The Importance of Screening for Hearing Loss in the Elderly

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ABSTRACT:
Aim: The aim was to compare hearing loss between men and women over 65 in pure tone audiometry and to evaluate the sensitivity of the abbreviated version of the Hearing Handicap Inventory (HHIE-S). This questionnaire highlights hearing handicaps in understanding speech.

Materials and Methods: The data was collected in the years 2011–2015 from respondents above 18 years of age using a standardized HHIE-S questionnaire and specialized tests. The cohort was divided into groups based on the severity of hearing loss in the better ear according to the World Health Organization (WHO) as measured by tone threshold audiometry at 500 Hertz (Hz), 1000 Hz, 2000 Hz and 4000 Hz.

Results: Of the 7070 people (61.8% female and 38.2% male), 68.93% had hearing impairment. Most people had a slight hearing loss. Based on HHIE-S, 56.94% reported impaired hearing. A statistically significant difference was found between the genders, but according to HHIE-S, females with impaired hearing were not statistically significantly more numerous than males. The diagnostic sensitivity of the HHIE-S was assessed in particular by its sensitivity (75.43%) and specificity (82.53%). The probability that a person has a hearing impairment when the HHIE-S test is positive is 90.21%.

Conclusions: The HHIE-S is fast, inexpensive and short, and can be included as a screening test for hearing impairment in caring for the elderly. Even a minor hearing impairment can be a significant handicap in elderly patients by restricting not only social interactions but also weakening mental functioning.

KEYWORDS: age-related hearing loss, Hearing Handicap Inventory, hearing impairment, presbycusis, vulnerable elderly

ABBREVIATIONS
HHIE – Hearing Handicap Inventory for the Elderly
HHIE-S – shortened version of the questionnaire; Hearing Handicap Inventory for the Elderly
ISO – International Organization for Standardization
LR – Likelihood Ratio
WHO – World Health Organization

INTRODUCTION
Presbycusis, or age-related hearing loss, describes the progressive decrease in hearing due to aging and the gradual deterioration of the hearing system. Age-related hearing loss can be due to impaired hair cells in the inner ear. The hair cells cannot be replaced and their natural decline leads to diminished hearing. It can also be due to damage to the auditory cortex in the back of the brain where the hearing center’s ability to distinguish sounds is lost. It is typically a combination of both processes. Advancing age also entails a reduction in the elasticity of the eardrum, the bones in the middle-ear, and the cochlear window. Other risk factors can exacerbate and accelerate this age-related condition, in particular, environmental and occupational noise, certain ototoxic drugs, frequent middle-ear inflammation and metabolic or cardiovascular diseases. Arteriosclerosis of the arteries in the ear may also contribute to presbycusis [1–5].

Progressive aging of the hearing apparatus is usually noticed after age 40. The World Health Organization (WHO) reports that approximately a third of the world’s population above 65 suffers from hearing loss, with the highest rate in Sub-Saharan Africa, the Pacific, and South Asia [6]. Hear-it, the American Society for Hearing Impaired People reports a prevalence of 30% among people over 65. Almost all people above 80 experience some sort of hearing disorder [7]. Impaired hearing in the elderly mainly affects understanding of speech, especially in noisy environments or where there is background noise. Old people realize that someone is talking to them, but they are unable to understand them. These problems, however, are associated not only with presbycusis, but are also often accompanied by a general decline in cognitive functions in old age and with changes in more central processes [8]. Such people are then identified as fragile seniors with reduced health potential (fitness, resilience and adaptability) and a lowered ability to withstand the stresses of regular life [9].
Given the WHO reports that the world’s population is aging and that people are living longer, government institutions worldwide are changing their approach towards care of the elderly. The aim is to keep seniors physically active and engaged in social contact for as long as possible. More and more emphasis is therefore being laid on diagnosing sensory defects and compensating for them.

The aim of the current study was to use pure tone audiometry to compare hearing loss between men and women over 65 and to evaluate the sensitivity of the HHIE-S questionnaire.

**MATERIAL AND METHODS**

Data for the analysis was collected between 2011 and 2015 as part of the Epidemiological and Genetic Study of Hearing Impairment Frequency. Data was collected in 11 otorhinolaryngologic outpatient clinics in industrial agglomerations, where the number of residents as of December 31, 2015 was 253,518 (of which 18.4% were over 65).

Data was collected using a non-standard questionnaire created specifically for this study. This questionnaire included identification questions (gender, year of birth, education, etc.), as well as questions pertaining to family, work, and personal background. The standard HHIE-S questionnaire was used to probe hearing for speech comprehension. The questionnaire can be used to obtain a rapid subjective assessment of speech comprehension from people with or without hearing impairment. HHIE-S comprises two parts – emotional and social. The original (unabridged) questionnaire consists of 30 questions, but this study used an abbreviated version, which recent studies have shown to be simpler and faster. The completed questionnaire can be used to determine the subjective emotional and social score; the overall score forms the basis for a reliable assessment of the hearing state.

The cohort was administered pure tone audiometry and tympanometric testing. The diagnostic devices used were calibrated properly and complied with valid international standards (ISO) as well as audiometric examination procedures [14, 15]. Participation in the study was voluntary and was subject to written informed consent. The study design was approved by the ethics committee of the Faculty of Medicine.

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The cohort was divided into three age groups according to WHO. They were also segregated into groups following the WHO classification for the extent of hearing impairment in the better ear. This segregation was based on the calculated average hearing loss measured by tone threshold audiometry at 500 Hertz (Hz), 1000 Hz, 2000 Hz, and 4000 Hz [10].

In order to determine the sensitivity of the diagnostic test, we combined groups based on the WHO classification for hearing impairment as well as groups based on HHIE-S response. In Group S1, we included all those that do not have a normal hearing threshold according to the WHO [hearing threshold more than 26 decibels (dB)]. Following the HHIE-S responses we grouped together all those with any kind of handicap (mild, moderate, severe, or profound).
and severe). According to the WHO, hearing impairment is damage that requires compensation and a hearing aid is indicated for people with a threshold greater than 40 dB. Therefore, for the purpose of better analysis of test sensitivity, we grouped together subjects without any hearing impairment and those with a mild hearing impairment (WHO classification). This group was labeled Group S2. Thus in Group S1, only subjects with a normal threshold were scored as non-impaired, while in Group S2 subjects with a normal threshold as well as those with mild impairment were scored as non-impaired.

The original cohort contained data from subjects between 18 and 95 years old. To assess hearing status among the elderly, we restricted the cohort to those aged over 65. This new cohort contained 9765 people, with 5992 women (61.4%) and 3773 men (38.6%). We further excluded those who had not filled in the HHIE-S questionnaire leaving 7070 (72.4% of the total) in the study cohort, of which 61.8% were women and 38.2% were men. Most people of both genders were in the 65–74 age group, with the number decreasing with age. The oldest man was 95 years old and the oldest woman was 96 (Tab. I.). The distribution of men and women in each age group showed a statistically significant difference (p = 0.001).

**STATISTICAL ANALYSIS**

The data were recorded in Epidata (Epidata Software, version 3.1; The EpiData Association, Odense, Denmark) as it is suitable for both recording and subsequent validation of data. Tables and charts were created in Microsoft Office Word 2010 (MS Word; Microsoft Corporation, Washington, USA) and Microsoft Office Excel 2010 (MS Excel; Microsoft Corporation, Washington, USA). Stata for Windows version 13.0 (Data Analysis and Statistical Software; StataCorp LP, Texas, USA) and the online program OpenEpi version 3.01 (Open Source Epidemiologic Statistics for Public Health; Epi Info Development Team, Atlanta, USA) were used for statistical analysis. The level of statistical significance was set at 5%.

**RESULTS**

In the study cohort, 68.93% of the subjects showed some hearing impairment. Of these, most people of both genders had mild hearing loss (together 2744), accounting for 38.8% of the total (22.8% women and 16% men). The next most numerous were those with a normal auditory threshold followed by those with moderate hearing loss. Only 32 people showed either severe or profound hearing loss (0.46% of the study cohort).

A statistically significant difference (p < 0.001) was found when comparing individual hearing disorders. Comparing the genders, more than 70% of women had a normal auditory threshold, and the proportion of women decreased with increasing severity. On the contrary, the number of men with impaired hearing increased with increasing severity. More men than women showed moderate, severe, and profound hearing loss (Fig. 1.).

56.94% of the cohort showed a hearing impairment with the HHIE-S. Among women, most showed no subjective impairment, followed by those with mild and moderate handicap scores, with the fewest showing a severe handicap. On the other hand, among men, most HHIE-S respondents showed a mild or moderate handicap, followed by men without any handicap. As with women, men with a severe handicap were the fewest (Fig. 2.). We also found a statistically significant difference between the genders (p < 0.001). Significantly more men report a hearing impairment with the HHIE-S, as opposed to women.

We evaluated the sensitivity of the diagnostic test – here the abbreviated version of the HHIE-S questionnaire – particularly its specificity. We used predictive values (both positive and negative) as well as the Likelihood Ratio of positive or negative results. Test sensitivity and specificity were 75.43% and 82.53%, respectively, in Group S1. Although the sensitivity and specificity are quite high, when we include people with hearing loss up to 40 dB (Group S2), the sensitivity rises to 92.61%, but the specificity drops to only 58.89%. The positive predictive value is also high in Group S1 (90.21%), but the negative predictive value
value is only 61.14%. However, the positive predictive value in Group S2 is very low and falls to below 50% (48.73%). Compared to Group S1, the negative predictive value is 94.97%.

Another possible indicator of test sensitivity is the Likelihood Ratio (LR). We calculated an LR for the positive test (LR+) of 4.317 for Group S1 and only 2.253 for Group S2. We calculated an LR for the negative test (LR-) of 0.2977 for Group S1 and 0.1254 for Group S2. All diagnostic test sensitivity calculations were performed and subsequently evaluated separately for both genders. A summary of the results is shown in Tab. II. and III.

**DISCUSSION**

The main aim of this work was to uncover hearing loss in the elderly and to identify a rapid and sensitive diagnostic test to monitor deterioration in speech comprehension. Pure tone audiometry is the gold standard for determining hearing threshold, but it is time-consuming and costly to administer [14]. What is required is a rapid and inexpensive hearing test that can also monitor speech comprehension in seniors. We therefore compared pure tone audiometry and the HHIE-S questionnaire to determine its sensitivity. We particularly evaluated its specificity, positive and negative predictive values, and the Likelihood Ratio of a positive or negative test. The ability of this test to identify impairment, or the likelihood that the test will actually be positive when the person has a hearing impairment, is 75.43%. On the contrary, the likelihood that healthy people, i.e., without hearing impairment, will be scored as un-impaired is 82.53%. Sensitivity and specificity are quite high, but in Group S2 the sensitivity rises to 92.61%, but the specificity drops to only 58.89%. This may be because alongside the healthy and un-impaired, Group S2 includes respondents with a hearing loss of 26–40 dB. Although it is only mild hearing loss, it can lead to defective speech comprehension, thus lowering specificity for the group. The rate of diagnosis of subjects with hearing loss requiring compensation with a hearing aid is 92.61%. These results draw attention to people that can be called fragile seniors with reduced health potential (fitness, resilience, and adaptability) and a lowered ability to withstand the stresses of regular life. They are less able to functionally cope with situations in normal life, get into frequent difficulties, require hospitalization and active care, as well as help with daily activities and continuous monitoring [9]. A fragile senior can lose not only cognitive but also sensory functions as a consequence of aging.

The sensitivity and specificity of HHIE-S compared to pure tone audiometry were confirmed by other indicators. The probability that a subject has a hearing impairment when the test is positive is 90.21%. On the other hand, the probability that a non-impaired person shows a negative test is very low – only 61.14%. Nevertheless, the positive predictive value in Group S2 is very low – under 50% (48.73%). Compared to Group S1, the negative predictive value is 94.97%.

Another possible indicator of the test’s sensitivity is the so-called Likelihood Ratio (LR). The LR for a positive test (LR+) is the ratio of two probabilities – the probability of a subject with a hearing impairment being diagnosed as positive and that of a subject without a hearing disability being mistakenly diagnosed as positive. We calculated an LR+ of 4.317 for Group S1 and only 2.253 for Group S2. The calculated LR for the negative test was 0.2977 and 0.1254 in Groups S1 and S2, respectively. These indicators bolster the sensitivity and specificity tests described above.

The sensitivity and specificity of the HHIE-S questionnaire was surveyed in Brazil in 2006. The study by Calviti et al. [16] included a total of 71 participants of both sexes aged 60 to 82. The results showed a sensitivity of 100% but a low specificity (53.4%). Similar results were found by a Brazilian study conducted in 2018 by Servidoni and Conterno [17]. The sensitivity was 93.9% and the specificity was 83.3% [17]. We used the same methodology as Calviti et al. [16] and Servidoni et al. [17] to determine the severity of hearing impairment in Group S1. The sensitivity in Group S1 is much lower – approximately 75.43%. In Group S2, where hearing impairment means having a hearing loss greater than 41 dB, the sensitivity is 90.21%. The specificity in Group S1 was 82.53% and 61.14% in Group S2. These discrepancies can be due to the different cohort sizes in the different studies.
Only 71 subjects were evaluated in the 2006 Brazilian study and the 2018 study included 138 subjects, whereas our study included a total of 7070 subjects.

In 2015, Sogebi et al. [18] evaluated the sensitivity and specificity of the unabridged HHI questionnaire in Nigeria. The sensitivity in this study was calculated as 79.6% and the specificity was 59.3%. Although the Nigerian study used a full HHIE questionnaire, the sensitivity is similar to our study, but the specificity is much lower. The difference in the results can be due to the version of the questionnaire used but also due to cohort size (total 103 subjects). Moreover, the average hearing loss was calculated differently in the Czech and Brazilian studies (audiometry according to WHO methodology), while the Nigerian study calculated the average hearing loss from the entire audiometry frequency spectrum (125 Hz to 8000 Hz).

A similar study to evaluate sensitivity and specificity was carried out by Deepthi et al. [19] in two rural areas in different parts of India. In contrast to the other studies, they used only one question from the HHIE questionnaire for subjective hearing assessment: “Do you feel handicapped by a hearing problem?” Based on the answer to this single question, they calculated a 76.2% sensitivity and an 87.7% specificity. Despite the divergent methodology and the low cohort size (total 175 subjects), the results are almost identical to that of our study. Another study was conducted by Wang et al. [20] in an industrial area of northeastern China. The sensitivity of the HHIE-S screen was 84.5% and the specificity was 58.3%. Based on the methodology of the Chinese study and the 570-strong cohort, this study is comparable to our Group S2. The sensitivity in our set is higher than the Chinese cohort (90.21%), while the specificity (58.89%) is almost identical.

The WHO estimates that approximately a third of the people worldwide over 65 years of age suffer from some hearing loss. 68.93% of our cohort over 65 was hearing impaired. According to the WHO, an estimated 35% of the adult population in Europe has mild hearing loss, more than 25% have moderate hearing loss, while severe hearing loss affects only 3% [6]. In our study we found that 38.8% have mild, 25.6% moderate, and 0.14% have severe hearing loss. The results thus correlate well with those reported by the WHO. The number of subjects decreases with increasing age in both genders in our cohort. This is also evidence for the inhabitants of industrial areas in the Czech Republic, where the yearbooks from 2011 to 2015 (the study period) record a decline in the number of people with increasing age. There are more women in all age groups than men in this area, which also correlates with the numbers in our study. In our group more than 58% of women (58.6%) were between 65 and 74 years old, which is similar to the wider Czech population, where women make up approximately 57% of this age group. Although the population changed between 2011 and 2015, women still outnumbered men. On average there were 1 222 007 inhabitants in this area over the study period [21, 22].

CONCLUSION

The results show that the test is very sensitive in detecting the severity of hearing loss ≥ 40 dB (sensitivity 92.61%) and has good specificity (82.53%) in detecting normal hearing (< 26 dB hearing loss). In this case, the HHIE-S questionnaire can identify people who are in fact hearing impaired. Although the specificity is low in Group S2 (where subjects were grouped together), the sensitivity is still high. Therefore, this quick, cheap and short questionnaire can be used to identify subjects with hearing loss who need audiometric tests. People with mild hearing loss could be trained in hearing cognition. For people with hearing impairment greater than 40 dB, compensation with a hearing aid should be considered in addition to hearing cognition training. In the elderly, hearing cognition training should always be considered and should be included in care plans for the elderly. Even a minor hearing impairment can be a significant handicap in elderly patients by restricting not only social interactions but also weakening mental functioning. Being hearing impaired, they find little incentive and thus isolate themselves from company, which further worsens mental function. In the future, it would be advisable to perform a quick screening test among the elderly, such as the HHIE-S test described above, or the more expensive word threshold audiometry instead of tone threshold audiometry. This is very important because although people are able to distinguish tones in tone threshold audiometry, they may have a serious and debilitating handicap when it comes to speech comprehension.

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