Original Article

Sensitivity and Specificity of the Hearing Handicap Inventory for Elderly-Screening Thai Version

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Background: Although hearing loss is one of the major handicaps in the elderly, many aging adults fail to recognize the deterioration of hearing and its effect in daily life. Moreover, many Thai elderly still cannot get a hearing evaluation and rehabilitation because of the limited number of audiologists. Therefore, Hearing Handicap Inventory for Elderly-Screening (HHIE-S) Thai version should be an effective screening tool for hearing problem in Thai elderly.

Objective: To evaluate the sensitivity and specificity of the HHIE-S Thai version.

Materials and Methods: Diagnostic study was done in Thai people aged 60 years or older who visited King Chulalongkorn Memorial Hospital. The questionnaires were completed by the participants themselves. Air-conduction pure-tone audiometry was done and pure-tone average threshold (PTA) at 0.5, 1, and 2 kHz were calculated. Sensitivity and specificity of the HHIE-S Thai version was evaluated.

Results: Two-hundred twenty-two participants were included in the present study. Seventy percent were females and 30% were males, with a mean age of 69.24±7.21 years. For the detection of moderate or greater hearing loss (PTA of 40 dB or more), the HHIE-S Thai version with a cut-off point of 8 had a sensitivity of 69.7% (95% CI 51.1 to 83.8) and a specificity of 74.9% (95% CI 67.9 to 80.8).

Conclusion: The HHIE-S Thai version with cut-off point of 8 is considered to be a reliable and valid screening tool with good sensitivity and specificity to identify hearing handicap in Thai elderly.

Keywords: Hearing loss, Elderly, Hearing screening

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Hearing impairment is one of the major handicaps in the elderly. The prevalence of hearing loss gradually increases with age due to degenerative change of hair cell (sensory presbycusis), cochlear neuron (neural presbycusis), stria vascularis (metabolic presbycusis), or stiffness of basilar membrane (cochlear conductive presbycusis)[1]. Hearing impairment affects quality of life not only in physical well-being but also in social and emotional well-being, leading to anxiety, social isolation, depression, loss of self-confidence, withdrawing, and cognitive impairment[2]. However, many elders do not recognize their hearing loss and thus, underestimate its effects in their daily life. To prevent these consequences, early detection and prompt treatment are the main strategies. The proper aural rehabilitation by using hearing aids demonstrate improvement in social and emotional well-being of elders with hearing loss[3-7]. In addition, the use of hearing aids proved to be a cost-effective strategy for hearing rehabilitation[8,9].

The ministry of Information and Communication Technology reported that bilateral sensorineural hearing loss is the second most common handicaps in Thailand (18.41%) in 2018. The prevalence of hearing loss in Thai population older than 60 years is up to 52.4%[10]. Most of the Thai elderly are not aware of their hearing loss, or accept the existence of their hearing problems, thus, do not seek care, which lead

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to social problem, psychological problem, and poor quality of life. Because of the burden of hearing loss, many countries have generated hearing screening program such as the U.S. Preventive Services Task Force that recommends hearing screening in population aged 50 years or older with various methods, including whispered voice test, finger rub test, watch tick test, single-item or multiple-item questionnaires, and handheld audiometer[11].

Pure-tone audiometry is the standard method to evaluate the severity of hearing loss, however, it does not represent the effect of hearing impairment in individual daily life. Hearing impairment refers to any restriction of sound detection, while hearing handicap refers to hearing impairment that is sufficient to affect an individual's activity. Hearing Handicap Inventory for Elderly (HHIE) was first introduced in 1982 by Ventry and Weinstein, which was a self-assessment 25-item questionnaires aimed to assess the effect of hearing loss on the emotional and social aspects in the elderly[12]. The authors also developed a 10-item version for screening purpose, known as Hearing Handicap Inventory for Elderly-Screening version (HHIE-S)[13]. HHIE-S consists of 5 items of emotional and 5 items of social dimensions. There are three responses, "yes", "sometimes", or "no" for each question, and are scored as 4, 2, and 0, respectively. A minimum total score is 0 and a maximum total score is 40 from 10 questions. The American Speech-Language-Hearing Association (ASHA) (2016) considers that a total HHIE-S score of more than 8 indicates a presence of hearing handicap. HHIE-S has been used in many countries and translated into many languages such as Japanese, Indian, Chinese, Finnish, and Arabic, etc.[14-18].

While the number of elderlies in Thailand is increasing rapidly, there are about 250 audiologists in Thailand at the time of the present study. The proportion of audiologist per population is 1:300,000. A comprehensive hearing evaluation requires an audiologist, a well-calibrated equipment, and a sound-proof room, which all of these are insufficient in Thailand at present. The HHIE-S Thai version will be an important screening tool for hearing impairment before referring patients for diagnostic audiometry. This will decrease the audiologist workload and the cost of health care. Moreover, it also increases awareness of hearing impairment and promotes hearing rehabilitation. However, one study demonstrated that hearing aid use was more common in patients with self-perceived hearing loss, regardless of hearing screening[19]. Therefore, increase awareness is better than unawareness. The aim of the present study was to evaluate the sensitivity and specificity of the HHIE-S Thai version and to evaluate the proper cut-off point of the HHIE-S score.

Materials and Methods

The prospective study was conducted in King Chulalongkorn Memorial Hospital, Thailand, between December 1, 2016 and November 30, 2017. The screening questionnaires, which included the inclusion and exclusion criteria, were sent randomly to elderly who visited the out-patient department and geriatric building of King Chulalongkorn Memorial Hospital. The participants eligible for inclusion were any Thai elderly aged 60 years or over willing to answer the questionnaires and undergo audiometry. The elderly who were illiterate, used hearing aid, diagnosed as hearing problem, ongoing ear infection, and dementia were excluded. All subjects were evaluated and screened for study eligibility by the authors prior to enroll in the present study.

Questionnaire

The translation of HHIE-S was permitted from Weinstein Barbara and ASHA. The Translation of HHIE-S was performed by the back-translation method by a certified translator, a native Thai speaker with proficiency in English, from Chulalongkorn University Language Institute. The authors reviewed the translation and the original questionnaires to reach a consensus on any discrepancies and produced the HHIE-S Thai version. Validity and reliability of the HHIE-S Thai version were evaluated. All the items of the questionnaire demonstrated Index of Item-Objective Congruence (IOC) of more than 0.5. The HHIE-S Thai version also showed good reliability with Cronbach's alpha coefficient (internal consistency) of more than 0.8, and Intraclass correlation coefficient (test-retest reliability) of more than 0.6 in all items.

Sensitivity and specificity

After the participant signed the informed consent form, both ears were examined, and ear wax was removed under otoscopy. All participants read and answered the questionnaires by themselves. One of the three responses, yes (score=4), sometimes (score=2), and no (score=0), was recorded for each question. According to the ASHA guideline, a total HHIE-S score of more than 8 indicated a hearing handicap[11]. After answering the questionnaires, pure-tone air-conduction threshold at 250, 500, 1,000, 2,000, 4,000, and 8,000 Hz were measured

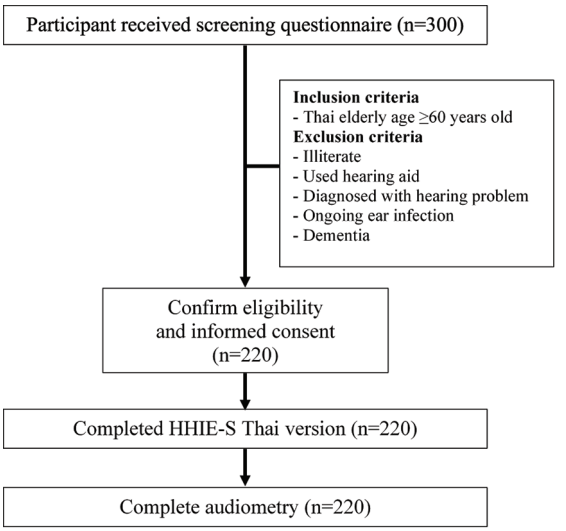


Figure 1. Flow of participant.

Table 1. Demographic data and hearing level of 220 participants

Demographic data	Total (n=220) n (%)
Sex	
Female	154 (70.0)
Male	66 (30.0)
Age	
60 to 69 years old	124 (56.4)
70 to 79 years old	72 (32.7)
>80 years old	24 (10.9)
Prevalence of hearing impairment*	
0 to 25 dB (normal hearing)	145 (65.9)
26 to 40 dB (mild hearing loss)	47 (21.4)
41 to 55 dB (moderate hearing loss)	19 (8.6)
56 to 70 dB (moderately severe hearing loss)	7 (3.2)
71 to 90 dB (severe hearing loss)	2 (0.9)

* Pure-tone average (PTA) 0.5, 1, and 2 kHz of the better ear

in a sound-proof room by audiologist or author. The assessor did not know the result of the questionnaire. The pure-tone average threshold (PTA) was calculated over the frequencies of 500, 1,000, and 2,000 Hz for the better ear hearing level. The severity of hearing impairment, which was based on PTA, classified to "no hearing loss" at or below 25 dB, "mild hearing loss" at 26 to 40 dB, "moderate hearing loss" at 41 to 55 dB, "moderately severe hearing loss" at 56 to 70 dB, and "severe hearing loss" at 71 to 90 dB. The Thai Social Development and Security Law (2009) defined hearing handicap as PTA at or greater than 40 dB in the better ear, so we used this hearing level as hearing handicap.

Statistical analysis

Descriptive data were analyzed by percentage, mean and standard deviation. The elderly who had PTA equal to or more than 40 dB and HHIE-S score of more than 8 were defined as true-positive. The elderly who had PTA less than 40 dB and a HHIE-S score equal to or less than 8 were considered true-negative. The sensitivity (true-positive over true-positive plus false negative), specificity (true-negative over true-negative plus false positive), positive predictive value (true-positive over true-positive plus false positive) and negative predictive value (true-negative over true-negative plus false negative) were calculated. The correlation between HHIE-S score and age and the severity of hearing impairment were evaluated by Spearman's correlation coefficient. Receivers operating characteristic (ROC) curve was generated to determine the appropriate cut-off point of HHIE-S score and hearing level. Statistical analysis was performed using the IBM statistics software SPSS (version 22). Statistical significance was considered to be a p-value of less than 0.05.

Study recruitment was calculated by an expected 52.4% prevalence of hearing loss in Thai elderly[10] and 89.1% sensitivity of HHIE-S[22]. The authors planned to recruit 200 participants to achieve a sufficient sample size.

The present study methodology was reviewed and approved by the Institutional Review Board of the Faculty of Medicine, Chulalongkorn University (IRB No.297/59). All participants gave written informed consents prior to participate in the present study.

Results

Three hundred elders received screening questionnaires. Two hundred twenty participants were included in the study (Figure 1). The participants were 154 females (70%) and 66 males (30%). The mean age of the subjects was 69.24±7.21 years old. Most of them were 60 to 69 years old (56.4%) (Table 1). The prevalence of mild, moderate, and moderately severe or severe hearing loss are shown in Table 1. The average of right PTA (28.23±15.14 dB) was similar to left PTA (27.10±15.32 dB). The median of HHIE-S score was 4 (P25=0, P75=12) Most of the subjects (68%) had HHIE-S score of not more than 8, while only 32% of subjects had a score of

Table 2. HHIE-S Thai version score in relation to PTA

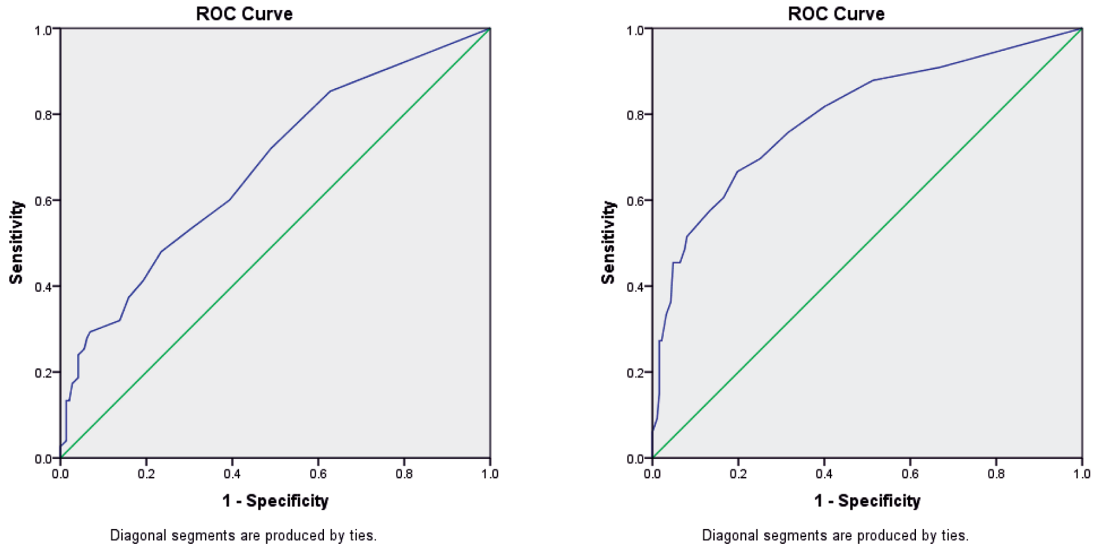
	PTA ≥40 dB	PTA <40 dB	
HHIE-S score >8	23	47	PPV 32.9% (95% CI 22.4 to 45.2)
HHIE-S score ≤8	10	140	NPV 93.3% (95% CI 87.8 to 96.9)
	Sensitivity 69.7% (95% CI 51.1 to 83.8)	Specificity 74.9% (95% CI 67.9 to 80.8)	

HHIE-S=hearing handicap inventory for elderly screening; NPV=negative predictive value; PPV=positive predictive value; PTA=pure-tone average at 500, 1,000, 2,000 Hz of better hearing

Table 3. Screening performance of HHIE-S Thai version at different cut-off points and level of hearing loss

	HHIE-S cut point	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
PTA >25 dB	6	64.8 (52.5 to 75.5)	62.4 (54.1 to 70.1)	45.1 (35.3 to 55.2)	78.8 (70.1 to 85.6)
AUC=0.676	8	57.7 (45.5 to 69.2)	71.1 (63.1 to 78.1)	48.8 (37.8 to 59.9)	77.9 (69.9 to 84.4)
	10	52.1 (40.0 to 64.0)	77.9 (70.2 to 84.1)	52.9 (40.6 to 64.8)	77.3 (69.6 to 83.6)
PTA ≥40 dB	6	81.8 (63.9 to 92.4)	59.9 (52.5 to 66.9)	26.5 (18.5 to 36.3)	94.9 (88.8 to 97.9)
AUC=0.797	8	75.8 (57.4 to 88.3)	68.5 (61.2 to 74.9)	29.8 (20.5 to 40.9)	94.1 (88.4 to 97.2)
	10	69.7 (51.1 to 83.8)	74.9 (67.9 to 80.8)	32.9 (22.4 to 45.2)	93.3 (87.8 to 96.9)

AUC=area under curve; HHIE-S=hearing handicap inventory for elderly screening; NPV=negative predictive value; PPV=positive predictive value; PTA=pure tone average



A. Hearing level >25 dB B. Hearing level ≥40 dB

Figure 2. ROC curves of HHIE-S Thai version score.

more than 8. There was a weak correlation between HHIE-S score and the severity of hearing impairment (Spearman's rank correlation 0.32) and no correlation between HHIE-S score and age (Pearson's correlation coefficient 0.064; p=0.346).

Sensitivity and specificity of HHIE-S Thai version when using a HHIE-S score greater than 8 and a PTA of 40 dB or more are shown in Table 2. Table 3 demonstrates the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for screening mild (PTA more than 25 dB) and moderate (PTA of 40 dB or more) hearing impairment at HHIE-S score 6, 8, and 10. ROC curves at different hearing impairment were created as shown in Figure 2. It demonstrates that HHIE-S was useful for screening moderate hearing loss.

Discussion

The prevalence of hearing impairment of Thai elderly in the present study was 34.1%, which is comparable to prior studies in Australia (39.4%) and Malaysia (36.9%)[20,21]. However, the prior Thai study (2002) reported a prevalence of hearing impairment of up to 52.4%[10]. The differences of prevalence were probably due to differences in the population studied, different hearing level criteria for diagnosing hearing impairment, and sample size.

In general, a screening tool should be cost-effective, fast, applicable in a large group of population, and reliable with high sensitivity and specificity. The aim of the present study is to evaluate the sensitivity and specificity of the HHIE-S Thai version. When using a HHIE-S score of 8 or more as a cut-off point for screening hearing handicap (40 dB or more) in the elderly, the HHIE-S Thai version demonstrated good sensitivity (69.7%), which was within the range of previous reports (56.8% to 100%)[14-18,20]. Moreover, the present study showed similar specificity to studies in Japan and Brazil, which was 77.5% and 75%, respectively[14,22]. The HHIE-S Thai version is a good screening tool for moderate hearing impairment (of 40 dB or more). If the PTA is more than 25 dB, the HHIE-S Thai version had a low sensitivity of 52.1%. Even though, a cut-off point of a HHIE-S score at 10 had lower sensitivity (69.7%) than a cut-off point at 8 (75.8%), the specificity of a cut-point at 10 (74.9%) was higher than a cut-off point at 8 (68.5%), which could reduce excessive unnecessary hearing test. The ROC curve confirmed that a HHIE-S score of 8 or more was beneficial in screening hearing handicap (40 dB or more) in the elderly. The PPV of the HHIE-S Thai version (32.9%) showed similar result to a previous study from Japan (41.9%)[14]. The low value of the PPV was probably from the lower number of subjects who had hearing handicap in the study (n=33, 15%). The sensitivity and specificity values can be affected by many factors. de Rosis et al found a sensitivity of 23.5% and a specificity of 73.7% at their audiology clinic but a high sensitivity (94.7%) and a specificity (75%) at the geriatric clinic[23]. Similarly, a study from Menegotto et al found low sensitivity (47%) and high specificity (75%) of HHIE-S in patients at the audiology clinic. The authors concluded that the HHIE-S was not suitable for screening hearing impairment in audiology clinics[24].

This questionnaire had a weak correlation between a total score and a degree of hearing impairment (Spearman's rank correlation 0.32), and no correlation between total score and age (Pearson's correlation coefficient 0.064). The reasons of these discordance may be because some patients may not concern themselves about hearing impairment or deny having a hearing problem. Some patients may be over-sensitive about their hearing. Moreover, the small sample size in the present study also affect these correlations.

There were some limitations of the present study. First, most of the prior studies were done in a community that included the elderly who were diagnosed and undiagnosed with hearing impairment. However, the present study was confined to the elderly who had undiagnosed hearing problem. This might affect a statistical evaluation. Further study should be done in a community and evaluates other aspects of the effect of hearing handicap in the elderly such as quality of life, psychological problem, and healthcare. Second, the PTA in the present study was calculated from hearing threshold level at 500, 1,000, and 2,000 Hz due to Thai Social Development and Security Law. However, most of presbycusis usually lose hearing at high frequency, which may affect statistical values.

Conclusion

HHIE-S Thai version with cut-off point of 8 demonstrated good sensitivity and specificity for screening hearing handicap (PTA of 40 dB or more) in Thai elderly. The questionnaire is easy to use, inexpensive, and does not require specialized training. HHIE-S can be used to identify patients with hearing impairment and to promote health awareness in Thai elderly.

What is already known on this topic?

The HHIE-S questionnaire has been accepted as screening tool for hearing handicap in elderly in many countries. It has been translated in many languages but not in Thai.

What this study adds?

HHIE-S Thai version has good sensitivity and specificity for detection of moderate or greater hearing loss (PTA of 40 dB or more), which was the criteria for registration of hearing handicap in Thailand. This screening tool can be used for detection of hearing loss and increase awareness of hearing impairment in elderly.

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Conflicts of interest

The authors declared that they had no competing interests with respect to authorship or publication of the present article.

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