



**UK National
Screening Committee**

Screening for Hearing Loss in Older Adults.

External review against programme

appraisal criteria for the

UK National Screening Committee (UK NSC)

2015

Dr J. Spiby

Spiby Health

2015

The UK NSC advises Ministers and the NHS in all four UK countries about all aspects of screening policy. Its policies are reviewed on a 3 yearly cycle. Current policies can be found in the policy database at <http://www.screening.nhs.uk/policies> and the policy review process is described in detail at <http://www.screening.nhs.uk/policyreview>

Template v1.2, June 2010

Summary

Hearing loss in older people is a major public health problem with significant health impacts. UK studies, albeit with small study populations, have estimated that 40% of 55 – 74 year olds experience mild hearing loss (25 – 40dB) in at least one ear and that 11% of this age group will experience hearing loss ≥ 35 dB.

There are a number of simple screening tools which may increase identification. However, the more extensively studied tests (for example the whisper test at two feet and questionnaire based approaches) do not appear to have both positive and negative predictive values of sufficient reliability and could result in a large proportion of people with false positive results being referred for evaluation. Conversely, tests which appear to have improved performance characteristics (for example the watch tick test) have not been extensively studied. A United States Preventive Services Task force (USPSTF) systematic review found that there is a lack of evidence on the; optimum approach to screening in terms of the type of test to be used, severity of hearing loss to target, age of the population to be screened, frequency of screening and where screening should be undertaken.

Despite the high prevalence of hearing loss and many effective options for amplification, only 10 to 20 percent of those with hearing loss have ever used hearing aids, and 20 to 29 percent of patients who have used hearing aids at some point stop using them.

Patients often experience dissatisfaction with hearing aids due to their; appearance, background noise, discomfort, difficulty handling, and unmet expectations regarding effects on hearing impairment. A recent Cochrane Review found that there is a lack of evidence on take up of hearing aids even when additional interventions, aimed at improving or encouraging hearing aid use, are provided. There is also a lack of standardisation on how usage is measured.

Screening has not been shown to provide any hearing related improvement in quality of life in comparison to hearing loss identified in other ways. Older people are often reluctant to attend for screening and those that do and receive hearing aids, often do not use them for any length of time.

Screening for hearing loss in older people is not supported by the evidence published since 2009. This does not mean that the evidence does not identify hearing loss in the elderly as a major public health problem. Further research in the UK is required before screening can be recommended in the UK. It has been suggested that a large scale Randomised controlled Trial (RCT) of screening for hearing impairment 35+ dB hearing impairment or poorer should be undertaken within the 55 – 74 age group. This may provide the point of departure for further discussion of research priorities.

1 Introduction

This paper reviews published evidence up to December 2012 and additional papers in 2014, on screening for hearing loss in adults (over 50 years of age), to appraise the viability, effectiveness and appropriateness of a screening programme for adult hearing loss against the UK National Screening Committee (NSC) criteria.¹

The rationale for screening is that although hearing loss is common in older adults, individuals may not realise that they have hearing loss because symptoms are relatively mild or progress slowly. They may perceive hearing loss but not seek treatment for it, or they may have difficulty recognising or reporting hearing loss due to other problems. Once someone is identified as having a hearing loss they can then be referred for treatments to address the deficiency.

The NSC policy is not to screen for hearing loss in adults. This was agreed in 2009 based on a systemic review of the evidence.² It was considered that acquired hearing loss remains a significant public health issue, with many affected individuals remaining untreated or only seeking treatment at a late stage when the efficacy of intervention may be compromised. However, it was felt that there were several research questions to be answered before a screening programme could be recommended. These were:

- the need for a prospective RCT of one and two stage hearing screening to identify bilateral 35+ dB HL hearing impairment in 60 to 70 year old people,
- a trial of simple, low cost , audiometric screening devices,
- a prospective pilot of hearing screen triage to identify people who should be referred for and benefit from audiological assessment and provision of hearing aids in a local setting,
- a trial of alternatives to audiometric screening devices,
- a workforce review to identify the organisational costs of introducing a screening service,
- modelling different screening programmes and their including costs.

For this update a literature review was carried out in December 2012 looking at English language literature published 01/01/2009 to 01/12/2012. Papers before 2009 were not included as evidence because these had been considered in the previous review. Earlier changes were included where they provided background information. Additional papers published between 2012 and 2014 are also included.

2 The Condition

2.1 The condition should be an important health problem

2 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, disease marker, latent period or early symptomatic stage

Hearing loss exists when there is diminished sensitivity to the sounds normally heard. There is no universal definition for hearing loss because frequency and intensity thresholds vary depending on the reference criteria used.

The WHO definition

- Mild/Slight 26-40dB
- Moderate 41-60dB
- Severe 61-80dB
- Profound 81 dB or more

Deafness is defined audiotogically where a person is unable to understand speech in the presence of amplification of thresholds greater than 90dBHL. Total deafness is when no sounds at all, regardless of amplification or method of production, are heard.

There is often discordance between objectively measured deficits in tonal perception and subjective perceptions of hearing problems. This means that people reporting hearing difficulty often have normal hearing tests and vice versa.

How hearing works

Sound waves enter the ear and cause the eardrum to vibrate. These vibrations are passed to the three small bones (ossicles) inside the middle ear. The ossicles amplify the vibrations and pass them on to the inner ear where tiny hair cells inside the cochlea move in response to the vibrations and send a signal through the auditory nerve to the brain. A person with normal hearing perceives sounds at frequencies between 20 and 20,000 Hz. Frequencies between 500 and 4000 Hz are most important for speech processing.

Types of hearing loss

There are three main types of hearing loss:

- **conductive hearing loss** – where sounds are unable to pass, as they would normally, from the outer to inner ear. The hearing loss is typically mild to moderate, and does not result in total deafness. This disorder is usually treatable. It is often as the result of a blockage such as earwax, glue ear due to a build-up of fluid, a perforated ear drum or a disorder of the hearing bones,
- **sensori-neural hearing loss** – the sensitive hair cells either inside the cochlea or the auditory nerve are damaged, most commonly naturally through ageing, or as a result of injury,
- **mixed hearing loss** – it is possible to get both types of hearing loss at the same time.

The most common cause of hearing loss in older adults is presbycusis or the progressive loss of the ability to hear high frequencies with increasing age. It is a type of sensori-neural hearing loss involving degeneration of the cells of the Organ of Corti. The hearing loss associated with presbycusis is typically gradual, progressive, and bilateral. The disease initially affects the higher frequencies before progressing to the lower frequencies. Many speech sounds are high frequency sounds, which mean that even a mild loss in these frequencies can greatly impair speech understanding. For these reasons, an elderly patient with presbycusis will typically complain first that they cannot understand people's speech, not necessarily that they cannot

hear speech. It is estimated that 25% of people aged 65-75 and 70 to 80% aged over 75 years suffer from presbycusis. Presbycusis is a long-term condition.

Noise is the next most common cause of hearing problems. Noise-induced hearing loss (NIHL) is a sensorineural hearing deficit that begins at the higher frequencies (3.000 to 6.000 Hz) and develops gradually as a result of chronic exposure to excessive sound levels. As noise damage progresses, damage spreads to affect lower and higher frequencies. Hearing loss can be inherited. Both dominant and recessive genes exist which can cause mild to profound impairment.

A variety of illnesses and exposures can also cause hearing loss including: infections such as measles, meningitis, mumps, HIV/AIDS and neurological disorders. Prematurity increases the risk of hearing impairment. Some drugs can also cause hearing impairment and irreversible damage to the ear such as gentamicin, some diuretics and aspirin. Metals including lead, solvents and toluene also can be ototoxic and may have an additive effect combined with noise.

Prevalence

Prevalence of hearing loss depends on the definition used. Population-based studies in adults over 50 years of age identified prevalence ranges from 20 to 40% and in those over 80 years of age, depending on the population evaluated and the criteria used to define hearing loss, over 80%.³ In a prospective study of 3755 adults ages 48 to 92 years without hearing loss at baseline the prevalence of hearing loss was 45.9% which increased with age (odds ratio =1.88 for 5 years) and was greater for men than women after adjusting for age, educational attainment, noise exposure and occupation. Hearing loss was defined as loss greater than 25dB in the worse ear.³

Davis estimated that in a population of 55 to 74 year olds 40% had a hearing impairment at 25 dB hearing level in one ear and 27% in both ears, 11% had a bilateral hearing impairment at 35dB and 12 % had a hearing problem that caused moderate or severe worry, annoyance or upset. Also, in a population of 31,793 people, 31.6% of 55 to 74 year olds had any hearing difficulty and over 46% in people over the age of 74.⁴

Health impact

Hearing loss can have a major impact on both quality of life and ability to function in older adults. Individuals with hearing loss may have difficulty with speech discrimination, participation in social activities, ability to enjoy music and localization of sounds.⁵ Hearing loss is associated with increased emotional dysfunction, depression, and social isolation^{6,7} and dementia. Gurgel et al in 2014 suggest that elderly individuals with hearing loss have an increased rate of developing dementia and more rapid decline.⁸ Older adults with moderate to severe hearing loss are more likely to experience impaired activities of daily living compared with those with mild or no hearing loss. Left untreated, these effects can become an ongoing contributor to the decline of health with age. Using WHO terminology, hearing loss ranks third after depression and other unintentional injuries as a leading cause of years lived with disability (YLDs) in adults.

Conclusion

Hearing loss over 35dB in older people is a major public health issue with a prevalence of some 40% of the population aged 55 to 74 years and nearly 50% over 75 years. This has major health and social impacts.

2.3. All the cost-effective primary prevention interventions should have been implemented as far as practicable

Some degree of sensory presbycusis is inevitable. The deterioration can be reduced to some extent by avoidance of hazardous noise exposure or the use of suitable hearing protection. The effects of noise accumulate over a lifetime. Legislation is now in place regarding occupational noise. Leisure noise from concerts and clubs is also regulated. A 2012 Cochrane database systematic review⁹ assessed the effectiveness of non-pharmaceutical interventions for preventing occupational noise exposure or occupational hearing loss compared to no intervention or alternative interventions. They found low quality evidence that implementation of stricter legislation can reduce noise levels in workplaces. Even though case studies showed that substantial reductions in noise levels in the workplace can be achieved, there are no controlled studies of the effectiveness of such measures. The effectiveness of hearing protection devices depends on training and their proper use. The systematic review found very low quality evidence that the better use of hearing protection devices as part of hearing loss prevention programmes reduces the risk of hearing loss. For other programme components no effect was found. The review suggests that better implementation and reinforcement of hearing loss prevention programmes is needed as is better evaluation of technical interventions and their long-term effects.⁹

The main cause of hearing loss is age which is not amendable to primary prevention.

Conclusion

One systematic review found low quality evidence that better of hearing protection devices and stricter legislation reduces the risk of hearing loss.

3 The Test

3.1. There should be a simple, safe, precise and validated screening test.

An audiometric assessment tests the ability to hear sounds. Sounds vary based on their loudness (intensity) and the speed of sound wave vibrations (tone).

Intensity of sound is measured in decibels (dB):

- A whisper is about 20 dB
- Loud music (some concerts) is around 80 - 120 dB
- A jet engine is about 140 - 180 dB

Tone of sound is measured in cycles per second (cps) or Hertz:

- Low bass tones range around 50 - 60 Hz

- Shrill, high-pitched tones range around 10,000 Hz or higher

The normal range of human hearing is about 20 Hz - 20,000 Hz. Human speech is usually 500 - 3,000 Hz.

Formal audiometric testing is used to diagnose hearing loss and

screening tests aim to identify those who should undergo a full audiometric evaluation. Screening tests should; provide a reasonable assessment of risk for a disease or disorder to limit unnecessary referrals and missed cases, be easy and quick to administer, be reproducible, be minimally invasive and not cause harm, be reasonably cheap and not cause stigma. It should be clear at what age and for whom screening test are relevant and how often they should be administered. The lack of a test with these characteristics was identified as an obstacle to screening in the last review.

Approaches to screening for hearing loss have included:

- clinical screening tests for hearing impairment such as testing whether the person can hear a whispered voice, a finger rub, or a watch tick at a specific distance,
- perceived hearing loss or hearing-associated problems can be assessed by asking a single question (e.g., "Do you have difficulty with your hearing?") or with a more detailed questionnaire. The Hearing Handicap Inventory for the Elderly-Screening (HHIE-S) is the most commonly used questionnaire which has been considered for screening purposes. It is a 10-item self-administered questionnaire that assesses social and emotional factors associated with hearing loss and requires about two minutes to complete,⁹
- the AudioScope which is a handheld screening instrument consisting of an otoscope with a built-in audiometer. It assesses the ability of patients to hear sounds of 20, 25, and 40 dB at frequencies of 500, 1000, 2000, and 4000 Hz and requires approximately 90 seconds to administer.¹⁰

A systematic review of the evidence on screening for hearing loss in adults, undertaken in 2011 by the Oregon Evidence-based Practice Centre on behalf of the U.S. Preventive Services Task Force included twenty studies evaluating the diagnostic accuracy of tests for identifying hearing loss in older adults. The systematic review included studies addressing: whispered voice test, watch tick, a single question, a questionnaire (HHIE-S), or a handheld audiometric device.¹¹

For detection of >25 or >30 dB hearing loss, four studies (one good-quality) found that the whispered voice test at 2 feet was associated with a median positive likelihood ratio (PLR) of 5.1 (range, 2.3 to 7.4) and median negative likelihood ratio (NLR) of 0.03 (range, 0.007 to 0.73) and a sensitivity of 0.47 to 1 and specificity of 0.80 to 0.87.

For detection of >25 dB hearing loss, six studies (four good-quality) found that a single question was associated with a median PLR of 3.0 (range, 2.4 to 3.8) and median NLR of 0.40 (range, 0.33 to 0.82). Sensitivity 0.27 to 0.78 and specificity 0.67 to 0.89.

Four good-quality studies found that the HHIE-S (based on a cut-off score of 8) was associated with a median PLR of 3.5 (range, 2.4 to 11) and median NLR of 0.52 (range, 0.43 to 0.70). Sensitivity 0.32 to 0.66 specificity 0.84 to 0.97.

For detection of >40 dB hearing loss, three studies (two good-quality) found that the AudioScope (based on ability to hear tones between 500 and 4000 Hz at 40 dB) was associated with a median PLR of 3.4 (range, 1.7 to 4.9) and median NLR of 0.05 (range, 0.03 to 0.08). Sensitivity 0.94 to 1 and Specificity 0.42 to 0.80.

In the same USPSTF report a direct comparison of different types of screening tests, one good-quality study found that the watch tick and finger rub tests were associated with similar median negative likelihood ratios (NLRs) but substantially stronger median positive likelihood ratio (PLRs) compared with the whispered voice test or a single screening question. However, both tests had only been evaluated in one study and the review concluded that further studies were required to establish their characteristics.

Regarding questionnaire based screening, three studies showed a trade-off between lower sensitivity and higher specificity for the HHIE-S compared with a single screening question, resulting in somewhat stronger PLRs and weaker NLRs. However the pooled estimate (table 1 below) for both tests showed only a marginal difference between these two tests.

Two studies found that the AudioScope was associated with stronger NLRs compared with the HHIE-S, with relatively small differences in PLR estimates. This can be seen most clearly when the two tests are compared at >40dB hearing loss.

Table 1: test performance adapted from the USPSTF *Screening for Hearing Loss in Older Adults*

Screening tests	Number of studies, References	Positive likelihood ratio	Negative likelihood ratio		
>25 or >30 dB hearing loss				Indicative Positive Predictive Value based on prevalence of ~25%*	Indicative Negative Predictive Value based on prevalence of ~25 %*
Whispered voice test	Four	Median: 5.1 Range: 2.3-7.4	Median: 0.03 Range: 0.007-0.73	62%	99%
Finger rub test	One	10 (95% CI, 2.6-43)	0.75 (95% CI, 0.68-0.84)	77%	80%
Watch tick test	One	70 (95% CI, 4.4-1120)	0.57 (95% CI, 0.49-0.66)	96%	84%
Single-question screening	Six	Median: 3.0 Range: 2.4-3.8	Median: 0.40 Range: 0.33-0.82	50%	88%
Screening questionnaire (Hearing Handicap in the Elderly-Screening ⁺)	Four	Median: 3.5 Range: 2.4-11	Median: 0.52 Range: 0.43-0.70	54%	85%
Handheld audiometric devices	Two	3.1 (95% CI not calculable) 5.8 (95% CI, 3.4-9.8)	0.10 (95% CI not calculable) 0.40 (95% CI not calculable)	51% 66%	97% 88%
>40 dB hearing loss				Indicative Positive Predictive Value based on prevalence of ~11%*	Indicative Negative Predictive Value based on prevalence of ~11%*
Single-question screening	Three	Median: 2.5 Range: 2.1-3.1	Median: 0.26 Range: 0.13-0.41	46%	92%
Screening questionnaire (Hearing Handicap in the Elderly-Screening ⁺)	Five	Median: 3.1 Range: 2.1-4.5	Median: 0.43 Range: 0.26-0.70	51%	87%
Handheld audiometric devices	Three	Median: 3.4 Range: 1.7-4.9	Median: 0.05 Range: 0.03-0.08	53%	98%

* Approximate UK prevalence based on values reported in 55 – 74 year old population

As can be seen from table 1, in the whispered voice test and the audiometric device, the performance of the tests evaluated in the systematic review negative results appear more reliable than positive test results. For example a negative screening result based on a handheld audiometric device or the whisper test at two feet at may be useful for ruling out hearing loss at >40 dB or >25 - >30 dB respectively. However when applied to population prevalence estimates the positive predictive values suggest that the tests would result in a large proportion of people with false positive results being referred for further assessment. The tests with the highest positive predictive values, the finger rub and watch tick tests were the least extensively studied.

The systematic reviewers found that a major challenge in interpreting the studies of diagnostic accuracy is that studies used different thresholds and criteria to define hearing loss. Choices regarding which screening test to use also depend in part on factors other than diagnostic accuracy, such as cost or convenience. For the whisper test, an important consideration is the need for clinicians to administer the test in a standardised and consistent fashion.¹² Although the finger rub and watch tick tests may be easier to standardise, more studies were considered necessary to clarify their diagnostic accuracy, as both were only evaluated in one study.¹² Only four studies were population based and four from community or primary care settings. The rest recruited from high risk population or audiology clinics thus making the results less generalisable to a UK population based screening scenario. None were looking at a screening population in the UK. The reviewers identified as the most common methodological problem the lack of information on the enrolment criteria.

More generally, the clinical value of screening at the milder end of the spectrum of hearing loss (25 to 40 dB) might be questioned as the only trial showing benefits of hearing aids enrolled patients with screening-detected >40 dB hearing loss.¹¹

Conclusion

A number of candidate screening tests have been evaluated in a systematic review of screening test accuracy undertaken by the USPSTF. At present a test with both positive and negative predictive values of sufficient reliability for screening has not been identified.

3.2. The distribution of test values in the target population should be known and a suitable cut-off level defined and agreed.

There is no clear consensus on what level of objective hearing loss screening should occur. Studies have ranged from 25 dB to over 40dB. The clinical relevance of detection at 25 to 40dB hearing loss is uncertain.

The 2007 HTA study suggested that the cut off for screening should be >35 dB in the 55 to 74 year old population. The study concluded that this required further exploration in large scale studies of hearing screening⁴.

3.3. The test should be acceptable to the population

There are no RCTs or studies on potential harms of screening or acceptability to the population.

3.5. 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

The British Academy of Audiology published guidelines in 2009 on the direct referral to audiology services of adults with hearing loss for treatment when a case has been identified during clinical care and provided there are no contraindications for direct referral. The guidelines did not consider requirements of screen detected cases.¹³ However there may be little difference, in terms of diagnostic process, between a clinically identified population and a screen detected population.⁴

4.1. 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

4.2. There should be agreed evidence- based policies covering which individuals should be offered treatment and the appropriate treatment to be offered

Treatment for hearing loss is usually the provision of a hearing aid or aids (HA). HAs vary and usually the audiologist selects the most appropriate according to the type of hearing loss and motor skills of the patient. They come in a range of shapes and sizes, including traditional behind the ear but also the in the canal, completely in the canal, and open fit models. Multidirectional microphones are also available. Digital hearing aids are the most commonly used and allow the implementation of many additional features not possible with analog hearing aids. Fully digital hearing aids can be programmed with multiple programmes that can be selected by the user, or that operate automatically and adaptively. These programmes; reduce acoustic feedback, reduce background noise, detect and automatically accommodate different listening environments.

Many people with severe to profound hearing loss (defined as thresholds of 80 dB or worse) attributed to presbycusis and other factors reach a point where HAs no longer provide sufficient gain or benefit. Cochlear implants (CI) were established to be effective for people over 60 years of age in the 1990s.^{14,15} CIs require surgery but intra-operative and postoperative complication rates were found to be low.¹⁵

For a group of people presenting with good low frequency hearing but poorer hearing in the high frequencies HAs are often of no benefit. Electric acoustic stimulation (EAS) which is the use of an HA and a CI together in one ear can be helpful.¹⁶ The HA component of the EAS system amplifies residual low frequency hearing while the CI provides electrical stimulation of the high frequency regions of the cochlea. Because presbycusis is characterised by hearing loss in the high frequencies, older patients without contra-indications and with relatively good hearing in the low frequencies may be candidates for EAS. In a 2011 study of 23 patients, 12 months after EAS subjects had significant improvements as reported using the global score; Abbreviated Profile of Hearing Aid Benefit test. There was a mean decrease in impairment from 74% pre-operatively to 45% after 3 months of EAS use.¹⁷ Helbig et al. (2011)¹⁸, Skarzynski and Lorens (2010)¹⁹, Prentiss et al. (2010)²⁰, and Skarzynski et al. (2009)²¹ report hearing preservation rates of 90% to 100% using EAS.

The 2011 Oregon Evidence-based Practice Centre review for the U.S. Preventive Services Task Force¹¹ considered four RCTs which evaluated benefits of amplification compared with no amplification for treatment of screen-detected hearing loss. One of the included studies was considered good-quality. This found that; “immediate hearing aids were associated with near normalization of hearing-specific quality of life and communication difficulties in US male veterans (service members and service veterans and their dependants), with primarily screen-detected moderate to severe hearing loss (>40 dB hearing loss), compared with essentially no changes in these outcomes in waiting list controls”. The study population was mainly white male military veterans (99% male mean age 72 years). The reviewers concluded that the ability to generalise to other settings was limited.

A smaller, fair-quality RCT found no clear difference between an assistive listening device and no treatment in veterans (100% male average age 68 years) who were ineligible for free hearing aids and with a less severe hearing loss (threshold 32 to 33 dB). Another fair-quality RCT found no difference between a hearing aid, an assistive listening device, or both compared with no amplification in a subgroup of patients not using hearing aids at enrolment, with mild baseline hearing loss and hearing-related handicap. A fourth poor quality RCT of hearing aids versus no hearing aids reported no improvement of the Geriatric depression scores after six months in people who were treated and did not report results for the not treated arm.

No studies on harms associated with screening for hearing loss in older adults were identified. Harms are unlikely to be greater than minimal because screening and confirmatory testing are non-invasive and treatment with hearing aids is not associated with significant harms.

A mini- systematic review looking at 431 studies , published in 2010, of technology and treatment options stated that HA were effective but that a key issue when considering the potential benefit of HAs in older people is the acceptance of the device itself.²² Usage depended on fitting, motivation and ability to use the device. Many older people considered hearing aids as cosmetically unappealing because they associate them with being “old”. Once fitted with HAs, estimates of usage vary but one study included in this review suggests that it is likely that 25 to 40% of adults will either stop wearing them or use them only occasionally. Women are more likely to continue with daily use and persevere with HA use.²³ The Cochrane study on improvements to hearing aid usage found variation in usage between 5 to 40 % and that usage was low even in countries where HAs are free. They did say that usage in more recent studies were the highest and that this may be due to better technologies but even so it could be improved.²⁴

The USPSTF systematic review found a number of factors associated with adherence to HA use. These were reported in the following way:¹¹

- older age (age vs. age plus 5 years: adjusted OR, 1.2 [95% CI, 1.1 to 1.3]),
- more severe hearing loss (moderate loss vs. mild loss: adjusted OR, 5.0 [95% CI, 3.0 to 8.6]),
- years in education (≥16 years of education vs. <12 years of education: adjusted OR, 3.2 [95% CI, 1.7 to 6.1]),
- lower word recognition scores (<80 vs. ≥90 percent: adjusted OR, 2.7 [95% CI, 1.6 to 4.4]),
- worse (Hearing Handicap inventory for elderly) HHIE scores (>26 vs. 0: adjusted OR, 7.8 [95% CI, 3.1 to 19]),
- self-reported hearing loss (presence vs. absence of self-reported loss: adjusted OR, 4.9 [95% CI, 2.0 to 12]).

However evidence demonstrating that increased adherence to HA use improves health outcomes was found to be limited to one randomised trial which reported in 1990. This found that increased HA use was positively associated with greater improvements in HHIE scores (a measure of the emotional and /or social impact of hearing loss). Increased HA use did not correlate with greater improvement in QDS scores (a self reported measures of communication function).

To address the lack of persistence by older people in the use of their aid either for cosmetic reasons or lack of belief in its efficacy the British Society of Audiology published practice guidance on rehabilitation of hearing impaired elder adults in 2012. It suggested that; “hearing and or balance related problems are often chronic conditions, which can be managed but not always cured. Effective rehabilitation is best achieved through a process that goes beyond addressing the sensory impairment by also providing support to the person experiencing the hearing problem and to the client’s significant other(s).”²⁵ The document focuses on relationships as well as technical issues for achieving a positive outcome for hearing loss in older people. This approach clearly takes time and effort on the part of the person with hearing loss and regular consultations with the audiologist. A 2010 study in California suggested that only a small portion of audiologists (fewer than 10%) offer auditory training to patients with hearing impairment, even though auditory training appears to lower the rate of hearing aid failure however patients to whom auditory training programmes are recommended often do not complete the training.²⁶

A 2011 systematic review of the literature of interventions offered after screening considered 37 papers. The review found that only four papers reported offering interventions in addition, or as alternatives, to HAs. These were communication programme elements such as speech reading, hearing tactics and/or advice on environmental aids.²⁷ The review concluded that the value of this kind of intervention should be explored further in research.

A 2014 the Cochrane review looking at interventions which supplemented HA fitting with the aim of improving or encouraging hearing aid use in adult rehabilitation²⁴ found that the evidence was very limited across a range of six potential intervention types and six outcomes. The interventions were: self management (4 studies), delivery system design (5 studies all relating to self management and none to staff roles and task distribution), decision support (no studies) , clinical information system (no studies) and health system intervention/community resource (no studies). The primary outcomes were: hearing aid use measured by adherence i.e. proportion of people who used the aid relative to the total number fitted (2 studies) and daily hours of usage (18 studies). Secondary outcomes were: quality of life, hearing handicap (24 studies but only one long term handicap), aid benefit (11 studies but only one long term) and communication (two studies used a single score measure). Adverse effects were damage to patient hearing (no studies) and patient complaints (1 study).

Overall, the evidence was considered to be low to very low quality. There was risk of bias in the way many of the studies were carried out or reported. The largest studies included only military veterans and it is unclear if these results are translatable to the general public. There were inadequate descriptions of patient allocation, only rarely blinding of allocation, incomplete outcome data, and selective reporting. Most of the other studies had small sample sizes. Very few studies measured long-term outcomes.

The key results were:

Delivery design interventions:

Adherence:

Control	Intervention group	
948 per 1000	967 per 1000	RR 1.02

Daily hours of aid use

The mean daily hours of use in the intervention groups was 0.06 lower than in the control groups i.e. the intervention groups used their aid for under a minute per day less than the controls.

Number of outstanding complaints

Control	Intervention group	
571 per 1000	429 per 1000	RR 0.75

Self reported hearing handicap

The mean self reported hearing handicap in the intervention groups was 0.7 lower than in the controls i.e. indicating less hearing handicap.

Hearing benefit

The mean hearing benefit in the intervention group was 1.8 higher than in the control group i.e. more hearing aid benefit.

Communication

The mean reported use of verbal communication strategy in the intervention group was 0.10 higher than in the control indicating increased use of verbal communication.

Combined self management support/delivery system design interventions

Outcomes

Adherence daily hours of hearing aid use

The mean daily hours of use was 0.04 higher in the intervention group.

Adverse effects

The mean quality of life score in the intervention group was 0.32 higher.

Hearing handicap

The mean hearing handicap was 0.31 standard deviations lower in the intervention groups.

Hearing benefit

The mean hearing benefit was 0.3 higher in the intervention group.

Verbal communication strategy

Verbal communication strategy was 0.3 higher in the intervention group.

“The authors thus conclude that there is some low to very low quality evidence to support the use of self management support and complex interventions combining components of self management support and delivery system design in hearing health care. However, the range of interventions that have been tested is relatively narrow and data on long term outcomes sparse.”²⁴

A key problem in using study data is the variability in the way HA usage is measured. A systematic review published in 2012 by Perez looked at studies published since 1999 which measured and reported on the usage of hearing aids in older adults.²⁷ A total of 64 studies were found to be eligible for review and were quality assessed on six dimensions: study design, choice of outcome instruments, level of reporting (usage, age, and audiometry) and cross validation of usage measures. Five papers were rated as being of high quality, 35 moderate quality and 24 as low or very low quality. Fifteen different metrics for evaluating the usage of hearing aids were identified with little consistency in the way that usage was recorded. The authors suggest that there is no standard tool for evaluating hearing aid usage. Some studies considered amount of time an aid was worn others how regularly it was worn and some a mixed model. The authors found that it was difficult to identify users and non users. Overall the reviewers found that the level of reporting in the studies reviewed was inconsistent and of variable quality. They suggest that “there is a need for higher levels of evidence in the form of RCTs to study the impact of hearing aids as a treatment for hearing loss, and in particular for monitoring advances in service and technology on the uptake and compliance with hearing aid provision. Only with greater standardisation and precision in the level of reporting will future reviews of the literature be able to perform greater levels of analysis (e.g., meta-analysis) and provide firm guidelines on auditory habilitation with hearing aids.”²⁷

A Cochrane Review of the Effectiveness of hearing aid for mild-moderate hearing loss is currently underway to synthesise the up-to-date evidence, which will provide high-quality evidence on the published research. This will help inform future research directions.²⁹

Conclusion

There are effective hearing aids and interventions to improve hearing in older people. Factors associated with increasing uptake of their use have been identified. The evidence relating to measures evaluating health benefit and interventions to improve uptake has been found to be limited in terms of volume and quality in systematic reviews. The need for further research in the effectiveness of HA and their usage has been recommended by systematic reviews in this area.

4.3. Clinical management of the condition and patient outcomes should be optimised in all healthcare providers prior to participation in a screening programme

The Select Committee for Health Fifth Special Report in 2007³⁰ commented on the Department of Health, Modernising Hearing Aid Services (MHAS) programme to improve audiology services. They considered that the programme’s main aim was to improve the provision of digital aids and that it had been successful in this. However, it had also caused a rise in demand from new patients and those people wishing to upgrade their analog aids. This had led to long waiting lists and waiting times which had exceeded two years in some places. Despite the publication of a new framework on

audiology in 2007, entitled; “Improving Access to Audiology Services in England”, the Select Committee concluded that “audiology is not a priority for some PCTs but also that it is still not a sufficiently high priority for the Government.” They considered that; “the framework added little that was new; instead it reiterated previous announcements.” The result of this report was that; audiology waiting times were monitored by the Department of Health, Audiology Improvement projects were implemented³¹ and the provision of audiology services by private and not for profit organisations was encouraged.

The 2012 waiting list figures showed that in March 2012 41,247 patients were treated via Direct Access Audiology treatment. Of these, the average (median) waiting time was 4.5 weeks and the 95th percentile was 15.5 weeks with 98.8% patients treated within 18 weeks.³² In June 2008 32,046 patient were treated with 94.29% treated in 14 weeks.

http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/en/Publicationandstatistics/Statistics/Perfomancedataandstatistics/Directaccessaudiology/DH_094308

Davis et al. published reports on how the NHS Improvement Programme in England used service improvement methods to identify referral pathways and tools which were most likely to make significant improvements in the study’s three objectives: diagnosing hearing loss , effective referrals and better patient outcomes for any patients, not just the elderly although they are in the. The service improvement pilots were in 18 sites across the UK. One of those looked at triage in primary care. Using an audiometric screening device GPs were reported to be able to identify patients with potential hearing loss. Patients could then be referred either to audiology for further assessment and HA fitting if positive or to a one stop service. The hypothesis being that there is better uptake (whether this is acceptance of an aid or actual usage isn’t clear). Of the 97 people identified 53 (55%) were considered not eligible for the new style service and of the remaining 44, 39 (40% of total) attended and 26 (27%) were fitted with an aid. There was no data for comparison of these two populations or any longer term follow up. The authors suggested that triage in the GP surgery enabled effective referrals to be made and that these revised referral criteria and direct access pathways could transform audiology service delivery making patient outcomes measurably better.³³ The numbers of patients were very small and there were no test characteristics to identify the usefulness of this work in relation to a screening programme.

Conclusion

Audiology services are reported to have improved in terms of waiting times. However a study considered in criterion three suggested that the majority of services could be further improved especially in relation to the provision of on-going rehabilitation to support long term use of hearing aids. The outcomes of the 2015 NHS England strategy have yet to be realised.

No studies were identified that assessed the capacity of present services or the level of service required if screening was introduced.

5. The Screening Programme

5.1. There should 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” (eg. 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

5.2. 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 rationale behind screening for hearing loss in older adults is that screening will identify individuals with hearing loss before they identify themselves or are identified by other methods. The aim is to identify those who could benefit from the use of hearing aids or other therapies to enhance their hearing capacity.¹¹

The Oregon systematic review for the USPSTF¹¹ identified one RCT on screening published in 2010 by Yueh.³⁴ This is the only trial that compares screening with no screening. Conducted in 2003/2 the SAI-WHAT trial compared three different screening strategies (the AudioScope, based on inability to hear a 40 dB tone at 2000 Hz in either ear; the HHIE-S, based on a score >10; or the AudioScope plus the HHIE-S) versus usual care without screening in 2305 predominantly (94 percent) male patients aged 50 years and older (mean age, 61 years) at a Department of Veteran Affairs (VA) Medical Centre. Participants were recruited by advertising the study in outpatient clinics and asking those interested to participate.

The study found that screening with the HHIE-S, the AudioScope, or both was associated with greater hearing aid use at 1 year compared with no screening - 6.3% to 7.4% of those screened compared to 3.3% in the control group. Usage was measured by a questionnaire at one year that asked the simple question “do you use your hearing aid”. It did not measure how much it was used and was not validated.

Table 2 Events within 1 Year of Screening, According to Screening Arm

Percentages in each column are of the total patients in that arm.

	Arm 1 Control (n=923)	Arm 2 Tone-Emitting Otoscope (n=462)	Arm 3 Questionnaire (n=461)	Arm 4 Both (n=459)	P value Likelihood ratio test
Patient screened positive for hearing loss		18.6	59.2	63.6	<.001
Patient contacted audiology	15.9	17.3	31.2	34.4	<.001
Patient kept audiology	10.8	14.7	23.0	26.6	<.001

	Arm 1 Control (n=923)	Arm 2 Tone-Emitting Otoscope (n=462)	Arm 3 Questionnaire (n=461)	Arm 4 Both (n=459)	P value Likelihood ratio test
appointment†					
Audiograms show correctable hearing loss	8.0	12.3	15.8	18.5	<.001
Patient fit with hearing aid	3.8	6.5	4.6	7.6	.01
Hearing aid use at 1 year	3.3	6.3	4.1	7.4	.003

Stratified analyses of the primary outcome variable of hearing aid use at 1 year demonstrated statistically significantly greater hearing aid use in the tone-emitting otoscope arms for patients who perceived hearing loss at baseline before screening but not in those who did not perceive hearing loss.

Three quarters of the patients enrolled in the trial reported perceived hearing loss at baseline which suggests the method of selection was biased towards those with existing hearing loss. Recruitment was by advertising the hearing test in the hospital outpatients and asking patients to present themselves. There was no analysis of how many patients who had hearing loss decided not to go for a test or how biased the study population was. All patients were eligible to receive a free hearing aid which makes the results more generalisable to the UK context. However, as identified in the USPSTF report¹¹ and the Cochrane review²⁴ the trial was primarily in a male population of military veterans in the US and so less generalisable to the UK context and other groups. The authors say that the lack of clinical outcomes detected is because the study was powered to detect hearing aid use not “patient centred clinical outcome measures”.

The authors considered that the study demonstrated that screening in an older male population (over 60 years) with a high prevalence of hearing disability was proven but that studies were needed in non-veteran elderly populations.

The USPSTF concluded in their recommendation of 2012 that the current evidence is insufficient to assess the balance of benefits and harms of screening for hearing loss in asymptomatic adults aged 50 years or older.³⁵ They considered that further research is need on; the effectiveness of screening in primary care settings, the optimal age to start screening, the severity of hearing loss to target optimal screening test thresholds and methods, effective methods for maximising follow-up rates and uptake of treatments after screening, understanding the effects of screening for hearing loss compared with no screening on health outcomes and the benefits of treatment under conditions, likely to be encountered in most primary care settings.

The rationale for screening has been challenged recently by Grandori and colleagues from Italy who, at the 2012 International conference on Adult Hearing Screening, in a special lecture said that screening for hearing loss is “gaining increasing momentum” but that screening programmes should move from merely detecting hearing loss to comprehensive approaches to identifying disability due to hearing loss and tailored treatment approaches.³⁶ They said that primary research is needed to develop accurate and practical screening tools and to evaluate the effectiveness of screening methods for use in various healthcare settings.

Conclusion

USPSTF systematic review did not find any RCTs in a general population setting. The review identified outstanding questions relating to the age of the population to be screened, the severity of hearing loss which might benefit from intervention, the optimum test and cut offs, ensuring uptake of interventions.

Other papers suggested that the aims of screening should be the focus of further debate and clarification.

5.6. The opportunity cost of the screening programme (including testing, diagnosis and 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). Assessment against these criteria should have regard to evidence from cost benefit and/or cost effectiveness analyses and have regard to the effective use of available resource.

Using the data from the 2010 Yeuh trial³⁴ the research team published economic data comparing the three arms of the trial with controls using an outcome measure of HA use for one year in 2,251 older veterans. The audiology cost measure included costs of hearing loss screening and audiology care for 1 year after screening. Incremental cost-effectiveness was the audiology cost of additional hearing aid use for each screening group compared with the control group. The mean total audiology cost per patient was \$77.04, \$122.70, \$121.37, and \$157.08 for the control, otoscope, questionnaire, and dual screening groups, respectively. They considered that the “tone-emitting otoscope appears to be the most cost-effective approach for hearing loss screening, with a significant increase in hearing aid use 1 year after screening (2.8%) and an insignificant incremental cost-effectiveness of \$1,439.00 per additional hearing aid user compared with the control group.”³⁷

Morris et al from Southampton³⁸ used theoretical Markov models to estimate the incremental cost-effectiveness ratio (ICER) of potential screening programmes compared with current UK provision (GP-referral), from a NHS health service perspective. The work was based on the 2007 Health Technology Assessment Report by Davis et al.⁴ Morris looked at alternative options through scenario analysis and probabilistic sensitivity analyses. All modelled screens were considered to be cost-effective and reduce unmet need for hearing aids. The most cost-effective option identified was a one-stage audiometric screen for bilateral hearing loss ≥ 30 dB hearing level (HL) at age 60, repeated at ages 65 and 70. This option has an ICER of £1461 compared to GP-referral and would mean an additional 15,437 adults benefiting from hearing intervention per 100 000 population aged over 60. The cost-effectiveness acceptability curve showed that screening is more cost-effective than GP-referral provided a Quality Adjusted Life Year is valued at £2000 or more.

The model was based on the probability of continued use of hearing aids for 5 years after screening. They used a base case of continued use of 62% for screened cases and 80% for GP referral. The HTA

study only followed hearing aid use for three months.⁴ In the questionnaire only group of the 307 invited in for treatment at three months 134 were using an aid and in the questionnaire and audiometry group of the 100 who failed 48 were aid users on follow up. The Cochrane review³³ found very few studies with a follow up of over one year.

Morris suggests that if a worse case of 43% aid uptake was used it would not affect the modelling significantly.³⁸ She also suggests that uptake could be higher using analogue aids and tailoring of interventions to individuals' communication needs. Morris recommends further research to consider the cost benefits of more tailored communication rehabilitation which would be more costly and says that any screening programme, if introduced, should be evaluated to verify the assumptions made in her paper.

5.7. 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.

The Department of Health modernisation programmes and the British Society of Audiology's proposals has not been fully implemented and evaluated.

5.8. There should be a plan for managing and monitoring the screening programme and an agreed set of quality assurance standards.

This would be required in advance of the implementation of a screening programme.

5.9. Adequate staffing and facilities for testing, diagnosis, treatment and programme management should be available prior to the commencement of the screening programme.

This would be required in advance of the implementation of a screening programme.

5. 10. 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.

This would be required in advance of the implementation of a screening programme.

6. Conclusions

Hearing loss is a serious public health issue. However, the following areas are uncertain.

- Age at which screening should begin and frequency of subsequent screening.
- Level of severity at which treatment becomes beneficial and therefore focus of a screening programme.
- Optimum screening test and cut off point.
- Long-term effectiveness of hearing aids in improving hearing and quality of life and methods of increasing compliance of use of aids.
- Diagnostic pathways for screen detected cases.

- Capacity of audiological services to meet potential screening programme increased demand.

There is therefore a lack of evidence on the effectiveness of screening in enhancing quality of life through improving hearing capacity.

6.1. Implications for policy

Hearing loss in older adults is a serious public health issue. However screening for hearing loss in adults is not supported by the evidence published since 2009.

6.2. Implications for research

The UK HTA 2007⁴ recommended:

- a 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
- modelling of different screening programmes, their cost-effectiveness and budget impact,
- a 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 primary care setting,
- the development and trial of simple, low-cost audiometric screen devices.

The USPSTF¹¹ recommendations for research to explore the impact of screening were:

- effectiveness of screening in typical primary care settings,
- optimal age at which to start screening,
- severity of hearing loss and hence optimal screening test thresholds and methods.
- effective methods for enhancing follow-up rates and uptake of treatments
- effects of screening for hearing loss compared with no screening on health outcomes.

The Cochrane Review²⁴ recommended research focusing on:

- investigating long-term outcomes including larger, appropriately powered studies in this context,
- interventions to improve hearing aid use in adult auditory rehabilitation including the elements of decision support, clinical information systems, health system and community-based interventions, where there is a lack of high-level evidence,
- changes in health service delivery required to support intervention types such as educative, counselling based self management support and auditory training, collaborative goal setting and problem-solving
- behavioural outcomes such as hearing aid use in terms of adherence rather than hours of use per day
- the development of an agreed set of core outcomes for future research both in terms of outcome type (e.g. benefit, hearing handicap, quality of life etc.) and in the measure used to record that outcome.

7. References

1. National Screening Committee. First report of the National Screening Committee. London: NSC; 1998. (http://www.doh.gov.uk/nsc/library/lib_ind.htm).
2. <http://www.screening.nhs.uk/hearing-adult>
3. Cruickshanks KJ, Wiley TL, Tweed TS, et al. Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin. The Epidemiology of Hearing Loss Study. *Am J Epidemiol*. 1998;148(9):879-886.
4. Davis A, Smith P, Ferguson M, Stephens D, Gianopoulos I. Acceptability, benefit and costs of early screening for hearing disability: a study of potential screening tests and models. *Health Technol Assess* 2007;11(42).
5. Gates GA, Mills JH. Presbycusis. *Lancet*. 2005;366(9491):1111-1120.
6. Mulrow CD, Aguilar C, Endicott JE, et al. Quality-of-life changes and hearing impairment: a randomized trial. *Ann Intern Med*. 1990;113(3):188-194.
7. Weinstein BE, Ventry IM. Hearing impairment and social isolation in the elderly. *J Speech Hear Res*. 1982;25(4):593-599.
8. Gurgel et al (2014) Relationship of hearing loss and dementia: a prospective, population-based study. *Otology & Neurotology* 35(5), 775-81.
9. [Verbeek JH](#), [Kateman E](#), [Morata TC](#), [Dreschler WA](#), [Mischke C](#). Interventions to prevent occupational noise-induced hearing loss. *Cochrane Database Syst Rev*. 2012 Oct 7;10:CD006396. doi: 10.1002/14651858.CD006396.pub3.
10. McBride WS, Mulrow CD, Aguilar C, Tuley MR. Methods for screening for hearing loss in older adults. *Am J Med Sci*. 1994;307(1):40-42.
11. Watson (2012) Telephone screening tests for functionally impaired hearing: current use in seven countries and development of a US version. *Journal of the American Academy of Audiology* 23, 757-767.
11. Chou R, Dana T, Bougatsos C, Fleming C, Beil T. Screening for Hearing Loss in Adults Ages 50 Years and Older: A Review of the Evidence for the U.S. Preventive Services Task Force. Evidence Synthesis No. 83. AHRQ Publication No. 11-05153-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; March 2011.

12. Boatman DF, Miglioretti DL, Eberwein C, Alidoost M, Reich SG. How accurate are bedside hearing tests? *Neurology*. 2007;68(16):1311-1314
14. Meyer C, Hickson L, Khan A, Hartley D, Dillon H, Seymour J. Investigation of the actions taken by adults who failed a telephone-based hearing screen. *Ear Hear*. 2011 Nov-Dec;32(6):720-31. doi: 10.1097/AUD.0b013e318220d973.
13. British Academy of Audiology Guidelines for Referral to Audiology of Adults with Hearing Difficulty (2009). British Academy of Audiology: 2009.
14. Horn KL, McMahon NB, McMahon DC, Lewis JS, Barker M, Gherini S: Functional use of the nucleus 22-channel cochlear implant in the elderly. *Laryngoscope* 1991; 101: 284–288.
15. Kelsall DC, Shalloo JK, Burnelli T: Cochlear implantation in the elderly. *Am J Otol* 1995; 16: 609–615.
16. Von Ilberg C, Kiefer J, Tillein J, Pfennigdorff T, Hartmann R, Stürzebecher E, Klinke R: Electric-acoustic stimulation of the auditory system: new technology for severe hearing loss. *ORL J Otorhinolaryngol Relat Spec* 1999; 61: 334–340.
17. Gstoettner W.K. · Van de Heyning P. · Fitzgerald O'Connor A. · Kiefer J. · Morera C. · Sainz M. · Vermeire K. · McDonald S. · Cavallé L. · García Valdecasas J. · Adunka O.F. · Baumann U. · Kleine-Punte A. · Brockmeier H. · Anderson I. · Helbig S. Assessment of the Subjective Benefit of Electric Acoustic Stimulation with the Abbreviated Profile of Hearing Aid Benefit *ORL* 2011;73:321–329 (DOI: 10.1159/000331917)
18. Helbig et al. Combined electric acoustic stimulation with the PULSARCI100 implant system using the FLEXEAS electrode array. *Acta Otolaryngol*, 2011 Jan 31. [Epub ahead of print]
19. Skarzynski H, Lorens A. Electric Acoustic Stimulation in Children. Van de Heyning P, Kleine Punte A (eds): *Cochlear Implants and Hearing Preservation*. Adv Otorhinolaryngol. Basel, Karger, 2010, 67: 135–143.
20. Prentiss et al. Partial deafness cochlear implantation at the University of Kansas: techniques and outcomes. *J Am Acad Audiol*, 2010 Mar; 21 (3): 197-203.
21. Skarzynski et al. Results of Partial Deafness Cochlear Implantation Using Various Electrode Designs. *Audiol Neurotol*, 2009; 14 (suppl 1): 39–45.
22. Sprinzl G.M. Riechelmann H. Current Trends in Treating Hearing Loss in Elderly People: A Review of the Technology and Treatment Options – A Mini-Review *Gerontology* 2010;56:351–358.
23. Staehelin K, Bertoli S, Probst R, Schindler C, Dratva J, Stutz EZ Gender and hearing aids: patterns of use and determinants of nonregular use. *Ear & Hearing*, 11-12 2011, vol./is. 32/6(e26-37), 0196-0202;1538-4667

24. Barker F, Mackenzie E, Elliott L, Jones S, de Lusignan S. Interventions to improve hearing aid use in adult auditory rehabilitation. CochraneDatabase of SystematicReviews 2014, Issue 7.Art.No.:CD010342.DOI: 10.1002/14651858.CD010342.pub2.

25. British Society of Audiology; Common principles of rehabilitation for adults with hearing- and/or balance-related problems in routine audiology services. British Society of Audiology:2012

26. Sweetow RW, Sabes JH. Auditory training and challenges associated with participation and compliance. Journal of the American Academy of Audiology, 10 2010, 21(9):586-93.

27. [Pronk M](#), [Kramer SE](#), [Davis AC](#), [Stephens D](#), [Smith PA](#), [Thodi C](#), [Anteunis LJ](#), [Parazzini M](#), [Grandori F](#). Interventions following hearing screening in adults: a systematic descriptive review. [Int J Audiol](#). 2011 50(9):594-609.

28. Perez and Edmonds (2012) A systematic review of studies measuring and reporting hearing aid usage in older adults since 1999: a descriptive summary of measurement tools. *PLoS ONE* 7 (3), e31831.

29. Personal communication.

30. House of Commons Health Committee. Fifth Report of Session 2006–07 Audiology Services London: The Stationery Office Limited. 2007
<http://www.publications.parliament.uk/pa/cm200607/cmselect/cmhealth/392/392.pdf>

31. Department of Health Audiology Improvement Programmes. Shaping the Future: Strengthening the evidence to transform audiology services. 2011

32. Department of Health Statistical
http://webarchive.nationalarchives.gov.uk/20130107105354/http://www.dh.gov.uk/en/Publicationandstatistics/Statistics/Performancedataandstatistics/Directaccessaudiology/DH_094308
accessed: 21 10 2014

33. Davis A, Smith P, Booth M, Martin M Diagnosing Patients with Age-Related Hearing Loss and Tinnitus: Supporting GP Clinical Engagement through Innovation and Pathway Redesign in Audiology Services. *Int J Otolaryngology*, 2012, doi:10.1155/2012/290291

34. Yueh B, Collins MP, Souza PE, Boyko EJ, Loovis CF, Heagerty PJ, et al. Long-term effectiveness of screening for hearing loss: the screening for auditory impairment—which hearing assessment test (SAI-WHAT) randomized trial. *J Am Geriatr Soc*. 2010;58:427-34. [PMID: 20398111]

35. U.S. Preventive Services Task Force. *Screening for Hearing Loss in Older Adults: U.S. Preventive Services Task Force Recommendation Statement*. AHRQ Publication No. 11-05153-EF-2, August 2012. <http://www.uspreventiveservicestaskforce.org/uspstf11/adultheating/adulthearrs.htm>

36. Grandori, F., Paglialonga, A., Tognola, G., Adult Hearing Screening: Guiding Principles and Methods, 2nd International Conference on Adult Hearing Screening (AHS 2012), Cernobbio (Italy), 2012.

371 Liu CF, Collins MP, Souza PE, Yueh B. Long-term cost-effectiveness of screening strategies for hearing loss. *J Rehabil Res Dev*. 48(3):235-43, 2011.

38. [Morris AE](#), [Lutman ME](#), [Cook AJ](#), [Turner D](#). An economic evaluation of screening 60- to 70-year-old adults for hearing loss. [J Public Health \(Oxf\)](#). 2013 Mar;35(1):139-46.

Jackie Spiby Nov 2015
