081	12.428	2.099
Worse ear 35+ dB HL		cscr3540	1	0.500	0.055	1.599	0.800	114.786	0.081	12.096	2.099
Worse ear 35+ dB HL	q1		0	0.897	0.365	1.611	–0.460	203.594	0.071	19.226	1.825
Worse ear 35+ dB HL	q2		0	0.868	0.324	1.575	–0.330	196.729	0.071	18.358	1.825
Worse ear 35+ dB HL	q3q4		0	0.818	0.233	1.639	–0.089	184.694	0.071	16.568	1.825
Worse ear 35+ dB HL	2q3q4		0	0.453	0.049	1.536	0.885	103.932	0.071	10.770	1.825
Worse ear 35+ dB HL	maxq34		0	0.819	0.233	1.643	–0.091	184.915	0.071	16.576	1.825
Worse ear 35+ dB HL	2maxq34		0	0.492	0.074	1.427	0.733	112.596	0.071	11.466	1.825
Worse ear 35+ dB HL	hear		0	0.812	0.217	1.667	–0.052	183.176	0.071	16.289	1.825
Worse ear 35+ dB HL	2hear		0	0.437	0.049	1.494	0.906	100.438	0.071	10.635	1.825
Worse ear 35+ dB HL	q12		0	0.862	0.308	1.590	–0.295	195.218	0.071	18.078	1.825
Worse ear 35+ dB HL	q1or2		0	0.903	0.380	1.605	–0.498	205.106	0.071	19.506	1.825
Worse ear 35+ dB HL	q1	crLW4K45	2	0.499	0.087	1.358	0.682	116.101	0.092	13.573	2.372
Worse ear 35+ dB HL	q2	crLW4K45	2	0.493	0.079	1.392	0.714	114.673	0.092	13.376	2.372
Worse ear 35+ dB HL	q3	crLW4K45	2	0.443	0.070	1.333	0.811	103.701	0.092	12.770	2.372
Worse ear 35+ dB HL	2q3	crLW4K45	2	0.248	0.021	1.361	1.360	61.254	0.092	10.196	2.372
Worse ear 35+ dB HL	max3	crLW4K45	2	0.440	0.070	1.327	0.814	103.162	0.092	12.749	2.372
Worse ear 35+ dB HL	2max3	crLW4K45	2	0.265	0.026	1.310	1.284	64.842	0.092	10.442	2.372
Worse ear 35+ dB HL	h	crLW4K45	2	0.443	0.070	1.333	0.811	103.701	0.092	12.770	2.372
Worse ear 35+ dB HL	h2	crLW4K45	2	0.248	0.021	1.361	1.360	61.254	0.092	10.196	2.372
Worse ear 35+ dB HL	q12	crLW4K45	2	0.493	0.079	1.392	0.714	114.673	0.092	13.376	2.372
Worse ear 35+ dB HL	q1o2	crLW4K45	2	0.499	0.087	1.358	0.682	116.101	0.092	13.573	2.372
Worse ear 35+ dB HL	q1	crLW4K40	2	0.548	0.109	1.352	0.555	127.076	0.092	14.422	2.372
Worse ear 35+ dB HL	q2	crLW4K40	2	0.542	0.102	1.378	0.582	125.705	0.092	14.230	2.372

continued

TABLE 57 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 35+ dB HL	q3	crLW4K40	2	0.492	0.087	1.342	0.692	114.554	0.092	13.509	2.372
Worse ear 35+ dB HL	2q3	crLW4K40	2	0.273	0.026	1.337	1.271	66.702	0.092	10.513	2.372
Worse ear 35+ dB HL	max3	crLW4K40	2	0.489	0.087	1.334	0.695	113.951	0.092	13.485	2.372
Worse ear 35+ dB HL	2max3	crLW4K40	2	0.295	0.034	1.291	1.183	71.544	0.092	10.843	2.372
Worse ear 35+ dB HL	h	crLW4K40	2	0.492	0.087	1.342	0.692	114.554	0.092	13.509	2.372
Worse ear 35+ dB HL	h2	crLW4K40	2	0.273	0.026	1.337	1.271	66.702	0.092	10.513	2.372
Worse ear 35+ dB HL	q12	crLW4K40	2	0.536	0.100	1.374	0.595	124.378	0.092	14.142	2.372
Worse ear 35+ dB HL	q1o2	crLW4K40	2	0.554	0.111	1.357	0.542	128.403	0.092	14.510	2.372
Worse ear 35+ dB HL	q1	crLW4K35	2	0.666	0.130	1.555	0.349	152.672	0.092	15.809	2.372
Worse ear 35+ dB HL	q2	crLW4K35	2	0.643	0.125	1.518	0.393	147.577	0.092	15.509	2.372
Worse ear 35+ dB HL	q3	crLW4K35	2	0.587	0.107	1.459	0.511	135.252	0.092	14.706	2.372
Worse ear 35+ dB HL	2q3	crLW4K35	2	0.327	0.028	1.460	1.179	78.123	0.092	10.992	2.372
Worse ear 35+ dB HL	max3	crLW4K35	2	0.583	0.107	1.451	0.515	134.533	0.092	14.678	2.372
Worse ear 35+ dB HL	2max3	crLW4K35	2	0.354	0.038	1.406	1.076	84.226	0.092	11.408	2.372
Worse ear 35+ dB HL	h	crLW4K35	2	0.587	0.107	1.459	0.511	135.252	0.092	14.706	2.372
Worse ear 35+ dB HL	h2	crLW4K35	2	0.327	0.028	1.460	1.179	78.123	0.092	10.992	2.372
Worse ear 35+ dB HL	q12	crLW4K35	2	0.637	0.121	1.521	0.411	146.212	0.092	15.383	2.372
Worse ear 35+ dB HL	q1o2	crLW4K35	2	0.672	0.134	1.553	0.331	154.037	0.092	15.935	2.372
Worse ear 35+ dB HL	q1	crLW3K40	2	0.469	0.057	1.506	0.831	109.103	0.092	12.731	2.372
Worse ear 35+ dB HL	q2	crLW3K40	2	0.451	0.051	1.513	0.878	105.254	0.092	12.477	2.372
Worse ear 35+ dB HL	q3	crLW3K40	2	0.412	0.055	1.380	0.911	96.964	0.092	12.224	2.372
Worse ear 35+ dB HL	2q3	crLW3K40	2	0.254	0.024	1.308	1.317	62.449	0.092	10.313	2.372
Worse ear 35+ dB HL	max3	crLW3K40	2	0.410	0.055	1.374	0.914	96.461	0.092	12.205	2.372
Worse ear 35+ dB HL	2max3	crLW3K40	2	0.264	0.028	1.277	1.269	64.778	0.092	10.476	2.372
Worse ear 35+ dB HL	h	crLW3K40	2	0.412	0.055	1.380	0.911	96.964	0.092	12.224	2.372
Worse ear 35+ dB HL	h2	crLW3K40	2	0.254	0.024	1.308	1.317	62.449	0.092	10.313	2.372
Worse ear 35+ dB HL	q12	crLW3K40	2	0.451	0.049	1.531	0.888	105.216	0.092	12.439	2.372
Worse ear 35+ dB HL	q1o2	crLW3K40	2	0.469	0.059	1.489	0.823	109.141	0.092	12.769	2.372
Worse ear 35+ dB HL	q1	crLW3K35	2	0.530	0.074	1.526	0.687	122.558	0.092	13.573	2.372
Worse ear 35+ dB HL	q2	crLW3K35	2	0.507	0.068	1.508	0.737	117.398	0.092	13.269	2.372
Worse ear 35+ dB HL	q3	crLW3K35	2	0.474	0.064	1.455	0.793	110.273	0.092	12.919	2.372
Worse ear 35+ dB HL	2q3	crLW3K35	2	0.279	0.022	1.420	1.296	67.783	0.092	10.483	2.372
Worse ear 35+ dB HL	max3	crLW3K35	2	0.471	0.064	1.448	0.797	109.692	0.092	12.896	2.372
Worse ear 35+ dB HL	2max3	crLW3K35	2	0.289	0.028	1.352	1.231	70.133	0.092	10.684	2.372
Worse ear 35+ dB HL	h	crLW3K35	2	0.474	0.064	1.455	0.793	110.273	0.092	12.919	2.372
Worse ear 35+ dB HL	h2	crLW3K35	2	0.279	0.022	1.420	1.296	67.783	0.092	10.483	2.372
Worse ear 35+ dB HL	q12	crLW3K35	2	0.507	0.066	1.522	0.744	117.360	0.092	13.231	2.372

continued

TABLE 57 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 35+ dB HL	q1o2	crLW3K35	2	0.530	0.075	1.512	0.680	122.596	0.092	13.611	2.372
Worse ear 35+ dB HL	q1	crLW3K30	2	0.607	0.109	1.502	0.479	139.722	0.092	14.915	2.372
Worse ear 35+ dB HL	q2	crLW3K30	2	0.584	0.104	1.472	0.524	134.562	0.092	14.610	2.372
Worse ear 35+ dB HL	q3	crLW3K30	2	0.568	0.089	1.520	0.589	130.825	0.092	14.179	2.372
Worse ear 35+ dB HL	2q3	crLW3K30	2	0.313	0.022	1.520	1.246	75.186	0.092	10.770	2.372
Worse ear 35+ dB HL	max3	crLW3K30	2	0.564	0.089	1.511	0.594	130.129	0.092	14.152	2.372
Worse ear 35+ dB HL	2max3	crLW3K30	2	0.335	0.032	1.427	1.139	80.082	0.092	11.141	2.372
Worse ear 35+ dB HL	h	crLW3K30	2	0.568	0.087	1.531	0.595	130.789	0.092	14.143	2.372
Worse ear 35+ dB HL	h2	crLW3K30	2	0.297	0.022	1.473	1.269	71.672	0.092	10.634	2.372
Worse ear 35+ dB HL	q12	crLW3K30	2	0.584	0.100	1.493	0.535	134.487	0.092	14.536	2.372
Worse ear 35+ dB HL	q1o2	crLW3K30	2	0.607	0.113	1.482	0.469	139.796	0.092	14.989	2.372
Worse ear 35+ dB HL	q1	crLS4K45	2	0.522	0.085	1.428	0.658	121.065	0.092	13.732	2.372
Worse ear 35+ dB HL	q2	crLS4K45	2	0.517	0.078	1.463	0.690	119.701	0.092	13.539	2.372
Worse ear 35+ dB HL	q3	crLS4K45	2	0.466	0.068	1.406	0.788	108.694	0.092	12.930	2.372
Worse ear 35+ dB HL	2q3	crLS4K45	2	0.260	0.023	1.361	1.323	63.806	0.092	10.332	2.372
Worse ear 35+ dB HL	max3	crLS4K45	2	0.463	0.068	1.399	0.792	108.126	0.092	12.908	2.372
Worse ear 35+ dB HL	2max3	crLS4K45	2	0.288	0.026	1.378	1.248	69.842	0.092	10.637	2.372
Worse ear 35+ dB HL	h	crLS4K45	2	0.466	0.068	1.406	0.788	108.694	0.092	12.930	2.372
Worse ear 35+ dB HL	h2	crLS4K45	2	0.260	0.023	1.361	1.323	63.806	0.092	10.332	2.372
Worse ear 35+ dB HL	q12	crLS4K45	2	0.511	0.076	1.461	0.704	118.382	0.092	13.451	2.372
Worse ear 35+ dB HL	q1o2	crLS4K45	2	0.528	0.087	1.431	0.644	122.384	0.092	13.820	2.372
Worse ear 35+ dB HL	q1	crLS4K40	2	0.590	0.110	1.456	0.501	135.963	0.092	14.774	2.372
Worse ear 35+ dB HL	q2	crLS4K40	2	0.584	0.100	1.492	0.534	134.556	0.092	14.545	2.372
Worse ear 35+ dB HL	q3	crLS4K40	2	0.533	0.093	1.409	0.621	123.603	0.092	13.972	2.372
Worse ear 35+ dB HL	2q3	crLS4K40	2	0.297	0.026	1.406	1.236	71.747	0.092	10.709	2.372
Worse ear 35+ dB HL	max3	crLS4K40	2	0.530	0.093	1.402	0.624	122.949	0.092	13.947	2.372
Worse ear 35+ dB HL	2max3	crLS4K40	2	0.325	0.036	1.347	1.128	77.888	0.092	11.128	2.372
Worse ear 35+ dB HL	h	crLS4K40	2	0.533	0.093	1.409	0.621	123.603	0.092	13.972	2.372
Worse ear 35+ dB HL	h2	crLS4K40	2	0.297	0.026	1.406	1.236	71.747	0.092	10.709	2.372
Worse ear 35+ dB HL	q12	crLS4K40	2	0.578	0.098	1.487	0.547	133.229	0.092	14.457	2.372
Worse ear 35+ dB HL	q1o2	crLS4K40	2	0.596	0.112	1.461	0.488	137.290	0.092	14.862	2.372
Worse ear 35+ dB HL	q1	crLS4K35	2	0.672	0.140	1.527	0.319	154.086	0.092	16.045	2.372
Worse ear 35+ dB HL	q2	crLS4K35	2	0.648	0.132	1.496	0.367	148.955	0.092	15.708	2.372
Worse ear 35+ dB HL	q3	crLS4K35	2	0.592	0.117	1.424	0.478	136.673	0.092	14.941	2.372
Worse ear 35+ dB HL	2q3	crLS4K35	2	0.321	0.028	1.443	1.187	76.827	0.092	10.942	2.372
Worse ear 35+ dB HL	max3	crLS4K35	2	0.589	0.117	1.415	0.483	135.947	0.092	14.913	2.372
Worse ear 35+ dB HL	2max3	crLS4K35	2	0.348	0.040	1.365	1.072	82.977	0.092	11.397	2.372

continued

TABLE 57 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 35+ dB HL	h	crLS4K35	2	0.592	0.117	1.424	0.478	136.673	0.092	14.941	2.372
Worse ear 35+ dB HL	h2	crLS4K35	2	0.321	0.028	1.443	1.187	76.827	0.092	10.942	2.372
Worse ear 35+ dB HL	q12	crLS4K35	2	0.642	0.129	1.498	0.384	147.590	0.092	15.582	2.372
Worse ear 35+ dB HL	q1o2	crLS4K35	2	0.678	0.144	1.526	0.302	155.451	0.092	16.171	2.372
Worse ear 35+ dB HL	q1	crLS3K40	2	0.499	0.053	1.614	0.810	115.395	0.092	12.906	2.372
Worse ear 35+ dB HL	q2	crLS3K40	2	0.481	0.047	1.624	0.859	111.546	0.092	12.652	2.372
Worse ear 35+ dB HL	q3	crLS3K40	2	0.442	0.051	1.490	0.890	103.292	0.092	12.400	2.372
Worse ear 35+ dB HL	2q3	crLS3K40	2	0.272	0.021	1.433	1.324	66.241	0.092	10.390	2.372
Worse ear 35+ dB HL	max3	crLS3K40	2	0.440	0.051	1.484	0.893	102.753	0.092	12.379	2.372
Worse ear 35+ dB HL	2max3	crLS3K40	2	0.282	0.025	1.392	1.272	68.548	0.092	10.552	2.372
Worse ear 35+ dB HL	h	crLS3K40	2	0.442	0.051	1.490	0.890	103.292	0.092	12.400	2.372
Worse ear 35+ dB HL	h2	crLS3K40	2	0.272	0.021	1.433	1.324	66.241	0.092	10.390	2.372
Worse ear 35+ dB HL	q12	crLS3K40	2	0.481	0.045	1.644	0.869	111.508	0.092	12.614	2.372
Worse ear 35+ dB HL	q1o2	crLS3K40	2	0.499	0.055	1.596	0.801	115.433	0.092	12.944	2.372
Worse ear 35+ dB HL	q1	crLS3K35	2	0.561	0.066	1.658	0.676	128.918	0.092	13.680	2.372
Worse ear 35+ dB HL	q2	crLS3K35	2	0.537	0.061	1.643	0.728	123.758	0.092	13.375	2.372
Worse ear 35+ dB HL	q3	crLS3K35	2	0.504	0.057	1.594	0.786	116.670	0.092	13.026	2.372
Worse ear 35+ dB HL	2q3	crLS3K35	2	0.297	0.024	1.439	1.252	71.709	0.092	10.671	2.372
Worse ear 35+ dB HL	max3	crLS3K35	2	0.501	0.057	1.587	0.790	116.052	0.092	13.002	2.372
Worse ear 35+ dB HL	2max3	crLS3K35	2	0.313	0.030	1.393	1.183	75.325	0.092	10.921	2.372
Worse ear 35+ dB HL	h	crLS3K35	2	0.504	0.057	1.594	0.786	116.670	0.092	13.026	2.372
Worse ear 35+ dB HL	h2	crLS3K35	2	0.297	0.024	1.439	1.252	71.709	0.092	10.671	2.372
Worse ear 35+ dB HL	q12	crLS3K35	2	0.537	0.059	1.659	0.736	123.719	0.092	13.337	2.372
Worse ear 35+ dB HL	q1o2	crLS3K35	2	0.561	0.068	1.643	0.669	128.956	0.092	13.718	2.372
Worse ear 35+ dB HL	q1	crLS3K30	2	0.643	0.104	1.626	0.448	147.140	0.092	15.097	2.372
Worse ear 35+ dB HL	q2	crLS3K30	2	0.619	0.095	1.616	0.505	141.908	0.092	14.720	2.372
Worse ear 35+ dB HL	q3	crLS3K30	2	0.597	0.087	1.607	0.558	137.064	0.092	14.384	2.372
Worse ear 35+ dB HL	2q3	crLS3K30	2	0.343	0.026	1.535	1.172	81.537	0.092	11.088	2.372
Worse ear 35+ dB HL	max3	crLS3K30	2	0.594	0.087	1.598	0.562	136.332	0.092	14.356	2.372
Worse ear 35+ dB HL	2max3	crLS3K30	2	0.365	0.036	1.456	1.074	86.396	0.092	11.457	2.372
Worse ear 35+ dB HL	h	crLS3K30	2	0.597	0.085	1.618	0.564	137.027	0.092	14.348	2.372
Worse ear 35+ dB HL	h2	crLS3K30	2	0.326	0.026	1.490	1.195	78.022	0.092	10.952	2.372
Worse ear 35+ dB HL	q12	crLS3K30	2	0.619	0.091	1.639	0.517	141.833	0.092	14.646	2.372
Worse ear 35+ dB HL	q1o2	crLS3K30	2	0.643	0.108	1.605	0.437	147.214	0.092	15.171	2.372
Worse ear 35+ dB HL	q	cwarble	2	0.472	0.068	1.420	0.781	109.931	0.092	12.979	2.372
Worse ear 35+ dB HL	q	cwarble	2	0.466	0.061	1.465	0.818	108.495	0.092	12.781	2.372
Worse ear 35+ dB HL	q	cwarble	2	0.415	0.059	1.352	0.891	97.574	0.092	12.321	2.372

continued

TABLE 57 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Worse ear 35+ dB HL	2q	cwarble	2	0.249	0.022	1.328	1.341	61.445	0.092	10.239	2.372
Worse ear 35+ dB HL	max	cwarble	2	0.412	0.059	1.346	0.894	97.066	0.092	12.301	2.372
Worse ear 35+ dB HL	2max	cwarble	2	0.260	0.026	1.293	1.291	63.793	0.092	10.403	2.372
Worse ear 35+ dB HL	h	cwarble	2	0.415	0.059	1.352	0.891	97.574	0.092	12.321	2.372
Worse ear 35+ dB HL	h	cwarble	2	0.249	0.022	1.328	1.341	61.445	0.092	10.239	2.372
Worse ear 35+ dB HL	q1	cwarble	2	0.466	0.061	1.465	0.818	108.495	0.092	12.781	2.372
Worse ear 35+ dB HL	q1o	cwarble	2	0.472	0.068	1.420	0.781	109.931	0.092	12.979	2.372
Worse ear 35+ dB HL	q	csteady	2	0.502	0.055	1.605	0.797	116.115	0.092	12.969	2.372
Worse ear 35+ dB HL	q	csteady	2	0.496	0.049	1.642	0.831	114.717	0.092	12.810	2.372
Worse ear 35+ dB HL	q	csteady	2	0.445	0.045	1.554	0.915	103.795	0.092	12.313	2.372
Worse ear 35+ dB HL	2q	csteady	2	0.267	0.022	1.384	1.313	65.333	0.092	10.389	2.372
Worse ear 35+ dB HL	max	csteady	2	0.443	0.045	1.547	0.918	103.250	0.092	12.292	2.372
Worse ear 35+ dB HL	2max	csteady	2	0.284	0.026	1.366	1.254	68.947	0.092	10.603	2.372
Worse ear 35+ dB HL	h	csteady	2	0.445	0.045	1.554	0.915	103.795	0.092	12.313	2.372
Worse ear 35+ dB HL	h	csteady	2	0.267	0.022	1.384	1.313	65.333	0.092	10.389	2.372
Worse ear 35+ dB HL	q1	csteady	2	0.496	0.047	1.661	0.841	114.679	0.092	12.772	2.372
Worse ear 35+ dB HL	q1o	csteady	2	0.502	0.057	1.587	0.789	116.153	0.092	13.007	2.372
Worse ear 35+ dB HL	q1	cscr3540	2	0.483	0.053	1.575	0.829	112.109	0.092	12.778	2.372
Worse ear 35+ dB HL	q2	cscr3540	2	0.466	0.047	1.585	0.878	108.237	0.092	12.523	2.372
Worse ear 35+ dB HL	q3	cscr3540	2	0.427	0.051	1.450	0.910	99.914	0.092	12.269	2.372
Worse ear 35+ dB HL	2q3	cscr3540	2	0.249	0.022	1.328	1.341	61.445	0.092	10.239	2.372
Worse ear 35+ dB HL	max3	cscr3540	2	0.424	0.051	1.444	0.913	99.391	0.092	12.249	2.372
Worse ear 35+ dB HL	2max3	cscr3540	2	0.260	0.026	1.293	1.291	63.793	0.092	10.403	2.372
Worse ear 35+ dB HL	h	cscr3540	2	0.427	0.051	1.450	0.910	99.914	0.092	12.269	2.372
Worse ear 35+ dB HL	h2	cscr3540	2	0.249	0.022	1.328	1.341	61.445	0.092	10.239	2.372
Worse ear 35+ dB HL	q12	cscr3540	2	0.466	0.045	1.605	0.888	108.199	0.092	12.485	2.372
Worse ear 35+ dB HL	q1o2	cscr3540	2	0.483	0.055	1.558	0.821	112.147	0.092	12.816	2.372

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 58

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Sig benefit FAAF (SiN)		crLW4K45	1	0.727	0.201	1.442	0.116	93.274	0.177	14.221	4.571
Sig benefit FAAF (SiN)		crLW4K40	1	0.746	0.245	1.352	0.016	96.186	0.177	15.167	4.571
Sig benefit FAAF (SiN)		crLW4K35	1	0.804	0.422	1.052	–0.330	106.366	0.177	18.988	4.571
Sig benefit FAAF (SiN)		crLW3K40	1	0.665	0.501	0.424	–0.215	92.237	0.177	19.952	4.571
Sig benefit FAAF (SiN)		crLW3K35	1	0.714	0.541	0.463	–0.333	98.538	0.177	20.959	4.571
Sig benefit FAAF (SiN)		crLW3K30	1	0.804	0.594	0.618	–0.546	109.755	0.177	22.418	4.571
Sig benefit FAAF (SiN)		crLS4K45	1	0.718	0.202	1.413	0.128	92.268	0.177	14.197	4.571
Sig benefit FAAF (SiN)		crLS4K40	1	0.746	0.266	1.289	–0.018	96.694	0.177	15.593	4.571
Sig benefit FAAF (SiN)		crLS4K35	1	0.814	0.443	1.033	–0.374	107.850	0.177	19.449	4.571
Sig benefit FAAF (SiN)		crLS3K40	1	0.657	0.501	0.401	–0.203	91.257	0.177	19.914	4.571
Sig benefit FAAF (SiN)		crLS3K35	1	0.724	0.515	0.557	–0.315	99.126	0.177	20.482	4.571
Sig benefit FAAF (SiN)		crLS3K30	1	0.794	0.598	0.574	–0.534	108.770	0.177	22.456	4.571
Sig benefit FAAF (SiN)		cwarble	1	0.675	0.174	1.393	0.244	86.742	0.177	13.433	4.571
Sig benefit FAAF (SiN)		csteady	1	0.684	0.157	1.485	0.263	87.482	0.177	13.150	4.571
Sig benefit FAAF (SiN)		cscr3540	1	0.665	0.158	1.430	0.288	85.362	0.177	13.077	4.571
Sig benefit FAAF (SiN)	q1		0	0.815	0.557	0.753	–0.521	108.487	0.154	19.896	3.975
Sig benefit FAAF (SiN)	q2		0	0.781	0.527	0.707	–0.422	104.076	0.154	19.223	3.975
Sig benefit FAAF (SiN)	q3q4		0	0.700	0.437	0.682	–0.182	93.330	0.154	17.292	3.975
Sig benefit FAAF (SiN)	2q3q4		0	0.381	0.155	0.711	0.659	52.375	0.154	10.987	3.975
Sig benefit FAAF (SiN)	maxq34		0	0.700	0.437	0.682	–0.182	93.330	0.154	17.292	3.975
Sig benefit FAAF (SiN)	2maxq34		0	0.428	0.171	0.767	0.566	57.937	0.154	11.471	3.975
Sig benefit FAAF (SiN)	hear		0	0.700	0.426	0.710	–0.169	93.144	0.154	17.106	3.975
Sig benefit FAAF (SiN)	2hear		0	0.381	0.155	0.711	0.659	52.375	0.154	10.987	3.975
Sig benefit FAAF (SiN)	q12		0	0.781	0.522	0.720	–0.415	103.983	0.154	19.130	3.975
Sig benefit FAAF (SiN)	q1or2		0	0.815	0.563	0.740	–0.528	108.580	0.154	19.989	3.975
Sig benefit FAAF (SiN)	q1	crLW4K45	2	0.543	0.201	0.944	0.365	73.303	0.200	14.324	5.168
Sig benefit FAAF (SiN)	q2	crLW4K45	2	0.508	0.201	0.858	0.408	69.414	0.200	14.173	5.168
Sig benefit FAAF (SiN)	q3	crLW4K45	2	0.471	0.156	0.939	0.543	64.119	0.200	12.973	5.168
Sig benefit FAAF (SiN)	2q3	crLW4K45	2	0.294	0.044	1.170	1.125	41.665	0.200	9.666	5.168
Sig benefit FAAF (SiN)	max3	crLW4K45	2	0.471	0.156	0.939	0.543	64.119	0.200	12.973	5.168
Sig benefit FAAF (SiN)	2max3	crLW4K45	2	0.322	0.044	1.249	1.086	44.817	0.200	9.788	5.168
Sig benefit FAAF (SiN)	h	crLW4K45	2	0.471	0.156	0.939	0.543	64.119	0.200	12.973	5.168
Sig benefit FAAF (SiN)	h2	crLW4K45	2	0.294	0.044	1.170	1.125	41.665	0.200	9.666	5.168
Sig benefit FAAF (SiN)	q12	crLW4K45	2	0.508	0.201	0.858	0.408	69.414	0.200	14.173	5.168
Sig benefit FAAF (SiN)	q1o2	crLW4K45	2	0.543	0.201	0.944	0.365	73.303	0.200	14.324	5.168
Sig benefit FAAF (SiN)	q1	crLW4K40	2	0.561	0.239	0.862	0.278	76.206	0.200	15.262	5.168
Sig benefit FAAF (SiN)	q2	crLW4K40	2	0.526	0.245	0.758	0.313	72.438	0.200	15.232	5.168

continued

TABLE 58 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Sig benefit FAAF (SiN)	q3	crLW4K40	2	0.489	0.194	0.836	0.446	67.028	0.200	13.916	5.168
Sig benefit FAAF (SiN)	2q3	crLW4K40	2	0.294	0.063	0.991	1.036	42.101	0.200	10.102	5.168
Sig benefit FAAF (SiN)	max3	crLW4K40	2	0.489	0.194	0.836	0.446	67.028	0.200	13.916	5.168
Sig benefit FAAF (SiN)	2max3	crLW4K40	2	0.322	0.068	1.028	0.975	45.374	0.200	10.345	5.168
Sig benefit FAAF (SiN)	h	crLW4K40	2	0.489	0.194	0.836	0.446	67.028	0.200	13.916	5.168
Sig benefit FAAF (SiN)	h2	crLW4K40	2	0.294	0.063	0.991	1.036	42.101	0.200	10.102	5.168
Sig benefit FAAF (SiN)	q12	crLW4K40	2	0.526	0.239	0.775	0.321	72.317	0.200	15.111	5.168
Sig benefit FAAF (SiN)	q1o2	crLW4K40	2	0.561	0.245	0.845	0.269	76.327	0.200	15.383	5.168
Sig benefit FAAF (SiN)	q1	crLW4K35	2	0.619	0.312	0.793	0.093	84.481	0.200	17.178	5.168
Sig benefit FAAF (SiN)	q2	crLW4K35	2	0.585	0.304	0.729	0.150	80.392	0.200	16.827	5.168
Sig benefit FAAF (SiN)	q3	crLW4K35	2	0.547	0.250	0.794	0.278	74.914	0.200	15.444	5.168
Sig benefit FAAF (SiN)	2q3	crLW4K35	2	0.334	0.063	1.102	0.980	46.586	0.200	10.276	5.168
Sig benefit FAAF (SiN)	max3	crLW4K35	2	0.547	0.250	0.794	0.278	74.914	0.200	15.444	5.168
Sig benefit FAAF (SiN)	2max3	crLW4K35	2	0.371	0.068	1.161	0.909	50.924	0.200	10.560	5.168
Sig benefit FAAF (SiN)	h	crLW4K35	2	0.547	0.250	0.794	0.278	74.914	0.200	15.444	5.168
Sig benefit FAAF (SiN)	h2	crLW4K35	2	0.334	0.063	1.102	0.980	46.586	0.200	10.276	5.168
Sig benefit FAAF (SiN)	q12	crLW4K35	2	0.585	0.298	0.744	0.157	80.271	0.200	16.706	5.168
Sig benefit FAAF (SiN)	q1o2	crLW4K35	2	0.619	0.318	0.778	0.085	84.602	0.200	17.299	5.168
Sig benefit FAAF (SiN)	q1	crLW3K40	2	0.480	0.163	0.934	0.516	65.393	0.200	13.182	5.168
Sig benefit FAAF (SiN)	q2	crLW3K40	2	0.455	0.154	0.907	0.565	62.369	0.200	12.873	5.168
Sig benefit FAAF (SiN)	q3	crLW3K40	2	0.408	0.149	0.810	0.637	56.923	0.200	12.546	5.168
Sig benefit FAAF (SiN)	2q3	crLW3K40	2	0.285	0.058	1.008	1.072	40.915	0.200	9.940	5.168
Sig benefit FAAF (SiN)	max3	crLW3K40	2	0.408	0.149	0.810	0.637	56.923	0.200	12.546	5.168
Sig benefit FAAF (SiN)	2max3	crLW3K40	2	0.304	0.063	1.018	1.022	43.166	0.200	10.143	5.168
Sig benefit FAAF (SiN)	h	crLW3K40	2	0.408	0.149	0.810	0.637	56.923	0.200	12.546	5.168
Sig benefit FAAF (SiN)	h2	crLW3K40	2	0.285	0.058	1.008	1.072	40.915	0.200	9.940	5.168
Sig benefit FAAF (SiN)	q12	crLW3K40	2	0.455	0.149	0.930	0.577	62.248	0.200	12.752	5.168
Sig benefit FAAF (SiN)	q1o2	crLW3K40	2	0.480	0.168	0.912	0.505	65.514	0.200	13.303	5.168
Sig benefit FAAF (SiN)	q1	crLW3K35	2	0.529	0.203	0.906	0.380	71.798	0.200	14.293	5.168
Sig benefit FAAF (SiN)	q2	crLW3K35	2	0.495	0.194	0.851	0.439	67.709	0.200	13.943	5.168
Sig benefit FAAF (SiN)	q3	crLW3K35	2	0.457	0.171	0.841	0.528	62.940	0.200	13.269	5.168
Sig benefit FAAF (SiN)	2q3	crLW3K35	2	0.315	0.058	1.095	1.028	44.335	0.200	10.072	5.168
Sig benefit FAAF (SiN)	max3	crLW3K35	2	0.457	0.171	0.841	0.528	62.940	0.200	13.269	5.168
Sig benefit FAAF (SiN)	2max3	crLW3K35	2	0.334	0.063	1.102	0.980	46.586	0.200	10.276	5.168
Sig benefit FAAF (SiN)	h	crLW3K35	2	0.457	0.171	0.841	0.528	62.940	0.200	13.269	5.168
Sig benefit FAAF (SiN)	h2	crLW3K35	2	0.315	0.058	1.095	1.028	44.335	0.200	10.072	5.168
Sig benefit FAAF (SiN)	q12	crLW3K35	2	0.495	0.188	0.871	0.448	67.588	0.200	13.822	5.168

continued

TABLE 58 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Sig benefit FAAF (SiN)	q1o2	crLW3K35	2	0.529	0.208	0.887	0.370	71.919	0.200	14.414	5.168
Sig benefit FAAF (SiN)	q1	crLW3K30	2	0.619	0.256	0.960	0.177	83.153	0.200	15.890	5.168
Sig benefit FAAF (SiN)	q2	crLW3K30	2	0.585	0.247	0.898	0.235	79.064	0.200	15.540	5.168
Sig benefit FAAF (SiN)	q3	crLW3K30	2	0.547	0.210	0.923	0.344	73.974	0.200	14.545	5.168
Sig benefit FAAF (SiN)	2q3	crLW3K30	2	0.325	0.058	1.121	1.015	45.400	0.200	10.114	5.168
Sig benefit FAAF (SiN)	max3	crLW3K30	2	0.547	0.210	0.923	0.344	73.974	0.200	14.545	5.168
Sig benefit FAAF (SiN)	2max3	crLW3K30	2	0.362	0.063	1.178	0.942	49.738	0.200	10.398	5.168
Sig benefit FAAF (SiN)	h	crLW3K30	2	0.547	0.210	0.923	0.344	73.974	0.200	14.545	5.168
Sig benefit FAAF (SiN)	h2	crLW3K30	2	0.325	0.058	1.121	1.015	45.400	0.200	10.114	5.168
Sig benefit FAAF (SiN)	q12	crLW3K30	2	0.585	0.242	0.915	0.244	78.943	0.200	15.419	5.168
Sig benefit FAAF (SiN)	q1o2	crLW3K30	2	0.619	0.261	0.943	0.169	83.274	0.200	16.011	5.168
Sig benefit FAAF (SiN)	q1	crLS4K45	2	0.534	0.197	0.938	0.384	72.177	0.200	14.181	5.168
Sig benefit FAAF (SiN)	q2	crLS4K45	2	0.499	0.202	0.833	0.418	68.409	0.200	14.151	5.168
Sig benefit FAAF (SiN)	q3	crLS4K45	2	0.462	0.151	0.935	0.564	62.999	0.200	12.836	5.168
Sig benefit FAAF (SiN)	2q3	crLS4K45	2	0.294	0.049	1.117	1.099	41.780	0.200	9.781	5.168
Sig benefit FAAF (SiN)	max3	crLS4K45	2	0.462	0.151	0.935	0.564	62.999	0.200	12.836	5.168
Sig benefit FAAF (SiN)	2max3	crLS4K45	2	0.313	0.049	1.171	1.072	43.910	0.200	9.864	5.168
Sig benefit FAAF (SiN)	h	crLS4K45	2	0.462	0.151	0.935	0.564	62.999	0.200	12.836	5.168
Sig benefit FAAF (SiN)	h2	crLS4K45	2	0.294	0.049	1.117	1.099	41.780	0.200	9.781	5.168
Sig benefit FAAF (SiN)	q12	crLS4K45	2	0.499	0.197	0.852	0.428	68.288	0.200	14.030	5.168
Sig benefit FAAF (SiN)	q1o2	crLS4K45	2	0.534	0.202	0.919	0.375	72.298	0.200	14.302	5.168
Sig benefit FAAF (SiN)	q1	crLS4K40	2	0.562	0.260	0.797	0.244	76.770	0.200	15.744	5.168
Sig benefit FAAF (SiN)	q2	crLS4K40	2	0.527	0.261	0.710	0.287	72.886	0.200	15.598	5.168
Sig benefit FAAF (SiN)	q3	crLS4K40	2	0.490	0.215	0.763	0.408	67.592	0.200	14.399	5.168
Sig benefit FAAF (SiN)	2q3	crLS4K40	2	0.294	0.063	0.991	1.036	42.101	0.200	10.102	5.168
Sig benefit FAAF (SiN)	max3	crLS4K40	2	0.490	0.215	0.763	0.408	67.592	0.200	14.399	5.168
Sig benefit FAAF (SiN)	2max3	crLS4K40	2	0.323	0.074	0.990	0.955	45.538	0.200	10.468	5.168
Sig benefit FAAF (SiN)	h	crLS4K40	2	0.490	0.215	0.763	0.408	67.592	0.200	14.399	5.168
Sig benefit FAAF (SiN)	h2	crLS4K40	2	0.294	0.063	0.991	1.036	42.101	0.200	10.102	5.168
Sig benefit FAAF (SiN)	q12	crLS4K40	2	0.527	0.255	0.726	0.295	72.765	0.200	15.477	5.168
Sig benefit FAAF (SiN)	q1o2	crLS4K40	2	0.562	0.266	0.781	0.235	76.891	0.200	15.865	5.168
Sig benefit FAAF (SiN)	q1	crLS4K35	2	0.629	0.333	0.759	0.051	86.020	0.200	17.693	5.168
Sig benefit FAAF (SiN)	q2	crLS4K35	2	0.594	0.319	0.708	0.115	81.815	0.200	17.226	5.168
Sig benefit FAAF (SiN)	q3	crLS4K35	2	0.557	0.271	0.753	0.234	76.453	0.200	15.959	5.168
Sig benefit FAAF (SiN)	2q3	crLS4K35	2	0.334	0.063	1.102	0.980	46.586	0.200	10.276	5.168
Sig benefit FAAF (SiN)	max3	crLS4K35	2	0.557	0.271	0.753	0.234	76.453	0.200	15.959	5.168
Sig benefit FAAF (SiN)	2max3	crLS4K35	2	0.372	0.074	1.123	0.888	51.088	0.200	10.683	5.168

continued

TABLE 58 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Sig benefit FAAF (SiN)	h	crLS4K35	2	0.557	0.271	0.753	0.234	76.453	0.200	15.959	5.168
Sig benefit FAAF (SiN)	h2	crLS4K35	2	0.334	0.063	1.102	0.980	46.586	0.200	10.276	5.168
Sig benefit FAAF (SiN)	q12	crLS4K35	2	0.594	0.314	0.723	0.123	81.694	0.200	17.105	5.168
Sig benefit FAAF (SiN)	q1o2	crLS4K35	2	0.629	0.339	0.745	0.044	86.141	0.200	17.814	5.168
Sig benefit FAAF (SiN)	q1	crLS3K40	2	0.472	0.163	0.912	0.527	64.413	0.200	13.144	5.168
Sig benefit FAAF (SiN)	q2	crLS3K40	2	0.447	0.154	0.885	0.576	61.389	0.200	12.835	5.168
Sig benefit FAAF (SiN)	q3	crLS3K40	2	0.400	0.149	0.788	0.648	55.943	0.200	12.508	5.168
Sig benefit FAAF (SiN)	2q3	crLS3K40	2	0.285	0.058	1.009	1.071	40.958	0.200	9.941	5.168
Sig benefit FAAF (SiN)	max3	crLS3K40	2	0.400	0.149	0.788	0.648	55.943	0.200	12.508	5.168
Sig benefit FAAF (SiN)	2max3	crLS3K40	2	0.304	0.063	1.019	1.022	43.208	0.200	10.145	5.168
Sig benefit FAAF (SiN)	h	crLS3K40	2	0.400	0.149	0.788	0.648	55.943	0.200	12.508	5.168
Sig benefit FAAF (SiN)	h2	crLS3K40	2	0.285	0.058	1.009	1.071	40.958	0.200	9.941	5.168
Sig benefit FAAF (SiN)	q12	crLS3K40	2	0.447	0.149	0.908	0.588	61.268	0.200	12.714	5.168
Sig benefit FAAF (SiN)	q1o2	crLS3K40	2	0.472	0.168	0.890	0.516	64.534	0.200	13.265	5.168
Sig benefit FAAF (SiN)	q1	crLS3K35	2	0.539	0.177	1.026	0.415	72.317	0.200	13.748	5.168
Sig benefit FAAF (SiN)	q2	crLS3K35	2	0.505	0.168	0.974	0.476	68.228	0.200	13.398	5.168
Sig benefit FAAF (SiN)	q3	crLS3K35	2	0.467	0.145	0.974	0.570	63.459	0.200	12.724	5.168
Sig benefit FAAF (SiN)	2q3	crLS3K35	2	0.325	0.058	1.121	1.015	45.400	0.200	10.114	5.168
Sig benefit FAAF (SiN)	max3	crLS3K35	2	0.467	0.145	0.974	0.570	63.459	0.200	12.724	5.168
Sig benefit FAAF (SiN)	2max3	crLS3K35	2	0.344	0.063	1.128	0.967	47.651	0.200	10.317	5.168
Sig benefit FAAF (SiN)	h	crLS3K35	2	0.467	0.145	0.974	0.570	63.459	0.200	12.724	5.168
Sig benefit FAAF (SiN)	h2	crLS3K35	2	0.325	0.058	1.121	1.015	45.400	0.200	10.114	5.168
Sig benefit FAAF (SiN)	q12	crLS3K35	2	0.505	0.162	0.996	0.487	68.107	0.200	13.277	5.168
Sig benefit FAAF (SiN)	q1o2	crLS3K35	2	0.539	0.182	1.006	0.405	72.438	0.200	13.869	5.168
Sig benefit FAAF (SiN)	q1	crLS3K30	2	0.610	0.260	0.922	0.183	82.178	0.200	15.940	5.168
Sig benefit FAAF (SiN)	q2	crLS3K30	2	0.575	0.246	0.877	0.249	77.973	0.200	15.473	5.168
Sig benefit FAAF (SiN)	q3	crLS3K30	2	0.537	0.209	0.904	0.358	72.879	0.200	14.473	5.168
Sig benefit FAAF (SiN)	2q3	crLS3K30	2	0.334	0.063	1.101	0.980	46.543	0.200	10.274	5.168
Sig benefit FAAF (SiN)	max3	crLS3K30	2	0.537	0.209	0.904	0.358	72.879	0.200	14.473	5.168
Sig benefit FAAF (SiN)	2max3	crLS3K30	2	0.362	0.068	1.136	0.921	49.859	0.200	10.519	5.168
Sig benefit FAAF (SiN)	h	crLS3K30	2	0.537	0.209	0.904	0.358	72.879	0.200	14.473	5.168
Sig benefit FAAF (SiN)	h2	crLS3K30	2	0.334	0.063	1.101	0.980	46.543	0.200	10.274	5.168
Sig benefit FAAF (SiN)	q12	crLS3K30	2	0.575	0.240	0.895	0.258	77.852	0.200	15.352	5.168
Sig benefit FAAF (SiN)	q1o2	crLS3K30	2	0.610	0.265	0.906	0.175	82.299	0.200	16.061	5.168
Sig benefit FAAF (SiN)	q	cwarble	2	0.490	0.174	0.915	0.483	66.698	0.200	13.464	5.168
Sig benefit FAAF (SiN)	q	cwarble	2	0.455	0.174	0.829	0.526	62.809	0.200	13.313	5.168
Sig benefit FAAF (SiN)	q	cwarble	2	0.418	0.142	0.864	0.639	57.836	0.200	12.435	5.168

continued

TABLE 58 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Sig benefit FAAF (SiN)	2q	cwarble	2	0.285	0.053	1.053	1.094	40.800	0.200	9.825	5.168
Sig benefit FAAF (SiN)	max	cwarble	2	0.418	0.142	0.864	0.639	57.836	0.200	12.435	5.168
Sig benefit FAAF (SiN)	2max	cwarble	2	0.304	0.058	1.060	1.043	43.052	0.200	10.029	5.168
Sig benefit FAAF (SiN)	h	cwarble	2	0.418	0.142	0.864	0.639	57.836	0.200	12.435	5.168
Sig benefit FAAF (SiN)	h	cwarble	2	0.285	0.053	1.053	1.094	40.800	0.200	9.825	5.168
Sig benefit FAAF (SiN)	q1	cwarble	2	0.455	0.174	0.829	0.526	62.809	0.200	13.313	5.168
Sig benefit FAAF (SiN)	q1o	cwarble	2	0.490	0.174	0.915	0.483	66.698	0.200	13.464	5.168
Sig benefit FAAF (SiN)	q	csteady	2	0.499	0.152	1.026	0.515	67.275	0.200	13.017	5.168
Sig benefit FAAF (SiN)	q	csteady	2	0.465	0.157	0.918	0.547	63.506	0.200	12.987	5.168
Sig benefit FAAF (SiN)	q	csteady	2	0.427	0.121	0.988	0.678	58.417	0.200	11.992	5.168
Sig benefit FAAF (SiN)	2q	csteady	2	0.294	0.058	1.035	1.058	41.980	0.200	9.981	5.168
Sig benefit FAAF (SiN)	max	csteady	2	0.427	0.121	0.988	0.678	58.417	0.200	11.992	5.168
Sig benefit FAAF (SiN)	2max	csteady	2	0.313	0.063	1.044	1.009	44.231	0.200	10.184	5.168
Sig benefit FAAF (SiN)	h	csteady	2	0.427	0.121	0.988	0.678	58.417	0.200	11.992	5.168
Sig benefit FAAF (SiN)	h	csteady	2	0.294	0.058	1.035	1.058	41.980	0.200	9.981	5.168
Sig benefit FAAF (SiN)	q1	csteady	2	0.465	0.152	0.940	0.558	63.385	0.200	12.866	5.168
Sig benefit FAAF (SiN)	q1o	csteady	2	0.499	0.157	1.004	0.504	67.396	0.200	13.138	5.168
Sig benefit FAAF (SiN)	q1	cscr3540	2	0.480	0.152	0.977	0.537	65.156	0.200	12.945	5.168
Sig benefit FAAF (SiN)	q2	cscr3540	2	0.455	0.144	0.952	0.588	62.132	0.200	12.636	5.168
Sig benefit FAAF (SiN)	q3	cscr3540	2	0.408	0.138	0.856	0.660	56.686	0.200	12.309	5.168
Sig benefit FAAF (SiN)	2q3	cscr3540	2	0.285	0.052	1.056	1.096	40.794	0.200	9.819	5.168
Sig benefit FAAF (SiN)	max3	cscr3540	2	0.408	0.138	0.856	0.660	56.686	0.200	12.309	5.168
Sig benefit FAAF (SiN)	2max3	cscr3540	2	0.304	0.058	1.062	1.044	43.045	0.200	10.022	5.168
Sig benefit FAAF (SiN)	h	cscr3540	2	0.408	0.138	0.856	0.660	56.686	0.200	12.309	5.168
Sig benefit FAAF (SiN)	h2	cscr3540	2	0.285	0.052	1.056	1.096	40.794	0.200	9.819	5.168
Sig benefit FAAF (SiN)	q12	cscr3540	2	0.455	0.138	0.976	0.600	62.011	0.200	12.515	5.168
Sig benefit FAAF (SiN)	q1o2	cscr3540	2	0.480	0.158	0.955	0.526	65.277	0.200	13.066	5.168

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen and audiometric screen.

TABLE 59

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP use aid >69%		crLW4K45	1	0.554	0.166	1.104	0.416	123.921	0.086	14.350	2.208
GHABP use aid >69%		crLW4K40	1	0.595	0.196	1.098	0.308	132.903	0.086	15.193	2.208
GHABP use aid >69%		crLW4K35	1	0.768	0.284	1.303	–0.081	170.027	0.086	18.131	2.208
GHABP use aid >69%		crLW3K40	1	0.493	0.643	–0.383	–0.175	119.784	0.086	22.251	2.208
GHABP use aid >69%		crLW3K35	1	0.548	0.668	–0.314	–0.279	131.558	0.086	23.142	2.208
GHABP use aid >69%		crLW3K30	1	0.641	0.706	–0.179	–0.451	151.322	0.086	24.538	2.208
GHABP use aid >69%		crLS4K45	1	0.563	0.161	1.148	0.415	125.622	0.086	14.328	2.208
GHABP use aid >69%		crLS4K40	1	0.602	0.227	1.005	0.245	134.764	0.086	15.801	2.208
GHABP use aid >69%		crLS4K35	1	0.780	0.308	1.273	–0.135	172.809	0.086	18.640	2.208
GHABP use aid >69%		crLS3K40	1	0.499	0.627	–0.326	–0.161	120.763	0.086	22.023	2.208
GHABP use aid >69%		crLS3K35	1	0.532	0.668	–0.356	–0.258	128.151	0.086	23.010	2.208
GHABP use aid >69%		crLS3K30	1	0.622	0.729	–0.299	–0.461	147.864	0.086	24.804	2.208
GHABP use aid >69%		cwarble	1	0.510	0.141	1.101	0.526	114.277	0.086	13.542	2.208
GHABP use aid >69%		csteady	1	0.496	0.149	1.030	0.526	111.555	0.086	13.572	2.208
GHABP use aid >69%		cscr3540	1	0.488	0.136	1.066	0.564	109.709	0.086	13.289	2.208
GHABP use aid >69%	q1		0	0.764	0.502	0.716	–0.362	171.128	0.074	20.067	1.920
GHABP use aid >69%	q2		0	0.743	0.457	0.760	–0.271	166.034	0.074	19.209	1.920
GHABP use aid >69%	q3q4		0	0.631	0.405	0.574	–0.047	142.211	0.074	17.525	1.920
GHABP use aid >69%	2q3q4		0	0.308	0.144	0.564	0.782	71.920	0.074	10.954	1.920
GHABP use aid >69%	maxq34		0	0.631	0.405	0.574	–0.047	142.211	0.074	17.525	1.920
GHABP use aid >69%	2maxq34		0	0.343	0.168	0.560	0.684	79.479	0.074	11.600	1.920
GHABP use aid >69%	hear		0	0.625	0.397	0.579	–0.028	140.882	0.074	17.356	1.920
GHABP use aid >69%	2hear		0	0.308	0.144	0.564	0.782	71.920	0.074	10.954	1.920
GHABP use aid >69%	q12		0	0.737	0.457	0.742	–0.262	164.827	0.074	19.162	1.920
GHABP use aid >69%	q1or2		0	0.770	0.502	0.735	–0.371	172.334	0.074	20.114	1.920
GHABP use aid >69%	q1	crLW4K45	2	0.438	0.166	0.813	0.561	101.204	0.097	14.514	2.496
GHABP use aid >69%	q2	crLW4K45	2	0.417	0.166	0.758	0.589	96.771	0.097	14.342	2.496
GHABP use aid >69%	q3	crLW4K45	2	0.362	0.141	0.724	0.715	84.967	0.097	13.393	2.496
GHABP use aid >69%	2q3	crLW4K45	2	0.209	0.031	1.052	1.335	51.381	0.097	9.997	2.496
GHABP use aid >69%	max3	crLW4K45	2	0.362	0.141	0.724	0.715	84.967	0.097	13.393	2.496
GHABP use aid >69%	2max3	crLW4K45	2	0.227	0.031	1.112	1.305	54.974	0.097	10.136	2.496
GHABP use aid >69%	h	crLW4K45	2	0.362	0.141	0.724	0.715	84.967	0.097	13.393	2.496
GHABP use aid >69%	h2	crLW4K45	2	0.209	0.031	1.052	1.335	51.381	0.097	9.997	2.496
GHABP use aid >69%	q12	crLW4K45	2	0.417	0.166	0.758	0.589	96.771	0.097	14.342	2.496
GHABP use aid >69%	q1o2	crLW4K45	2	0.438	0.166	0.813	0.561	101.204	0.097	14.514	2.496
GHABP use aid >69%	q1	crLW4K40	2	0.474	0.196	0.793	0.461	109.186	0.097	15.382	2.496
GHABP use aid >69%	q2	crLW4K40	2	0.459	0.196	0.754	0.480	105.986	0.097	15.258	2.496

continued

TABLE 59 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP use aid >69%	q3	crLW4K40	2	0.398	0.170	0.697	0.606	93.042	0.097	14.265	2.496
GHABP use aid >69%	2q3	crLW4K40	2	0.214	0.061	0.757	1.171	52.917	0.097	10.615	2.496
GHABP use aid >69%	max3	crLW4K40	2	0.398	0.170	0.697	0.606	93.042	0.097	14.265	2.496
GHABP use aid >69%	2max3	crLW4K40	2	0.237	0.061	0.835	1.133	57.695	0.097	10.800	2.496
GHABP use aid >69%	h	crLW4K40	2	0.398	0.170	0.697	0.606	93.042	0.097	14.265	2.496
GHABP use aid >69%	h2	crLW4K40	2	0.214	0.061	0.757	1.171	52.917	0.097	10.615	2.496
GHABP use aid >69%	q12	crLW4K40	2	0.453	0.196	0.739	0.488	104.780	0.097	15.211	2.496
GHABP use aid >69%	q1o2	crLW4K40	2	0.480	0.196	0.808	0.453	110.393	0.097	15.429	2.496
GHABP use aid >69%	q1	crLW4K35	2	0.532	0.284	0.651	0.245	122.851	0.097	17.606	2.496
GHABP use aid >69%	q2	crLW4K35	2	0.517	0.263	0.676	0.296	119.229	0.097	17.060	2.496
GHABP use aid >69%	q3	crLW4K35	2	0.456	0.233	0.620	0.420	106.195	0.097	15.978	2.496
GHABP use aid >69%	2q3	crLW4K35	2	0.239	0.061	0.839	1.130	57.998	0.097	10.812	2.496
GHABP use aid >69%	max3	crLW4K35	2	0.456	0.233	0.620	0.420	106.195	0.097	15.978	2.496
GHABP use aid >69%	2max3	crLW4K35	2	0.262	0.077	0.791	1.033	63.095	0.097	11.316	2.496
GHABP use aid >69%	h	crLW4K35	2	0.456	0.233	0.620	0.420	106.195	0.097	15.978	2.496
GHABP use aid >69%	h2	crLW4K35	2	0.239	0.061	0.839	1.130	57.998	0.097	10.812	2.496
GHABP use aid >69%	q12	crLW4K35	2	0.511	0.263	0.661	0.303	118.022	0.097	17.013	2.496
GHABP use aid >69%	q1o2	crLW4K35	2	0.538	0.284	0.666	0.237	124.057	0.097	17.653	2.496
GHABP use aid >69%	q1	crLW3K40	2	0.372	0.144	0.736	0.693	87.173	0.097	13.546	2.496
GHABP use aid >69%	q2	crLW3K40	2	0.363	0.123	0.808	0.755	84.758	0.097	13.046	2.496
GHABP use aid >69%	q3	crLW3K40	2	0.312	0.144	0.571	0.776	74.740	0.097	13.064	2.496
GHABP use aid >69%	2q3	crLW3K40	2	0.196	0.061	0.695	1.202	49.296	0.097	10.475	2.496
GHABP use aid >69%	max3	crLW3K40	2	0.312	0.144	0.571	0.776	74.740	0.097	13.064	2.496
GHABP use aid >69%	2max3	crLW3K40	2	0.214	0.061	0.757	1.171	52.917	0.097	10.615	2.496
GHABP use aid >69%	h	crLW3K40	2	0.312	0.144	0.571	0.776	74.740	0.097	13.064	2.496
GHABP use aid >69%	h2	crLW3K40	2	0.196	0.061	0.695	1.202	49.296	0.097	10.475	2.496
GHABP use aid >69%	q12	crLW3K40	2	0.357	0.123	0.793	0.763	83.551	0.097	13.000	2.496
GHABP use aid >69%	q1o2	crLW3K40	2	0.378	0.144	0.751	0.686	88.380	0.097	13.593	2.496
GHABP use aid >69%	q1	crLW3K35	2	0.427	0.170	0.771	0.568	99.006	0.097	14.496	2.496
GHABP use aid >69%	q2	crLW3K35	2	0.412	0.149	0.819	0.632	95.384	0.097	13.950	2.496
GHABP use aid >69%	q3	crLW3K35	2	0.367	0.144	0.721	0.700	86.062	0.097	13.503	2.496
GHABP use aid >69%	2q3	crLW3K35	2	0.221	0.053	0.852	1.195	54.219	0.097	10.512	2.496
GHABP use aid >69%	max3	crLW3K35	2	0.367	0.144	0.721	0.700	86.062	0.097	13.503	2.496
GHABP use aid >69%	2max3	crLW3K35	2	0.239	0.053	0.910	1.166	57.839	0.097	10.653	2.496
GHABP use aid >69%	h	crLW3K35	2	0.367	0.144	0.721	0.700	86.062	0.097	13.503	2.496
GHABP use aid >69%	h2	crLW3K35	2	0.221	0.053	0.852	1.195	54.219	0.097	10.512	2.496
GHABP use aid >69%	q12	crLW3K35	2	0.406	0.149	0.804	0.640	94.178	0.097	13.903	2.496

continued

TABLE 59 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP use aid >69%	q1o2	crLW3K35	2	0.433	0.170	0.786	0.561	100.213	0.097	14.543	2.496
GHABP use aid >69%	q1	crLW3K30	2	0.520	0.207	0.867	0.383	118.856	0.097	15.977	2.496
GHABP use aid >69%	q2	crLW3K30	2	0.505	0.186	0.905	0.440	115.234	0.097	15.431	2.496
GHABP use aid >69%	q3	crLW3K30	2	0.444	0.182	0.770	0.525	102.711	0.097	14.860	2.496
GHABP use aid >69%	2q3	crLW3K30	2	0.227	0.053	0.872	1.185	55.426	0.097	10.559	2.496
GHABP use aid >69%	max3	crLW3K30	2	0.444	0.182	0.770	0.525	102.711	0.097	14.860	2.496
GHABP use aid >69%	2max3	crLW3K30	2	0.250	0.069	0.813	1.080	60.523	0.097	11.063	2.496
GHABP use aid >69%	h	crLW3K30	2	0.444	0.182	0.770	0.525	102.711	0.097	14.860	2.496
GHABP use aid >69%	h2	crLW3K30	2	0.227	0.053	0.872	1.185	55.426	0.097	10.559	2.496
GHABP use aid >69%	q12	crLW3K30	2	0.499	0.186	0.890	0.448	114.027	0.097	15.384	2.496
GHABP use aid >69%	q1o2	crLW3K30	2	0.526	0.207	0.882	0.375	120.062	0.097	16.024	2.496
GHABP use aid >69%	q1	crLS4K45	2	0.442	0.161	0.843	0.568	101.826	0.097	14.438	2.496
GHABP use aid >69%	q2	crLS4K45	2	0.426	0.161	0.804	0.587	98.626	0.097	14.314	2.496
GHABP use aid >69%	q3	crLS4K45	2	0.366	0.136	0.758	0.721	85.681	0.097	13.321	2.496
GHABP use aid >69%	2q3	crLS4K45	2	0.214	0.039	0.966	1.276	52.494	0.097	10.193	2.496
GHABP use aid >69%	max3	crLS4K45	2	0.366	0.136	0.758	0.721	85.681	0.097	13.321	2.496
GHABP use aid >69%	2max3	crLS4K45	2	0.226	0.047	0.918	1.212	55.067	0.097	10.446	2.496
GHABP use aid >69%	h	crLS4K45	2	0.366	0.136	0.758	0.721	85.681	0.097	13.321	2.496
GHABP use aid >69%	h2	crLS4K45	2	0.214	0.039	0.966	1.276	52.494	0.097	10.193	2.496
GHABP use aid >69%	q12	crLS4K45	2	0.421	0.161	0.789	0.595	97.419	0.097	14.267	2.496
GHABP use aid >69%	q1o2	crLS4K45	2	0.448	0.161	0.858	0.560	103.032	0.097	14.485	2.496
GHABP use aid >69%	q1	crLS4K40	2	0.481	0.227	0.699	0.398	111.120	0.097	16.063	2.496
GHABP use aid >69%	q2	crLS4K40	2	0.465	0.220	0.686	0.430	107.767	0.097	15.786	2.496
GHABP use aid >69%	q3	crLS4K40	2	0.405	0.202	0.595	0.538	94.975	0.097	14.945	2.496
GHABP use aid >69%	2q3	crLS4K40	2	0.214	0.061	0.757	1.171	52.917	0.097	10.615	2.496
GHABP use aid >69%	max3	crLS4K40	2	0.405	0.202	0.595	0.538	94.975	0.097	14.945	2.496
GHABP use aid >69%	2max3	crLS4K40	2	0.232	0.085	0.641	1.054	57.014	0.097	11.233	2.496
GHABP use aid >69%	h	crLS4K40	2	0.405	0.202	0.595	0.538	94.975	0.097	14.945	2.496
GHABP use aid >69%	h2	crLS4K40	2	0.214	0.061	0.757	1.171	52.917	0.097	10.615	2.496
GHABP use aid >69%	q12	crLS4K40	2	0.459	0.220	0.671	0.438	106.560	0.097	15.739	2.496
GHABP use aid >69%	q1o2	crLS4K40	2	0.487	0.227	0.714	0.390	112.326	0.097	16.109	2.496
GHABP use aid >69%	q1	crLS4K35	2	0.544	0.308	0.612	0.196	125.687	0.097	18.169	2.496
GHABP use aid >69%	q2	crLS4K35	2	0.528	0.279	0.657	0.257	121.912	0.097	17.470	2.496
GHABP use aid >69%	q3	crLS4K35	2	0.468	0.257	0.573	0.367	109.032	0.097	16.540	2.496
GHABP use aid >69%	2q3	crLS4K35	2	0.239	0.061	0.839	1.130	57.998	0.097	10.812	2.496
GHABP use aid >69%	max3	crLS4K35	2	0.468	0.257	0.573	0.367	109.032	0.097	16.540	2.496
GHABP use aid >69%	2max3	crLS4K35	2	0.262	0.085	0.738	1.006	63.303	0.097	11.477	2.496

continued

TABLE 59 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP use aid >69%	h	crLS4K35	2	0.468	0.257	0.573	0.367	109.032	0.097	16.540	2.496
GHABP use aid >69%	h2	crLS4K35	2	0.239	0.061	0.839	1.130	57.998	0.097	10.812	2.496
GHABP use aid >69%	q12	crLS4K35	2	0.522	0.279	0.642	0.265	120.706	0.097	17.423	2.496
GHABP use aid >69%	q1o2	crLS4K35	2	0.550	0.308	0.627	0.188	126.894	0.097	18.216	2.496
GHABP use aid >69%	q1	crLS3K40	2	0.378	0.129	0.823	0.721	88.116	0.097	13.282	2.496
GHABP use aid >69%	q2	crLS3K40	2	0.369	0.107	0.905	0.788	85.701	0.097	12.783	2.496
GHABP use aid >69%	q3	crLS3K40	2	0.318	0.129	0.660	0.803	75.683	0.097	12.800	2.496
GHABP use aid >69%	2q3	crLS3K40	2	0.208	0.045	0.884	1.255	51.398	0.097	10.256	2.496
GHABP use aid >69%	max3	crLS3K40	2	0.318	0.129	0.660	0.803	75.683	0.097	12.800	2.496
GHABP use aid >69%	2max3	crLS3K40	2	0.226	0.045	0.944	1.225	55.018	0.097	10.397	2.496
GHABP use aid >69%	h	crLS3K40	2	0.318	0.129	0.660	0.803	75.683	0.097	12.800	2.496
GHABP use aid >69%	h2	crLS3K40	2	0.208	0.045	0.884	1.255	51.398	0.097	10.256	2.496
GHABP use aid >69%	q12	crLS3K40	2	0.363	0.107	0.890	0.795	84.494	0.097	12.736	2.496
GHABP use aid >69%	q1o2	crLS3K40	2	0.384	0.129	0.839	0.713	89.323	0.097	13.329	2.496
GHABP use aid >69%	q1	crLS3K35	2	0.411	0.170	0.729	0.590	95.600	0.097	14.364	2.496
GHABP use aid >69%	q2	crLS3K35	2	0.395	0.149	0.776	0.654	91.978	0.097	13.818	2.496
GHABP use aid >69%	q3	crLS3K35	2	0.350	0.144	0.677	0.723	82.655	0.097	13.371	2.496
GHABP use aid >69%	2q3	crLS3K35	2	0.227	0.053	0.872	1.185	55.426	0.097	10.559	2.496
GHABP use aid >69%	max3	crLS3K35	2	0.350	0.144	0.677	0.723	82.655	0.097	13.371	2.496
GHABP use aid >69%	2max3	crLS3K35	2	0.245	0.061	0.858	1.121	59.205	0.097	10.859	2.496
GHABP use aid >69%	h	crLS3K35	2	0.350	0.144	0.677	0.723	82.655	0.097	13.371	2.496
GHABP use aid >69%	h2	crLS3K35	2	0.227	0.053	0.872	1.185	55.426	0.097	10.559	2.496
GHABP use aid >69%	q12	crLS3K35	2	0.389	0.149	0.761	0.661	90.771	0.097	13.771	2.496
GHABP use aid >69%	q1o2	crLS3K35	2	0.417	0.170	0.744	0.582	96.806	0.097	14.411	2.496
GHABP use aid >69%	q1	crLS3K30	2	0.502	0.231	0.740	0.366	115.452	0.097	16.298	2.496
GHABP use aid >69%	q2	crLS3K30	2	0.486	0.202	0.799	0.435	111.677	0.097	15.599	2.496
GHABP use aid >69%	q3	crLS3K30	2	0.426	0.197	0.664	0.520	99.148	0.097	15.022	2.496
GHABP use aid >69%	2q3	crLS3K30	2	0.233	0.061	0.820	1.140	56.743	0.097	10.763	2.496
GHABP use aid >69%	max3	crLS3K30	2	0.426	0.197	0.664	0.520	99.148	0.097	15.022	2.496
GHABP use aid >69%	2max3	crLS3K30	2	0.250	0.077	0.755	1.051	60.682	0.097	11.222	2.496
GHABP use aid >69%	h	crLS3K30	2	0.426	0.197	0.664	0.520	99.148	0.097	15.022	2.496
GHABP use aid >69%	h2	crLS3K30	2	0.233	0.061	0.820	1.140	56.743	0.097	10.763	2.496
GHABP use aid >69%	q12	crLS3K30	2	0.480	0.202	0.785	0.442	110.470	0.097	15.552	2.496
GHABP use aid >69%	q1o2	crLS3K30	2	0.507	0.231	0.754	0.359	116.659	0.097	16.345	2.496
GHABP use aid >69%	q	cwarble	2	0.394	0.141	0.807	0.673	91.502	0.097	13.646	2.496
GHABP use aid >69%	q	cwarble	2	0.372	0.141	0.751	0.701	87.069	0.097	13.474	2.496
GHABP use aid >69%	q	cwarble	2	0.333	0.115	0.768	0.816	78.484	0.097	12.650	2.496

continued

TABLE 59 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP use aid >69%	2q	cwarble	2	0.198	0.053	0.770	1.236	49.376	0.097	10.325	2.496
GHABP use aid >69%	max	cwarble	2	0.333	0.115	0.768	0.816	78.484	0.097	12.650	2.496
GHABP use aid >69%	2max	cwarble	2	0.215	0.053	0.832	1.204	53.017	0.097	10.466	2.496
GHABP use aid >69%	h	cwarble	2	0.333	0.115	0.768	0.816	78.484	0.097	12.650	2.496
GHABP use aid >69%	h	cwarble	2	0.198	0.053	0.770	1.236	49.376	0.097	10.325	2.496
GHABP use aid >69%	q1	cwarble	2	0.372	0.141	0.751	0.701	87.069	0.097	13.474	2.496
GHABP use aid >69%	q1o	cwarble	2	0.394	0.141	0.807	0.673	91.502	0.097	13.646	2.496
GHABP use aid >69%	q	csteady	2	0.375	0.149	0.722	0.681	87.731	0.097	13.653	2.496
GHABP use aid >69%	q	csteady	2	0.359	0.149	0.681	0.701	84.531	0.097	13.529	2.496
GHABP use aid >69%	q	csteady	2	0.314	0.123	0.676	0.822	74.786	0.097	12.660	2.496
GHABP use aid >69%	2q	csteady	2	0.208	0.053	0.807	1.217	51.551	0.097	10.409	2.496
GHABP use aid >69%	max	csteady	2	0.314	0.123	0.676	0.822	74.786	0.097	12.660	2.496
GHABP use aid >69%	2max	csteady	2	0.226	0.061	0.797	1.152	55.330	0.097	10.709	2.496
GHABP use aid >69%	h	csteady	2	0.314	0.123	0.676	0.822	74.786	0.097	12.660	2.496
GHABP use aid >69%	h	csteady	2	0.208	0.053	0.807	1.217	51.551	0.097	10.409	2.496
GHABP use aid >69%	q1	csteady	2	0.353	0.149	0.665	0.709	83.324	0.097	13.482	2.496
GHABP use aid >69%	q1o	csteady	2	0.381	0.149	0.737	0.673	88.937	0.097	13.700	2.496
GHABP use aid >69%	q1	cscr3540	2	0.367	0.136	0.756	0.719	85.856	0.097	13.342	2.496
GHABP use aid >69%	q2	cscr3540	2	0.357	0.115	0.833	0.783	83.440	0.097	12.842	2.496
GHABP use aid >69%	q3	cscr3540	2	0.306	0.136	0.591	0.802	73.422	0.097	12.860	2.496
GHABP use aid >69%	2q3	cscr3540	2	0.196	0.053	0.766	1.238	49.137	0.097	10.315	2.496
GHABP use aid >69%	max3	cscr3540	2	0.306	0.136	0.591	0.802	73.422	0.097	12.860	2.496
GHABP use aid >69%	2max3	cscr3540	2	0.214	0.053	0.828	1.207	52.757	0.097	10.456	2.496
GHABP use aid >69%	h	cscr3540	2	0.306	0.136	0.591	0.802	73.422	0.097	12.860	2.496
GHABP use aid >69%	h2	cscr3540	2	0.196	0.053	0.766	1.238	49.137	0.097	10.315	2.496
GHABP use aid >69%	q12	cscr3540	2	0.351	0.115	0.818	0.791	82.234	0.097	12.795	2.496
GHABP use aid >69%	q1o2	cscr3540	2	0.373	0.136	0.772	0.711	87.062	0.097	13.388	2.496

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 60

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Any benefit FAAF (SiN)		crLW4K45	1	0.386	0.500	–0.289	0.145	85.761	0.101	18.834	2.614
Any benefit FAAF (SiN)		crLW4K40	1	0.418	0.556	–0.349	0.033	92.469	0.101	20.080	2.614
Any benefit FAAF (SiN)		crLW4K35	1	0.462	0.653	–0.487	–0.149	102.252	0.101	22.154	2.614
Any benefit FAAF (SiN)		crLW3K40	1	0.718	0.397	0.840	–0.158	143.771	0.101	19.268	2.614
Any benefit FAAF (SiN)		crLW3K35	1	0.753	0.456	0.796	–0.287	151.144	0.101	20.591	2.614
Any benefit FAAF (SiN)		crLW3K30	1	0.802	0.585	0.632	–0.532	162.257	0.101	23.300	2.614
Any benefit FAAF (SiN)		crLS4K45	1	0.377	0.528	–0.383	0.122	84.581	0.101	19.274	2.614
Any benefit FAAF (SiN)		crLS4K40	1	0.423	0.589	–0.419	–0.016	94.093	0.101	20.724	2.614
Any benefit FAAF (SiN)		crLS4K35	1	0.484	0.664	–0.463	–0.192	106.416	0.101	22.514	2.614
Any benefit FAAF (SiN)		crLS3K40	1	0.730	0.386	0.903	–0.161	145.652	0.101	19.150	2.614
Any benefit FAAF (SiN)		crLS3K35	1	0.750	0.442	0.819	–0.265	150.279	0.101	20.326	2.614
Any benefit FAAF (SiN)		crLS3K30	1	0.813	0.562	0.732	–0.521	163.784	0.101	22.944	2.614
Any benefit FAAF (SiN)		cwarble	1	0.345	0.450	–0.271	0.262	77.486	0.101	17.630	2.614
Any benefit FAAF (SiN)		csteady	1	0.353	0.432	–0.205	0.275	78.531	0.101	17.353	2.614
Any benefit FAAF (SiN)		cscr3540	1	0.360	0.386	–0.067	0.324	79.023	0.101	16.567	2.614
Any benefit FAAF (SiN)	q1		0	0.536	0.989	–2.203	–1.193	118.830	0.088	25.849	2.273
Any benefit FAAF (SiN)	q2		0	0.516	0.938	–1.502	–0.791	114.341	0.088	24.901	2.273
Any benefit FAAF (SiN)	q3q4		0	0.468	0.788	–0.882	–0.360	103.232	0.088	22.179	2.273
Any benefit FAAF (SiN)	2q3q4		0	0.227	0.353	–0.373	0.564	52.838	0.088	13.576	2.273
Any benefit FAAF (SiN)	maxq34		0	0.468	0.788	–0.882	–0.360	103.232	0.088	22.179	2.273
Any benefit FAAF (SiN)	2maxq34		0	0.227	0.440	–0.599	0.451	54.215	0.088	14.953	2.273
Any benefit FAAF (SiN)	hear		0	0.468	0.767	–0.809	–0.323	102.886	0.088	21.833	2.273
Any benefit FAAF (SiN)	2hear		0	0.227	0.353	–0.373	0.564	52.838	0.088	13.576	2.273
Any benefit FAAF (SiN)	q12		0	0.516	0.928	–1.418	–0.749	114.168	0.088	24.728	2.273
Any benefit FAAF (SiN)	q1or2		0	0.536	0.989	–2.198	–1.190	118.828	0.088	25.846	2.273
Any benefit FAAF (SiN)	q1	crLW4K45	2	0.275	0.500	–0.597	0.299	67.568	0.115	19.867	2.955
Any benefit FAAF (SiN)	q2	crLW4K45	2	0.275	0.471	–0.524	0.335	66.965	0.115	19.264	2.955
Any benefit FAAF (SiN)	q3	crLW4K45	2	0.240	0.402	–0.461	0.477	59.124	0.115	17.603	2.955
Any benefit FAAF (SiN)	2q3	crLW4K45	2	0.134	0.205	–0.282	0.965	36.064	0.115	12.786	2.955
Any benefit FAAF (SiN)	max3	crLW4K45	2	0.240	0.402	–0.461	0.477	59.124	0.115	17.603	2.955
Any benefit FAAF (SiN)	2max3	crLW4K45	2	0.134	0.237	–0.391	0.910	36.737	0.115	13.459	2.955
Any benefit FAAF (SiN)	h	crLW4K45	2	0.240	0.402	–0.461	0.477	59.124	0.115	17.603	2.955
Any benefit FAAF (SiN)	h2	crLW4K45	2	0.134	0.205	–0.282	0.965	36.064	0.115	12.786	2.955
Any benefit FAAF (SiN)	q12	crLW4K45	2	0.275	0.471	–0.524	0.335	66.965	0.115	19.264	2.955
Any benefit FAAF (SiN)	q1o2	crLW4K45	2	0.275	0.500	–0.597	0.299	67.568	0.115	19.867	2.955
Any benefit FAAF (SiN)	q1	crLW4K40	2	0.307	0.545	–0.619	0.196	74.185	0.115	21.021	2.955
Any benefit FAAF (SiN)	q2	crLW4K40	2	0.307	0.527	–0.573	0.218	73.813	0.115	20.650	2.955

continued

TABLE 60 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Any benefit FAAF (SiN)	q3	crLW4K40	2	0.271	0.449	–0.481	0.369	65.762	0.115	18.779	2.955
Any benefit FAAF (SiN)	2q3	crLW4K40	2	0.140	0.242	–0.382	0.890	37.859	0.115	13.600	2.955
Any benefit FAAF (SiN)	max3	crLW4K40	2	0.271	0.449	–0.481	0.369	65.762	0.115	18.779	2.955
Any benefit FAAF (SiN)	2max3	crLW4K40	2	0.140	0.285	–0.514	0.824	38.749	0.115	14.491	2.955
Any benefit FAAF (SiN)	h	crLW4K40	2	0.271	0.449	–0.481	0.369	65.762	0.115	18.779	2.955
Any benefit FAAF (SiN)	h2	crLW4K40	2	0.140	0.242	–0.382	0.890	37.859	0.115	13.600	2.955
Any benefit FAAF (SiN)	q12	crLW4K40	2	0.307	0.516	–0.546	0.232	73.588	0.115	20.425	2.955
Any benefit FAAF (SiN)	q1o2	crLW4K40	2	0.307	0.556	–0.646	0.182	74.410	0.115	21.246	2.955
Any benefit FAAF (SiN)	q1	crLW4K35	2	0.351	0.642	–0.745	0.010	84.198	0.115	23.325	2.955
Any benefit FAAF (SiN)	q2	crLW4K35	2	0.336	0.624	–0.738	0.054	81.122	0.115	22.849	2.955
Any benefit FAAF (SiN)	q3	crLW4K35	2	0.316	0.545	–0.594	0.183	75.775	0.115	21.083	2.955
Any benefit FAAF (SiN)	2q3	crLW4K35	2	0.164	0.242	–0.280	0.839	42.154	0.115	13.767	2.955
Any benefit FAAF (SiN)	max3	crLW4K35	2	0.316	0.545	–0.594	0.183	75.775	0.115	21.083	2.955
Any benefit FAAF (SiN)	2max3	crLW4K35	2	0.164	0.296	–0.444	0.757	43.270	0.115	14.882	2.955
Any benefit FAAF (SiN)	h	crLW4K35	2	0.316	0.545	–0.594	0.183	75.775	0.115	21.083	2.955
Any benefit FAAF (SiN)	h2	crLW4K35	2	0.164	0.242	–0.280	0.839	42.154	0.115	13.767	2.955
Any benefit FAAF (SiN)	q12	crLW4K35	2	0.336	0.613	–0.709	0.068	80.897	0.115	22.624	2.955
Any benefit FAAF (SiN)	q1o2	crLW4K35	2	0.351	0.653	–0.774	–0.005	84.423	0.115	23.550	2.955
Any benefit FAAF (SiN)	q1	crLW3K40	2	0.255	0.386	–0.369	0.475	61.537	0.115	17.365	2.955
Any benefit FAAF (SiN)	q2	crLW3K40	2	0.240	0.368	–0.369	0.522	58.461	0.115	16.889	2.955
Any benefit FAAF (SiN)	q3	crLW3K40	2	0.219	0.353	–0.398	0.576	54.433	0.115	16.441	2.955
Any benefit FAAF (SiN)	2q3	crLW3K40	2	0.117	0.242	–0.490	0.944	33.779	0.115	13.442	2.955
Any benefit FAAF (SiN)	max3	crLW3K40	2	0.219	0.353	–0.398	0.576	54.433	0.115	16.441	2.955
Any benefit FAAF (SiN)	2max3	crLW3K40	2	0.117	0.275	–0.591	0.893	34.454	0.115	14.117	2.955
Any benefit FAAF (SiN)	h	crLW3K40	2	0.219	0.353	–0.398	0.576	54.433	0.115	16.441	2.955
Any benefit FAAF (SiN)	h2	crLW3K40	2	0.117	0.242	–0.490	0.944	33.779	0.115	13.442	2.955
Any benefit FAAF (SiN)	q12	crLW3K40	2	0.240	0.357	–0.340	0.537	58.236	0.115	16.664	2.955
Any benefit FAAF (SiN)	q1o2	crLW3K40	2	0.255	0.397	–0.397	0.461	61.762	0.115	17.590	2.955
Any benefit FAAF (SiN)	q1	crLW3K35	2	0.290	0.445	–0.415	0.346	69.051	0.115	18.829	2.955
Any benefit FAAF (SiN)	q2	crLW3K35	2	0.275	0.427	–0.414	0.392	65.975	0.115	18.352	2.955
Any benefit FAAF (SiN)	q3	crLW3K35	2	0.254	0.377	–0.349	0.487	61.225	0.115	17.183	2.955
Any benefit FAAF (SiN)	2q3	crLW3K35	2	0.141	0.231	–0.341	0.905	37.850	0.115	13.384	2.955
Any benefit FAAF (SiN)	max3	crLW3K35	2	0.254	0.377	–0.349	0.487	61.225	0.115	17.183	2.955
Any benefit FAAF (SiN)	2max3	crLW3K35	2	0.141	0.264	–0.444	0.853	38.524	0.115	14.058	2.955
Any benefit FAAF (SiN)	h	crLW3K35	2	0.254	0.377	–0.349	0.487	61.225	0.115	17.183	2.955
Any benefit FAAF (SiN)	h2	crLW3K35	2	0.141	0.231	–0.341	0.905	37.850	0.115	13.384	2.955
Any benefit FAAF (SiN)	q12	crLW3K35	2	0.275	0.416	–0.386	0.405	65.750	0.115	18.127	2.955

continued

TABLE 60 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Any benefit FAAF (SiN)	q1o2	crLW3K35	2	0.290	0.456	–0.443	0.333	69.276	0.115	19.053	2.955
Any benefit FAAF (SiN)	q1	crLW3K30	2	0.338	0.574	–0.605	0.115	80.473	0.115	21.847	2.955
Any benefit FAAF (SiN)	q2	crLW3K30	2	0.323	0.556	–0.601	0.158	77.397	0.115	21.371	2.955
Any benefit FAAF (SiN)	q3	crLW3K30	2	0.303	0.478	–0.462	0.286	72.051	0.115	19.605	2.955
Any benefit FAAF (SiN)	2q3	crLW3K30	2	0.152	0.231	–0.292	0.880	39.890	0.115	13.463	2.955
Any benefit FAAF (SiN)	max3	crLW3K30	2	0.303	0.478	–0.462	0.286	72.051	0.115	19.605	2.955
Any benefit FAAF (SiN)	2max3	crLW3K30	2	0.152	0.285	–0.459	0.796	41.005	0.115	14.578	2.955
Any benefit FAAF (SiN)	h	crLW3K30	2	0.303	0.478	–0.462	0.286	72.051	0.115	19.605	2.955
Any benefit FAAF (SiN)	h2	crLW3K30	2	0.152	0.231	–0.292	0.880	39.890	0.115	13.463	2.955
Any benefit FAAF (SiN)	q12	crLW3K30	2	0.323	0.546	–0.573	0.172	77.172	0.115	21.146	2.955
Any benefit FAAF (SiN)	q1o2	crLW3K30	2	0.338	0.585	–0.633	0.101	80.698	0.115	22.072	2.955
Any benefit FAAF (SiN)	q1	crLS4K45	2	0.266	0.517	–0.667	0.292	66.229	0.115	20.148	2.955
Any benefit FAAF (SiN)	q2	crLS4K45	2	0.266	0.499	–0.622	0.314	65.858	0.115	19.777	2.955
Any benefit FAAF (SiN)	q3	crLS4K45	2	0.230	0.420	–0.537	0.470	57.807	0.115	17.906	2.955
Any benefit FAAF (SiN)	2q3	crLS4K45	2	0.140	0.213	–0.286	0.937	37.263	0.115	13.004	2.955
Any benefit FAAF (SiN)	max3	crLS4K45	2	0.230	0.420	–0.537	0.470	57.807	0.115	17.906	2.955
Any benefit FAAF (SiN)	2max3	crLS4K45	2	0.140	0.246	–0.394	0.884	37.937	0.115	13.679	2.955
Any benefit FAAF (SiN)	h	crLS4K45	2	0.230	0.420	–0.537	0.470	57.807	0.115	17.906	2.955
Any benefit FAAF (SiN)	h2	crLS4K45	2	0.140	0.213	–0.286	0.937	37.263	0.115	13.004	2.955
Any benefit FAAF (SiN)	q12	crLS4K45	2	0.266	0.488	–0.595	0.328	65.633	0.115	19.552	2.955
Any benefit FAAF (SiN)	q1o2	crLS4K45	2	0.266	0.528	–0.695	0.278	66.454	0.115	20.373	2.955
Any benefit FAAF (SiN)	q1	crLS4K40	2	0.312	0.578	–0.687	0.146	75.888	0.115	21.744	2.955
Any benefit FAAF (SiN)	q2	crLS4K40	2	0.307	0.560	–0.656	0.176	74.537	0.115	21.335	2.955
Any benefit FAAF (SiN)	q3	crLS4K40	2	0.277	0.482	–0.547	0.319	67.466	0.115	19.502	2.955
Any benefit FAAF (SiN)	2q3	crLS4K40	2	0.140	0.242	–0.382	0.890	37.859	0.115	13.600	2.955
Any benefit FAAF (SiN)	max3	crLS4K40	2	0.277	0.482	–0.547	0.319	67.466	0.115	19.502	2.955
Any benefit FAAF (SiN)	2max3	crLS4K40	2	0.140	0.297	–0.547	0.807	38.983	0.115	14.725	2.955
Any benefit FAAF (SiN)	h	crLS4K40	2	0.277	0.482	–0.547	0.319	67.466	0.115	19.502	2.955
Any benefit FAAF (SiN)	h2	crLS4K40	2	0.140	0.242	–0.382	0.890	37.859	0.115	13.600	2.955
Any benefit FAAF (SiN)	q12	crLS4K40	2	0.307	0.549	–0.629	0.190	74.313	0.115	21.110	2.955
Any benefit FAAF (SiN)	q1o2	crLS4K40	2	0.312	0.589	–0.714	0.132	76.113	0.115	21.969	2.955
Any benefit FAAF (SiN)	q1	crLS4K35	2	0.373	0.653	–0.717	–0.035	88.389	0.115	23.712	2.955
Any benefit FAAF (SiN)	q2	crLS4K35	2	0.353	0.635	–0.723	0.016	84.334	0.115	23.198	2.955
Any benefit FAAF (SiN)	q3	crLS4K35	2	0.338	0.556	–0.561	0.139	79.967	0.115	21.470	2.955
Any benefit FAAF (SiN)	2q3	crLS4K35	2	0.164	0.242	–0.280	0.839	42.154	0.115	13.767	2.955
Any benefit FAAF (SiN)	max3	crLS4K35	2	0.338	0.556	–0.561	0.139	79.967	0.115	21.470	2.955
Any benefit FAAF (SiN)	2max3	crLS4K35	2	0.164	0.308	–0.476	0.741	43.504	0.115	15.116	2.955
Any benefit FAAF (SiN)	h	crLS4K35	2	0.338	0.556	–0.561	0.139	79.967	0.115	21.470	2.955

continued

TABLE 60 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Any benefit FAAF (SiN)	h2	crLS4K35	2	0.164	0.242	–0.280	0.839	42.154	0.115	13.767	2.955
Any benefit FAAF (SiN)	q12	crLS4K35	2	0.353	0.624	–0.694	0.031	84.109	0.115	22.973	2.955
Any benefit FAAF (SiN)	q1o2	crLS4K35	2	0.373	0.664	–0.746	–0.050	88.614	0.115	23.937	2.955
Any benefit FAAF (SiN)	q1	crLS3K40	2	0.266	0.375	–0.305	0.471	63.393	0.115	17.221	2.955
Any benefit FAAF (SiN)	q2	crLS3K40	2	0.251	0.357	–0.303	0.518	60.316	0.115	16.745	2.955
Any benefit FAAF (SiN)	q3	crLS3K40	2	0.231	0.342	–0.330	0.571	56.289	0.115	16.297	2.955
Any benefit FAAF (SiN)	2q3	crLS3K40	2	0.134	0.231	–0.372	0.920	36.614	0.115	13.336	2.955
Any benefit FAAF (SiN)	max3	crLS3K40	2	0.231	0.342	–0.330	0.571	56.289	0.115	16.297	2.955
Any benefit FAAF (SiN)	2max3	crLS3K40	2	0.134	0.264	–0.475	0.868	37.289	0.115	14.010	2.955
Any benefit FAAF (SiN)	h	crLS3K40	2	0.231	0.342	–0.330	0.571	56.289	0.115	16.297	2.955
Any benefit FAAF (SiN)	h2	crLS3K40	2	0.134	0.231	–0.372	0.920	36.614	0.115	13.336	2.955
Any benefit FAAF (SiN)	q12	crLS3K40	2	0.251	0.346	–0.274	0.533	60.092	0.115	16.520	2.955
Any benefit FAAF (SiN)	q1o2	crLS3K40	2	0.266	0.386	–0.333	0.457	63.617	0.115	17.446	2.955
Any benefit FAAF (SiN)	q1	crLS3K35	2	0.286	0.432	–0.392	0.368	68.154	0.115	18.532	2.955
Any benefit FAAF (SiN)	q2	crLS3K35	2	0.271	0.414	–0.390	0.414	65.078	0.115	18.056	2.955
Any benefit FAAF (SiN)	q3	crLS3K35	2	0.251	0.364	–0.324	0.510	60.328	0.115	16.886	2.955
Any benefit FAAF (SiN)	2q3	crLS3K35	2	0.152	0.231	–0.292	0.880	39.890	0.115	13.463	2.955
Any benefit FAAF (SiN)	max3	crLS3K35	2	0.251	0.364	–0.324	0.510	60.328	0.115	16.886	2.955
Any benefit FAAF (SiN)	2max3	crLS3K35	2	0.152	0.275	–0.428	0.812	40.789	0.115	14.362	2.955
Any benefit FAAF (SiN)	h	crLS3K35	2	0.251	0.364	–0.324	0.510	60.328	0.115	16.886	2.955
Any benefit FAAF (SiN)	h2	crLS3K35	2	0.152	0.231	–0.292	0.880	39.890	0.115	13.463	2.955
Any benefit FAAF (SiN)	q12	crLS3K35	2	0.271	0.403	–0.362	0.428	64.853	0.115	17.831	2.955
Any benefit FAAF (SiN)	q1o2	crLS3K35	2	0.286	0.442	–0.419	0.354	68.379	0.115	18.757	2.955
Any benefit FAAF (SiN)	q1	crLS3K30	2	0.349	0.551	–0.515	0.130	81.943	0.115	21.435	2.955
Any benefit FAAF (SiN)	q2	crLS3K30	2	0.329	0.533	–0.526	0.181	77.888	0.115	20.920	2.955
Any benefit FAAF (SiN)	q3	crLS3K30	2	0.313	0.443	–0.344	0.314	73.296	0.115	18.967	2.955
Any benefit FAAF (SiN)	2q3	crLS3K30	2	0.158	0.242	–0.304	0.851	41.094	0.115	13.726	2.955
Any benefit FAAF (SiN)	max3	crLS3K30	2	0.313	0.443	–0.344	0.314	73.296	0.115	18.967	2.955
Any benefit FAAF (SiN)	2max3	crLS3K30	2	0.158	0.286	–0.438	0.784	41.993	0.115	14.625	2.955
Any benefit FAAF (SiN)	h	crLS3K30	2	0.313	0.443	–0.344	0.314	73.296	0.115	18.967	2.955
Any benefit FAAF (SiN)	h2	crLS3K30	2	0.158	0.242	–0.304	0.851	41.094	0.115	13.726	2.955
Any benefit FAAF (SiN)	q12	crLS3K30	2	0.329	0.522	–0.499	0.194	77.663	0.115	20.695	2.955
Any benefit FAAF (SiN)	q1o2	crLS3K30	2	0.349	0.562	–0.543	0.116	82.168	0.115	21.659	2.955
Any benefit FAAF (SiN)	q	cwarble	2	0.234	0.450	–0.598	0.425	59.173	0.115	18.543	2.955
Any benefit FAAF (SiN)	q	cwarble	2	0.234	0.420	–0.524	0.463	58.570	0.115	17.940	2.955
Any benefit FAAF (SiN)	q	cwarble	2	0.199	0.381	–0.544	0.574	51.332	0.115	16.881	2.955
Any benefit FAAF (SiN)	2q	cwarble	2	0.117	0.234	–0.463	0.957	33.607	0.115	13.270	2.955

continued

TABLE 60 *(cont'd)*

Any benefit FAAF (SiN)	max	cwarble	2	0.199	0.381	–0.544	0.574	51.332	0.115	16.881	2.955
Any benefit FAAF (SiN)	2max	cwarble	2	0.117	0.267	–0.566	0.905	34.289	0.115	13.952	2.955
Any benefit FAAF (SiN)	h	cwarble	2	0.199	0.381	–0.544	0.574	51.332	0.115	16.881	2.955
Any benefit FAAF (SiN)	h	cwarble	2	0.117	0.234	–0.463	0.957	33.607	0.115	13.270	2.955
Any benefit FAAF (SiN)	q1	cwarble	2	0.234	0.420	–0.524	0.463	58.570	0.115	17.940	2.955
Any benefit FAAF (SiN)	q1o	cwarble	2	0.234	0.450	–0.598	0.425	59.173	0.115	18.543	2.955
Any benefit FAAF (SiN)	q	csteady	2	0.242	0.421	–0.500	0.450	59.950	0.115	17.998	2.955
Any benefit FAAF (SiN)	q	csteady	2	0.242	0.403	–0.453	0.473	59.579	0.115	17.626	2.955
Any benefit FAAF (SiN)	q	csteady	2	0.206	0.353	–0.442	0.598	52.124	0.115	16.352	2.955
Any benefit FAAF (SiN)	2q	csteady	2	0.134	0.231	–0.372	0.920	36.614	0.115	13.336	2.955
Any benefit FAAF (SiN)	max	csteady	2	0.206	0.353	–0.442	0.598	52.124	0.115	16.352	2.955
Any benefit FAAF (SiN)	2max	csteady	2	0.134	0.275	–0.508	0.852	37.514	0.115	14.235	2.955
Any benefit FAAF (SiN)	h	csteady	2	0.206	0.353	–0.442	0.598	52.124	0.115	16.352	2.955
Any benefit FAAF (SiN)	h	csteady	2	0.134	0.231	–0.372	0.920	36.614	0.115	13.336	2.955
Any benefit FAAF (SiN)	q1	csteady	2	0.242	0.392	–0.425	0.487	59.354	0.115	17.401	2.955
Any benefit FAAF (SiN)	q1o	csteady	2	0.242	0.432	–0.527	0.436	60.175	0.115	18.223	2.955
Any benefit FAAF (SiN)	q1	cscr3540	2	0.249	0.375	–0.357	0.498	60.333	0.115	17.102	2.955
Any benefit FAAF (SiN)	q2	cscr3540	2	0.234	0.357	–0.357	0.546	57.257	0.115	16.626	2.955
Any benefit FAAF (SiN)	q3	cscr3540	2	0.214	0.342	–0.387	0.600	53.229	0.115	16.178	2.955
Any benefit FAAF (SiN)	2q3	cscr3540	2	0.117	0.231	–0.454	0.961	33.554	0.115	13.217	2.955
Any benefit FAAF (SiN)	max3	cscr3540	2	0.214	0.342	–0.387	0.600	53.229	0.115	16.178	2.955
Any benefit FAAF (SiN)	2max3	cscr3540	2	0.117	0.264	–0.558	0.910	34.229	0.115	13.892	2.955
Any benefit FAAF (SiN)	h	cscr3540	2	0.214	0.342	–0.387	0.600	53.229	0.115	16.178	2.955
Any benefit FAAF (SiN)	h2	cscr3540	2	0.117	0.231	–0.454	0.961	33.554	0.115	13.217	2.955
Any benefit FAAF (SiN)	q12	cscr3540	2	0.234	0.346	–0.328	0.560	57.032	0.115	16.401	2.955
Any benefit FAAF (SiN)	q1o2	cscr3540	2	0.249	0.386	–0.386	0.483	60.558	0.115	17.327	2.955

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 61

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Offered aid		crLW4K45	1	0.360	0.018	1.733	1.224	173.149	0.024	13.634	0.612
Offered aid		crLW4K40	1	0.444	0.024	1.834	1.059	211.497	0.024	15.181	0.612
Offered aid		crLW4K35	1	0.548	0.060	1.672	0.716	259.770	0.024	17.432	0.612
Offered aid		crLW3K40	1	0.305	0.018	1.580	1.300	147.653	0.024	12.645	0.612
Offered aid		crLW3K35	1	0.387	0.018	1.804	1.190	185.155	0.024	14.098	0.612
Offered aid		crLW3K30	1	0.483	0.074	1.403	0.745	230.105	0.024	16.427	0.612
Offered aid		crLS4K45	1	0.405	0.038	1.541	1.010	194.066	0.024	14.646	0.612
Offered aid		crLS4K40	1	0.483	0.037	1.737	0.912	229.568	0.024	16.022	0.612
Offered aid		crLS4K35	1	0.542	0.040	1.850	0.820	256.838	0.024	17.111	0.612
Offered aid		crLS3K40	1	0.325	0.018	1.637	1.271	157.038	0.024	13.010	0.612
Offered aid		crLS3K35	1	0.369	0.021	1.692	1.180	177.140	0.024	13.820	0.612
Offered aid		crLS3K30	1	0.512	0.066	1.539	0.739	243.475	0.024	16.858	0.612
Offered aid		cwarble	1	0.310	0.015	1.668	1.329	149.966	0.024	12.703	0.612
Offered aid		csteady	1	0.319	0.015	1.691	1.316	154.051	0.024	12.862	0.612
Offered aid		cscr3540	1	0.296	0.015	1.625	1.349	143.340	0.024	12.447	0.612
Offered aid	q1		0	0.716	0.250	1.246	0.051	337.543	0.021	20.584	0.532
Offered aid	q2		0	0.689	0.199	1.338	0.176	324.581	0.021	19.617	0.532
Offered aid	q3q4		0	0.581	0.147	1.255	0.422	274.449	0.021	17.198	0.532
Offered aid	2q3q4		0	0.254	0.030	1.223	1.274	122.630	0.021	10.240	0.532
Offered aid	maxq34		0	0.582	0.147	1.257	0.421	274.959	0.021	17.218	0.532
Offered aid	2maxq34		0	0.289	0.051	1.083	1.097	139.047	0.021	11.068	0.532
Offered aid	hear		0	0.573	0.129	1.316	0.474	270.487	0.021	16.879	0.532
Offered aid	2hear		0	0.254	0.021	1.364	1.344	122.551	0.021	10.161	0.532
Offered aid	q12		0	0.678	0.184	1.363	0.219	319.375	0.021	19.276	0.532
Offered aid	q1or2		0	0.727	0.265	1.232	0.011	342.748	0.021	20.925	0.532
Offered aid	q1	crLW4K45	2	0.341	0.018	1.680	1.250	165.731	0.027	14.885	0.692
Offered aid	q2	crLW4K45	2	0.327	0.018	1.643	1.269	159.474	0.027	14.642	0.692
Offered aid	q3	crLW4K45	2	0.290	0.018	1.536	1.322	142.128	0.027	13.970	0.692
Offered aid	2q3	crLW4K45	2	0.140	0.006	1.421	1.793	72.912	0.027	11.142	0.692
Offered aid	max3	crLW4K45	2	0.289	0.018	1.534	1.324	141.775	0.027	13.956	0.692
Offered aid	2max3	crLW4K45	2	0.150	0.012	1.216	1.644	77.828	0.027	11.404	0.692
Offered aid	h	crLW4K45	2	0.290	0.018	1.536	1.322	142.128	0.027	13.970	0.692
Offered aid	h2	crLW4K45	2	0.140	0.006	1.421	1.793	72.912	0.027	11.142	0.692
Offered aid	q12	crLW4K45	2	0.327	0.018	1.643	1.269	159.474	0.027	14.642	0.692
Offered aid	q1o2	crLW4K45	2	0.341	0.018	1.680	1.250	165.731	0.027	14.885	0.692
Offered aid	q1	crLW4K40	2	0.389	0.024	1.693	1.129	187.801	0.027	15.809	0.692
Offered aid	q2	crLW4K40	2	0.381	0.018	1.789	1.198	184.051	0.027	15.594	0.692

continued

TABLE 61 (cont'd)

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Offered aid	q3	crLW4K40	2	0.330	0.024	1.535	1.209	160.573	0.027	14.753	0.692
Offered aid	2q3	crLW4K40	2	0.161	0.003	1.748	1.865	82.678	0.027	11.484	0.692
Offered aid	max3	crLW4K40	2	0.329	0.024	1.533	1.210	160.171	0.027	14.738	0.692
Offered aid	2max3	crLW4K40	2	0.174	0.012	1.318	1.597	88.873	0.027	11.831	0.692
Offered aid	h	crLW4K40	2	0.330	0.024	1.535	1.209	160.573	0.027	14.753	0.692
Offered aid	h2	crLW4K40	2	0.161	0.003	1.748	1.865	82.678	0.027	11.484	0.692
Offered aid	q12	crLW4K40	2	0.375	0.018	1.774	1.205	181.489	0.027	15.495	0.692
Offered aid	q1o2	crLW4K40	2	0.394	0.024	1.708	1.122	190.363	0.027	15.908	0.692
Offered aid	q1	crLW4K35	2	0.470	0.027	1.850	0.999	225.441	0.027	17.305	0.692
Offered aid	q2	crLW4K35	2	0.457	0.021	1.920	1.068	219.232	0.027	16.994	0.692
Offered aid	q3	crLW4K35	2	0.401	0.027	1.673	1.088	193.315	0.027	16.059	0.692
Offered aid	2q3	crLW4K35	2	0.185	0.006	1.607	1.699	93.996	0.027	11.960	0.692
Offered aid	max3	crLW4K35	2	0.400	0.027	1.670	1.090	192.827	0.027	16.040	0.692
Offered aid	2max3	crLW4K35	2	0.204	0.015	1.340	1.497	102.722	0.027	12.404	0.692
Offered aid	h	crLW4K35	2	0.401	0.027	1.673	1.088	193.315	0.027	16.059	0.692
Offered aid	h2	crLW4K35	2	0.185	0.006	1.607	1.699	93.996	0.027	11.960	0.692
Offered aid	q12	crLW4K35	2	0.449	0.021	1.899	1.078	215.389	0.027	16.845	0.692
Offered aid	q1o2	crLW4K35	2	0.479	0.027	1.871	0.989	229.284	0.027	17.454	0.692
Offered aid	q1	crLW3K40	2	0.283	0.018	1.516	1.332	138.978	0.027	13.848	0.692
Offered aid	q2	crLW3K40	2	0.269	0.015	1.545	1.388	132.743	0.027	13.571	0.692
Offered aid	q3	crLW3K40	2	0.253	0.018	1.426	1.377	125.403	0.027	13.321	0.692
Offered aid	2q3	crLW3K40	2	0.147	0.006	1.454	1.776	76.357	0.027	11.276	0.692
Offered aid	max3	crLW3K40	2	0.253	0.018	1.424	1.378	125.094	0.027	13.309	0.692
Offered aid	2max3	crLW3K40	2	0.155	0.009	1.341	1.686	80.059	0.027	11.456	0.692
Offered aid	h	crLW3K40	2	0.253	0.018	1.426	1.377	125.403	0.027	13.321	0.692
Offered aid	h2	crLW3K40	2	0.147	0.006	1.454	1.776	76.357	0.027	11.276	0.692
Offered aid	q12	crLW3K40	2	0.267	0.015	1.537	1.392	131.462	0.027	13.521	0.692
Offered aid	q1o2	crLW3K40	2	0.286	0.018	1.524	1.328	140.259	0.027	13.897	0.692
Offered aid	q1	crLW3K35	2	0.334	0.018	1.665	1.260	162.731	0.027	14.767	0.692
Offered aid	q2	crLW3K35	2	0.318	0.015	1.690	1.318	155.215	0.027	14.441	0.692
Offered aid	q3	crLW3K35	2	0.294	0.018	1.551	1.317	144.221	0.027	14.050	0.692
Offered aid	2q3	crLW3K35	2	0.158	0.003	1.736	1.871	81.317	0.027	11.432	0.692
Offered aid	max3	crLW3K35	2	0.293	0.018	1.549	1.318	143.862	0.027	14.036	0.692
Offered aid	2max3	crLW3K35	2	0.169	0.006	1.543	1.731	86.286	0.027	11.661	0.692
Offered aid	h	crLW3K35	2	0.294	0.018	1.551	1.317	144.221	0.027	14.050	0.692
Offered aid	h2	crLW3K35	2	0.158	0.003	1.736	1.871	81.317	0.027	11.432	0.692
Offered aid	q12	crLW3K35	2	0.315	0.015	1.682	1.322	153.934	0.027	14.391	0.692

continued

TABLE 61 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Offered aid	q1o2	crLW3K35	2	0.337	0.018	1.672	1.256	164.012	0.027	14.817	0.692
Offered aid	q1	crLW3K30	2	0.416	0.024	1.761	1.093	200.406	0.027	16.299	0.692
Offered aid	q2	crLW3K30	2	0.400	0.021	1.774	1.141	192.890	0.027	15.973	0.692
Offered aid	q3	crLW3K30	2	0.360	0.033	1.485	1.102	174.599	0.027	15.398	0.692
Offered aid	2q3	crLW3K30	2	0.164	0.015	1.203	1.581	84.027	0.027	11.672	0.692
Offered aid	max3	crLW3K30	2	0.359	0.033	1.482	1.103	174.161	0.027	15.381	0.692
Offered aid	2max3	crLW3K30	2	0.182	0.021	1.136	1.474	92.806	0.027	12.084	0.692
Offered aid	h	crLW3K30	2	0.357	0.033	1.478	1.105	173.378	0.027	15.351	0.692
Offered aid	h2	crLW3K30	2	0.164	0.006	1.522	1.741	83.924	0.027	11.569	0.692
Offered aid	q12	crLW3K30	2	0.394	0.021	1.760	1.148	190.391	0.027	15.876	0.692
Offered aid	q1o2	crLW3K30	2	0.421	0.024	1.775	1.086	202.906	0.027	16.396	0.692
Offered aid	q1	crLS4K45	2	0.343	0.024	1.569	1.189	166.751	0.027	14.995	0.692
Offered aid	q2	crLS4K45	2	0.335	0.018	1.663	1.258	163.001	0.027	14.780	0.692
Offered aid	q3	crLS4K45	2	0.292	0.024	1.425	1.261	143.217	0.027	14.082	0.692
Offered aid	2q3	crLS4K45	2	0.147	0.006	1.455	1.775	76.523	0.027	11.282	0.692
Offered aid	max3	crLS4K45	2	0.291	0.024	1.423	1.262	142.862	0.027	14.068	0.692
Offered aid	2max3	crLS4K45	2	0.158	0.015	1.164	1.585	81.516	0.027	11.582	0.692
Offered aid	h	crLS4K45	2	0.292	0.024	1.425	1.261	143.217	0.027	14.082	0.692
Offered aid	h2	crLS4K45	2	0.147	0.006	1.455	1.775	76.523	0.027	11.282	0.692
Offered aid	q12	crLS4K45	2	0.329	0.018	1.647	1.265	160.440	0.027	14.680	0.692
Offered aid	q1o2	crLS4K45	2	0.349	0.024	1.584	1.181	169.313	0.027	15.094	0.692
Offered aid	q1	crLS4K40	2	0.408	0.024	1.742	1.104	196.732	0.027	16.156	0.692
Offered aid	q2	crLS4K40	2	0.397	0.018	1.831	1.176	191.763	0.027	15.894	0.692
Offered aid	q3	crLS4K40	2	0.357	0.024	1.609	1.170	173.277	0.027	15.247	0.692
Offered aid	2q3	crLS4K40	2	0.172	0.003	1.790	1.843	87.676	0.027	11.678	0.692
Offered aid	max3	crLS4K40	2	0.356	0.024	1.606	1.172	172.842	0.027	15.230	0.692
Offered aid	2max3	crLS4K40	2	0.191	0.012	1.379	1.565	96.482	0.027	12.126	0.692
Offered aid	h	crLS4K40	2	0.357	0.024	1.609	1.170	173.277	0.027	15.247	0.692
Offered aid	h2	crLS4K40	2	0.172	0.003	1.790	1.843	87.676	0.027	11.678	0.692
Offered aid	q12	crLS4K40	2	0.392	0.018	1.817	1.183	189.202	0.027	15.794	0.692
Offered aid	q1o2	crLS4K40	2	0.414	0.024	1.757	1.097	199.294	0.027	16.255	0.692
Offered aid	q1	crLS4K35	2	0.487	0.027	1.891	0.979	233.002	0.027	17.598	0.692
Offered aid	q2	crLS4K35	2	0.471	0.021	1.955	1.051	225.574	0.027	17.240	0.692
Offered aid	q3	crLS4K35	2	0.417	0.027	1.715	1.067	200.896	0.027	16.353	0.692
Offered aid	2q3	crLS4K35	2	0.185	0.003	1.844	1.817	93.958	0.027	11.922	0.692
Offered aid	max3	crLS4K35	2	0.416	0.027	1.712	1.068	200.388	0.027	16.333	0.692
Offered aid	2max3	crLS4K35	2	0.207	0.012	1.439	1.536	104.027	0.027	12.418	0.692
Offered aid	h	crLS4K35	2	0.417	0.027	1.715	1.067	200.896	0.027	16.353	0.692

continued

TABLE 61 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Offered aid	h2	crLS4K35	2	0.185	0.003	1.844	1.817	93.958	0.027	11.922	0.692
Offered aid	q12	crLS4K35	2	0.462	0.021	1.934	1.061	221.732	0.027	17.091	0.692
Offered aid	q1o2	crLS4K35	2	0.495	0.027	1.912	0.968	236.844	0.027	17.747	0.692
Offered aid	q1	crLS3K40	2	0.291	0.018	1.539	1.319	142.844	0.027	13.998	0.692
Offered aid	q2	crLS3K40	2	0.278	0.015	1.569	1.374	136.609	0.027	13.722	0.692
Offered aid	q3	crLS3K40	2	0.262	0.018	1.451	1.364	129.278	0.027	13.472	0.692
Offered aid	2q3	crLS3K40	2	0.150	0.006	1.466	1.769	77.705	0.027	11.328	0.692
Offered aid	max3	crLS3K40	2	0.261	0.018	1.449	1.365	128.960	0.027	13.460	0.692
Offered aid	2max3	crLS3K40	2	0.158	0.009	1.352	1.679	81.403	0.027	11.508	0.692
Offered aid	h	crLS3K40	2	0.262	0.018	1.451	1.364	129.278	0.027	13.472	0.692
Offered aid	h2	crLS3K40	2	0.150	0.006	1.466	1.769	77.705	0.027	11.328	0.692
Offered aid	q12	crLS3K40	2	0.275	0.015	1.561	1.379	135.328	0.027	13.672	0.692
Offered aid	q1o2	crLS3K40	2	0.294	0.018	1.547	1.315	144.125	0.027	14.048	0.692
Offered aid	q1	crLS3K35	2	0.335	0.021	1.600	1.227	162.950	0.027	14.813	0.692
Offered aid	q2	crLS3K35	2	0.319	0.018	1.616	1.280	155.434	0.027	14.487	0.692
Offered aid	q3	crLS3K35	2	0.295	0.021	1.486	1.283	144.440	0.027	14.096	0.692
Offered aid	2q3	crLS3K35	2	0.166	0.006	1.532	1.735	85.146	0.027	11.617	0.692
Offered aid	max3	crLS3K35	2	0.294	0.021	1.484	1.284	144.081	0.027	14.082	0.692
Offered aid	2max3	crLS3K35	2	0.180	0.009	1.437	1.635	91.386	0.027	11.895	0.692
Offered aid	h	crLS3K35	2	0.295	0.021	1.486	1.283	144.440	0.027	14.096	0.692
Offered aid	h2	crLS3K35	2	0.166	0.006	1.532	1.735	85.146	0.027	11.617	0.692
Offered aid	q12	crLS3K35	2	0.316	0.018	1.608	1.284	154.153	0.027	14.437	0.692
Offered aid	q1o2	crLS3K35	2	0.338	0.021	1.607	1.223	164.231	0.027	14.863	0.692
Offered aid	q1	crLS3K30	2	0.424	0.024	1.782	1.082	204.164	0.027	16.445	0.692
Offered aid	q2	crLS3K30	2	0.403	0.021	1.781	1.137	194.212	0.027	16.024	0.692
Offered aid	q3	crLS3K30	2	0.371	0.033	1.514	1.087	179.549	0.027	15.590	0.692
Offered aid	2q3	crLS3K30	2	0.182	0.015	1.277	1.544	92.752	0.027	12.011	0.692
Offered aid	max3	crLS3K30	2	0.370	0.033	1.511	1.089	179.097	0.027	15.573	0.692
Offered aid	2max3	crLS3K30	2	0.201	0.021	1.206	1.440	101.508	0.027	12.422	0.692
Offered aid	h	crLS3K30	2	0.368	0.033	1.507	1.091	178.327	0.027	15.543	0.692
Offered aid	h2	crLS3K30	2	0.182	0.006	1.596	1.704	92.649	0.027	11.907	0.692
Offered aid	q12	crLS3K30	2	0.397	0.021	1.767	1.144	191.712	0.027	15.927	0.692
Offered aid	q1o2	crLS3K30	2	0.430	0.024	1.796	1.075	206.664	0.027	16.542	0.692
Offered aid	q	cwarble	2	0.303	0.015	1.646	1.340	148.079	0.027	14.164	0.692
Offered aid	q	cwarble	2	0.292	0.012	1.698	1.397	143.008	0.027	13.933	0.692
Offered aid	q	cwarble	2	0.262	0.015	1.527	1.400	129.478	0.027	13.443	0.692
Offered aid	2q	cwarble	2	0.145	0.003	1.679	1.899	75.221	0.027	11.195	0.692

continued

TABLE 61 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Offered aid	max	cwarble	2	0.262	0.015	1.524	1.401	129.157	0.027	13.431	0.692
Offered aid	2max	cwarble	2	0.153	0.006	1.477	1.764	78.936	0.027	11.376	0.692
Offered aid	h	cwarble	2	0.262	0.015	1.527	1.400	129.478	0.027	13.443	0.692
Offered aid	h	cwarble	2	0.145	0.003	1.679	1.899	75.221	0.027	11.195	0.692
Offered aid	q1	cwarble	2	0.292	0.012	1.698	1.397	143.008	0.027	13.933	0.692
Offered aid	q1o	cwarble	2	0.303	0.015	1.646	1.340	148.079	0.027	14.164	0.692
Offered aid	q	csteady	2	0.297	0.015	1.628	1.348	145.372	0.027	14.060	0.692
Offered aid	q	csteady	2	0.289	0.012	1.688	1.401	141.596	0.027	13.879	0.692
Offered aid	q	csteady	2	0.256	0.015	1.507	1.408	126.816	0.027	13.341	0.692
Offered aid	2q	csteady	2	0.153	0.003	1.713	1.881	78.888	0.027	11.337	0.692
Offered aid	max	csteady	2	0.256	0.015	1.505	1.409	126.503	0.027	13.329	0.692
Offered aid	2max	csteady	2	0.163	0.006	1.521	1.741	83.864	0.027	11.567	0.692
Offered aid	h	csteady	2	0.256	0.015	1.507	1.408	126.816	0.027	13.341	0.692
Offered aid	h	csteady	2	0.153	0.003	1.713	1.881	78.888	0.027	11.337	0.692
Offered aid	q1	csteady	2	0.286	0.012	1.680	1.405	140.315	0.027	13.829	0.692
Offered aid	q1o	csteady	2	0.300	0.015	1.636	1.344	146.653	0.027	14.110	0.692
Offered aid	q1	cscr3540	2	0.285	0.015	1.595	1.364	140.182	0.027	13.859	0.692
Offered aid	q2	cscr3540	2	0.272	0.012	1.639	1.426	133.947	0.027	13.582	0.692
Offered aid	q3	cscr3540	2	0.256	0.015	1.506	1.409	126.610	0.027	13.333	0.692
Offered aid	2q3	cscr3540	2	0.144	0.003	1.676	1.899	75.035	0.027	11.188	0.692
Offered aid	max3	cscr3540	2	0.255	0.015	1.504	1.410	126.298	0.027	13.321	0.692
Offered aid	2max3	cscr3540	2	0.152	0.006	1.474	1.764	78.741	0.027	11.368	0.692
Offered aid	h	cscr3540	2	0.256	0.015	1.506	1.409	126.610	0.027	13.333	0.692
Offered aid	h2	cscr3540	2	0.144	0.003	1.676	1.899	75.035	0.027	11.188	0.692
Offered aid	q12	cscr3540	2	0.269	0.012	1.630	1.430	132.666	0.027	13.533	0.692
Offered aid	q1o2	cscr3540	2	0.288	0.015	1.603	1.360	141.463	0.027	13.909	0.692

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 62

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Accept and use aid		crLW4K45	1	0.479	0.043	1.661	0.884	157.230	0.047	13.439	1.221
Accept and use aid		crLW4K40	1	0.533	0.085	1.453	0.644	174.802	0.047	14.718	1.221
Accept and use aid		crLW4K35	1	0.664	0.124	1.579	0.365	216.510	0.047	16.887	1.221
Accept and use aid		crLW3K40	1	0.426	0.027	1.747	1.059	140.637	0.047	12.560	1.221
Accept and use aid		crLW3K35	1	0.490	0.058	1.550	0.799	161.139	0.047	13.797	1.221
Accept and use aid		crLW3K30	1	0.599	0.118	1.438	0.468	195.933	0.047	15.998	1.221
Accept and use aid		crLS4K45	1	0.485	0.090	1.301	0.688	159.982	0.047	14.216	1.221
Accept and use aid		crLS4K40	1	0.573	0.105	1.441	0.535	187.777	0.047	15.497	1.221
Accept and use aid		crLS4K35	1	0.689	0.091	1.826	0.421	223.594	0.047	16.694	1.221
Accept and use aid		crLS3K40	1	0.427	0.043	1.530	0.950	141.007	0.047	12.810	1.221
Accept and use aid		crLS3K35	1	0.487	0.048	1.636	0.850	159.949	0.047	13.607	1.221
Accept and use aid		crLS3K30	1	0.615	0.126	1.435	0.426	201.070	0.047	16.323	1.221
Accept and use aid		cwarble	1	0.422	0.031	1.669	1.031	139.451	0.047	12.577	1.221
Accept and use aid		csteady	1	0.417	0.041	1.530	0.974	138.016	0.047	12.662	1.221
Accept and use aid		cscr3540	1	0.401	0.031	1.612	1.058	132.673	0.047	12.315	1.221
Accept and use aid	q1		0	0.956	0.238	2.417	–0.497	307.815	0.041	20.582	1.062
Accept and use aid	q2		0	0.908	0.205	2.152	–0.252	292.389	0.041	19.573	1.062
Accept and use aid	q3q4		0	0.799	0.138	1.930	0.126	257.554	0.041	17.390	1.062
Accept and use aid	2q3q4		0	0.362	0.029	1.550	1.128	119.413	0.041	10.683	1.062
Accept and use aid	maxq34		0	0.799	0.140	1.921	0.122	257.578	0.041	17.414	1.062
Accept and use aid	2maxq34		0	0.411	0.046	1.457	0.954	134.908	0.041	11.503	1.062
Accept and use aid	hear		0	0.787	0.124	1.950	0.179	253.596	0.041	17.070	1.062
Accept and use aid	2hear		0	0.362	0.022	1.654	1.181	119.333	0.041	10.603	1.062
Accept and use aid	q12		0	0.904	0.187	2.193	–0.208	290.875	0.041	19.293	1.062
Accept and use aid	q1or2		0	0.960	0.256	2.406	–0.548	309.329	0.041	20.863	1.062
Accept and use aid	q1	crLW4K45	2	0.467	0.033	1.751	0.957	154.726	0.054	14.292	1.381
Accept and use aid	q2	crLW4K45	2	0.447	0.033	1.701	0.983	148.452	0.054	14.049	1.381
Accept and use aid	q3	crLW4K45	2	0.395	0.031	1.596	1.065	131.955	0.054	13.374	1.381
Accept and use aid	2q3	crLW4K45	2	0.202	0.007	1.636	1.654	71.222	0.054	10.626	1.381
Accept and use aid	max3	crLW4K45	2	0.395	0.031	1.597	1.066	131.954	0.054	13.373	1.381
Accept and use aid	2max3	crLW4K45	2	0.218	0.011	1.506	1.533	76.322	0.054	10.895	1.381
Accept and use aid	h	crLW4K45	2	0.395	0.031	1.596	1.065	131.955	0.054	13.374	1.381
Accept and use aid	h2	crLW4K45	2	0.202	0.007	1.636	1.654	71.222	0.054	10.626	1.381
Accept and use aid	q12	crLW4K45	2	0.447	0.033	1.701	0.983	148.452	0.054	14.049	1.381
Accept and use aid	q1o2	crLW4K45	2	0.467	0.033	1.751	0.957	154.726	0.054	14.292	1.381
Accept and use aid	q1	crLW4K40	2	0.518	0.049	1.702	0.807	170.663	0.054	15.156	1.381
Accept and use aid	q2	crLW4K40	2	0.502	0.047	1.683	0.837	165.664	0.054	14.929	1.381

continued

TABLE 62 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Accept and use aid	q3	crLW4K40	2	0.445	0.040	1.615	0.945	147.875	0.054	14.130	1.381
Accept and use aid	2q3	crLW4K40	2	0.225	0.009	1.618	1.565	78.529	0.054	10.942	1.381
Accept and use aid	max3	crLW4K40	2	0.445	0.040	1.616	0.946	147.874	0.054	14.129	1.381
Accept and use aid	2max3	crLW4K40	2	0.245	0.015	1.470	1.425	84.927	0.054	11.296	1.381
Accept and use aid	h	crLW4K40	2	0.445	0.040	1.615	0.945	147.875	0.054	14.130	1.381
Accept and use aid	h2	crLW4K40	2	0.225	0.009	1.618	1.565	78.529	0.054	10.942	1.381
Accept and use aid	q12	crLW4K40	2	0.498	0.044	1.696	0.854	164.343	0.054	14.841	1.381
Accept and use aid	q1o2	crLW4K40	2	0.522	0.051	1.690	0.791	171.984	0.054	15.244	1.381
Accept and use aid	q1	crLW4K35	2	0.638	0.051	1.989	0.641	208.355	0.054	16.654	1.381
Accept and use aid	q2	crLW4K35	2	0.610	0.051	1.913	0.677	199.649	0.054	16.320	1.381
Accept and use aid	q3	crLW4K35	2	0.550	0.042	1.851	0.801	180.576	0.054	15.434	1.381
Accept and use aid	2q3	crLW4K35	2	0.261	0.011	1.647	1.464	89.832	0.054	11.417	1.381
Accept and use aid	max3	crLW4K35	2	0.550	0.042	1.852	0.801	180.575	0.054	15.433	1.381
Accept and use aid	2max3	crLW4K35	2	0.289	0.018	1.549	1.330	98.796	0.054	11.871	1.381
Accept and use aid	h	crLW4K35	2	0.550	0.042	1.851	0.801	180.576	0.054	15.434	1.381
Accept and use aid	h2	crLW4K35	2	0.261	0.011	1.647	1.464	89.832	0.054	11.417	1.381
Accept and use aid	q12	crLW4K35	2	0.606	0.047	1.948	0.705	198.290	0.054	16.194	1.381
Accept and use aid	q1o2	crLW4K35	2	0.642	0.056	1.958	0.615	209.714	0.054	16.780	1.381
Accept and use aid	q1	crLW3K40	2	0.393	0.027	1.662	1.102	131.468	0.054	13.282	1.381
Accept and use aid	q2	crLW3K40	2	0.373	0.024	1.646	1.146	125.225	0.054	13.005	1.381
Accept and use aid	q3	crLW3K40	2	0.349	0.027	1.543	1.160	117.566	0.054	12.744	1.381
Accept and use aid	2q3	crLW3K40	2	0.209	0.009	1.559	1.591	73.399	0.054	10.745	1.381
Accept and use aid	max3	crLW3K40	2	0.349	0.027	1.544	1.160	117.565	0.054	12.743	1.381
Accept and use aid	2max3	crLW3K40	2	0.221	0.011	1.516	1.527	77.285	0.054	10.932	1.381
Accept and use aid	h	crLW3K40	2	0.349	0.027	1.543	1.160	117.566	0.054	12.744	1.381
Accept and use aid	h2	crLW3K40	2	0.209	0.009	1.559	1.591	73.399	0.054	10.745	1.381
Accept and use aid	q12	crLW3K40	2	0.369	0.024	1.635	1.151	123.942	0.054	12.955	1.381
Accept and use aid	q1o2	crLW3K40	2	0.397	0.027	1.673	1.096	132.751	0.054	13.332	1.381
Accept and use aid	q1	crLW3K35	2	0.457	0.033	1.728	0.971	151.621	0.054	14.169	1.381
Accept and use aid	q2	crLW3K35	2	0.433	0.031	1.698	1.016	144.094	0.054	13.843	1.381
Accept and use aid	q3	crLW3K35	2	0.397	0.033	1.573	1.048	132.727	0.054	13.438	1.381
Accept and use aid	2q3	crLW3K35	2	0.224	0.007	1.720	1.617	78.353	0.054	10.901	1.381
Accept and use aid	max3	crLW3K35	2	0.397	0.033	1.574	1.048	132.726	0.054	13.437	1.381
Accept and use aid	2max3	crLW3K35	2	0.241	0.009	1.667	1.537	83.521	0.054	11.137	1.381
Accept and use aid	h	crLW3K35	2	0.397	0.033	1.573	1.048	132.727	0.054	13.438	1.381
Accept and use aid	h2	crLW3K35	2	0.224	0.007	1.720	1.617	78.353	0.054	10.901	1.381
Accept and use aid	q12	crLW3K35	2	0.429	0.031	1.687	1.022	142.812	0.054	13.793	1.381

continued

TABLE 62 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Accept and use aid	q1o2	crLW3K35	2	0.462	0.033	1.739	0.966	152.904	0.054	14.219	1.381
Accept and use aid	q1	crLW3K30	2	0.566	0.044	1.868	0.768	185.715	0.054	15.670	1.381
Accept and use aid	q2	crLW3K30	2	0.538	0.044	1.798	0.803	177.004	0.054	15.332	1.381
Accept and use aid	q3	crLW3K30	2	0.494	0.044	1.690	0.861	163.068	0.054	14.785	1.381
Accept and use aid	2q3	crLW3K30	2	0.233	0.015	1.437	1.449	81.060	0.054	11.142	1.381
Accept and use aid	max3	crLW3K30	2	0.494	0.044	1.691	0.862	163.066	0.054	14.784	1.381
Accept and use aid	2max3	crLW3K30	2	0.261	0.020	1.424	1.352	90.050	0.054	11.561	1.381
Accept and use aid	h	crLW3K30	2	0.490	0.044	1.680	0.866	161.848	0.054	14.738	1.381
Accept and use aid	h2	crLW3K30	2	0.233	0.009	1.639	1.550	80.956	0.054	11.038	1.381
Accept and use aid	q12	crLW3K30	2	0.534	0.042	1.811	0.820	175.685	0.054	15.246	1.381
Accept and use aid	q1o2	crLW3K30	2	0.570	0.047	1.856	0.752	187.034	0.054	15.755	1.381
Accept and use aid	q1	crLS4K45	2	0.470	0.038	1.701	0.926	155.586	0.054	14.396	1.381
Accept and use aid	q2	crLS4K45	2	0.454	0.036	1.687	0.959	150.586	0.054	14.169	1.381
Accept and use aid	q3	crLS4K45	2	0.397	0.036	1.544	1.032	132.909	0.054	13.482	1.381
Accept and use aid	2q3	crLS4K45	2	0.213	0.007	1.675	1.634	74.749	0.054	10.763	1.381
Accept and use aid	max3	crLS4K45	2	0.397	0.036	1.545	1.033	132.907	0.054	13.480	1.381
Accept and use aid	2max3	crLS4K45	2	0.229	0.013	1.475	1.479	79.928	0.054	11.070	1.381
Accept and use aid	h	crLS4K45	2	0.397	0.036	1.544	1.032	132.909	0.054	13.482	1.381
Accept and use aid	h2	crLS4K45	2	0.213	0.007	1.675	1.634	74.749	0.054	10.763	1.381
Accept and use aid	q12	crLS4K45	2	0.450	0.033	1.706	0.979	149.265	0.054	14.082	1.381
Accept and use aid	q1o2	crLS4K45	2	0.474	0.040	1.685	0.907	156.906	0.054	14.484	1.381
Accept and use aid	q1	crLS4K40	2	0.558	0.042	1.873	0.790	183.241	0.054	15.538	1.381
Accept and use aid	q2	crLS4K40	2	0.538	0.040	1.846	0.827	177.021	0.054	15.264	1.381
Accept and use aid	q3	crLS4K40	2	0.486	0.040	1.716	0.894	160.564	0.054	14.623	1.381
Accept and use aid	2q3	crLS4K40	2	0.241	0.009	1.670	1.538	83.520	0.054	11.136	1.381
Accept and use aid	max3	crLS4K40	2	0.486	0.040	1.717	0.894	160.563	0.054	14.622	1.381
Accept and use aid	2max3	crLS4K40	2	0.269	0.015	1.544	1.387	92.547	0.054	11.592	1.381
Accept and use aid	h	crLS4K40	2	0.486	0.040	1.716	0.894	160.564	0.054	14.623	1.381
Accept and use aid	h2	crLS4K40	2	0.241	0.009	1.670	1.538	83.520	0.054	11.136	1.381
Accept and use aid	q12	crLS4K40	2	0.534	0.038	1.863	0.846	175.700	0.054	15.176	1.381
Accept and use aid	q1o2	crLS4K40	2	0.562	0.044	1.858	0.773	184.562	0.054	15.626	1.381
Accept and use aid	q1	crLS4K35	2	0.662	0.051	2.054	0.609	215.927	0.054	16.947	1.381
Accept and use aid	q2	crLS4K35	2	0.630	0.051	1.967	0.650	206.000	0.054	16.566	1.381
Accept and use aid	q3	crLS4K35	2	0.574	0.042	1.913	0.770	188.147	0.054	15.728	1.381
Accept and use aid	2q3	crLS4K35	2	0.261	0.009	1.734	1.507	89.794	0.054	11.379	1.381
Accept and use aid	max3	crLS4K35	2	0.574	0.042	1.914	0.771	188.146	0.054	15.726	1.381
Accept and use aid	2max3	crLS4K35	2	0.294	0.015	1.617	1.351	100.103	0.054	11.885	1.381

continued

TABLE 62 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Accept and use aid	h	crLS4K35	2	0.574	0.042	1.913	0.770	188.147	0.054	15.728	1.381
Accept and use aid	h2	crLS4K35	2	0.261	0.009	1.734	1.507	89.794	0.054	11.379	1.381
Accept and use aid	q12	crLS4K35	2	0.626	0.047	2.001	0.678	204.641	0.054	16.440	1.381
Accept and use aid	q1o2	crLS4K35	2	0.666	0.056	2.023	0.582	217.285	0.054	17.073	1.381
Accept and use aid	q1	crLS3K40	2	0.394	0.033	1.564	1.052	131.706	0.054	13.399	1.381
Accept and use aid	q2	crLS3K40	2	0.374	0.031	1.542	1.093	125.462	0.054	13.122	1.381
Accept and use aid	q3	crLS3K40	2	0.349	0.033	1.445	1.110	117.803	0.054	12.861	1.381
Accept and use aid	2q3	crLS3K40	2	0.213	0.009	1.573	1.583	74.745	0.054	10.797	1.381
Accept and use aid	max3	crLS3K40	2	0.349	0.033	1.446	1.110	117.802	0.054	12.860	1.381
Accept and use aid	2max3	crLS3K40	2	0.225	0.011	1.530	1.520	78.631	0.054	10.984	1.381
Accept and use aid	h	crLS3K40	2	0.349	0.033	1.445	1.110	117.803	0.054	12.861	1.381
Accept and use aid	h2	crLS3K40	2	0.213	0.009	1.573	1.583	74.745	0.054	10.797	1.381
Accept and use aid	q12	crLS3K40	2	0.370	0.031	1.531	1.098	124.180	0.054	13.072	1.381
Accept and use aid	q1o2	crLS3K40	2	0.398	0.033	1.575	1.046	132.989	0.054	13.449	1.381
Accept and use aid	q1	crLS3K35	2	0.454	0.038	1.662	0.946	150.657	0.054	14.205	1.381
Accept and use aid	q2	crLS3K35	2	0.430	0.036	1.628	0.990	143.130	0.054	13.878	1.381
Accept and use aid	q3	crLS3K35	2	0.394	0.038	1.506	1.023	131.763	0.054	13.474	1.381
Accept and use aid	2q3	crLS3K35	2	0.233	0.011	1.557	1.508	80.993	0.054	11.075	1.381
Accept and use aid	max3	crLS3K35	2	0.394	0.038	1.507	1.023	131.762	0.054	13.472	1.381
Accept and use aid	2max3	crLS3K35	2	0.253	0.013	1.551	1.440	87.444	0.054	11.361	1.381
Accept and use aid	h	crLS3K35	2	0.394	0.038	1.506	1.023	131.763	0.054	13.474	1.381
Accept and use aid	h2	crLS3K35	2	0.233	0.011	1.557	1.508	80.993	0.054	11.075	1.381
Accept and use aid	q12	crLS3K35	2	0.426	0.036	1.618	0.995	141.847	0.054	13.828	1.381
Accept and use aid	q1o2	crLS3K35	2	0.458	0.038	1.672	0.941	151.939	0.054	14.255	1.381
Accept and use aid	q1	crLS3K30	2	0.582	0.042	1.933	0.760	190.683	0.054	15.827	1.381
Accept and use aid	q2	crLS3K30	2	0.546	0.042	1.843	0.805	179.533	0.054	15.394	1.381
Accept and use aid	q3	crLS3K30	2	0.505	0.046	1.697	0.835	166.827	0.054	14.966	1.381
Accept and use aid	2q3	crLS3K30	2	0.257	0.017	1.460	1.384	88.590	0.054	11.469	1.381
Accept and use aid	max3	crLS3K30	2	0.505	0.046	1.698	0.836	166.826	0.054	14.964	1.381
Accept and use aid	2max3	crLS3K30	2	0.285	0.022	1.453	1.294	97.580	0.054	11.888	1.381
Accept and use aid	h	crLS3K30	2	0.502	0.046	1.687	0.840	165.607	0.054	14.919	1.381
Accept and use aid	h2	crLS3K30	2	0.257	0.011	1.634	1.471	88.487	0.054	11.365	1.381
Accept and use aid	q12	crLS3K30	2	0.542	0.040	1.857	0.823	178.214	0.054	15.308	1.381
Accept and use aid	q1o2	crLS3K30	2	0.586	0.044	1.920	0.743	192.002	0.054	15.913	1.381
Accept and use aid	q	cwarble	2	0.411	0.031	1.640	1.045	137.087	0.054	13.571	1.381
Accept and use aid	q	cwarble	2	0.395	0.029	1.631	1.082	132.002	0.054	13.339	1.381
Accept and use aid	q	cwarble	2	0.350	0.031	1.480	1.124	118.115	0.054	12.837	1.381

continued

TABLE 62 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
Accept and use aid	2q	cwarble	2	0.205	0.007	1.654	1.650	72.342	0.054	10.668	1.381
Accept and use aid	max	cwarble	2	0.350	0.031	1.481	1.125	118.114	0.054	12.835	1.381
Accept and use aid	2max	cwarble	2	0.218	0.009	1.590	1.575	76.244	0.054	10.855	1.381
Accept and use aid	h	cwarble	2	0.350	0.031	1.480	1.124	118.115	0.054	12.837	1.381
Accept and use aid	h	cwarble	2	0.205	0.007	1.654	1.650	72.342	0.054	10.668	1.381
Accept and use aid	q1	cwarble	2	0.395	0.029	1.631	1.082	132.002	0.054	13.339	1.381
Accept and use aid	q1o	cwarble	2	0.411	0.031	1.640	1.045	137.087	0.054	13.571	1.381
Accept and use aid	q	csteady	2	0.402	0.031	1.616	1.056	134.238	0.054	13.462	1.381
Accept and use aid	q	csteady	2	0.390	0.029	1.617	1.088	130.457	0.054	13.280	1.381
Accept and use aid	q	csteady	2	0.342	0.031	1.455	1.136	115.344	0.054	12.730	1.381
Accept and use aid	2q	csteady	2	0.217	0.007	1.693	1.630	75.927	0.054	10.807	1.381
Accept and use aid	max	csteady	2	0.342	0.031	1.456	1.136	115.343	0.054	12.729	1.381
Accept and use aid	2max	csteady	2	0.233	0.009	1.641	1.549	81.096	0.054	11.044	1.381
Accept and use aid	h	csteady	2	0.342	0.031	1.455	1.136	115.344	0.054	12.730	1.381
Accept and use aid	h	csteady	2	0.217	0.007	1.693	1.630	75.927	0.054	10.807	1.381
Accept and use aid	q1	csteady	2	0.386	0.029	1.606	1.093	129.174	0.054	13.230	1.381
Accept and use aid	q1o	csteady	2	0.406	0.031	1.626	1.051	135.521	0.054	13.511	1.381
Accept and use aid	q1	cscr3540	2	0.385	0.031	1.573	1.078	129.041	0.054	13.260	1.381
Accept and use aid	q2	cscr3540	2	0.365	0.029	1.552	1.120	122.797	0.054	12.983	1.381
Accept and use aid	q3	cscr3540	2	0.341	0.031	1.453	1.137	115.138	0.054	12.722	1.381
Accept and use aid	2q3	cscr3540	2	0.204	0.007	1.650	1.651	72.079	0.054	10.658	1.381
Accept and use aid	max3	cscr3540	2	0.341	0.031	1.454	1.137	115.137	0.054	12.721	1.381
Accept and use aid	2max3	cscr3540	2	0.217	0.009	1.586	1.576	75.965	0.054	10.845	1.381
Accept and use aid	h	cscr3540	2	0.341	0.031	1.453	1.137	115.138	0.054	12.722	1.381
Accept and use aid	h2	cscr3540	2	0.204	0.007	1.650	1.651	72.079	0.054	10.658	1.381
Accept and use aid	q12	cscr3540	2	0.361	0.029	1.541	1.125	121.514	0.054	12.933	1.381
Accept and use aid	q1o2	cscr3540	2	0.389	0.031	1.583	1.072	130.324	0.054	13.310	1.381

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 63

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >59%		crLW4K45	1	0.418	0.442	–0.061	0.176	109.733	0.075	18.225	1.931
GHABP benefit >59%		crLW4K40	1	0.442	0.527	–0.215	0.039	116.500	0.075	19.879	1.931
GHABP benefit >59%		crLW4K35	1	0.487	0.635	–0.378	–0.156	128.646	0.075	22.112	1.931
GHABP benefit >59%		crLW3K40	1	0.672	0.437	0.606	–0.144	167.458	0.075	20.372	1.931
GHABP benefit >59%		crLW3K35	1	0.737	0.423	0.827	–0.220	181.878	0.075	20.707	1.931
GHABP benefit >59%		crLW3K30	1	0.789	0.564	0.643	–0.482	196.167	0.075	23.562	1.931
GHABP benefit >59%		crLS4K45	1	0.418	0.455	–0.094	0.159	109.953	0.075	18.445	1.931
GHABP benefit >59%		crLS4K40	1	0.447	0.568	–0.306	–0.020	118.410	0.075	20.625	1.931
GHABP benefit >59%		crLS4K35	1	0.502	0.662	–0.414	–0.212	132.510	0.075	22.710	1.931
GHABP benefit >59%		crLS3K40	1	0.683	0.423	0.670	–0.141	169.598	0.075	20.231	1.931
GHABP benefit >59%		crLS3K35	1	0.717	0.451	0.699	–0.225	177.896	0.075	21.001	1.931
GHABP benefit >59%		crLS3K30	1	0.778	0.590	0.536	–0.497	194.051	0.075	23.919	1.931
GHABP benefit >59%		cwarble	1	0.368	0.415	–0.123	0.276	97.839	0.075	17.318	1.931
GHABP benefit >59%		csteady	1	0.353	0.451	–0.252	0.250	95.111	0.075	17.792	1.931
GHABP benefit >59%		cscr3540	1	0.349	0.423	–0.195	0.291	93.588	0.075	17.284	1.931
GHABP benefit >59%	q1		0	0.581	0.986	–2.001	–1.205	153.060	0.065	25.956	1.679
GHABP benefit >59%	q2		0	0.568	0.909	–1.168	–0.754	148.837	0.065	24.698	1.679
GHABP benefit >59%	q3q4		0	0.492	0.805	–0.880	–0.421	130.159	0.065	22.491	1.679
GHABP benefit >59%	2q3q4		0	0.253	0.316	–0.186	0.573	68.407	0.065	13.124	1.679
GHABP benefit >59%	maxq34		0	0.492	0.805	–0.880	–0.421	130.159	0.065	22.491	1.679
GHABP benefit >59%	2maxq34		0	0.258	0.411	–0.424	0.438	70.982	0.065	14.580	1.679
GHABP benefit >59%	hear		0	0.492	0.778	–0.785	–0.373	129.753	0.065	22.085	1.679
GHABP benefit >59%	2hear		0	0.253	0.316	–0.186	0.573	68.407	0.065	13.124	1.679
GHABP benefit >59%	q12		0	0.568	0.896	–1.088	–0.714	148.634	0.065	24.495	1.679
GHABP benefit >59%	q1or2		0	0.581	0.986	–1.996	–1.203	153.057	0.065	25.953	1.679
GHABP benefit >59%	q1	crLW4K45	2	0.318	0.442	–0.328	0.309	88.677	0.085	19.101	2.182
GHABP benefit >59%	q2	crLW4K45	2	0.318	0.406	–0.234	0.356	87.968	0.085	18.393	2.182
GHABP benefit >59%	q3	crLW4K45	2	0.264	0.378	–0.319	0.471	75.199	0.085	17.384	2.182
GHABP benefit >59%	2q3	crLW4K45	2	0.143	0.200	–0.228	0.954	44.116	0.085	12.895	2.182
GHABP benefit >59%	max3	crLW4K45	2	0.264	0.378	–0.319	0.471	75.199	0.085	17.384	2.182
GHABP benefit >59%	2max3	crLW4K45	2	0.148	0.228	–0.299	0.896	45.803	0.085	13.464	2.182
GHABP benefit >59%	h	crLW4K45	2	0.264	0.378	–0.319	0.471	75.199	0.085	17.384	2.182
GHABP benefit >59%	h2	crLW4K45	2	0.143	0.200	–0.228	0.954	44.116	0.085	12.895	2.182
GHABP benefit >59%	q12	crLW4K45	2	0.318	0.406	–0.234	0.356	87.968	0.085	18.393	2.182
GHABP benefit >59%	q1o2	crLW4K45	2	0.318	0.442	–0.328	0.309	88.677	0.085	19.101	2.182
GHABP benefit >59%	q1	crLW4K40	2	0.341	0.514	–0.443	0.187	95.369	0.085	20.680	2.182
GHABP benefit >59%	q2	crLW4K40	2	0.341	0.491	–0.386	0.215	94.934	0.085	20.245	2.182

continued

TABLE 63 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >59%	q3	crLW4K40	2	0.288	0.450	–0.434	0.343	81.909	0.085	18.980	2.182
GHABP benefit >59%	2q3	crLW4K40	2	0.143	0.261	–0.429	0.854	45.289	0.085	14.068	2.182
GHABP benefit >59%	max3	crLW4K40	2	0.288	0.450	–0.434	0.343	81.909	0.085	18.980	2.182
GHABP benefit >59%	2max3	crLW4K40	2	0.148	0.302	–0.527	0.782	47.233	0.085	14.894	2.182
GHABP benefit >59%	h	crLW4K40	2	0.288	0.450	–0.434	0.343	81.909	0.085	18.980	2.182
GHABP benefit >59%	h2	crLW4K40	2	0.143	0.261	–0.429	0.854	45.289	0.085	14.068	2.182
GHABP benefit >59%	q12	crLW4K40	2	0.341	0.477	–0.352	0.233	94.670	0.085	19.982	2.182
GHABP benefit >59%	q1o2	crLW4K40	2	0.341	0.527	–0.477	0.170	95.633	0.085	20.944	2.182
GHABP benefit >59%	q1	crLW4K35	2	0.387	0.621	–0.597	–0.011	107.755	0.085	23.153	2.182
GHABP benefit >59%	q2	crLW4K35	2	0.373	0.599	–0.573	0.037	104.234	0.085	22.598	2.182
GHABP benefit >59%	q3	crLW4K35	2	0.333	0.558	–0.577	0.143	94.294	0.085	21.452	2.182
GHABP benefit >59%	2q3	crLW4K35	2	0.164	0.261	–0.338	0.808	50.189	0.085	14.258	2.182
GHABP benefit >59%	max3	crLW4K35	2	0.333	0.558	–0.577	0.143	94.294	0.085	21.452	2.182
GHABP benefit >59%	2max3	crLW4K35	2	0.169	0.316	–0.476	0.718	52.397	0.085	15.347	2.182
GHABP benefit >59%	h	crLW4K35	2	0.333	0.558	–0.577	0.143	94.294	0.085	21.452	2.182
GHABP benefit >59%	h2	crLW4K35	2	0.164	0.261	–0.338	0.808	50.189	0.085	14.258	2.182
GHABP benefit >59%	q12	crLW4K35	2	0.373	0.585	–0.538	0.054	103.970	0.085	22.334	2.182
GHABP benefit >59%	q1o2	crLW4K35	2	0.387	0.635	–0.633	–0.029	108.018	0.085	23.416	2.182
GHABP benefit >59%	q1	crLW3K40	2	0.253	0.423	–0.470	0.429	73.607	0.085	18.162	2.182
GHABP benefit >59%	q2	crLW3K40	2	0.240	0.401	–0.455	0.479	70.086	0.085	17.607	2.182
GHABP benefit >59%	q3	crLW3K40	2	0.230	0.359	–0.380	0.550	66.968	0.085	16.726	2.182
GHABP benefit >59%	2q3	crLW3K40	2	0.127	0.248	–0.457	0.910	41.535	0.085	13.669	2.182
GHABP benefit >59%	max3	crLW3K40	2	0.230	0.359	–0.380	0.550	66.968	0.085	16.726	2.182
GHABP benefit >59%	2max3	crLW3K40	2	0.133	0.275	–0.517	0.856	43.226	0.085	14.242	2.182
GHABP benefit >59%	h	crLW3K40	2	0.230	0.359	–0.380	0.550	66.968	0.085	16.726	2.182
GHABP benefit >59%	h2	crLW3K40	2	0.127	0.248	–0.457	0.910	41.535	0.085	13.669	2.182
GHABP benefit >59%	q12	crLW3K40	2	0.240	0.387	–0.419	0.497	69.822	0.085	17.343	2.182
GHABP benefit >59%	q1o2	crLW3K40	2	0.253	0.437	–0.505	0.411	73.870	0.085	18.425	2.182
GHABP benefit >59%	q1	crLW3K35	2	0.318	0.409	–0.245	0.351	87.997	0.085	18.466	2.182
GHABP benefit >59%	q2	crLW3K35	2	0.304	0.387	–0.225	0.400	84.476	0.085	17.911	2.182
GHABP benefit >59%	q3	crLW3K35	2	0.278	0.346	–0.193	0.493	77.622	0.085	16.885	2.182
GHABP benefit >59%	2q3	crLW3K35	2	0.149	0.234	–0.315	0.884	46.172	0.085	13.596	2.182
GHABP benefit >59%	max3	crLW3K35	2	0.278	0.346	–0.193	0.493	77.622	0.085	16.885	2.182
GHABP benefit >59%	2max3	crLW3K35	2	0.154	0.261	–0.380	0.829	47.862	0.085	14.168	2.182
GHABP benefit >59%	h	crLW3K35	2	0.278	0.346	–0.193	0.493	77.622	0.085	16.885	2.182
GHABP benefit >59%	h2	crLW3K35	2	0.149	0.234	–0.315	0.884	46.172	0.085	13.596	2.182
GHABP benefit >59%	q12	crLW3K35	2	0.304	0.373	–0.189	0.418	84.213	0.085	17.648	2.182

continued

TABLE 63 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >59%	q1o2	crLW3K35	2	0.318	0.423	–0.280	0.334	88.261	0.085	18.730	2.182
GHABP benefit >59%	q1	crLW3K30	2	0.370	0.550	–0.457	0.103	102.598	0.085	21.633	2.182
GHABP benefit >59%	q2	crLW3K30	2	0.357	0.527	–0.436	0.150	99.077	0.085	21.078	2.182
GHABP benefit >59%	q3	crLW3K30	2	0.316	0.486	–0.443	0.256	89.137	0.085	19.932	2.182
GHABP benefit >59%	2q3	crLW3K30	2	0.159	0.234	–0.272	0.862	48.499	0.085	13.686	2.182
GHABP benefit >59%	max3	crLW3K30	2	0.316	0.486	–0.443	0.256	89.137	0.085	19.932	2.182
GHABP benefit >59%	2max3	crLW3K30	2	0.164	0.288	–0.418	0.768	50.706	0.085	14.775	2.182
GHABP benefit >59%	h	crLW3K30	2	0.316	0.486	–0.443	0.256	89.137	0.085	19.932	2.182
GHABP benefit >59%	h2	crLW3K30	2	0.159	0.234	–0.272	0.862	48.499	0.085	13.686	2.182
GHABP benefit >59%	q12	crLW3K30	2	0.357	0.514	–0.402	0.167	98.814	0.085	20.814	2.182
GHABP benefit >59%	q1o2	crLW3K30	2	0.370	0.564	–0.492	0.086	102.862	0.085	21.896	2.182
GHABP benefit >59%	q1	crLS4K45	2	0.318	0.442	–0.326	0.310	88.662	0.085	19.087	2.182
GHABP benefit >59%	q2	crLS4K45	2	0.318	0.419	–0.269	0.339	88.227	0.085	18.652	2.182
GHABP benefit >59%	q3	crLS4K45	2	0.264	0.378	–0.319	0.471	75.202	0.085	17.386	2.182
GHABP benefit >59%	2q3	crLS4K45	2	0.143	0.225	–0.313	0.912	44.590	0.085	13.369	2.182
GHABP benefit >59%	max3	crLS4K45	2	0.264	0.378	–0.319	0.471	75.202	0.085	17.386	2.182
GHABP benefit >59%	2max3	crLS4K45	2	0.148	0.252	–0.379	0.856	46.281	0.085	13.942	2.182
GHABP benefit >59%	h	crLS4K45	2	0.264	0.378	–0.319	0.471	75.202	0.085	17.386	2.182
GHABP benefit >59%	h2	crLS4K45	2	0.143	0.225	–0.313	0.912	44.590	0.085	13.369	2.182
GHABP benefit >59%	q12	crLS4K45	2	0.318	0.405	–0.233	0.356	87.963	0.085	18.388	2.182
GHABP benefit >59%	q1o2	crLS4K45	2	0.318	0.455	–0.361	0.293	88.926	0.085	19.350	2.182
GHABP benefit >59%	q1	crLS4K40	2	0.347	0.555	–0.532	0.128	97.370	0.085	21.518	2.182
GHABP benefit >59%	q2	crLS4K40	2	0.347	0.519	–0.442	0.173	96.682	0.085	20.830	2.182
GHABP benefit >59%	q3	crLS4K40	2	0.293	0.491	–0.522	0.284	83.909	0.085	19.818	2.182
GHABP benefit >59%	2q3	crLS4K40	2	0.143	0.261	–0.429	0.854	45.289	0.085	14.068	2.182
GHABP benefit >59%	max3	crLS4K40	2	0.293	0.491	–0.522	0.284	83.909	0.085	19.818	2.182
GHABP benefit >59%	2max3	crLS4K40	2	0.148	0.316	–0.567	0.762	47.507	0.085	15.168	2.182
GHABP benefit >59%	h	crLS4K40	2	0.293	0.491	–0.522	0.284	83.909	0.085	19.818	2.182
GHABP benefit >59%	h2	crLS4K40	2	0.143	0.261	–0.429	0.854	45.289	0.085	14.068	2.182
GHABP benefit >59%	q12	crLS4K40	2	0.347	0.505	–0.407	0.190	96.418	0.085	20.566	2.182
GHABP benefit >59%	q1o2	crLS4K40	2	0.347	0.568	–0.566	0.111	97.634	0.085	21.782	2.182
GHABP benefit >59%	q1	crLS4K35	2	0.402	0.649	–0.631	–0.066	111.679	0.085	23.812	2.182
GHABP benefit >59%	q2	crLS4K35	2	0.388	0.613	–0.571	–0.001	107.906	0.085	23.004	2.182
GHABP benefit >59%	q3	crLS4K35	2	0.348	0.585	–0.606	0.088	98.219	0.085	22.111	2.182
GHABP benefit >59%	2q3	crLS4K35	2	0.164	0.261	–0.338	0.808	50.189	0.085	14.258	2.182
GHABP benefit >59%	max3	crLS4K35	2	0.348	0.585	–0.606	0.088	98.219	0.085	22.111	2.182
GHABP benefit >59%	2max3	crLS4K35	2	0.169	0.330	–0.516	0.699	52.671	0.085	15.621	2.182

continued

TABLE 63 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >59%	h	crLS4K35	2	0.348	0.585	–0.606	0.088	98.219	0.085	22.111	2.182
GHABP benefit >59%	h2	crLS4K35	2	0.164	0.261	–0.338	0.808	50.189	0.085	14.258	2.182
GHABP benefit >59%	q12	crLS4K35	2	0.388	0.599	–0.536	0.016	107.642	0.085	22.740	2.182
GHABP benefit >59%	q1o2	crLS4K35	2	0.402	0.662	–0.668	–0.085	111.943	0.085	24.075	2.182
GHABP benefit >59%	q1	crLS3K40	2	0.264	0.409	–0.402	0.430	75.717	0.085	17.990	2.182
GHABP benefit >59%	q2	crLS3K40	2	0.250	0.387	–0.386	0.480	72.196	0.085	17.435	2.182
GHABP benefit >59%	q3	crLS3K40	2	0.240	0.346	–0.309	0.551	69.078	0.085	16.554	2.182
GHABP benefit >59%	2q3	crLS3K40	2	0.143	0.234	–0.342	0.897	44.762	0.085	13.541	2.182
GHABP benefit >59%	max3	crLS3K40	2	0.240	0.346	–0.309	0.551	69.078	0.085	16.554	2.182
GHABP benefit >59%	2max3	crLS3K40	2	0.148	0.261	–0.406	0.843	46.453	0.085	14.114	2.182
GHABP benefit >59%	h	crLS3K40	2	0.240	0.346	–0.309	0.551	69.078	0.085	16.554	2.182
GHABP benefit >59%	h2	crLS3K40	2	0.143	0.234	–0.342	0.897	44.762	0.085	13.541	2.182
GHABP benefit >59%	q12	crLS3K40	2	0.250	0.373	–0.350	0.498	71.932	0.085	17.172	2.182
GHABP benefit >59%	q1o2	crLS3K40	2	0.264	0.423	–0.438	0.413	75.980	0.085	18.254	2.182
GHABP benefit >59%	q1	crLS3K35	2	0.298	0.437	–0.370	0.344	84.076	0.085	18.821	2.182
GHABP benefit >59%	q2	crLS3K35	2	0.285	0.414	–0.352	0.393	80.555	0.085	18.266	2.182
GHABP benefit >59%	q3	crLS3K35	2	0.258	0.373	–0.326	0.486	73.700	0.085	17.240	2.182
GHABP benefit >59%	2q3	crLS3K35	2	0.159	0.234	–0.272	0.862	48.499	0.085	13.686	2.182
GHABP benefit >59%	max3	crLS3K35	2	0.258	0.373	–0.326	0.486	73.700	0.085	17.240	2.182
GHABP benefit >59%	2max3	crLS3K35	2	0.164	0.275	–0.379	0.787	50.453	0.085	14.522	2.182
GHABP benefit >59%	h	crLS3K35	2	0.258	0.373	–0.326	0.486	73.700	0.085	17.240	2.182
GHABP benefit >59%	h2	crLS3K35	2	0.159	0.234	–0.272	0.862	48.499	0.085	13.686	2.182
GHABP benefit >59%	q12	crLS3K35	2	0.285	0.401	–0.317	0.410	80.291	0.085	18.002	2.182
GHABP benefit >59%	q1o2	crLS3K35	2	0.298	0.451	–0.405	0.327	84.339	0.085	19.084	2.182
GHABP benefit >59%	q1	crLS3K30	2	0.359	0.577	–0.555	0.084	100.542	0.085	22.049	2.182
GHABP benefit >59%	q2	crLS3K30	2	0.345	0.541	–0.501	0.148	96.768	0.085	21.241	2.182
GHABP benefit >59%	q3	crLS3K30	2	0.305	0.499	–0.508	0.256	86.817	0.085	20.085	2.182
GHABP benefit >59%	2q3	crLS3K30	2	0.159	0.261	–0.357	0.820	49.015	0.085	14.203	2.182
GHABP benefit >59%	max3	crLS3K30	2	0.305	0.499	–0.508	0.256	86.817	0.085	20.085	2.182
GHABP benefit >59%	2max3	crLS3K30	2	0.164	0.302	–0.458	0.748	50.970	0.085	15.039	2.182
GHABP benefit >59%	h	crLS3K30	2	0.305	0.499	–0.508	0.256	86.817	0.085	20.085	2.182
GHABP benefit >59%	h2	crLS3K30	2	0.159	0.261	–0.357	0.820	49.015	0.085	14.203	2.182
GHABP benefit >59%	q12	crLS3K30	2	0.345	0.527	–0.467	0.165	96.504	0.085	20.978	2.182
GHABP benefit >59%	q1o2	crLS3K30	2	0.359	0.590	–0.590	0.066	100.805	0.085	22.313	2.182
GHABP benefit >59%	q	cwarble	2	0.268	0.415	–0.405	0.417	76.723	0.085	18.134	2.182
GHABP benefit >59%	q	cwarble	2	0.268	0.378	–0.309	0.465	76.014	0.085	17.426	2.182
GHABP benefit >59%	q	cwarble	2	0.228	0.351	–0.363	0.565	66.331	0.085	16.536	2.182

continued

TABLE 63 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >59%	2q	cwarble	2	0.127	0.237	–0.423	0.927	41.334	0.085	13.468	2.182
GHABP benefit >59%	max	cwarble	2	0.228	0.351	–0.363	0.565	66.331	0.085	16.536	2.182
GHABP benefit >59%	2max	cwarble	2	0.133	0.265	–0.486	0.871	43.032	0.085	14.048	2.182
GHABP benefit >59%	h	cwarble	2	0.228	0.351	–0.363	0.565	66.331	0.085	16.536	2.182
GHABP benefit >59%	h	cwarble	2	0.127	0.237	–0.423	0.927	41.334	0.085	13.468	2.182
GHABP benefit >59%	q1	cwarble	2	0.268	0.378	–0.309	0.465	76.014	0.085	17.426	2.182
GHABP benefit >59%	q1o	cwarble	2	0.268	0.415	–0.405	0.417	76.723	0.085	18.134	2.182
GHABP benefit >59%	q	csteady	2	0.253	0.437	–0.505	0.412	73.809	0.085	18.423	2.182
GHABP benefit >59%	q	csteady	2	0.253	0.414	–0.448	0.441	73.374	0.085	17.987	2.182
GHABP benefit >59%	q	csteady	2	0.213	0.373	–0.473	0.560	63.434	0.085	16.842	2.182
GHABP benefit >59%	2q	csteady	2	0.143	0.234	–0.342	0.897	44.762	0.085	13.541	2.182
GHABP benefit >59%	max	csteady	2	0.213	0.373	–0.473	0.560	63.434	0.085	16.842	2.182
GHABP benefit >59%	2max	csteady	2	0.148	0.275	–0.448	0.822	46.717	0.085	14.377	2.182
GHABP benefit >59%	h	csteady	2	0.213	0.373	–0.473	0.560	63.434	0.085	16.842	2.182
GHABP benefit >59%	h	csteady	2	0.143	0.234	–0.342	0.897	44.762	0.085	13.541	2.182
GHABP benefit >59%	q1	csteady	2	0.253	0.401	–0.412	0.458	73.110	0.085	17.724	2.182
GHABP benefit >59%	q1o	csteady	2	0.253	0.451	–0.540	0.394	74.073	0.085	18.686	2.182
GHABP benefit >59%	q1	cscr3540	2	0.249	0.409	–0.450	0.454	72.226	0.085	17.855	2.182
GHABP benefit >59%	q2	cscr3540	2	0.235	0.387	–0.435	0.505	68.705	0.085	17.300	2.182
GHABP benefit >59%	q3	cscr3540	2	0.225	0.346	–0.359	0.576	65.587	0.085	16.419	2.182
GHABP benefit >59%	2q3	cscr3540	2	0.127	0.234	–0.413	0.932	41.272	0.085	13.406	2.182
GHABP benefit >59%	max3	cscr3540	2	0.225	0.346	–0.359	0.576	65.587	0.085	16.419	2.182
GHABP benefit >59%	2max3	cscr3540	2	0.133	0.261	–0.475	0.877	42.962	0.085	13.978	2.182
GHABP benefit >59%	h	cscr3540	2	0.225	0.346	–0.359	0.576	65.587	0.085	16.419	2.182
GHABP benefit >59%	h2	cscr3540	2	0.127	0.234	–0.413	0.932	41.272	0.085	13.406	2.182
GHABP benefit >59%	q12	cscr3540	2	0.235	0.373	–0.399	0.523	68.442	0.085	17.036	2.182
GHABP benefit >59%	q1o2	cscr3540	2	0.249	0.423	–0.485	0.436	72.490	0.085	18.118	2.182

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

TABLE 64

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >79%		crLW4K45	1	0.112	0.561	–1.367	0.530	29.368	0.211	18.899	5.446
GHABP benefit >79%		crLW4K40	1	0.124	0.613	–1.441	0.434	31.572	0.211	20.003	5.446
GHABP benefit >79%		crLW4K35	1	0.176	0.680	–1.397	0.232	37.961	0.211	21.564	5.446
GHABP benefit >79%		crLW3K40	1	0.880	0.491	1.196	–0.575	102.266	0.211	20.344	5.446
GHABP benefit >79%		crLW3K35	1	0.919	0.535	1.310	–0.744	107.012	0.211	21.408	5.446
GHABP benefit >79%		crLW3K30	1	0.931	0.640	1.125	–0.920	110.289	0.211	23.585	5.446
GHABP benefit >79%		crLS4K45	1	0.112	0.565	–1.378	0.525	29.458	0.211	18.989	5.446
GHABP benefit >79%		crLS4K40	1	0.112	0.639	–1.571	0.428	30.973	0.211	20.504	5.446
GHABP benefit >79%		crLS4K35	1	0.176	0.706	–1.472	0.195	38.498	0.211	22.101	5.446
GHABP benefit >79%		crLS3K40	1	0.868	0.501	1.112	–0.560	101.340	0.211	20.518	5.446
GHABP benefit >79%		crLS3K35	1	0.919	0.526	1.334	–0.732	106.813	0.211	21.209	5.446
GHABP benefit >79%		crLS3K30	1	0.931	0.638	1.129	–0.918	110.261	0.211	23.557	5.446
GHABP benefit >79%		cwarble	1	0.112	0.498	–1.208	0.610	28.074	0.211	17.605	5.446
GHABP benefit >79%		csteady	1	0.112	0.496	–1.203	0.612	28.035	0.211	17.566	5.446
GHABP benefit >79%		cscr3540	1	0.112	0.480	–1.164	0.632	27.717	0.211	17.249	5.446
GHABP benefit >79%	q1		0	0.233	0.890	–1.956	–0.249	45.062	0.184	23.377	4.736
GHABP benefit >79%	q2		0	0.233	0.846	–1.749	–0.145	44.277	0.184	22.592	4.736
GHABP benefit >79%	q3q4		0	0.221	0.732	–1.389	0.076	41.059	0.184	20.520	4.736
GHABP benefit >79%	2q3q4		0	0.113	0.338	–0.793	0.815	23.617	0.184	13.103	4.736
GHABP benefit >79%	maxq34		0	0.221	0.732	–1.389	0.076	41.059	0.184	20.520	4.736
GHABP benefit >79%	2maxq34		0	0.113	0.380	–0.907	0.758	24.373	0.184	13.858	4.736
GHABP benefit >79%	hear		0	0.221	0.721	–1.357	0.092	40.869	0.184	20.330	4.736
GHABP benefit >79%	2hear		0	0.113	0.338	–0.793	0.815	23.617	0.184	13.103	4.736
GHABP benefit >79%	q12		0	0.233	0.841	–1.726	–0.134	44.182	0.184	22.497	4.736
GHABP benefit >79%	q1or2		0	0.233	0.895	–1.985	–0.263	45.156	0.184	23.472	4.736
GHABP benefit >79%	q1	crLW4K45	2	0.112	0.456	–1.103	0.663	28.763	0.239	18.294	6.157
GHABP benefit >79%	q2	crLW4K45	2	0.112	0.442	–1.067	0.680	28.434	0.239	17.965	6.157
GHABP benefit >79%	q3	crLW4K45	2	0.100	0.380	–0.975	0.794	25.812	0.239	16.490	6.157
GHABP benefit >79%	2q3	crLW4K45	2	0.049	0.206	–0.837	1.239	16.818	0.239	12.278	6.157
GHABP benefit >79%	max3	crLW4K45	2	0.100	0.380	–0.975	0.794	25.812	0.239	16.490	6.157
GHABP benefit >79%	2max3	crLW4K45	2	0.049	0.222	–0.891	1.212	17.185	0.239	12.645	6.157
GHABP benefit >79%	h	crLW4K45	2	0.100	0.380	–0.975	0.794	25.812	0.239	16.490	6.157
GHABP benefit >79%	h2	crLW4K45	2	0.049	0.206	–0.837	1.239	16.818	0.239	12.278	6.157
GHABP benefit >79%	q12	crLW4K45	2	0.112	0.442	–1.067	0.680	28.434	0.239	17.965	6.157
GHABP benefit >79%	q1o2	crLW4K45	2	0.112	0.456	–1.103	0.663	28.763	0.239	18.294	6.157
GHABP benefit >79%	q1	crLW4K40	2	0.124	0.503	–1.161	0.574	30.995	0.239	19.425	6.157
GHABP benefit >79%	q2	crLW4K40	2	0.124	0.494	–1.139	0.585	30.791	0.239	19.222	6.157

continued

TABLE 64 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >79%	q3	crLW4K40	2	0.112	0.427	–1.033	0.700	28.054	0.239	17.631	6.157
GHABP benefit >79%	2q3	crLW4K40	2	0.049	0.230	–0.917	1.199	17.367	0.239	12.827	6.157
GHABP benefit >79%	max3	crLW4K40	2	0.112	0.427	–1.033	0.700	28.054	0.239	17.631	6.157
GHABP benefit >79%	2max3	crLW4K40	2	0.049	0.251	–0.985	1.165	17.856	0.239	13.316	6.157
GHABP benefit >79%	h	crLW4K40	2	0.112	0.427	–1.033	0.700	28.054	0.239	17.631	6.157
GHABP benefit >79%	h2	crLW4K40	2	0.049	0.230	–0.917	1.199	17.367	0.239	12.827	6.157
GHABP benefit >79%	q12	crLW4K40	2	0.124	0.489	–1.126	0.591	30.668	0.239	19.098	6.157
GHABP benefit >79%	q1o2	crLW4K40	2	0.124	0.508	–1.174	0.567	31.118	0.239	19.549	6.157
GHABP benefit >79%	q1	crLW4K35	2	0.176	0.570	–1.106	0.378	37.562	0.239	21.165	6.157
GHABP benefit >79%	q2	crLW4K35	2	0.176	0.547	–1.048	0.407	37.031	0.239	20.634	6.157
GHABP benefit >79%	q3	crLW4K35	2	0.164	0.494	–0.964	0.497	34.621	0.239	19.370	6.157
GHABP benefit >79%	2q3	crLW4K35	2	0.101	0.230	–0.538	1.009	22.390	0.239	13.021	6.157
GHABP benefit >79%	max3	crLW4K35	2	0.164	0.494	–0.964	0.497	34.621	0.239	19.370	6.157
GHABP benefit >79%	2max3	crLW4K35	2	0.101	0.256	–0.623	0.967	23.002	0.239	13.634	6.157
GHABP benefit >79%	h	crLW4K35	2	0.164	0.494	–0.964	0.497	34.621	0.239	19.370	6.157
GHABP benefit >79%	h2	crLW4K35	2	0.101	0.230	–0.538	1.009	22.390	0.239	13.021	6.157
GHABP benefit >79%	q12	crLW4K35	2	0.176	0.541	–1.034	0.413	36.908	0.239	20.510	6.157
GHABP benefit >79%	q1o2	crLW4K35	2	0.176	0.575	–1.119	0.371	37.686	0.239	21.288	6.157
GHABP benefit >79%	q1	crLW3K40	2	0.112	0.381	–0.910	0.759	27.029	0.239	16.560	6.157
GHABP benefit >79%	q2	crLW3K40	2	0.112	0.358	–0.850	0.789	26.498	0.239	16.029	6.157
GHABP benefit >79%	q3	crLW3K40	2	0.100	0.336	–0.859	0.852	24.811	0.239	15.489	6.157
GHABP benefit >79%	2q3	crLW3K40	2	0.049	0.208	–0.845	1.235	16.873	0.239	12.333	6.157
GHABP benefit >79%	max3	crLW3K40	2	0.100	0.336	–0.859	0.852	24.811	0.239	15.489	6.157
GHABP benefit >79%	2max3	crLW3K40	2	0.049	0.224	–0.900	1.207	17.243	0.239	12.703	6.157
GHABP benefit >79%	h	crLW3K40	2	0.100	0.336	–0.859	0.852	24.811	0.239	15.489	6.157
GHABP benefit >79%	h2	crLW3K40	2	0.049	0.208	–0.845	1.235	16.873	0.239	12.333	6.157
GHABP benefit >79%	q12	crLW3K40	2	0.112	0.352	–0.835	0.796	26.374	0.239	15.905	6.157
GHABP benefit >79%	q1o2	crLW3K40	2	0.112	0.386	–0.924	0.752	27.152	0.239	16.683	6.157
GHABP benefit >79%	q1	crLW3K35	2	0.152	0.426	–0.840	0.608	31.893	0.239	17.743	6.157
GHABP benefit >79%	q2	crLW3K35	2	0.152	0.403	–0.781	0.637	31.362	0.239	17.212	6.157
GHABP benefit >79%	q3	crLW3K35	2	0.140	0.364	–0.734	0.715	29.280	0.239	16.276	6.157
GHABP benefit >79%	2q3	crLW3K35	2	0.088	0.208	–0.539	1.082	20.703	0.239	12.482	6.157
GHABP benefit >79%	max3	crLW3K35	2	0.140	0.364	–0.734	0.715	29.280	0.239	16.276	6.157
GHABP benefit >79%	2max3	crLW3K35	2	0.088	0.224	–0.594	1.055	21.073	0.239	12.852	6.157
GHABP benefit >79%	h	crLW3K35	2	0.140	0.364	–0.734	0.715	29.280	0.239	16.276	6.157
GHABP benefit >79%	h2	crLW3K35	2	0.088	0.208	–0.539	1.082	20.703	0.239	12.482	6.157
GHABP benefit >79%	q12	crLW3K35	2	0.152	0.397	–0.768	0.644	31.239	0.239	17.088	6.157

continued

TABLE 64 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >79%	q1o2	crLW3K35	2	0.152	0.431	–0.854	0.601	32.017	0.239	17.866	6.157
GHABP benefit >79%	q1	crLW3K30	2	0.164	0.530	–1.054	0.452	35.449	0.239	20.198	6.157
GHABP benefit >79%	q2	crLW3K30	2	0.164	0.507	–0.996	0.481	34.917	0.239	19.666	6.157
GHABP benefit >79%	q3	crLW3K30	2	0.151	0.454	–0.915	0.573	32.507	0.239	18.403	6.157
GHABP benefit >79%	2q3	crLW3K30	2	0.088	0.219	–0.576	1.063	20.950	0.239	12.728	6.157
GHABP benefit >79%	max3	crLW3K30	2	0.151	0.454	–0.915	0.573	32.507	0.239	18.403	6.157
GHABP benefit >79%	2max3	crLW3K30	2	0.088	0.245	–0.663	1.020	21.562	0.239	13.341	6.157
GHABP benefit >79%	h	crLW3K30	2	0.151	0.454	–0.915	0.573	32.507	0.239	18.403	6.157
GHABP benefit >79%	h2	crLW3K30	2	0.088	0.219	–0.576	1.063	20.950	0.239	12.728	6.157
GHABP benefit >79%	q12	crLW3K30	2	0.164	0.501	–0.983	0.488	34.794	0.239	19.543	6.157
GHABP benefit >79%	q1o2	crLW3K30	2	0.164	0.535	–1.067	0.446	35.572	0.239	20.321	6.157
GHABP benefit >79%	q1	crLS4K45	2	0.112	0.455	–1.102	0.663	28.754	0.239	18.286	6.157
GHABP benefit >79%	q2	crLS4K45	2	0.112	0.447	–1.080	0.674	28.551	0.239	18.082	6.157
GHABP benefit >79%	q3	crLS4K45	2	0.100	0.380	–0.975	0.794	25.813	0.239	16.491	6.157
GHABP benefit >79%	2q3	crLS4K45	2	0.049	0.216	–0.870	1.222	17.039	0.239	12.499	6.157
GHABP benefit >79%	max3	crLS4K45	2	0.100	0.380	–0.975	0.794	25.813	0.239	16.491	6.157
GHABP benefit >79%	2max3	crLS4K45	2	0.049	0.232	–0.923	1.195	17.410	0.239	12.870	6.157
GHABP benefit >79%	h	crLS4K45	2	0.100	0.380	–0.975	0.794	25.813	0.239	16.491	6.157
GHABP benefit >79%	h2	crLS4K45	2	0.049	0.216	–0.870	1.222	17.039	0.239	12.499	6.157
GHABP benefit >79%	q12	crLS4K45	2	0.112	0.441	–1.066	0.681	28.427	0.239	17.958	6.157
GHABP benefit >79%	q1o2	crLS4K45	2	0.112	0.461	–1.115	0.656	28.878	0.239	18.409	6.157
GHABP benefit >79%	q1	crLS4K40	2	0.112	0.529	–1.288	0.570	30.467	0.239	19.998	6.157
GHABP benefit >79%	q2	crLS4K40	2	0.112	0.515	–1.253	0.588	30.145	0.239	19.676	6.157
GHABP benefit >79%	q3	crLS4K40	2	0.100	0.454	–1.165	0.699	27.526	0.239	18.203	6.157
GHABP benefit >79%	2q3	crLS4K40	2	0.049	0.230	–0.917	1.199	17.367	0.239	12.827	6.157
GHABP benefit >79%	max3	crLS4K40	2	0.100	0.454	–1.165	0.699	27.526	0.239	18.203	6.157
GHABP benefit >79%	2max3	crLS4K40	2	0.049	0.256	–1.003	1.156	17.984	0.239	13.444	6.157
GHABP benefit >79%	h	crLS4K40	2	0.100	0.454	–1.165	0.699	27.526	0.239	18.203	6.157
GHABP benefit >79%	h2	crLS4K40	2	0.049	0.230	–0.917	1.199	17.367	0.239	12.827	6.157
GHABP benefit >79%	q12	crLS4K40	2	0.112	0.510	–1.239	0.594	30.021	0.239	19.552	6.157
GHABP benefit >79%	q1o2	crLS4K40	2	0.112	0.535	–1.301	0.563	30.590	0.239	20.122	6.157
GHABP benefit >79%	q1	crLS4K35	2	0.176	0.596	–1.173	0.344	38.169	0.239	21.772	6.157
GHABP benefit >79%	q2	crLS4K35	2	0.176	0.568	–1.101	0.380	37.520	0.239	21.122	6.157
GHABP benefit >79%	q3	crLS4K35	2	0.164	0.520	–1.030	0.464	35.228	0.239	19.977	6.157
GHABP benefit >79%	2q3	crLS4K35	2	0.101	0.230	–0.538	1.009	22.390	0.239	13.021	6.157
GHABP benefit >79%	max3	crLS4K35	2	0.164	0.520	–1.030	0.464	35.228	0.239	19.977	6.157
GHABP benefit >79%	2max3	crLS4K35	2	0.101	0.262	–0.640	0.958	23.130	0.239	13.762	6.157

continued

TABLE 64 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >79%	h	crLS4K35	2	0.164	0.520	–1.030	0.464	35.228	0.239	19.977	6.157
GHABP benefit >79%	h2	crLS4K35	2	0.101	0.230	–0.538	1.009	22.390	0.239	13.021	6.157
GHABP benefit >79%	q12	crLS4K35	2	0.176	0.562	–1.087	0.387	37.396	0.239	20.999	6.157
GHABP benefit >79%	q1o2	crLS4K35	2	0.176	0.601	–1.187	0.337	38.293	0.239	21.895	6.157
GHABP benefit >79%	q1	crLS3K40	2	0.101	0.391	–1.003	0.777	26.130	0.239	16.762	6.157
GHABP benefit >79%	q2	crLS3K40	2	0.101	0.368	–0.942	0.807	25.599	0.239	16.231	6.157
GHABP benefit >79%	q3	crLS3K40	2	0.088	0.347	–0.958	0.872	23.913	0.239	15.691	6.157
GHABP benefit >79%	2q3	crLS3K40	2	0.049	0.219	–0.882	1.216	17.120	0.239	12.580	6.157
GHABP benefit >79%	max3	crLS3K40	2	0.088	0.347	–0.958	0.872	23.913	0.239	15.691	6.157
GHABP benefit >79%	2max3	crLS3K40	2	0.049	0.235	–0.935	1.190	17.490	0.239	12.950	6.157
GHABP benefit >79%	h	crLS3K40	2	0.088	0.347	–0.958	0.872	23.913	0.239	15.691	6.157
GHABP benefit >79%	h2	crLS3K40	2	0.049	0.219	–0.882	1.216	17.120	0.239	12.580	6.157
GHABP benefit >79%	q12	crLS3K40	2	0.101	0.363	–0.928	0.814	25.476	0.239	16.108	6.157
GHABP benefit >79%	q1o2	crLS3K40	2	0.101	0.397	–1.017	0.770	26.254	0.239	16.886	6.157
GHABP benefit >79%	q1	crLS3K35	2	0.152	0.416	–0.815	0.620	31.668	0.239	17.518	6.157
GHABP benefit >79%	q2	crLS3K35	2	0.152	0.393	–0.756	0.650	31.137	0.239	16.987	6.157
GHABP benefit >79%	q3	crLS3K35	2	0.140	0.354	–0.708	0.728	29.055	0.239	16.051	6.157
GHABP benefit >79%	2q3	crLS3K35	2	0.088	0.219	–0.576	1.063	20.950	0.239	12.728	6.157
GHABP benefit >79%	max3	crLS3K35	2	0.140	0.354	–0.708	0.728	29.055	0.239	16.051	6.157
GHABP benefit >79%	2max3	crLS3K35	2	0.088	0.240	–0.646	1.028	21.444	0.239	13.222	6.157
GHABP benefit >79%	h	crLS3K35	2	0.140	0.354	–0.708	0.728	29.055	0.239	16.051	6.157
GHABP benefit >79%	h2	crLS3K35	2	0.088	0.219	–0.576	1.063	20.950	0.239	12.728	6.157
GHABP benefit >79%	q12	crLS3K35	2	0.152	0.387	–0.742	0.657	31.014	0.239	16.863	6.157
GHABP benefit >79%	q1o2	crLS3K35	2	0.152	0.421	–0.829	0.614	31.792	0.239	17.641	6.157
GHABP benefit >79%	q1	crLS3K30	2	0.164	0.528	–1.050	0.454	35.418	0.239	20.167	6.157
GHABP benefit >79%	q2	crLS3K30	2	0.164	0.500	–0.980	0.489	34.768	0.239	19.517	6.157
GHABP benefit >79%	q3	crLS3K30	2	0.151	0.447	–0.898	0.581	32.353	0.239	18.248	6.157
GHABP benefit >79%	2q3	crLS3K30	2	0.088	0.229	–0.611	1.046	21.192	0.239	12.970	6.157
GHABP benefit >79%	max3	crLS3K30	2	0.151	0.447	–0.898	0.581	32.353	0.239	18.248	6.157
GHABP benefit >79%	2max3	crLS3K30	2	0.088	0.251	–0.680	1.012	21.686	0.239	13.464	6.157
GHABP benefit >79%	h	crLS3K30	2	0.151	0.447	–0.898	0.581	32.353	0.239	18.248	6.157
GHABP benefit >79%	h2	crLS3K30	2	0.088	0.229	–0.611	1.046	21.192	0.239	12.970	6.157
GHABP benefit >79%	q12	crLS3K30	2	0.164	0.495	–0.967	0.496	34.644	0.239	19.393	6.157
GHABP benefit >79%	q1o2	crLS3K30	2	0.164	0.534	–1.064	0.447	35.541	0.239	20.290	6.157
GHABP benefit >79%	q	cwarble	2	0.112	0.393	–0.941	0.743	27.301	0.239	16.832	6.157
GHABP benefit >79%	q	cwarble	2	0.112	0.378	–0.904	0.762	26.972	0.239	16.503	6.157
GHABP benefit >79%	q	cwarble	2	0.100	0.331	–0.843	0.859	24.679	0.239	15.357	6.157

continued

TABLE 66 *(cont'd)*

Description of outcome criterion	Question	Audio screen	Screening stages[a]	sen	fa	d′	crit	cost.avg	cost.slope	cost.sc.avg	cost.sc.slope
GHABP benefit >79%	2q	cwarble	2	0.049	0.204	–0.830	1.242	16.775	0.239	12.235	6.157
GHABP benefit >79%	max	cwarble	2	0.100	0.331	–0.843	0.859	24.679	0.239	15.357	6.157
GHABP benefit >79%	2max	cwarble	2	0.049	0.220	–0.886	1.214	17.147	0.239	12.607	6.157
GHABP benefit >79%	h	cwarble	2	0.100	0.331	–0.843	0.859	24.679	0.239	15.357	6.157
GHABP benefit >79%	h	cwarble	2	0.049	0.204	–0.830	1.242	16.775	0.239	12.235	6.157
GHABP benefit >79%	q1	cwarble	2	0.112	0.378	–0.904	0.762	26.972	0.239	16.503	6.157
GHABP benefit >79%	q1o	cwarble	2	0.112	0.393	–0.941	0.743	27.301	0.239	16.832	6.157
GHABP benefit >79%	q	csteady	2	0.112	0.386	–0.924	0.752	27.146	0.239	16.677	6.157
GHABP benefit >79%	q	csteady	2	0.112	0.377	–0.901	0.764	26.942	0.239	16.473	6.157
GHABP benefit >79%	q	csteady	2	0.100	0.324	–0.826	0.868	24.532	0.239	15.210	6.157
GHABP benefit >79%	2q	csteady	2	0.049	0.219	–0.882	1.216	17.120	0.239	12.580	6.157
GHABP benefit >79%	max	csteady	2	0.100	0.324	–0.826	0.868	24.532	0.239	15.210	6.157
GHABP benefit >79%	2max	csteady	2	0.049	0.240	–0.952	1.181	17.614	0.239	13.074	6.157
GHABP benefit >79%	h	csteady	2	0.100	0.324	–0.826	0.868	24.532	0.239	15.210	6.157
GHABP benefit >79%	h	csteady	2	0.049	0.219	–0.882	1.216	17.120	0.239	12.580	6.157
GHABP benefit >79%	q1	csteady	2	0.112	0.372	–0.886	0.771	26.818	0.239	16.350	6.157
GHABP benefit >79%	q1o	csteady	2	0.112	0.391	–0.938	0.745	27.269	0.239	16.800	6.157
GHABP benefit >79%	q1	cscr3540	2	0.112	0.370	–0.883	0.772	26.787	0.239	16.318	6.157
GHABP benefit >79%	q2	cscr3540	2	0.112	0.347	–0.821	0.803	26.256	0.239	15.787	6.157
GHABP benefit >79%	q3	cscr3540	2	0.100	0.326	–0.830	0.866	24.569	0.239	15.247	6.157
GHABP benefit >79%	2q3	cscr3540	2	0.049	0.203	–0.826	1.244	16.750	0.239	12.210	6.157
GHABP benefit >79%	max3	cscr3540	2	0.100	0.326	–0.830	0.866	24.569	0.239	15.247	6.157
GHABP benefit >79%	2max3	cscr3540	2	0.049	0.219	–0.882	1.216	17.120	0.239	12.580	6.157
GHABP benefit >79%	h	cscr3540	2	0.100	0.326	–0.830	0.866	24.569	0.239	15.247	6.157
GHABP benefit >79%	h2	cscr3540	2	0.049	0.203	–0.826	1.244	16.750	0.239	12.210	6.157
GHABP benefit >79%	q12	cscr3540	2	0.112	0.342	–0.807	0.810	26.132	0.239	15.663	6.157
GHABP benefit >79%	q1o2	cscr3540	2	0.112	0.376	–0.897	0.765	26.910	0.239	16.441	6.157

[a] 1, audiometric screen alone; 0, questionnaire alone; 2, combination of questionnaire and audiometric screen.

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Volume 1, 1997

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By Hobbs FDR, Delaney BC, Fitzmaurice DA, Wilson S, Hyde CJ, Thorpe GH, *et al*.

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Volume 3, 1999

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Volume 4, 2000

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Systematic reviews of wound care management: (3) antimicrobial agents for chronic wounds; (4) diabetic foot ulceration.
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Using routine data to complement and enhance the results of randomised controlled trials.
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Coronary artery stents in the treatment of ischaemic heart disease: a rapid and systematic review.
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A randomised controlled trial of prehospital intravenous fluid replacement therapy in serious trauma.
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Intrathecal pumps for giving opioids in chronic pain: a systematic review.
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Combination therapy (interferon alfa and ribavirin) in the treatment of chronic hepatitis C: a rapid and systematic review.
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A systematic review of comparisons of effect sizes derived from randomised and non-randomised studies.
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No. 36
A randomised controlled trial to evaluate the effectiveness and cost-effectiveness of counselling patients with chronic depression.
By Simpson S, Corney R, Fitzgerald P, Beecham J.

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Systematic review of treatments for atopic eczema.
By Hoare C, Li Wan Po A, Williams H.

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By Spiegelhalter DJ, Myles JP, Jones DR, Abrams KR.

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The management of dyspepsia: a systematic review.
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A systematic review of treatments for severe psoriasis.
By Griffiths CEM, Clark CM, Chalmers RJG, Li Wan Po A, Williams HC.

Volume 5, 2001

No. 1
Clinical and cost-effectiveness of donepezil, rivastigmine and galantamine for Alzheimer's disease: a rapid and systematic review.
By Clegg A, Bryant J, Nicholson T, McIntyre L, De Broe S, Gerard K, *et al*.

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The clinical effectiveness and cost-effectiveness of riluzole for motor neurone disease: a rapid and systematic review.
By Stewart A, Sandercock J, Bryan S, Hyde C, Barton PM, Fry-Smith A, *et al*.

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Equity and the economic evaluation of healthcare.
By Sassi F, Archard L, Le Grand J.

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By Eiser C, Morse R.

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By Ryan M, Scott DA, Reeves C, Bate A, van Teijlingen ER, Russell EM, *et al*.

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By Riemsma RP, Forbes CA, Glanville JM, Eastwood AJ, Kleijnen J.

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By Pembrey ME, Barnicoat AJ, Carmichael B, Bobrow M, Turner G.

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By Lilford RJ, Richardson A, Stevens A, Fitzpatrick R, Edwards S, Rock F, *et al*.

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Systematic reviews of wound care management: (5) beds; (6) compression; (7) laser therapy, therapeutic ultrasound, electrotherapy and electromagnetic therapy.
By Cullum N, Nelson EA, Flemming K, Sheldon T.

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Effectiveness of autologous chondrocyte transplantation for hyaline cartilage defects in knees: a rapid and systematic review.
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Statistical assessment of the learning curves of health technologies.
By Ramsay CR, Grant AM, Wallace SA, Garthwaite PH, Monk AF, Russell IT.

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The effectiveness and cost-effectiveness of temozolomide for the treatment of recurrent malignant glioma: a rapid and systematic review.
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A rapid and systematic review of the clinical effectiveness and cost-effectiveness of debriding agents in treating surgical wounds healing by secondary intention.
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Home treatment for mental health problems: a systematic review.
By Burns T, Knapp M, Catty J, Healey A, Henderson J, Watt H, *et al*.

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How to develop cost-conscious guidelines.
By Eccles M, Mason J.

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The role of specialist nurses in multiple sclerosis: a rapid and systematic review.
By De Broe S, Christopher F, Waugh N.

No. 18
A rapid and systematic review of the clinical effectiveness and cost-effectiveness of orlistat in the management of obesity.
By O'Meara S, Riemsma R, Shirran L, Mather L, ter Riet G.

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The clinical effectiveness and cost-effectiveness of pioglitazone for type 2 diabetes mellitus: a rapid and systematic review.
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Extended scope of nursing practice: a multicentre randomised controlled trial of appropriately trained nurses and preregistration house officers in pre-operative assessment in elective general surgery.
By Kinley H, Czoski-Murray C, George S, McCabe C, Primrose J, Reilly C, *et al*.

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Systematic reviews of the effectiveness of day care for people with severe mental disorders: (1) Acute day hospital versus admission; (2) Vocational rehabilitation; (3) Day hospital versus outpatient care.
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The measurement and monitoring of surgical adverse events.
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No. 26
Comparison of the effectiveness of inhaler devices in asthma and chronic obstructive airways disease: a systematic review of the literature.
By Brocklebank D, Ram F, Wright J, Barry P, Cates C, Davies L, *et al*.

No. 27
The cost-effectiveness of magnetic resonance imaging for investigation of the knee joint.
By Bryan S, Weatherburn G, Bungay H, Hatrick C, Salas C, Parry D, *et al*.

No. 28
A rapid and systematic review of the clinical effectiveness and cost-effectiveness of topotecan for ovarian cancer.
By Forbes C, Shirran L, Bagnall A-M, Duffy S, ter Riet G.

No. 29
Superseded by a report published in a later volume.

No. 30
The role of radiography in primary care patients with low back pain of at least 6 weeks duration: a randomised (unblinded) controlled trial.
By Kendrick D, Fielding K, Bentley E, Miller P, Kerslake R, Pringle M.

No. 31
Design and use of questionnaires: a review of best practice applicable to surveys of health service staff and patients.
By McColl E, Jacoby A, Thomas L, Soutter J, Bamford C, Steen N, *et al*.

No. 32
A rapid and systematic review of the clinical effectiveness and cost-effectiveness of paclitaxel, docetaxel, gemcitabine and vinorelbine in non-small-cell lung cancer.
By Clegg A, Scott DA, Sidhu M, Hewitson P, Waugh N.

No. 33
Subgroup analyses in randomised controlled trials: quantifying the risks of false-positives and false-negatives.
By Brookes ST, Whitley E, Peters TJ, Mulheran PA, Egger M, Davey Smith G.

No. 34
Depot antipsychotic medication in the treatment of patients with schizophrenia: (1) Meta-review; (2) Patient and nurse attitudes.
By David AS, Adams C.

No. 35
A systematic review of controlled trials of the effectiveness and cost-effectiveness of brief psychological treatments for depression.
By Churchill R, Hunot V, Corney R, Knapp M, McGuire H, Tylee A, *et al*.

No. 36
Cost analysis of child health surveillance.
By Sanderson D, Wright D, Acton C, Duree D.

Volume 6, 2002

No. 1
A study of the methods used to select review criteria for clinical audit.
By Hearnshaw H, Harker R, Cheater F, Baker R, Grimshaw G.

No. 2
Fludarabine as second-line therapy for B cell chronic lymphocytic leukaemia: a technology assessment.
By Hyde C, Wake B, Bryan S, Barton P, Fry-Smith A, Davenport C, *et al*.

No. 3
Rituximab as third-line treatment for refractory or recurrent Stage III or IV follicular non-Hodgkin's lymphoma: a systematic review and economic evaluation.
By Wake B, Hyde C, Bryan S, Barton P, Song F, Fry-Smith A, *et al*.

No. 4
A systematic review of discharge arrangements for older people.
By Parker SG, Peet SM, McPherson A, Cannaby AM, Baker R, Wilson A, *et al*.

No. 5
The clinical effectiveness and cost-effectiveness of inhaler devices used in the routine management of chronic asthma in older children: a systematic review and economic evaluation.
By Peters J, Stevenson M, Beverley C, Lim J, Smith S.

No. 6
The clinical effectiveness and cost-effectiveness of sibutramine in the management of obesity: a technology assessment.
By O'Meara S, Riemsma R, Shirran L, Mather L, ter Riet G.

No. 7
The cost-effectiveness of magnetic resonance angiography for carotid artery stenosis and peripheral vascular disease: a systematic review.
By Berry E, Kelly S, Westwood ME, Davies LM, Gough MJ, Bamford JM, *et al*.

No. 8
Promoting physical activity in South Asian Muslim women through 'exercise on prescription'.
By Carroll B, Ali N, Azam N.

No. 9
Zanamivir for the treatment of influenza in adults: a systematic review and economic evaluation.
By Burls A, Clark W, Stewart T, Preston C, Bryan S, Jefferson T, *et al*.

No. 10
A review of the natural history and epidemiology of multiple sclerosis: implications for resource allocation and health economic models.
By Richards RG, Sampson FC, Beard SM, Tappenden P.

No. 11
Screening for gestational diabetes: a systematic review and economic evaluation.
By Scott DA, Loveman E, McIntyre L, Waugh N.

No. 12
The clinical effectiveness and cost-effectiveness of surgery for people with morbid obesity: a systematic review and economic evaluation.
By Clegg AJ, Colquitt J, Sidhu MK, Royle P, Loveman E, Walker A.

No. 13
The clinical effectiveness of trastuzumab for breast cancer: a systematic review.
By Lewis R, Bagnall A-M, Forbes C, Shirran E, Duffy S, Kleijnen J, *et al*.

No. 14
The clinical effectiveness and cost-effectiveness of vinorelbine for breast cancer: a systematic review and economic evaluation.
By Lewis R, Bagnall A-M, King S, Woolacott N, Forbes C, Shirran L, *et al*.

No. 15
A systematic review of the effectiveness and cost-effectiveness of metal-on-metal hip resurfacing arthroplasty for treatment of hip disease.
By Vale L, Wyness L, McCormack K, McKenzie L, Brazzelli M, Stearns SC.

No. 16
The clinical effectiveness and cost-effectiveness of bupropion and nicotine replacement therapy for smoking cessation: a systematic review and economic evaluation.
By Woolacott NF, Jones L, Forbes CA, Mather LC, Sowden AJ, Song FJ, *et al*.

No. 17
A systematic review of effectiveness and economic evaluation of new drug treatments for juvenile idiopathic arthritis: etanercept.
By Cummins C, Connock M, Fry-Smith A, Burls A.

No. 18
Clinical effectiveness and cost-effectiveness of growth hormone in children: a systematic review and economic evaluation.
By Bryant J, Cave C, Mihaylova B, Chase D, McIntyre L, Gerard K, *et al*.

No. 19
Clinical effectiveness and cost-effectiveness of growth hormone in adults in relation to impact on quality of life: a systematic review and economic evaluation.
By Bryant J, Loveman E, Chase D, Mihaylova B, Cave C, Gerard K, *et al*.

No. 20
Clinical medication review by a pharmacist of patients on repeat prescriptions in general practice: a randomised controlled trial.
By Zermansky AG, Petty DR, Raynor DK, Lowe CJ, Freementle N, Vail A.

No. 21
The effectiveness of infliximab and etanercept for the treatment of rheumatoid arthritis: a systematic review and economic evaluation.
By Jobanputra P, Barton P, Bryan S, Burls A.

No. 22
A systematic review and economic evaluation of computerised cognitive behaviour therapy for depression and anxiety.
By Kaltenthaler E, Shackley P, Stevens K, Beverley C, Parry G, Chilcott J.

No. 23
A systematic review and economic evaluation of pegylated liposomal doxorubicin hydrochloride for ovarian cancer.
By Forbes C, Wilby J, Richardson G, Sculpher M, Mather L, Reimsma R.

No. 24
A systematic review of the effectiveness of interventions based on a stages-of-change approach to promote individual behaviour change.
By Riemsma RP, Pattenden J, Bridle C, Sowden AJ, Mather L, Watt IS, *et al*.

No. 25
A systematic review update of the clinical effectiveness and cost-effectiveness of glycoprotein IIb/IIIa antagonists.
By Robinson M, Ginnelly L, Sculpher M, Jones L, Riemsma R, Palmer S, *et al*.

No. 26
A systematic review of the effectiveness, cost-effectiveness and barriers to implementation of thrombolytic and neuroprotective therapy for acute ischaemic stroke in the NHS.
By Sandercock P, Berge E, Dennis M, Forbes J, Hand P, Kwan J, *et al*.

No. 27
A randomised controlled crossover trial of nurse practitioner versus doctor-led outpatient care in a bronchiectasis clinic.
By Caine N, Sharples LD, Hollingworth W, French J, Keogan M, Exley A, *et al*.

No. 28
Clinical effectiveness and cost – consequences of selective serotonin reuptake inhibitors in the treatment of sex offenders.
By Adi Y, Ashcroft D, Browne K, Beech A, Fry-Smith A, Hyde C.

No. 29
Treatment of established osteoporosis: a systematic review and cost–utility analysis.
By Kanis JA, Brazier JE, Stevenson M, Calvert NW, Lloyd Jones M.

No. 30
Which anaesthetic agents are cost-effective in day surgery? Literature review, national survey of practice and randomised controlled trial.
By Elliott RA Payne K, Moore JK, Davies LM, Harper NJN, St Leger AS, *et al*.

No. 31
Screening for hepatitis C among injecting drug users and in genitourinary medicine clinics: systematic reviews of effectiveness, modelling study and national survey of current practice.
By Stein K, Dalziel K, Walker A, McIntyre L, Jenkins B, Horne J, *et al*.

No. 32
The measurement of satisfaction with healthcare: implications for practice from a systematic review of the literature.
By Crow R, Gage H, Hampson S, Hart J, Kimber A, Storey L, *et al*.

No. 33
The effectiveness and cost-effectiveness of imatinib in chronic myeloid leukaemia: a systematic review.
By Garside R, Round A, Dalziel K, Stein K, Royle R.

No. 34
A comparative study of hypertonic saline, daily and alternate-day rhDNase in children with cystic fibrosis.
By Suri R, Wallis C, Bush A, Thompson S, Normand C, Flather M, *et al*.

No. 35
A systematic review of the costs and effectiveness of different models of paediatric home care.
By Parker G, Bhakta P, Lovett CA, Paisley S, Olsen R, Turner D, *et al*.

Volume 7, 2003

No. 1
How important are comprehensive literature searches and the assessment of trial quality in systematic reviews? Empirical study.
By Egger M, Jüni P, Bartlett C, Holenstein F, Sterne J.

No. 2
Systematic review of the effectiveness and cost-effectiveness, and economic evaluation, of home versus hospital or satellite unit haemodialysis for people with end-stage renal failure.
By Mowatt G, Vale L, Perez J, Wyness L, Fraser C, MacLeod A, *et al*.

No. 3
Systematic review and economic evaluation of the effectiveness of infliximab for the treatment of Crohn's disease.
By Clark W, Raftery J, Barton P, Song F, Fry-Smith A, Burls A.

No. 4
A review of the clinical effectiveness and cost-effectiveness of routine anti-D prophylaxis for pregnant women who are rhesus negative.
By Chilcott J, Lloyd Jones M, Wight J, Forman K, Wray J, Beverley C, *et al*.

No. 5
Systematic review and evaluation of the use of tumour markers in paediatric oncology: Ewing's sarcoma and neuroblastoma.
By Riley RD, Burchill SA, Abrams KR, Heney D, Lambert PC, Jones DR, *et al*.

No. 6
The cost-effectiveness of screening for *Helicobacter pylori* to reduce mortality and morbidity from gastric cancer and peptic ulcer disease: a discrete-event simulation model.
By Roderick P, Davies R, Raftery J, Crabbe D, Pearce R, Bhandari P, *et al*.

No. 7
The clinical effectiveness and cost-effectiveness of routine dental checks: a systematic review and economic evaluation.
By Davenport C, Elley K, Salas C, Taylor-Weetman CL, Fry-Smith A, Bryan S, *et al*.

No. 8
A multicentre randomised controlled trial assessing the costs and benefits of using structured information and analysis of women's preferences in the management of menorrhagia.
By Kennedy ADM, Sculpher MJ, Coulter A, Dwyer N, Rees M, Horsley S, *et al*.

No. 9
Clinical effectiveness and cost–utility of photodynamic therapy for wet age-related macular degeneration: a systematic review and economic evaluation.
By Meads C, Salas C, Roberts T, Moore D, Fry-Smith A, Hyde C.

No. 10
Evaluation of molecular tests for prenatal diagnosis of chromosome abnormalities.
By Grimshaw GM, Szczepura A, Hultén M, MacDonald F, Nevin NC, Sutton F, *et al*.

No. 11
First and second trimester antenatal screening for Down's syndrome: the results of the Serum, Urine and Ultrasound Screening Study (SURUSS).
By Wald NJ, Rodeck C, Hackshaw AK, Walters J, Chitty L, Mackinson AM.

No. 12
The effectiveness and cost-effectiveness of ultrasound locating devices for central venous access: a systematic review and economic evaluation.
By Calvert N, Hind D, McWilliams RG, Thomas SM, Beverley C, Davidson A.

No. 13
A systematic review of atypical antipsychotics in schizophrenia.
By Bagnall A-M, Jones L, Lewis R, Ginnelly L, Glanville J, Torgerson D, *et al*.

No. 14
Prostate Testing for Cancer and Treatment (ProtecT) feasibility study.
By Donovan J, Hamdy F, Neal D, Peters T, Oliver S, Brindle L, *et al*.

No. 15
Early thrombolysis for the treatment of acute myocardial infarction: a systematic review and economic evaluation.
By Boland A, Dundar Y, Bagust A, Haycox A, Hill R, Mujica Mota R, *et al*.

No. 16
Screening for fragile X syndrome: a literature review and modelling.
By Song FJ, Barton P, Sleightholme V, Yao GL, Fry-Smith A.

No. 17
Systematic review of endoscopic sinus surgery for nasal polyps.
By Dalziel K, Stein K, Round A, Garside R, Royle P.

No. 18
Towards efficient guidelines: how to monitor guideline use in primary care.
By Hutchinson A, McIntosh A, Cox S, Gilbert C.

No. 19
Effectiveness and cost-effectiveness of acute hospital-based spinal cord injuries services: systematic review.
By Bagnall A-M, Jones L, Richardson G, Duffy S, Riemsma R.

No. 20
Prioritisation of health technology assessment. The PATHS model: methods and case studies.
By Townsend J, Buxton M, Harper G.

No. 21
Systematic review of the clinical effectiveness and cost-effectiveness of tension-free vaginal tape for treatment of urinary stress incontinence.
By Cody J, Wyness L, Wallace S, Glazener C, Kilonzo M, Stearns S, *et al*.

No. 22
The clinical and cost-effectiveness of patient education models for diabetes: a systematic review and economic evaluation.
By Loveman E, Cave C, Green C, Royle P, Dunn N, Waugh N.

No. 23
The role of modelling in prioritising and planning clinical trials.
By Chilcott J, Brennan A, Booth A, Karnon J, Tappenden P.

No. 24
Cost–benefit evaluation of routine influenza immunisation in people 65–74 years of age.
By Allsup S, Gosney M, Haycox A, Regan M.

No. 25
The clinical and cost-effectiveness of pulsatile machine perfusion versus cold storage of kidneys for transplantation retrieved from heart-beating and non-heart-beating donors.
By Wight J, Chilcott J, Holmes M, Brewer N.

No. 26
Can randomised trials rely on existing electronic data? A feasibility study to explore the value of routine data in health technology assessment.
By Williams JG, Cheung WY, Cohen DR, Hutchings HA, Longo MF, Russell IT.

No. 27
Evaluating non-randomised intervention studies.
By Deeks JJ, Dinnes J, D'Amico R, Sowden AJ, Sakarovitch C, Song F, *et al*.

No. 28
A randomised controlled trial to assess the impact of a package comprising a patient-orientated, evidence-based self-help guidebook and patient-centred consultations on disease management and satisfaction in inflammatory bowel disease.
By Kennedy A, Nelson E, Reeves D, Richardson G, Roberts C, Robinson A, *et al*.

No. 29
The effectiveness of diagnostic tests for the assessment of shoulder pain due to soft tissue disorders: a systematic review.
By Dinnes J, Loveman E, McIntyre L, Waugh N.

No. 30
The value of digital imaging in diabetic retinopathy.
By Sharp PF, Olson J, Strachan F, Hipwell J, Ludbrook A, O'Donnell M, *et al*.

No. 31
Lowering blood pressure to prevent myocardial infarction and stroke: a new preventive strategy.
By Law M, Wald N, Morris J.

No. 32
Clinical and cost-effectiveness of capecitabine and tegafur with uracil for the treatment of metastatic colorectal cancer: systematic review and economic evaluation.
By Ward S, Kaltenthaler E, Cowan J, Brewer N.

No. 33
Clinical and cost-effectiveness of new and emerging technologies for early localised prostate cancer: a systematic review.
By Hummel S, Paisley S, Morgan A, Currie E, Brewer N.

No. 34
Literature searching for clinical and cost-effectiveness studies used in health technology assessment reports carried out for the National Institute for Clinical Excellence appraisal system.
By Royle P, Waugh N.

No. 35
Systematic review and economic decision modelling for the prevention and treatment of influenza A and B.
By Turner D, Wailoo A, Nicholson K, Cooper N, Sutton A, Abrams K.

No. 36
A randomised controlled trial to evaluate the clinical and cost-effectiveness of Hickman line insertions in adult cancer patients by nurses.
By Boland A, Haycox A, Bagust A, Fitzsimmons L.

No. 37
Redesigning postnatal care: a randomised controlled trial of protocol-based midwifery-led care focused on individual women's physical and psychological health needs.
By MacArthur C, Winter HR, Bick DE, Lilford RJ, Lancashire RJ, Knowles H, *et al*.

No. 38
Estimating implied rates of discount in healthcare decision-making.
By West RR, McNabb R, Thompson AGH, Sheldon TA, Grimley Evans J.

No. 39
Systematic review of isolation policies in the hospital management of methicillin-resistant *Staphylococcus aureus*: a review of the literature with epidemiological and economic modelling.
By Cooper BS, Stone SP, Kibbler CC, Cookson BD, Roberts JA, Medley GF, *et al*.

No. 40
Treatments for spasticity and pain in multiple sclerosis: a systematic review.
By Beard S, Hunn A, Wight J.

No. 41
The inclusion of reports of randomised trials published in languages other than English in systematic reviews.
By Moher D, Pham B, Lawson ML, Klassen TP.

No. 42
The impact of screening on future health-promoting behaviours and health beliefs: a systematic review.
By Bankhead CR, Brett J, Bukach C, Webster P, Stewart-Brown S, Munafo M, *et al*.

Volume 8, 2004

No. 1
What is the best imaging strategy for acute stroke?
By Wardlaw JM, Keir SL, Seymour J, Lewis S, Sandercock PAG, Dennis MS, *et al*.

No. 2
Systematic review and modelling of the investigation of acute and chronic chest pain presenting in primary care.
By Mant J, McManus RJ, Oakes RAL, Delaney BC, Barton PM, Deeks JJ, *et al*.

No. 3
The effectiveness and cost-effectiveness of microwave and thermal balloon endometrial ablation for heavy menstrual bleeding: a systematic review and economic modelling.
By Garside R, Stein K, Wyatt K, Round A, Price A.

No. 4
A systematic review of the role of bisphosphonates in metastatic disease.
By Ross JR, Saunders Y, Edmonds PM, Patel S, Wonderling D, Normand C, *et al*.

No. 5
Systematic review of the clinical effectiveness and cost-effectiveness of capecitabine (Xeloda®) for locally advanced and/or metastatic breast cancer.
By Jones L, Hawkins N, Westwood M, Wright K, Richardson G, Riemsma R.

No. 6
Effectiveness and efficiency of guideline dissemination and implementation strategies.
By Grimshaw JM, Thomas RE, MacLennan G, Fraser C, Ramsay CR, Vale L, *et al*.

No. 7
Clinical effectiveness and costs of the Sugarbaker procedure for the treatment of pseudomyxoma peritonei.
By Bryant J, Clegg AJ, Sidhu MK, Brodin H, Royle P, Davidson P.

No. 8
Psychological treatment for insomnia in the regulation of long-term hypnotic drug use.
By Morgan K, Dixon S, Mathers N, Thompson J, Tomeny M.

No. 9
Improving the evaluation of therapeutic interventions in multiple sclerosis: development of a patient-based measure of outcome.
By Hobart JC, Riazi A, Lamping DL, Fitzpatrick R, Thompson AJ.

No. 10
A systematic review and economic evaluation of magnetic resonance cholangiopancreatography compared with diagnostic endoscopic retrograde cholangiopancreatography.
By Kaltenthaler E, Bravo Vergel Y, Chilcott J, Thomas S, Blakeborough T, Walters SJ, *et al*.

No. 11
The use of modelling to evaluate new drugs for patients with a chronic condition: the case of antibodies against tumour necrosis factor in rheumatoid arthritis.
By Barton P, Jobanputra P, Wilson J, Bryan S, Burls A.

No. 12
Clinical effectiveness and cost-effectiveness of neonatal screening for inborn errors of metabolism using tandem mass spectrometry: a systematic review.
By Pandor A, Eastham J, Beverley C, Chilcott J, Paisley S.

No. 13
Clinical effectiveness and cost-effectiveness of pioglitazone and rosiglitazone in the treatment of type 2 diabetes: a systematic review and economic evaluation.
By Czoski-Murray C, Warren E, Chilcott J, Beverley C, Psyllaki MA, Cowan J.

No. 14
Routine examination of the newborn: the EMREN study. Evaluation of an extension of the midwife role including a randomised controlled trial of appropriately trained midwives and paediatric senior house officers.
By Townsend J, Wolke D, Hayes J, Davé S, Rogers C, Bloomfield L, *et al*.

No. 15
Involving consumers in research and development agenda setting for the NHS: developing an evidence-based approach.
By Oliver S, Clarke-Jones L, Rees R, Milne R, Buchanan P, Gabbay J, *et al*.

No. 16
A multi-centre randomised controlled trial of minimally invasive direct coronary bypass grafting versus percutaneous transluminal coronary angioplasty with stenting for proximal stenosis of the left anterior descending coronary artery.
By Reeves BC, Angelini GD, Bryan AJ, Taylor FC, Cripps T, Spyt TJ, *et al*.

No. 17
Does early magnetic resonance imaging influence management or improve outcome in patients referred to secondary care with low back pain? A pragmatic randomised controlled trial.
By Gilbert FJ, Grant AM, Gillan MGC, Vale L, Scott NW, Campbell MK, *et al*.

No. 18
The clinical and cost-effectiveness of anakinra for the treatment of rheumatoid arthritis in adults: a systematic review and economic analysis.
By Clark W, Jobanputra P, Barton P, Burls A.

No. 19
A rapid and systematic review and economic evaluation of the clinical and cost-effectiveness of newer drugs for treatment of mania associated with bipolar affective disorder.
By Bridle C, Palmer S, Bagnall A-M, Darba J, Duffy S, Sculpher M, *et al*.

No. 20
Liquid-based cytology in cervical screening: an updated rapid and systematic review and economic analysis.
By Karnon J, Peters J, Platt J, Chilcott J, McGoogan E, Brewer N.

No. 21
Systematic review of the long-term effects and economic consequences of treatments for obesity and implications for health improvement.
By Avenell A, Broom J, Brown TJ, Poobalan A, Aucott L, Stearns SC, *et al*.

No. 22
Autoantibody testing in children with newly diagnosed type 1 diabetes mellitus.
By Dretzke J, Cummins C, Sandercock J, Fry-Smith A, Barrett T, Burls A.

No. 23
Clinical effectiveness and cost-effectiveness of prehospital intravenous fluids in trauma patients.
By Dretzke J, Sandercock J, Bayliss S, Burls A.

No. 24
Newer hypnotic drugs for the short-term management of insomnia: a systematic review and economic evaluation.
By Dündar Y, Boland A, Strobl J, Dodd S, Haycox A, Bagust A, *et al*.

No. 25
Development and validation of methods for assessing the quality of diagnostic accuracy studies.
By Whiting P, Rutjes AWS, Dinnes J, Reitsma JB, Bossuyt PMM, Kleijnen J.

No. 26
EVALUATE hysterectomy trial: a multicentre randomised trial comparing abdominal, vaginal and laparoscopic methods of hysterectomy.
By Garry R, Fountain J, Brown J, Manca A, Mason S, Sculpher M, *et al*.

No. 27
Methods for expected value of information analysis in complex health economic models: developments on the health economics of interferon-β and glatiramer acetate for multiple sclerosis.
By Tappenden P, Chilcott JB, Eggington S, Oakley J, McCabe C.

No. 28
Effectiveness and cost-effectiveness of imatinib for first-line treatment of chronic myeloid leukaemia in chronic phase: a systematic review and economic analysis.
By Dalziel K, Round A, Stein K, Garside R, Price A.

No. 29
VenUS I: a randomised controlled trial of two types of bandage for treating venous leg ulcers.
By Iglesias C, Nelson EA, Cullum NA, Torgerson DJ on behalf of the VenUS Team.

No. 30
Systematic review of the effectiveness and cost-effectiveness, and economic evaluation, of myocardial perfusion scintigraphy for the diagnosis and management of angina and myocardial infarction.
By Mowatt G, Vale L, Brazzelli M, Hernandez R, Murray A, Scott N, *et al*.

No. 31
A pilot study on the use of decision theory and value of information analysis as part of the NHS Health Technology Assessment programme.
By Claxton K, Ginnelly L, Sculpher M, Philips Z, Palmer S.

No. 32
The Social Support and Family Health Study: a randomised controlled trial and economic evaluation of two alternative forms of postnatal support for mothers living in disadvantaged inner-city areas.
By Wiggins M, Oakley A, Roberts I, Turner H, Rajan L, Austerberry H, *et al*.

No. 33
Psychosocial aspects of genetic screening of pregnant women and newborns: a systematic review.
By Green JM, Hewison J, Bekker HL, Bryant, Cuckle HS.

No. 34
Evaluation of abnormal uterine bleeding: comparison of three outpatient procedures within cohorts defined by age and menopausal status.
By Critchley HOD, Warner P, Lee AJ, Brechin S, Guise J, Graham B.

No. 35
Coronary artery stents: a rapid systematic review and economic evaluation.
By Hill R, Bagust A, Bakhai A, Dickson R, Dündar Y, Haycox A, *et al*.

No. 36
Review of guidelines for good practice in decision-analytic modelling in health technology assessment.
By Philips Z, Ginnelly L, Sculpher M, Claxton K, Golder S, Riemsma R, *et al*.

No. 37
Rituximab (MabThera®) for aggressive non-Hodgkin's lymphoma: systematic review and economic evaluation.
By Knight C, Hind D, Brewer N, Abbott V.

No. 38
Clinical effectiveness and cost-effectiveness of clopidogrel and modified-release dipyridamole in the secondary prevention of occlusive vascular events: a systematic review and economic evaluation.
By Jones L, Griffin S, Palmer S, Main C, Orton V, Sculpher M, *et al.*

No. 39
Pegylated interferon α-2a and -2b in combination with ribavirin in the treatment of chronic hepatitis C: a systematic review and economic evaluation.
By Shepherd J, Brodin H, Cave C, Waugh N, Price A, Gabbay J.

No. 40
Clopidogrel used in combination with aspirin compared with aspirin alone in the treatment of non-ST-segment-elevation acute coronary syndromes: a systematic review and economic evaluation.
By Main C, Palmer S, Griffin S, Jones L, Orton V, Sculpher M, *et al.*

No. 41
Provision, uptake and cost of cardiac rehabilitation programmes: improving services to under-represented groups.
By Beswick AD, Rees K, Griebsch I, Taylor FC, Burke M, West RR, *et al.*

No. 42
Involving South Asian patients in clinical trials.
By Hussain-Gambles M, Leese B, Atkin K, Brown J, Mason S, Tovey P.

No. 43
Clinical and cost-effectiveness of continuous subcutaneous insulin infusion for diabetes.
By Colquitt JL, Green C, Sidhu MK, Hartwell D, Waugh N.

No. 44
Identification and assessment of ongoing trials in health technology assessment reviews.
By Song FJ, Fry-Smith A, Davenport C, Bayliss S, Adi Y, Wilson JS, *et al*.

No. 45
Systematic review and economic evaluation of a long-acting insulin analogue, insulin glargine
By Warren E, Weatherley-Jones E, Chilcott J, Beverley C.

No. 46
Supplementation of a home-based exercise programme with a class-based programme for people with osteoarthritis of the knees: a randomised controlled trial and health economic analysis.
By McCarthy CJ, Mills PM, Pullen R, Richardson G, Hawkins N, Roberts CR, *et al*.

No. 47
Clinical and cost-effectiveness of once-daily versus more frequent use of same potency topical corticosteroids for atopic eczema: a systematic review and economic evaluation.
By Green C, Colquitt JL, Kirby J, Davidson P, Payne E.

No. 48
Acupuncture of chronic headache disorders in primary care: randomised controlled trial and economic analysis.
By Vickers AJ, Rees RW, Zollman CE, McCarney R, Smith CM, Ellis N, *et al*.

No. 49
Generalisability in economic evaluation studies in healthcare: a review and case studies.
By Sculpher MJ, Pang FS, Manca A, Drummond MF, Golder S, Urdahl H, *et al*.

No. 50
Virtual outreach: a randomised controlled trial and economic evaluation of joint teleconferenced medical consultations.
By Wallace P, Barber J, Clayton W, Currell R, Fleming K, Garner P, *et al*.

Volume 9, 2005

No. 1
Randomised controlled multiple treatment comparison to provide a cost-effectiveness rationale for the selection of antimicrobial therapy in acne.
By Ozolins M, Eady EA, Avery A, Cunliffe WJ, O'Neill C, Simpson NB, *et al*.

No. 2
Do the findings of case series studies vary significantly according to methodological characteristics?
By Dalziel K, Round A, Stein K, Garside R, Castelnuovo E, Payne L.

No. 3
Improving the referral process for familial breast cancer genetic counselling: findings of three randomised controlled trials of two interventions.
By Wilson BJ, Torrance N, Mollison J, Wordsworth S, Gray JR, Haites NE, *et al*.

No. 4
Randomised evaluation of alternative electrosurgical modalities to treat bladder outflow obstruction in men with benign prostatic hyperplasia.
By Fowler C, McAllister W, Plail R, Karim O, Yang Q.

No. 5
A pragmatic randomised controlled trial of the cost-effectiveness of palliative therapies for patients with inoperable oesophageal cancer.
By Shenfine J, McNamee P, Steen N, Bond J, Griffin SM.

No. 6
Impact of computer-aided detection prompts on the sensitivity and specificity of screening mammography.
By Taylor P, Champness J, Given-Wilson R, Johnston K, Potts H.

No. 7
Issues in data monitoring and interim analysis of trials.
By Grant AM, Altman DG, Babiker AB, Campbell MK, Clemens FJ, Darbyshire JH, *et al*.

No. 8
Lay public's understanding of equipoise and randomisation in randomised controlled trials.
By Robinson EJ, Kerr CEP, Stevens AJ, Lilford RJ, Braunholtz DA, Edwards SJ, *et al*.

No. 9
Clinical and cost-effectiveness of electroconvulsive therapy for depressive illness, schizophrenia, catatonia and mania: systematic reviews and economic modelling studies.
By Greenhalgh J, Knight C, Hind D, Beverley C, Walters S.

No. 10
Measurement of health-related quality of life for people with dementia: development of a new instrument (DEMQOL) and an evaluation of current methodology.
By Smith SC, Lamping DL, Banerjee S, Harwood R, Foley B, Smith P, *et al*.

No. 11
Clinical effectiveness and cost-effectiveness of drotrecogin alfa (activated) (Xigris®) for the treatment of severe sepsis in adults: a systematic review and economic evaluation.
By Green C, Dinnes J, Takeda A, Shepherd J, Hartwell D, Cave C, *et al*.

No. 12
A methodological review of how heterogeneity has been examined in systematic reviews of diagnostic test accuracy.
By Dinnes J, Deeks J, Kirby J, Roderick P.

No. 13
Cervical screening programmes: can automation help? Evidence from systematic reviews, an economic analysis and a simulation modelling exercise applied to the UK.
By Willis BH, Barton P, Pearmain P, Bryan S, Hyde C.

No. 14
Laparoscopic surgery for inguinal hernia repair: systematic review of effectiveness and economic evaluation.
By McCormack K, Wake B, Perez J, Fraser C, Cook J, McIntosh E, *et al*.

No. 15
Clinical effectiveness, tolerability and cost-effectiveness of newer drugs for epilepsy in adults: a systematic review and economic evaluation.
By Wilby J, Kainth A, Hawkins N, Epstein D, McIntosh H, McDaid C, *et al*.

No. 16
A randomised controlled trial to compare the cost-effectiveness of tricyclic antidepressants, selective serotonin reuptake inhibitors and lofepramine.
By Peveler R, Kendrick T, Buxton M, Longworth L, Baldwin D, Moore M, *et al*.

No. 17
Clinical effectiveness and cost-effectiveness of immediate angioplasty for acute myocardial infarction: systematic review and economic evaluation.
By Hartwell D, Colquitt J, Loveman E, Clegg AJ, Brodin H, Waugh N, *et al*.

No. 18
A randomised controlled comparison of alternative strategies in stroke care.
By Kalra L, Evans A, Perez I, Knapp M, Swift C, Donaldson N.

No. 19
The investigation and analysis of critical incidents and adverse events in healthcare.
By Woloshynowych M, Rogers S, Taylor-Adams S, Vincent C.

No. 20
Potential use of routine databases in health technology assessment.
By Raftery J, Roderick P, Stevens A.

No. 21
Clinical and cost-effectiveness of newer immunosuppressive regimens in renal transplantation: a systematic review and modelling study.
By Woodroffe R, Yao GL, Meads C, Bayliss S, Ready A, Raftery J, *et al*.

No. 22
A systematic review and economic evaluation of alendronate, etidronate, risedronate, raloxifene and teriparatide for the prevention and treatment of postmenopausal osteoporosis.
By Stevenson M, Lloyd Jones M, De Nigris E, Brewer N, Davis S, Oakley J.

No. 23
A systematic review to examine the impact of psycho-educational interventions on health outcomes and costs in adults and children with difficult asthma.
By Smith JR, Mugford M, Holland R, Candy B, Noble MJ, Harrison BDW, *et al*.

No. 24
An evaluation of the costs, effectiveness and quality of renal replacement therapy provision in renal satellite units in England and Wales.
By Roderick P, Nicholson T, Armitage A, Mehta R, Mullee M, Gerard K, *et al*.

No. 25
Imatinib for the treatment of patients with unresectable and/or metastatic gastrointestinal stromal tumours: systematic review and economic evaluation.
By Wilson J, Connock M, Song F, Yao G, Fry-Smith A, Raftery J, *et al*.

No. 26
Indirect comparisons of competing interventions.
By Glenny AM, Altman DG, Song F, Sakarovitch C, Deeks JJ, D'Amico R, *et al*.

No. 27
Cost-effectiveness of alternative strategies for the initial medical management of non-ST elevation acute coronary syndrome: systematic review and decision-analytical modelling.
By Robinson M, Palmer S, Sculpher M, Philips Z, Ginnelly L, Bowens A, *et al*.

No. 28
Outcomes of electrically stimulated gracilis neosphincter surgery.
By Tillin T, Chambers M, Feldman R.

No. 29
The effectiveness and cost-effectiveness of pimecrolimus and tacrolimus for atopic eczema: a systematic review and economic evaluation.
By Garside R, Stein K, Castelnuovo E, Pitt M, Ashcroft D, Dimmock P, *et al*.

No. 30
Systematic review on urine albumin testing for early detection of diabetic complications.
By Newman DJ, Mattock MB, Dawnay ABS, Kerry S, McGuire A, Yaqoob M, *et al*.

No. 31
Randomised controlled trial of the cost-effectiveness of water-based therapy for lower limb osteoarthritis.
By Cochrane T, Davey RC, Matthes Edwards SM.

No. 32
Longer term clinical and economic benefits of offering acupuncture care to patients with chronic low back pain.
By Thomas KJ, MacPherson H, Ratcliffe J, Thorpe L, Brazier J, Campbell M, *et al*.

No. 33
Cost-effectiveness and safety of epidural steroids in the management of sciatica.
By Price C, Arden N, Coglan L, Rogers P.

No. 34
The British Rheumatoid Outcome Study Group (BROSG) randomised controlled trial to compare the effectiveness and cost-effectiveness of aggressive versus symptomatic therapy in established rheumatoid arthritis.
By Symmons D, Tricker K, Roberts C, Davies L, Dawes P, Scott DL.

No. 35
Conceptual framework and systematic review of the effects of participants' and professionals' preferences in randomised controlled trials.
By King M, Nazareth I, Lampe F, Bower P, Chandler M, Morou M, *et al*.

No. 36
The clinical and cost-effectiveness of implantable cardioverter defibrillators: a systematic review.
By Bryant J, Brodin H, Loveman E, Payne E, Clegg A.

No. 37
A trial of problem-solving by community mental health nurses for anxiety, depression and life difficulties among general practice patients. The CPN-GP study.
By Kendrick T, Simons L, Mynors-Wallis L, Gray A, Lathlean J, Pickering R, *et al*.

No. 38
The causes and effects of socio-demographic exclusions from clinical trials.
By Bartlett C, Doyal L, Ebrahim S, Davey P, Bachmann M, Egger M, *et al*.

No. 39
Is hydrotherapy cost-effective? A randomised controlled trial of combined hydrotherapy programmes compared with physiotherapy land techniques in children with juvenile idiopathic arthritis.
By Epps H, Ginnelly L, Utley M, Southwood T, Gallivan S, Sculpher M, *et al*.

No. 40
A randomised controlled trial and cost-effectiveness study of systematic screening (targeted and total population screening) versus routine practice for the detection of atrial fibrillation in people aged 65 and over. The SAFE study.
By Hobbs FDR, Fitzmaurice DA, Mant J, Murray E, Jowett S, Bryan S, *et al*.

No. 41
Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty.
By Keating JF, Grant A, Masson M, Scott NW, Forbes JF.

No. 42
Long-term outcome of cognitive behaviour therapy clinical trials in central Scotland.
By Durham RC, Chambers JA, Power KG, Sharp DM, Macdonald RR, Major KA, *et al*.

No. 43
The effectiveness and cost-effectiveness of dual-chamber pacemakers compared with single-chamber pacemakers for bradycardia due to atrioventricular block or sick sinus syndrome: systematic review and economic evaluation.
By Castelnuovo E, Stein K, Pitt M, Garside R, Payne E.

No. 44
Newborn screening for congenital heart defects: a systematic review and cost-effectiveness analysis.
By Knowles R, Griebsch I, Dezateux C, Brown J, Bull C, Wren C.

No. 45
The clinical and cost-effectiveness of left ventricular assist devices for end-stage heart failure: a systematic review and economic evaluation.
By Clegg AJ, Scott DA, Loveman E, Colquitt J, Hutchinson J, Royle P, *et al*.

No. 46
The effectiveness of the Heidelberg Retina Tomograph and laser diagnostic glaucoma scanning system (GDx) in detecting and monitoring glaucoma.
By Kwartz AJ, Henson DB, Harper RA, Spencer AF, McLeod D.

No. 47
Clinical and cost-effectiveness of autologous chondrocyte implantation for cartilage defects in knee joints: systematic review and economic evaluation.
By Clar C, Cummins E, McIntyre L, Thomas S, Lamb J, Bain L, *et al*.

No. 48
Systematic review of effectiveness of different treatments for childhood retinoblastoma.
By McDaid C, Hartley S, Bagnall A-M, Ritchie G, Light K, Riemsma R.

No. 49
Towards evidence-based guidelines for the prevention of venous thromboembolism: systematic reviews of mechanical methods, oral anticoagulation, dextran and regional anaesthesia as thromboprophylaxis.
By Roderick P, Ferris G, Wilson K, Halls H, Jackson D, Collins R, *et al*.

No. 50
The effectiveness and cost-effectiveness of parent training/education programmes for the treatment of conduct disorder, including oppositional defiant disorder, in children.
By Dretzke J, Frew E, Davenport C, Barlow J, Stewart-Brown S, Sandercock J, *et al*.

Volume 10, 2006

No. 1
The clinical and cost-effectiveness of donepezil, rivastigmine, galantamine and memantine for Alzheimer's disease.
By Loveman E, Green C, Kirby J, Takeda A, Picot J, Payne E, *et al*.

No. 2
FOOD: a multicentre randomised trial evaluating feeding policies in patients admitted to hospital with a recent stroke.
By Dennis M, Lewis S, Cranswick G, Forbes J.

No. 3
The clinical effectiveness and cost-effectiveness of computed tomography screening for lung cancer: systematic reviews.
By Black C, Bagust A, Boland A, Walker S, McLeod C, De Verteuil R, *et al*.

No. 4
A systematic review of the effectiveness and cost-effectiveness of neuroimaging assessments used to visualise the seizure focus in people with refractory epilepsy being considered for surgery.
By Whiting P, Gupta R, Burch J, Mujica Mota RE, Wright K, Marson A, *et al*.

No. 5
Comparison of conference abstracts and presentations with full-text articles in the health technology assessments of rapidly evolving technologies.
By Dundar Y, Dodd S, Dickson R, Walley T, Haycox A, Williamson PR.

No. 6
Systematic review and evaluation of methods of assessing urinary incontinence.
By Martin JL, Williams KS, Abrams KR, Turner DA, Sutton AJ, Chapple C, *et al*.

No. 7
The clinical effectiveness and cost-effectiveness of newer drugs for children with epilepsy. A systematic review.
By Connock M, Frew E, Evans B-W, Bryan S, Cummins C, Fry-Smith A, *et al*.

No. 8
Surveillance of Barrett's oesophagus: exploring the uncertainty through systematic review, expert workshop and economic modelling.
By Garside R, Pitt M, Somerville M, Stein K, Price A, Gilbert N.

No. 9
Topotecan, pegylated liposomal doxorubicin hydrochloride and paclitaxel for second-line or subsequent treatment of advanced ovarian cancer: a systematic review and economic evaluation.
By Main C, Bojke L, Griffin S, Norman G, Barbieri M, Mather L, *et al*.

No. 10
Evaluation of molecular techniques in prediction and diagnosis of cytomegalovirus disease in immunocompromised patients.
By Szczepura A, Westmoreland D, Vinogradova Y, Fox J, Clark M.

No. 11
Screening for thrombophilia in high-risk situations: systematic review and cost-effectiveness analysis. The Thrombosis: Risk and Economic Assessment of Thrombophilia Screening (TREATS) study.
By Wu O, Robertson L, Twaddle S, Lowe GDO, Clark P, Greaves M, *et al*.

No. 12
A series of systematic reviews to inform a decision analysis for sampling and treating infected diabetic foot ulcers.
By Nelson EA, O'Meara S, Craig D, Iglesias C, Golder S, Dalton J, *et al*.

No. 13
Randomised clinical trial, observational study and assessment of cost-effectiveness of the treatment of varicose veins (REACTIV trial).
By Michaels JA, Campbell WB, Brazier JE, MacIntyre JB, Palfreyman SJ, Ratcliffe J, *et al*.

No. 14
The cost-effectiveness of screening for oral cancer in primary care.
By Speight PM, Palmer S, Moles DR, Downer MC, Smith DH, Henriksson M *et al*.

No. 15
Measurement of the clinical and cost-effectiveness of non-invasive diagnostic testing strategies for deep vein thrombosis.
By Goodacre S, Sampson F, Stevenson M, Wailoo A, Sutton A, Thomas S, *et al*.

No. 16
Systematic review of the effectiveness and cost-effectiveness of HealOzone® for the treatment of occlusal pit/fissure caries and root caries.
By Brazzelli M, McKenzie L, Fielding S, Fraser C, Clarkson J, Kilonzo M, *et al*.

No. 17
Randomised controlled trials of conventional antipsychotic versus new atypical drugs, and new atypical drugs versus clozapine, in people with schizophrenia responding poorly to, or intolerant of, current drug treatment.
By Lewis SW, Davies L, Jones PB, Barnes TRE, Murray RM, Kerwin R, *et al*.

No. 18
Diagnostic tests and algorithms used in the investigation of haematuria: systematic reviews and economic evaluation.
By Rodgers M, Nixon J, Hempel S, Aho T, Kelly J, Neal D, *et al*.

No. 19
Cognitive behavioural therapy in addition to antispasmodic therapy for irritable bowel syndrome in primary care: randomised controlled trial.
By Kennedy TM, Chalder T, McCrone P, Darnley S, Knapp M, Jones RH, *et al*.

No. 20
A systematic review of the clinical effectiveness and cost-effectiveness of enzyme replacement therapies for Fabry's disease and mucopolysaccharidosis type 1.
By Connock M, Juarez-Garcia A, Frew E, Mans A, Dretzke J, Fry-Smith A, *et al*.

No. 21
Health benefits of antiviral therapy for mild chronic hepatitis C: randomised controlled trial and economic evaluation.
By Wright M, Grieve R, Roberts J, Main J, Thomas HC on behalf of the UK Mild Hepatitis C Trial Investigators.

No. 22
Pressure relieving support surfaces: a randomised evaluation.
By Nixon J, Nelson EA, Cranny G, Iglesias CP, Hawkins K, Cullum NA, *et al*.

No. 23
A systematic review and economic model of the effectiveness and cost-effectiveness of methylphenidate, dexamfetamine and atomoxetine for the treatment of attention deficit hyperactivity disorder in children and adolescents.
By King S, Griffin S, Hodges Z, Weatherly H, Asseburg C, Richardson G, *et al*.

No. 24
The clinical effectiveness and cost-effectiveness of enzyme replacement therapy for Gaucher's disease: a systematic review.
By Connock M, Burls A, Frew E, Fry-Smith A, Juarez-Garcia A, McCabe C, *et al*.

No. 25
Effectiveness and cost-effectiveness of salicylic acid and cryotherapy for cutaneous warts. An economic decision model.
By Thomas KS, Keogh-Brown MR, Chalmers JR, Fordham RJ, Holland RC, Armstrong SJ, *et al*.

No. 26
A systematic literature review of the effectiveness of non-pharmacological interventions to prevent wandering in dementia and evaluation of the ethical implications and acceptability of their use.
By Robinson L, Hutchings D, Corner L, Beyer F, Dickinson H, Vanoli A, *et al*.

No. 27
A review of the evidence on the effects and costs of implantable cardioverter defibrillator therapy in different patient groups, and modelling of cost-effectiveness and cost–utility for these groups in a UK context.
By Buxton M, Caine N, Chase D, Connelly D, Grace A, Jackson C, *et al*.

No. 28
Adefovir dipivoxil and pegylated interferon alfa-2a for the treatment of chronic hepatitis B: a systematic review and economic evaluation.
By Shepherd J, Jones J, Takeda A, Davidson P, Price A.

No. 29
An evaluation of the clinical and cost-effectiveness of pulmonary artery catheters in patient management in intensive care: a systematic review and a randomised controlled trial.
By Harvey S, Stevens K, Harrison D, Young D, Brampton W, McCabe C, *et al*.

No. 30
Accurate, practical and cost-effective assessment of carotid stenosis in the UK.
By Wardlaw JM, Chappell FM, Stevenson M, De Nigris E, Thomas S, Gillard J, *et al*.

No. 31
Etanercept and infliximab for the treatment of psoriatic arthritis: a systematic review and economic evaluation.
By Woolacott N, Bravo Vergel Y, Hawkins N, Kainth A, Khadjesari Z, Misso K, *et al*.

No. 32
The cost-effectiveness of testing for hepatitis C in former injecting drug users.
By Castelnuovo E, Thompson-Coon J, Pitt M, Cramp M, Siebert U, Price A, *et al*.

No. 33
Computerised cognitive behaviour therapy for depression and anxiety update: a systematic review and economic evaluation.
By Kaltenthaler E, Brazier J, De Nigris E, Tumur I, Ferriter M, Beverley C, *et al*.

No. 34
Cost-effectiveness of using prognostic information to select women with breast cancer for adjuvant systemic therapy.
By Williams C, Brunskill S, Altman D, Briggs A, Campbell H, Clarke M, *et al*.

No. 35
Psychological therapies including dialectical behaviour therapy for borderline personality disorder: a systematic review and preliminary economic evaluation.
By Brazier J, Tumur I, Holmes M, Ferriter M, Parry G, Dent-Brown K, *et al*.

No. 36
Clinical effectiveness and cost-effectiveness of tests for the diagnosis and investigation of urinary tract infection in children: a systematic review and economic model.
By Whiting P, Westwood M, Bojke L, Palmer S, Richardson G, Cooper J, *et al*.

No. 37
Cognitive behavioural therapy in chronic fatigue syndrome: a randomised controlled trial of an outpatient group programme.
By O'Dowd H, Gladwell P, Rogers CA, Hollinghurst S, Gregory A.

No. 38
A comparison of the cost-effectiveness of five strategies for the prevention of non-steroidal anti-inflammatory drug-induced gastrointestinal toxicity: a systematic review with economic modelling.
By Brown TJ, Hooper L, Elliott RA, Payne K, Webb R, Roberts C, *et al*.

No. 39
The effectiveness and cost-effectiveness of computed tomography screening for coronary artery disease: systematic review.
By Waugh N, Black C, Walker S, McIntyre L, Cummins E, Hillis G.

No. 40
What are the clinical outcome and cost-effectiveness of endoscopy undertaken by nurses when compared with doctors? A Multi-Institution Nurse Endoscopy Trial (MINuET).
By Williams J, Russell I, Durai D, Cheung W-Y, Farrin A, Bloor K, *et al*.

No. 41
The clinical and cost-effectiveness of oxaliplatin and capecitabine for the adjuvant treatment of colon cancer: systematic review and economic evaluation.
By Pandor A, Eggington S, Paisley S, Tappenden P, Sutcliffe P.

No. 42
A systematic review of the effectiveness of adalimumab, etanercept and infliximab for the treatment of rheumatoid arthritis in adults and an economic evaluation of their cost-effectiveness.
By Chen Y-F, Jobanputra P, Barton P, Jowett S, Bryan S, Clark W, *et al*.

No. 43
Telemedicine in dermatology: a randomised controlled trial.
By Bowns IR, Collins K, Walters SJ, McDonagh AJG.

No. 44
Cost-effectiveness of cell salvage and alternative methods of minimising perioperative allogeneic blood transfusion: a systematic review and economic model.
By Davies L, Brown TJ, Haynes S, Payne K, Elliott RA, McCollum C.

No. 45
Clinical effectiveness and cost-effectiveness of laparoscopic surgery for colorectal cancer: systematic reviews and economic evaluation.
By Murray A, Lourenco T, de Verteuil R, Hernandez R, Fraser C, McKinley A, *et al*.

No. 46
Etanercept and efalizumab for the treatment of psoriasis: a systematic review.
By Woolacott N, Hawkins N, Mason A, Kainth A, Khadjesari Z, Bravo Vergel Y, *et al*.

No. 47
Systematic reviews of clinical decision tools for acute abdominal pain.
By Liu JLY, Wyatt JC, Deeks JJ, Clamp S, Keen J, Verde P, *et al*.

No. 48
Evaluation of the ventricular assist device programme in the UK.
By Sharples L, Buxton M, Caine N, Cafferty F, Demiris N, Dyer M, *et al*.

No. 49
A systematic review and economic model of the clinical and cost-effectiveness of immunosuppressive therapy for renal transplantation in children.
By Yao G, Albon E, Adi Y, Milford D, Bayliss S, Ready A, *et al*.

No. 50
Amniocentesis results: investigation of anxiety. The ARIA trial.
By Hewison J, Nixon J, Fountain J, Cocks K, Jones C, Mason G, *et al*.

Volume 11, 2007

No. 1
Pemetrexed disodium for the treatment of malignant pleural mesothelioma: a systematic review and economic evaluation.
By Dundar Y, Bagust A, Dickson R, Dodd S, Green J, Haycox A, *et al*.

No. 2
A systematic review and economic model of the clinical effectiveness and cost-effectiveness of docetaxel in combination with prednisone or prednisolone for the treatment of hormone-refractory metastatic prostate cancer.
By Collins R, Fenwick E, Trowman R, Perard R, Norman G, Light K, *et al*.

No. 3
A systematic review of rapid diagnostic tests for the detection of tuberculosis infection.
By Dinnes J, Deeks J, Kunst H, Gibson A, Cummins E, Waugh N, *et al*.

No. 4
The clinical effectiveness and cost-effectiveness of strontium ranelate for the prevention of osteoporotic fragility fractures in postmenopausal women.
By Stevenson M, Davis S, Lloyd-Jones M, Beverley C.

No. 5
A systematic review of quantitative and qualitative research on the role and effectiveness of written information available to patients about individual medicines.
By Raynor DK, Blenkinsopp A, Knapp P, Grime J, Nicolson DJ, Pollock K, *et al*.

No. 6
Oral naltrexone as a treatment for relapse prevention in formerly opioid-dependent drug users: a systematic review and economic evaluation.
By Adi Y, Juarez-Garcia A, Wang D, Jowett S, Frew E, Day E, *et al*.

No. 7
Glucocorticoid-induced osteoporosis: a systematic review and cost–utility analysis.
By Kanis JA, Stevenson M, McCloskey EV, Davis S, Lloyd-Jones M.

No. 8
Epidemiological, social, diagnostic and economic evaluation of population screening for genital chlamydial infection.
By Low N, McCarthy A, Macleod J, Salisbury C, Campbell R, Roberts TE, *et al*.

No. 9
Methadone and buprenorphine for the management of opioid dependence: a systematic review and economic evaluation.
By Connock M, Juarez-Garcia A, Jowett S, Frew E, Liu Z, Taylor RJ, *et al*.

No. 10
Exercise Evaluation Randomised Trial (EXERT): a randomised trial comparing GP referral for leisure centre-based exercise, community-based walking and advice only.
By Isaacs AJ, Critchley JA, See Tai S, Buckingham K, Westley D, Harridge SDR, *et al*.

No. 11
Interferon alfa (pegylated and non-pegylated) and ribavirin for the treatment of mild chronic hepatitis C: a systematic review and economic evaluation.
By Shepherd J, Jones J, Hartwell D, Davidson P, Price A, Waugh N.

No. 12
Systematic review and economic evaluation of bevacizumab and cetuximab for the treatment of metastatic colorectal cancer.
By Tappenden P, Jones R, Paisley S, Carroll C.

No. 13
A systematic review and economic evaluation of epoetin alfa, epoetin beta and darbepoetin alfa in anaemia associated with cancer, especially that attributable to cancer treatment.
By Wilson J, Yao GL, Raftery J, Bohlius J, Brunskill S, Sandercock J, *et al*.

No. 14
A systematic review and economic evaluation of statins for the prevention of coronary events.
By Ward S, Lloyd Jones M, Pandor A, Holmes M, Ara R, Ryan A, *et al*.

No. 15
A systematic review of the effectiveness and cost-effectiveness of different models of community-based respite care for frail older people and their carers.
By Mason A, Weatherly H, Spilsbury K, Arksey H, Golder S, Adamson J, *et al*.

No. 16
Additional therapy for young children with spastic cerebral palsy: a randomised controlled trial.
By Weindling AM, Cunningham CC, Glenn SM, Edwards RT, Reeves DJ.

No. 17
Screening for type 2 diabetes: literature review and economic modelling.
By Waugh N, Scotland G, McNamee P, Gillett M, Brennan A, Goyder E, *et al*.

No. 18
The effectiveness and cost-effectiveness of cinacalcet for secondary hyperparathyroidism in end-stage renal disease patients on dialysis: a systematic review and economic evaluation.
By Garside R, Pitt M, Anderson R, Mealing S, Roome C, Snaith A, *et al*.

No. 19
The clinical effectiveness and cost-effectiveness of gemcitabine for metastatic breast cancer: a systematic review and economic evaluation.
By Takeda AL, Jones J, Loveman E, Tan SC, Clegg AJ.

No. 20
A systematic review of duplex ultrasound, magnetic resonance angiography and computed tomography angiography for the diagnosis and assessment of symptomatic, lower limb peripheral arterial disease.
By Collins R, Cranny G, Burch J, Aguiar-Ibáñez R, Craig D, Wright K, *et al*.

No. 21
The clinical effectiveness and cost-effectiveness of treatments for children with idiopathic steroid-resistant nephrotic syndrome: a systematic review.
By Colquitt JL, Kirby J, Green C, Cooper K, Trompeter RS.

No. 22
A systematic review of the routine monitoring of growth in children of primary school age to identify growth-related conditions.
By Fayter D, Nixon J, Hartley S, Rithalia A, Butler G, Rudolf M, *et al*.

No. 23
Systematic review of the effectiveness of preventing and treating *Staphylococcus aureus* carriage in reducing peritoneal catheter-related infections.
By McCormack K, Rabindranath K, Kilonzo M, Vale L, Fraser C, McIntyre L, *et al*.

No. 24
The clinical effectiveness and cost of repetitive transcranial magnetic stimulation versus electroconvulsive therapy in severe depression: a multicentre pragmatic randomised controlled trial and economic analysis.
By McLoughlin DM, Mogg A, Eranti S, Pluck G, Purvis R, Edwards D, *et al*.

No. 25
A randomised controlled trial and economic evaluation of direct versus indirect and individual versus group modes of speech and language therapy for children with primary language impairment.
By Boyle J, McCartney E, Forbes J, O'Hare A.

No. 26
Hormonal therapies for early breast cancer: systematic review and economic evaluation.
By Hind D, Ward S, De Nigris E, Simpson E, Carroll C, Wyld L.

No. 27
Cardioprotection against the toxic effects of anthracyclines given to children with cancer: a systematic review.
By Bryant J, Picot J, Levitt G, Sullivan I, Baxter L, Clegg A.

No. 28
Adalimumab, etanercept and infliximab for the treatment of ankylosing spondylitis: a systematic review and economic evaluation.
By McLeod C, Bagust A, Boland A, Dagenais P, Dickson R, Dundar Y, *et al*.

No. 29
Prenatal screening and treatment strategies to prevent group B streptococcal and other bacterial infections in early infancy: cost-effectiveness and expected value of information analyses.
By Colbourn T, Asseburg C, Bojke L, Philips Z, Claxton K, Ades AE, *et al*.

No. 30
Clinical effectiveness and cost-effectiveness of bone morphogenetic proteins in the non-healing of fractures and spinal fusion: a systematic review.
By Garrison KR, Donell S, Ryder J, Shemilt I, Mugford M, Harvey I, *et al*.

No. 31
A randomised controlled trial of postoperative radiotherapy following breast-conserving surgery in a minimum-risk older population. The PRIME trial.
By Prescott RJ, Kunkler IH, Williams LJ, King CC, Jack W, van der Pol M, *et al*.

No. 32
Current practice, accuracy, effectiveness and cost-effectiveness of the school entry hearing screen.
By Bamford J, Fortnum H, Bristow K, Smith J, Vamvakas G, Davies L, *et al*.

No. 33
The clinical effectiveness and cost-effectiveness of inhaled insulin in diabetes mellitus: a systematic review and economic evaluation.
By Black C, Cummins E, Royle P, Philip S, Waugh N.

No. 34
Surveillance of cirrhosis for hepatocellular carcinoma: systematic review and economic analysis.
By Thompson Coon J, Rogers G, Hewson P, Wright D, Anderson R, Cramp M, *et al*.

No. 35
The Birmingham Rehabilitation Uptake Maximisation Study (BRUM). Home-based compared with hospital-based cardiac rehabilitation in a multi-ethnic population: cost-effectiveness and patient adherence.
By Jolly K, Taylor R, Lip GYH, Greenfield S, Raftery J, Mant J, *et al*.

No. 36
A systematic review of the clinical, public health and cost-effectiveness of rapid diagnostic tests for the detection and identification of bacterial intestinal pathogens in faeces and food.
By Abubakar I, Irvine L, Aldus CF, Wyatt GM, Fordham R, Schelenz S, *et al*.

No. 37
A randomised controlled trial examining the longer-term outcomes of standard versus new antiepileptic drugs. The SANAD trial.
By Marson AG, Appleton R, Baker GA, Chadwick DW, Doughty J, Eaton B, *et al*.

No. 38
Clinical effectiveness and cost-effectiveness of different models of managing long-term oral anticoagulation therapy: a systematic review and economic modelling.
By Connock M, Stevens C, Fry-Smith A, Jowett S, Fitzmaurice D, Moore D, *et al*.

No. 39
A systematic review and economic model of the clinical effectiveness and cost-effectiveness of interventions for preventing relapse in people with bipolar disorder.
By Soares-Weiser K, Bravo Vergel Y, Beynon S, Dunn G, Barbieri M, Duffy S, *et al*.

No. 40
Taxanes for the adjuvant treatment of early breast cancer: systematic review and economic evaluation.
By Ward S, Simpson E, Davis S, Hind D, Rees A, Wilkinson A.

No. 41
The clinical effectiveness and cost-effectiveness of screening for open angle glaucoma: a systematic review and economic evaluation.
By Burr JM, Mowatt G, Hernández R, Siddiqui MAR, Cook J, Lourenco T, *et al*.

No. 42
Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models.
By Davis A, Smith P, Ferguson M, Stephens D, Gianopoulos I.

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We look forward to hearing from you.

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