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EFFECTIVENESS OF SCREENING TOOLS EMPLOYED FOR IDENTIFYING HEARING LOSS IN OLDER ADULTS

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ABSTRACT — The study evaluated the effectiveness of screening tests by identifying hearing loss in 127 adults of the older age groups (aged 60–87). We performed a quantitative assessment of the HHIE-S questionnaire (accuracy, sensitivity, specificity) comparing to the pure-tone threshold audiometry (the gold standard for detecting hearing loss). The analysis of hearing impairment prevalence in the target population relied on both methods. We have observed a high rate of hearing loss — 81% in the patients of the older age group, of which 30% had mild hearing loss, 38% — moderate hearing loss, 9% — severe hearing loss, the remaining 4% with profound hearing loss. We have evaluated the average accuracy (62.2%), sensitivity (64.0%), specificity (54.0%) as well as the positive predictive value (85.7%) of the HHIE-S questionnaire, whereas it was the negative predictive value only that revealed a low rate (26%). The study outcomes confirm the possibility of using HHIE-S questionnaire as a screening tool for hearing loss in the older age group. HHIE-S can prove particularly useful for primary care physicians as well as for physical examination due to its reliable accuracy and ease of use. The probability of a false positive outcome and an overestimated hearing impairment in the older age group is relatively low. However, pure-tone threshold audiometry is required in patients with detected hearing loss.

KEYWORDS — audiological screening, hearing loss, chronic sensorineural hearing loss, older age group, questionnaire survey.

INTRODUCTION

In the context of the modern development of medical science and practice, diagnostics is one of the rapidly developing areas [1–3]. Computerization and integration of high-tech research methods into medicine contributes to the active development of functional diagnostics, an annual increase in research methods and the number of functional tests performed. Functional diagnostics is widely used for the

early detection of pathology, differential diagnosis of various diseases and monitoring the effectiveness of treatment [4, 5].

One of the most discussed issues within practical healthcare is that of aging as well as the growing rate of chronic diseases that are entailed naturally [6]. According to the World Health Organization (WHO), the total number of people suffering from socially significant hearing loss in 2012 was 360 million people (5.3% of the world population), of which 328 million (91%) were adults, with the remaining 32 million (9%) being children [7]. The prevalence of hearing loss increases over age and, along with other sensory issues, there is a growing risk of developing and progressing dementia, degenerative diseases, and, consequently, disability affecting the populations within the older age group. Hearing disorders in geriatric patients reveal their own specific features — initial changes in speech intelligibility, especially in noisy contexts; frequent increase in sensitivity to sounds (hyperacusis), as well as complaints of tinnitus. All this points at the need to undergo audiometry within an extended frequency range, speech tests as well as getting the auditory evoked potentials registered, if necessary. At the same time, there are a number of questionnaires for hearing self-assessment, as well as primary screening tools [8,9]. Correct interpretation of the questionnaire results is of extreme importance in terms of forecasting possible audiometric changes and designing an individual patient examination plan.

A number of studies focused on the discrepancy between the self-report data on the hearing status and the tonal threshold audiometry outcomes [10]. The reasons for this discrepancy, according to a number of authors, may be several underlying factors, the age being a major one. In view of this, the older age group reveals a higher discrepancy rate between audiometry and self-report [11] due to the earlier existing hearing problems or the patient's personality factor [12].

Aim of study

to evaluate the effectiveness of screening tools used to detect hearing loss in older age groups through quantitative evaluation of the HHIE-S questionnaire (accuracy, sensitivity, specificity) as compared to tonal threshold audiometry (the gold standard for detecting hearing loss).

MATERIALS AND METHODS

The study focused on patients belonging to the older age group (60+) who were undergoing treatment at the Regional Clinical Hospital for War Veterans in the City of Samara (Russia). Since this clinic is not a specialized one, people who had their appointments scheduled randomly through the week, did not always present hearing complaints.

The study excluded all patients using hearing aids as well as patients who were already going through the process of audiological rehabilitation, those who failed to reveal a minimum level of listening to qualify for the testing procedures, and persons with active inflammatory issues and tumors diagnosed during the otoscopic examination. Of the 135 participants who were found to have normal eardrums, 127 completed the survey fully. The study was carried out as a weekly targeted screening with ENT endoscopy. The participants' age fell within the range of 60 to 87 (median age — 79.7 ± 5.2), of them the share of males was 46.5% (59 people), females accounting for 53.5% (68 persons). The majority of the patients were elderly people (over 81) who made up 57% (72 persons); people aged 60–70 made up 25% (32 persons); aged 71–80 accounted for 18% only (23 persons). The prevailing part of the target group was the people with a degree in specialized technical training (80%), while holders of university degrees were 37%.

Written informed consent was obtained from each participant prior to completing the questionnaire and tonal threshold audiometry. The study was carried out within a project run jointly by the Chair and the ENT University Clinic (Samara, Russia) in accordance with the principles of the Helsinki Declaration for Biomedical Research, and was approved by the University's Bioethics Committee.

The perceived hearing impairment was assessed with the HHIE-S questionnaire (Hearing Handicap Inventory for the Elderly – Screening Version) for elderly people with hearing issues [13]. We used a shortened screening version of the questionnaire, which includes 10 questions, 5 of them implying socio-situational assessment (scale S), and another 5 — emotional assessment (scale E). The T scale combines the data from both scales. Following the survey outcomes, there were three groups identified: lack of issues (0–8 points); mild/moderate disorders (10–24 points); severe disorders affecting the patient (26–40 points), which are associated with hearing loss. The questionnaire was always used by the same researcher, whereas the average interview time varied from 5 to 10 minutes, considering the patient's individual features.

Upon filling in the HHIE-S questionnaire form, a hearing test was held using the tonal threshold au-

diometry method. The audiometric examination was carried out in a sound-proof booth with an audiometer (AC-40, Interacoustic, Denmark) used (Fig. 1). In order to analyze the tonal threshold audiometry results (Fig. 2, 3), the patients were divided into three groups based on their hearing capacity levels. The hearing capacity level was defined as the average threshold value for air conductivity at frequencies of 500, 1000, 2000 and 4000 Hz in the better ear. Subject to the WHO classification, the following groups were identified: persons with normal hearing (hearing threshold below 25 dB); persons with mild hearing loss (threshold between 26 dB and 40 dB); persons with moderate hearing loss (threshold between 41 dB and 60 dB); persons with severe hearing loss (hearing threshold within the range of 61 dB and 80 dB); persons with deafness (hearing threshold exceeding 81 dB). The number of patients in the groups was 24, 39, 48, 11, and 5, respectively, while the average hearing loss was 18, 35, 56, 74, and 83 dB. 115 patients of the first three groups featured symmetric audiometry data with an accuracy of ± 10 dB; 15 patients with severe hearing loss could hear better with their right ears, while in 7 listeners with deafness, the difference between the ears' hearing capacity was more than 10 dB, the left ear functioning better.

The accuracy of the HHIE-S questionnaire was determined through calculating its sensitivity and specificity, as well as by matching the results that were



Fig. 1. Tonal threshold audiometry procedure

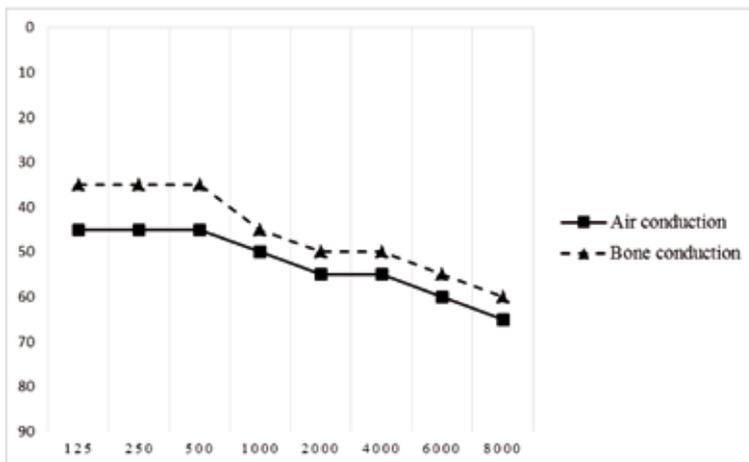


Fig. 2. Tonal threshold audiometry blank form (right ear)

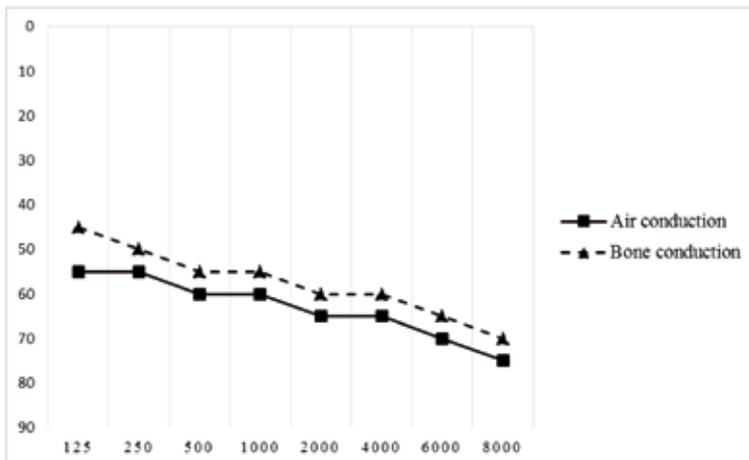


Fig. 3. Tonal threshold audiometry blank form (left ear)

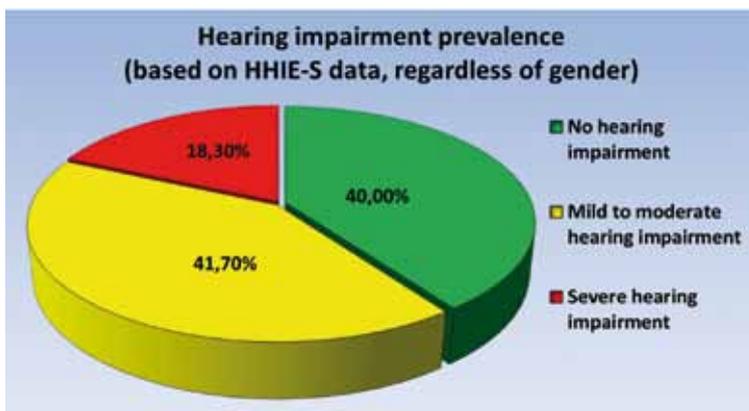


Fig. 4. Hearing impairment prevalence (based on HHIE-S data, regardless of gender)

true positive, false positive, true negative, and false negative with the average hearing thresholds. The respective confidence intervals were calculated using the Clopper-Pearson method in order to evaluate the sensitivity, specificity, positive predictive value, and the negative predictive value. The analysis was carried out using the Microsoft Excel application package and the Statistica 9.0 software.

RESULTS AND DISCUSSION

The HHIE-S outcomes revealed that 51 elderly patients (40.0%) had no hearing impairment; 53 patients (41.7%) had mild/moderate impairment, while 23 (18.3%) had severe impairment (Fig. 4). Given that, the prevalence of hearing impairment based on the HHIE-S questionnaire (in view of the lack or presence of any hearing impairment perception) was 60% (76/127).

The analysis of the survey outcomes, taking into account the patients' gender (Fig. 5), showed a hearing decrease of 61.8% ($n = 42$) in males based on self-assessment, while in females the rate was 57.6% ($n = 34$). The number of males and females with hearing impairment was almost equal — 38.2% ($n = 26$) and 42.4% ($n = 25$), respectively. As far as severe hearing impairment was concerned, both males and females featured almost the same rate — 17.6% ($n=12$) and 18.6% ($n=11$), respectively. Mild and moderate hearing impairment prevailed in males — 44.2% ($n=30$), whereas in females the rate was 39% ($n=23$).

The audiometric assessment of the patients, taking into account the general level of hearing (Table 1), showed the following rates: normal hearing was diagnosed in 24 patients (19.0%); mild hearing loss was to be observed in 39 patients (30.0%); moderate hearing loss — in another 48 persons (38.0%); severe hearing loss — in 11 patients (9.0%), with another 5 patients (4.0%) accounting for profound hearing loss. The hearing impairment prevalence identified through audiometric testing, in view of the overall result and including all its intensity degrees, was 81.0% (103/127).

A comparison of the data obtained through the HHIE-S survey with the audiometry results, we could note that of 51 patients in the older age group who had normal hearing (according to the survey data) only 24 (19%) showed no issue through the audiometric examination. As for 76 patients with hearing impairments (according to the questionnaire), 87 patients (68%) had mild to moderate hearing loss, while another 16 patients (13%) had severe hearing loss. Table 2 offers a view at the results received by the matching the two diagnostic methods (HHIE-S and tonal threshold audiometry).

When comparing the HHIE-S overall results with the tonal threshold audiometry regardless of the intensity levels, i.e. considering the hearing impairment only as lacking or present, and the audiometric test as normal or abnormal, we calculated (Table 3) the sensitivity, specificity, as well as the positive and negative predictive values, and the accuracy of the HHIE-S questionnaire, if compared to the gold standard (tonal threshold audiometry).

When evaluating the sensitivity, the specificity, and the positive and negative predictive values, as well as their confidence interval, while viewing the two methods together, taking into account the gender, we observed that all results were higher for females.

The sensitivity rate in females, for instance, was 65% (28/43); the specificity rate was 62.5% (10/16); the positive predictive value rate was 82.4% (28/34), while the negative predictive value rate was 40% (10/25). As for males, we could observe a sensitivity rate of 45% (27/60); the specificity rate was 37.5% (3/8); the positive predictive value was at 64% (27/42), whereas the negative predictive value was at 11.5% (3/26).

While analyzing the HHIE-S questionnaire alone, we could see that 40.0% of the participants did not perceive hearing impairment, while 60.0% reported perception impairment of varying severity (from mild/moderate to severe); when comparing the result, we observed predominating perception problems in female patients (61.8%) in contrast to male patients (57.6%). At the moment, the available data on the prevalence of hearing disorders, unfortunately, are extremely scattered in terms of the population sample and the survey scenario. Our results are consistent with the data obtained through the Servidonietal study [14] regarding the total share of patients with hearing impairment based on self-report data (76.1%). As for respective Russian literature, we failed to find any items on the prevalence of hearing disorders as defined by HHIE-S only, which might allow any broader comparative analysis.

In view of the overall hearing thresholds result, as well as including all of its intensity degrees, following the WHO audiometric classification, we could observe a high prevalence of hearing loss — 81.0%. Less severe hearing loss was most common, with 30.0% of the participants suffering from mild hearing loss and 38.0% — from moderate hearing loss; more disabling hearing loss was less common, with 9.0% of the participants suffering from severe hearing loss and 4.0% featuring profound hearing loss. Despite the difficulties comparing the data on the prevalence rates, notable is a higher (if compared to the Servidonietal study) rate of patients belonging to the older group with hearing impairment [14] — 79.7%.

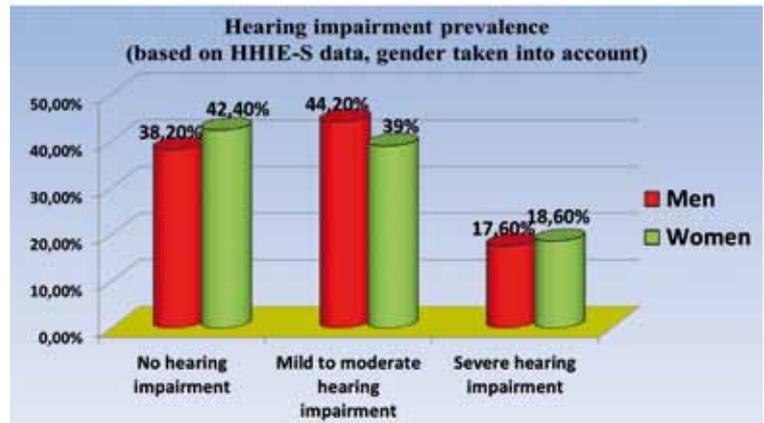


Fig. 5. Hearing impairment prevalence (based on HHIE-S data, gender taken into account)

The above-described study allowed identifying the average values in the accuracy (62.2%), the sensitivity (64.0%), the specificity (54.0%), as well as a high result of the positive predictive value (85.7%), while it was only the negative predictive value (26%) that demonstrated a lower rate. Given that, HHIE-S will not always allow independent detection of impaired auditory perception, whereas this screening method can be employed by medical services that are not specific to audiology, such as general geriatrics or primary care clinics [15].

CONCLUSION

1. Based on the HHIE-S outcomes, the prevalence of hearing impairment with or without its perception was 60% in our study.
2. The prevalence of self-reported hearing loss in male patients was by 4.2% higher than in female patients. Besides, mild and moderate hearing loss predominated in males (by 5.2%) if compared to women.
3. The prevalence of hearing impairment in audiometric testing, taking into account all degrees of severity, was 81% within our study.
4. Our findings confirm the feasibility of the HHIE-S questionnaire for evaluation of hearing loss screening in older age groups, especially by primary care physicians and for physical examination due to its reliable accuracy and ease of use (mean testing takes 10 minutes). The probability of a false positive result or overestimation of hearing impairment in older adults is not high. However, the survey should be accompanied by tonal threshold audiometry in all patients with detected hearing loss.

Table 1. Hearing impairment prevalence based on audiometry and the intensity levels, by ears (right and left) and in general

Hearing level	Right ear	Left ear	Total
	Quantity / Percentage	Quantity / Percentage	Quantity / Percentage
Norm	17/13,4%	16/12,6%	24/19%
Easy loss	36/28,3%	36/28,3%	39/30%
Moderate loss	50/39,4%	43/33,8%	48/38%
Heavy loss	10/7,9%	25/19,7%	11/9%
Profound loss	14/11%	7/5,6%	5/4%

Table 2. Connection between HHIE-S outcomes and tonal threshold audiometry

Audiometry	Norm	Mild hearing loss	Moderate hearing loss	Severe hearing loss	Deafness	General
HHIE-S	Total (%)	Total (%)	Total (%)	Total (%)	Total (%)	Total (%)
No violations	13 (54,2%)	20 (51,2%)	17 (35,4%)	0 (0%)	0 (0%)	50 (39,4%)
Mild / moderate impairment	9 (37,5%)	15 (38,5%)	21 (43,8%)	7 (63,6%)	2 (40%)	54 (42,5%)
Severe impairment	2 (8,3%)	4 (10,3%)	10 (20,8%)	4 (36,4%)	3 (60%)	23 (18,1%)
Total	24 (100%)	39 (100%)	48 (100%)	11 (100%)	5 (100%)	127 (100%)

Table 3. HHIE-S data matched against tonal threshold audiometry

Index	Calculation	Results	95% CI
Accuracy	(13 + 66)/127	62,2%	46,4–80,0
Sensitivity	66/103	64,0%	44,7–82,2
Specificity	13/24	54,0%	34,1–92,3
Positive predictive value	66/77	85,7%	79,8–91,3
Negative predictive value	13/50	26,0%	19,1–74,6

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