OPEN ACCESS GUIDE TO AUDIOLOGY AND HEARING AIDS FOR OTOLARYNGOLOGISTS

Hearing loss is the 3rd most common chronic disorder affecting adults and the elderly [1,2] and is estimated to affect 33% of adults over the age of 65 years globally[3]. Approximately 360 million people across the world suffer from permanent disabling hearing loss [4]. About 1/5 adults have bilateral hearing difficulty that influences their quality of life [5].

Causes of adult hearing loss

Sensorineural hearing loss (SNHL)

SNHL is caused by damage to the cochlea or auditory nerve (8th cranial nerve) [6] and is the most common type of hearing loss in adults.

Presbycusis is the most common type of SNHL in adults. It is most likely caused by general aging [4,5]. Another common SNHL in adults is a noise induced hearing loss which is caused by excessive noise exposure[7]. When exposed to excessive noise, hair cells transducing high frequencies (most sensitive to noise) may become permanently damaged. Noise induced hearing loss may coexist with presbycusis, causing a more significant hearing loss than age alone [7].

Certain drugs and chemicals can be toxic to the auditory system. Examples of ototoxic drugs include quinine, gentamy-cin, neomycin and cytotoxic drugs *e.g.* cisplatinum. Ototoxic drugs usually cause permanent SNHL by damaging the hair cells in the cochlea [8].

Conductive hearing loss (CHL)

CHL occurs when there is an obstruction to sound from anywhere in the external ear to the cochlea. Causes can be located in the external auditory canal, the tympanic membrane or abnormality of the ossicles. Mild CHL can be caused by otitis media with effusion (OME). Moderate CHL is seen with perforations of the tympanic membrane or obstruction of the external ear canal *e.g.* excessive earwax.

Mixed hearing loss

Mixed hearing loss is a combination of CHL and SNHL. It may for instance occur with external auditory canal obstruction and damage to the cochlear hair cells or auditory nerve.

Impact of adult hearing loss

Hearing loss is an underestimated disability and handicap affecting physical, cognitive, behavioral and social functioning, as well as general quality of life [9]. Hearing loss impairs the ability to localise sound and to identify speech, and to partake in social events resulting in isolation, exclu-sion and depression [9].

Despite its impact on quality of life, hearing disability has been ignored as part of the diagnosis and treatment of cognitive functioning in the elderly. A study by Lin *et al* (2011) showed that an elderly person with untreated mild hearing loss has twice the probability of developing a cognitive disability (such as dementia) than a person with normal hearing [10]. It is therefore important that screening programs are implemented to detect adults with hearing difficulty so they might benefit from appropriate amplification to improve their general quality of life.

Benefits of early detection of adult hearing loss

Most adults and elderly people are not assessed or treated for a hearing loss,

despite the impact that hearing loss has on health [1,2]. Even though the impact of hearing loss can be reduced by using amplification devices such as hearing aids, FM microphones and assistive listening devices, people are reluctant to seek hearing healthcare because of poor self-esteem [11]. Hearing health should therefore follow a holistic approach by including the relatives during counseling and aural re-habilitation sessions [12]. Creating a suppor-tive environment will assist with early acceptance of hearing disability and demonstrate the ability to improve quality of life, cognitive functioning and delay the onset of auditory deprivation [9,13,14]. A screening program could aid with early identification of hearing loss to ensure optimal diagnosis, treatment and counseling [3,15,16,17].

The remainder of this chapter deals with guidelines for hearing screening and the available hearing screening options.

Guidelines for developing an adult hearing screening program

An adult hearing screening program aims to detect a hearing impairment and to refer adults or the elderly for further evaluation. *Table 1* summarizes 7 processes that need to be considered before implementing an adult hearing screening program.

Process	Guidelines for implementing a hearing screening program
1	Implemented at any facility in need of hearing screening services, e.g. private audiology practice, clinic, hospital or nursing home
2	Audiologist remains responsible to manage and develop the hearing screening pro-gram. The following needs to be considered before implementing a hearing screening program: • Ensure that patient records are kept and that confidentiality is maintained • Test results must be sensitive for a hearing loss • PASS and REFER criteria for results should be specific • Check and calibrate equipment annually to avoid malfunction, inaccu-rate results and appropriate referral • Test environment must be hygienic and equipment cleaned to avoid infections
3	Personnel at various facilities can be trained to administer the hearing screening program. The following need to be considered during training: • Personnel need to be trained by the audiologist to operate and manage the screening equipment • Appropriate testing procedures must be followed to obtain accurate results • Suitable feedback of results and counseling should be provided • Apply infection control • Patient confidentiality should be maintained at all times • Audiologist remains responsible and liable for the screening program and must supervise and support personnel administering the screening tests.
4	Hearing screening programs should not only detect hearing loss, but identify patients willing to seek treatment. The ideal hearing screening patient is someone who might possibly suffer from hearing loss who is motivated to meet the diagnostic evaluation appointment and seek treatment
5	Healthcare facilities implementing a hearing screening program should be able to cope with and manage such a program. A hearing screening program should be cost and time effective. Appropriate diagnostic services should be established prior to development of a hearing screening program
6	A hearing screening program should be implemented on a trial basis to determine the effectiveness of the hearing screening program. The trial should establish whether the program leads to successful follow-up evaluations
7	Each hearing screening program is unique, therefore the audiologist needs to evaluate the program on an ongoing basis to identify and correct factors that may obstruct optimum program performance and patient care

Table 1: Guidelines for developing and implementing hearing screening programs [18,19,20]

Target disorder for adult hearing screening

The purpose of an adult hearing screening program is to identify patients who are unable to hear normally and is willing to seek treatment. Adult hearing screening may be directed to detect a range of different degrees of hearing loss depending on the target disorder. For detecting mild losses a criteria of pure tone thresholds greater than 25 dB HL may be used or in more resource constrained environments it may need to focus on identifying people with a disabling hearing loss. A disabling hearing loss for adults, as defined by the WHO (2012), is described as a loss in the better ear greater than 40 dB HL at the averaged pure-tone thresholds of 500, 1000, 2000 and 4000 Hz [21]. The recommended pure-tone hearing screening procedure and cut-off value are discussed in the pure-tone screening section of this chapter.

Hearing screening test options

Hearing loss in adults can be identified at an early stage by using a number of hearing screening technologies or techni-ques. The basic hearing screening proce-dures should include a self-reported hearing loss questionnaire, otoscopy and a hearing test that is easy to administer and that is specific [4,7]. The techniques that will be discussed include self-reported hearing loss questionnaires, pure-tone screening, otoacoustic emissions and speech-in-noise hearing screening tests [16,22].

1. Self-reported hearing loss question-naires

Various self-reported hearing loss ques-tionnaires have been developed to detect hearing impairment. Self-reported hearing loss questionnaires are very effective de-tection tools but are likely to miss milder hearing losses [23]. Examples include a single question about hearing ("do you think you have a hearing loss?"), the *Hearing Handicap Inventory for Elderly: Screening version (HHIE-S), Social Hearing Handicap Index*, *Hearing Perfor-mance Inventory* and the *Hearing Handicap Inventory for Adults (HHIA).* Even a simple question on how a person perceives their own hearing may be as ef-fective as a questionnaire [16]. Also, a person who self-reports hearing loss is more likely to be a good candidate for intervention than a person who denies hearing difficulty due to poor motivation [16].

The *HHIE-S questionnaire* has been used as an example of a self-reported hearing loss questionnaire *(Figure 1)*. The *HHIE-S* was designed to be used at various facilities with non-institutionalized adults. It is also helpful in cases of profound hearing loss when a patient is unable to follow an oral case history. The *HHIE-S* has 10 questions developed to assess the social and emotional challenges of living with an untreated hearing loss. The higher the HHIE-S score, the more severe the hearing loss [24].

		Yes (4)	Sometimes (2)	No (0)
E-1	Does a hearing problem cause you to feel embar-rassed when meeting new people?			
E-2	Does a hearing problem cause you to feel frustrated when talking to members of your family?			
S-3	Do you have difficulty hearing when someone speaks in a whisper?			
E-4	Do you feel handicapped by a hearing problem?			
S-5	Does a hearing problem cause you difficulty when visiting friends, neigh-bours, or relatives?			
S-6	Does a hearing problem cause you to attend reli-gious services less often than you would like?			
E-7	Does a hearing problem cause you to have argu-			

	ments with family members?			
S-8	Does a hearing problem cause you difficulty when listening to the TV or radio?			
E-9	Do you feel that any difficulty with your hearing limits or hampers your personal or social life?			
S-10	Does a hearing problem cause you difficulty when in a restaurant with relati-ves or friends?			

Total Score (E & S):……..…….
Subtotal Social (S):…….
Subtotal Total Emotional (E):…….

0-8: No referral
10-24: Moderate handicap
26-40: Refer

Figure 1: HHIE-S questionnaire

Advantages of a self-reported hearing loss questionnaire:

- Affordable and time-effective
- Can be placed at any health care facility
- Can be an effective way to detect greater-than-mild hearing loss
- Appropriate referrals can be made based on the outcome scores
- A person that indicates a hearing impairment is more likely to approve rehabilitation

Disadvantages of a self-reported hearing loss questionnaire:

- The person conducting the questionnaire needs to be literate
- A self-reported hearing loss questionnaire is insensitive to mild hearing loss [16]

2. Free field voice testing

In underserved settings without audiological equipment, clinicians can revert to free field voice testing. Whilst its accuracy may be compromised by several factors, if conducted under controlled conditions such as specified in the chapter entitled Clinical assessment of hearing: free field voice testing & tuning forks it may be a useful tool.

3. Pure-tone screening

Pure-tone screening is the most common method used to determine hearing ability at a specific intensity (25 dB HL / 40 dB HL for a disabling hearing loss) across specified octave frequencies (500, 1000 and 4000 Hz) [18]. The following are guidelines how to perform pure-tone hearing screening.

Preparation

1. Seat the patient facing away from the screener (*Figure 2)*

Figure 2: Hearing screening setup.

2. Give test instructions before placing the earphones on the patient
3. Tell the patient that different tones will be played
4. Instruct the patient to respond to each tone heard by either raising a hand or respond by saying “yes”
5. Confirm that the patient understands what is expected of him/her during the test

Pure-tone hearing screening

1. Conduct pure-tone screening in a quiet room
2. Place the earphones over the patient’s ears. Take note to place the RED earphone on the RIGHT ear and the

BLUE earphone on the LEFT ear *(Figure 3)*

3. Set the loudness dial of the screener at 25dB
4. Present the stimulus twice at 25dB as short tones
5. Do not present the stimulus in such a way that the patient notices a rhythmic pattern in stimulus presentation
6. Screen frequencies 500, 1000 and 4000Hz at 25dB
7. The screening test is PASSED if a response is obtained at 25dB across the screening frequencies (500, 1000 and 4000Hz)
8. The screening test is FAILED if no responses are obtained at any of the screening frequencies (500, 1000 and 4000Hz) at 25dB

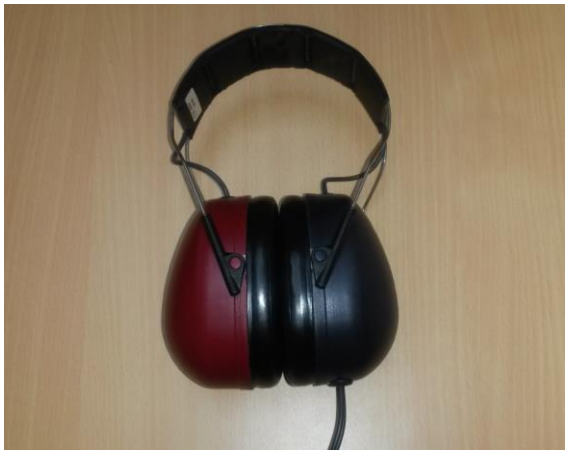

Figure 3: An example of audiometric headphones where the red earphone is placed on the right ear and the blue earphone is placed on the left ear.

Advantages of pure-tone audiometry hearing screening include:

- Testing can be done at old-aged homes, clinics or any other facility
- Test results are ear specific
- Test results are specific
- It is time-efficient
- Equipment is portable

Disadvantages include:

- Testing must be conducted in a quiet room
- Errors are likely when an inexperienced screener conducts the test
- Pure-tone screening equipment is expensive due to calibration costs
- Pure-tone screening equipment should be calibrated once a year

4. Otoacoustic Emissions (see chapter about OAE´s)

OAEs are an alternative screening method for children when behavioural responses *e.g.* using pure-tone screening, are not possible. OAE screening is not for adults, however it may be used in certain instances. It may be appropriate to screen adults with OAEs he/she is unable to respond to pure-tones or complete a self-reported hearing loss questionnaire *e.g.* with dementia or illiteracy. The test is easy to administer with a single probe inserted into the external ear canal of the test ear. OAEs are objective and require no response from the patient. It takes about 2 minutes to test each ear providing a PASS or REFER [18]. It is important to note that OAEs disappear when a patient has mild hearing loss. OAE testing is also affected by the status of the external and middle ear, *e.g.* with OME [18].

Advantages of OAEs:

- Objective hearing screening
- Test is ear specific
- Potential to detect hearing loss
- An expert is not needed to administer the test
- Time efficient
- Relatively cost effective.
- Portable

Disadvantages:

- No information is obtained on the degree of hearing loss
- Does not test full hearing, but only cochlear outer hair cell function [25]
- Not recommended as a screening tool in adults as OAE's are a suggested tool for new-born hearing screening.

5. Telephone based speech-in-noise hearing screening

Speech-in-noise hearing screening tests, especially the digits-triplet speech-in-noise hearing screening test, have been developed and widely deployed over the past 10yrs as an easy and accessible test. The digit-triplet telephone based test is available to anyone with access to a landline telephone or cellular phone. The test is conducted by administering a fixed background noise with three pre-recorded digits (0 – 9) randomly presented in the presence of the noise. The individual responds by entering the digits on the telephone keypad. If the digits are entered correctly, the intensity of the digits is decreased automatically. When the digits are entered incorrectly, the intensity of the digits is increased automatically. The test takes approximately 3 minutes to complete and provides a PASS or REFER upon completion. The digit-triplet speech-in-noise tests have become popular in deve-loped countries such as the USA, Australia, and Europe, and have been developed in different languages. The digit-triplet screening test also has the added benefit that it provides information on how a person understands speech in background noise [2,22,26,27,28].

Advantages of digit-triplet speech-in-noise hearing screening tests:

- Evaluates an everyday speech-in-noise environment
- Test is specific
- Anyone with a landline telephone or cellular phone can access it
- Is an automatic test; therefore a layperson can administer it
- Time-efficient
- Cost effective

Disadvantages:

- Speech may sound distorted over the telephone
- Not available in all countries

Summary

Approximately one-third of the adult population >65 years has hearing loss. Early rehabilitation of an adult hearing loss could positively influence a person's social interactions and be of importance for alertness and mental health. Adult hearing screening is an important way to provide early detection at facilities such as clinics and nursing homes.

A successful adult hearing screening program follows pre-specified guidelines and requires appropriate staff training. Currently self-reported hearing loss questionnaires and pure-tone screening are recommended as the most appropriate adult hearing screening tools.

References

1. Kochkin S. MarkeTrak VII: Obstacles to adult non-user adoption of hearing aids. *Hear J* 2007; *60:*24-50
2. Watson CS, Kidd GR, Miller JD, Smits C, Humes LE. Telephone screening tests for functionally impaired hearing: Current use in seven countries and development of a US version. *J Am Acad Audiol* 2012; 23:757-767
3. World Health Organization. WHO: Multi-country assessment of national capacity to provide hearing care 2013. http://www.who.int/pbd/publications/WHOReportHearingCare_Englishweb.pdf?ua=1
4. World Health Organization. WHO: Millions of people in the world have hearing loss that can be treated or prevented 2013. http://www.who.int/pbd/deafness/news/Millionslivewithhearingloss.pdf
5. Gates GA, Mills JH. Presbycusis. *The Lancet Seminars* 2005; 366:1111-1120

6. American Speech-Language-Hearing Association. ASHA: Types, degrees and configuration of hearing loss 2011. http://www.asha.org/uploadedFiles/AIS-Hearing-Loss-Types-Degree-Configuration.pdf
7. World Health Organization. WHO: Prevention of noise induced hearing loss 1997. http://www.who.int/pbd/deafness/en/noise.pdf
8. World Health Organization. WHO: Report of an informal consultation on strategies for prevention of hearing impairment from ototoxic drugs 1994. http://www.who.int/pbd/deafness/ototoxic_drugs.pdf
9. Arlinger S. Negative consequences of uncorrected hearing loss – a review. *Int J Audiol* 2003; 42: 2S17-2S20
10. Lin, F. R., Metter, E. J., O'Brien, R. J., Resnick, S. M., Zonderman, A. B., & Ferrucci, L. (2011). Hearing loss and incident dementia. *Arch Neurol; 68:-* 214–20
11. Gagné J-P, Southall K, Jennings M B. Stigma and self-stigma associated with acquired hearing loss in adults. *Hearing Review* 2011, *18*(8), 16–22
12. Saunders GH, Echt K. Dual sensory impairment in an aging population. *The ASHA Leader* 2011*; 16*(3):5-7
13. Boothroyd A. Adult aural rehabilitation: What is it and does it work? *Trends Amplif* 2007; 11(2):63-71
14. Kramer SE, Allessie GH, Dondorp AW, Zekveld AA, Kapteyn TS. A home education program for older adults with hearing impairment and their significant others: A randomized trial evaluating short- and long-term effects. 2005 *Int J Audiol; 44*: 255–64
15. Kiessling J, Pichora-Fuller MK, Gatehouse S, Stephens D, Arlinger S, Chisobn T, *et al*. Candidature for and delivering of audiological services: Special needs of older people. *Int J Audiol* 2003; *42*: 2S92-2S101
16. Swanepoel D, Eikelboom RH, Hunters ML, Friedland PL, Atlas MD. Self-reported hearing loss in baby boomers from the busselton healthy ageing study: Audiometric correspondence and predictive value. *J Am Acad Audiol* 2003; 24:514-21
17. Willot JF. *Aging and the auditory system: Anatomy, Physiology and Psychophysics* 1991. Singular Press. San Diego
18. American Speech-Language-Hearing Association. ASHA: Guidelines for Audiologic Screening 1997. http://www.asha.org/docs/html/GL1997-00199.html#sec1.1.3
19. Yueh B, Collins MP, Pamela ES, Heagerty PJ, Liu C, Boyko EJ et al. Screening for Auditory Impairment – Which Hearing Assessment Test (SAI-WHAT): RCT design and baseline characteristics. *Contemp Clin Trials* 2007; 28:303-15
20. Missouri Department of Health and Senior Services. Guidelines for hearing screening in the school setting 2015. http://health.mo.gov/living/families/schoolhealth/pdf/HearingScreeningGuidelines.pdf
21. World Health Organization. WHO: Prevention of blindness and deafness 2012. http://www.who.int/pbd/deafness/facts/en/
22. Smits C, Goverts T, Festern JM. The digits-in-noise test: Assessing auditory speech recognition abilities in noise. *J Acoust Soc Am* 2013; 133:1693-1706
23. Deepthi R & Kasthuri A. Validation of the use of self-reported hearing loss and the Hearing Handicap Inventory for elderly among rural Indian elderly population. *Arch Gerontol Geriatr* 2012; 55:762-7
24. Demers K. Hearing screening in older adults. The Heartford Institute for Geriatric Nursing, No 12 (2013)

http://www.advhearing.net/Patient_Questionnaire.pdf
25. Hall JW & Swanepoel D. *Objective Assessment of Hearing*. 2010. Plural Publishing Inc. United States
26. Smits C & Houtgast T. Results from the Dutch speech-in-noise screening test by telephone. *Ear Hear* 2005; 26:89-95
27. Smits C, Kapteyn TS, Houtgast T. Development and validation of an automatic speech-in-noise screening test by telephone. *Int J Audiol* 2004; 43:15-28
28. Jansen S, Luts H, Wagener KC, Frachet B, Wouters J. The French digit triplet test: A hearing screening tool for speech intelligibility in noise. *Int J Audiol* 2010; 49:378-87

Author

Jenni-Marí Potgieter
Post-graduate student at the University of Pretoria
Department Speech-Language Pathology and Audiology
University of Pretoria
Pretoria, South Africa
Potgieter.jennimari@gmail.com

Author & Editor

De Wet Swanepoel PhD
Professor
Department of Speech-Language Pathology and Audiology
University of Pretoria
Pretoria, South Africa
Dewet.swanepoel@up.ac.za

Editors

Claude Laurent MD, PhD
Professor in ENT
ENT Unit
Department of Clinical Science
University of Umeå
Umeå, Sweden
claude.laurent@ent.umu.se

Johan Fagan MBChB, FCS(ORL), MMed
Professor and Chairman
Division of Otolaryngology
University of Cape Town
Cape Town
South Africa
johannes.fagan@uct.ac.za

OPEN ACCESS GUIDE TO AUDIOLOGY & HEARING AIDS FOR OTOLARYNGOLOGISTS
http://www.entdev.uct.ac.za