

Validation of self-reported hearing loss. The Blue Mountains Hearing Study

Doungkamol Sindhusake,[a] Paul Mitchell,[b] Wayne Smith,[c] Maryanne Golding,[d] Philip Newall,[d] David Hartley[e] and George Rubin[a]

Purpose Large-scale epidemiological studies have often used self-report to estimate prevalence of age-related hearing loss. However, few large population-based studies have validated self-report against measured hearing loss. Our study aimed to assess the performance of a single question and a brief hearing handicap questionnaire in identifying individuals with hearing loss, against the gold standard of pure-tone audiometry.

Methods We examined 2015 residents, aged 55–99 years, living in the west of Sydney, Australia, who participated in the Blue Mountains Hearing Study during 1997–1999. Audiologists administered a comprehensive questionnaire, including the question: 'Do you feel you have a hearing loss?' The Shortened Hearing Handicap Inventory for Elderly (HHIE-S) was also administered during the hearing examination, which included pure-tone audiometry. The single question and HHIE-S were compared with measured losses at levels >25, >40 and >60 decibels hearing level (dBHL) to indicate mild, moderate and marked hearing impairment, for pure-tone averages (PTA) of responses to 500, 1000, 2000 and 4000 Hz.

Results The single question yielded reasonable sensitivity and specificity for hearing impairment, and was minimally affected by age and gender. HHIE-S scores >8 had lower sensitivity but higher specificity and positive predictive value. The HHIE-S performed slightly better in younger than older subjects and performed better for moderate hearing impairment.

Conclusions In this older population with a high prevalence of hearing loss (39.4%), both a question about hearing and the HHIE-S appeared sufficiently sensitive and specific to provide reasonable estimates of hearing loss prevalence. Both could be recommended for use in epidemiological studies that aim to assess the magnitude of the burden caused by age-related sensory impairment but cannot measure hearing loss by audiometry.

Keywords Blue Mountains Hearing Study, hearing loss, hearing impairment, deafness, questionnaire, validation, sensitivity, specificity, positive predictive value, negative predictive value, accuracy, pure-tone average, Hearing Handicap Inventory for the Elderly, HHIE-S

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Hearing loss has been identified as one of the most frequent chronic conditions affecting older populations, with a reported prevalence between 30% and 46% of older adults in various populations.[1–3] Hearing loss can result in frustration, social isolation, increasing dependency and need for support services, hospital care and potentially earlier nursing home placement. Survey data indicate that hearing loss is strongly age-related. The Epidemiology of Hearing Loss Study (EHLS)[3] recently reported an increased prevalence of measured hearing loss from 21% of people aged 48–59 years to 90% of those aged ⩾80 years.

Departments of [a] Public Health & Community Medicine, and [b]Ophthalmology, The University of Sydney (Westmead Hospital), Australia.

[c] National Centre for Epidemiology and Population Health, Australian National University, Canberra, Australia.

[d] Speech, Hearing and Language Research Centre, Macquarie University, Sydney, Australia.

[e] Australian Hearing, Sydney, Australia.

Correspondence: Assoc. Prof. Paul Mitchell, Department of Ophthalmology, The University of Sydney, Eye Clinic, Westmead Hospital, Hawkesbury Rd, Westmead, NSW, Australia, 2145. E-mail: paulmi@westgate.wh.usyd.edu.au

Accurate prevalence estimates for hearing loss in older general populations are needed to identify its scope, magnitude and impact. These data should also assist in the planning of hearing rehabilitation services, including hearing aid provision. A number of population-based studies have employed audiometric measures to examine the prevalence of hearing loss in different communities.[1,3,4–6] Selected populations such as clinic patients, compensation claimants, or workers in noisy industries have reported higher prevalence rates for hearing loss than in community studies. While standardized audiometric assessment of hearing loss could be considered the gold standard for estimating its prevalence, large studies are often constrained by limited budget, expertise and the logistic difficulty of performing audiometric screening on a large scale. Many large surveys from the US,[7] Sweden[8] and Australia[9] have used self-report data to assess prevalence of diseases and chronic conditions such as hearing loss.

Several questionnaire instruments for assessing hearing disability and handicap have been developed and used, including: Social Hearing Handicap Index,[10] Hearing Performance Inventory (HPI)[11] and the Hearing Handicap Inventory for the Elderly: Screening version (HHIE-S).[12,13] Single questions about hearing, such as: 'Do you have a problem with your hearing?' or 'Do you feel you have a hearing loss?' have also frequently been used.

Self-report can in itself be a revealing indicator of handicap and is quick and inexpensive to administer. The use of self-reported hearing loss data in population-based prevalence surveys however, should be validated against standard audiometric measure of hearing impairment.

Although self-reported hearing loss has been validated in many small specific subgroups, detailed validation studies have been previously conducted in only a few small general older populations.[14,15] Large-scale epidemiological studies in the UK and South Australia[1,16] have reported the relationship between self-reported and measured hearing status as part of prevalence studies, however, no detailed information about validation was published. A large-scale validation of self-reported hearing loss was conducted in the older population from the EHLS, Wisconsin, USA.[17] This study validated four separate questions about hearing loss, together with the HHIE-S, against pure-tone audiometry in a representative sample of 3753 older adults from a semi-rural community.

Our study aimed to assess the performance of a single question: 'Do you feel you have a hearing loss?' plus the HHIE-S instrument in identifying older individuals with hearing loss against measured hearing loss, using pure-tone air conduction audiometry as the gold standard.

Methods

The Blue Mountains Hearing Study (BMHS) is a population-based survey of age-related hearing loss in a representative older Australian community, conducted during the period 1997–1999. Examinations followed participation in 5-year examinations of the Blue Mountains Eye Study (BMES) cohort, which assessed 3654 people aged ⩾49 years during 1992–1994, living in two suburban postcode areas, west of Sydney, Australia. The baseline BMES followed a door-to-door census of 38 census districts in this region and achieved an 87.9% response, after excluding subjects who died or moved from the study area during the study period.[18] This cohort was invited to re-participate in 5-year eye examinations (BMES-2), and subsequently, in a detailed hearing assessment. Of the original 3654 participants, 575 (16.8%) died and 383 (10.5%) had moved from the study area before commencement of the BMHS, leaving 2696 eligible subjects. From those eligible subjects, 2015 (74.7%) participated in the hearing examinations and 681 (25.3%) did not take part.

Our hearing questionnaire included the single question: 'Do you feel you have a hearing loss?', which provided possible responses of 'yes', 'no' or 'don't know'. Missing and 'don't know' responses accounted for 72 subjects (3.6%), who were excluded from the analysis.

The HHIE-S was developed by Ventry and Weinstein[12] as a diagnostic tool to identify older people with hearing difficulties and was included as part of the hearing questionnaire administered by an audiologist to all participants. This instrument consists of 10 questions designed to assess perceived emotional and social problems associated with impaired hearing (e.g. frustration, embarrassment or difficulty in certain situations). One of three responses ('yes', 'sometimes' or 'no') was recorded for each question and scored as 4, 2 or 0, respectively. Missing values (198 subjects, 9.8%) were excluded and scores from the 10 questions were totalled for a minimum score of 0 and a maximum score of 40. According to ASHA draft guidelines (American Speech-Language-Hearing Association),[19] total HHIE-S scores >8 are defined as indicating the presence of hearing handicap, so we used this cut-point to validate the HHIE-S instrument against hearing loss defined using pure-tone audiometric measurements of both ears.

Our comprehensive questionnaire also documented history of subjective hearing loss and exposures to potential risk factors. Included were industrial or work-related noise exposure, diseases associated with hearing loss, family history, past use of ototoxic drugs, past medical or surgical treatment of various ENT conditions and hearing aid provision or use.

Pure-tone audiometry was conducted in sound treated facilities, using standard TDH-39 earphones and a Madsen OB822 audiometer (Madsen Electronics Copenhagen, Denmark) which was calibrated regularly during the study period to Australian Standards. Testing was performed by an audiologist who also examined the ears for wax occlusion. If present, the subject was asked to return for assessment after treatment. Audiometric thresholds for air conducted (AC) stimuli (right and left ears) were established for frequencies of 250, 500, 1000, 4000, 6000 and 8000 Hz with 3000 Hz added if 20 dB difference existed between 2000 and 4000 Hz thresholds. Bone conduction (BC) was evaluated whenever AC thresholds were >15 dBHL for frequencies of 500, 1000, 2000 and 4000 Hz. Results were examined for any evidence of collapsed canals and if present, AC thresholds at the higher frequencies were re-assessed taking care to reduce the pressure on the external ear.

Hearing levels of 25 dB and 40 dB are often used as screening criteria for mild and moderate hearing losses.[20] For the purposes of this analysis, we defined hearing impairment as the pure-tone average of audiometric hearing thresholds at 500, 1000, 2000 and 4000 Hz (PTA), >25, 40 or 60 decibels hearing level (dBHL), in the better of the two ears. Hearing thresholds >25 dBHL were defined to indicate 'mild' hearing impairment; thresholds >40 dBHL indicated 'moderate' hearing impairment and thresholds >60 dBHL indicated 'marked' hearing impairment.[3] Twelve subjects (0.06%) with incomplete audiograms were excluded from the analysis, leaving 2003 (99.4%) subjects with analysable data. The screening performance of the question 'Do you feel you have a hearing loss?' and an HHIE-S score >8 were separately assessed for sensitivity, specificity, positive and negative predictive values, and the difference between measured and estimated prevalence.

Sensitivity was measured in the group of participants identified as having bilateral hearing loss on audiometry, defined as the proportion who reported hearing loss. Specificity was measured in the group of participants identified as having normal hearing in both ears, defined as the proportion who reported normal hearing. Positive predictive value (PPV) is the probability that the question would correctly identify a person as having bilateral hearing impairment. Negative predictive value (NPV) indicates the probability that the question would correctly identify a person whose hearing was normal. Differences between measured and estimated prevalence rates (using the referent standard and self-report data, respectively), were tested for statistical significance using the McNemar statistic. These parameters, together with corresponding asymmetric 95% CI which were estimated using exact methods,[21] were calculated for cut-points of >25, >40 and >60 dBHL in both ears. Age- and gender-specific estimates were also calculated.

Receiver operating characteristic (ROC) curves were generated for the three severity levels of hearing loss by computing the true positive rate (sensitivity) and false positive rate (1-specificity) of the test at several cut-points, using an HHIE-S score >8. These pairs (sensitivity, 1-specificity) were then plotted to graph the ROC. The area under the ROC curve (AUC) represents the discrimination power of an HHIE-S score >8 at each level of hearing loss and varies from 0.5 (accuracy occurring by chance) to 1.0 (perfect accuracy). As the ROC curve shifts towards the left and top boundaries of the graph, the AUC is closer to 1.0.

Results

Demographic characteristics of participants examined compared with the Australian population for people aged ⩾55 years are shown in Table 1. Study participants were likely to be slightly older and more likely to be female. There were only minor differences in the proportion born outside Australia or having a non-English speaking background and in the occupation distribution between participants and the overall Australian population.

The prevalence of mild, moderate and marked hearing loss as assessed by PTA in this study was 39.1%, 13.4% and 2.2% respectively. Screening characteristics of the question 'Do you feel you have a hearing loss?' and an HHIE-S score >8 are shown in Table 2, including sensitivity, specificity, PPV and NPV, and the difference between true (measured) and estimated prevalence (from question or HHIE-S). Findings are indicated for mild, moderate and marked hearing loss (using the ear with better hearing) from pure-tone audiometric measurements. The question 'Do you feel you have a hearing loss?' demonstrated reasonable sensitivity and specificity for any degree of hearing loss and for the three levels of measured hearing loss. HHIE-S scores >8 had slightly lower sensitivity, but somewhat higher specificity and PPV for the three levels of measured hearing loss.

Effects of age and gender on screening performance characteristics for both the single question and an HHIE-S score >8 are shown in Table 3. For the single question, these characteristics

Table 1 Demographic characteristics (%) of participants in the Blue Mountains Hearing Study (BMHS) compared with the Australian population for people aged ⩾55 years

	BMHS	Australia
Gender		
Women	57.4	53.4
Men	42.6	46.6
Age		
55–<65	29.8	41.2
65–<75	41.1	33.9
75–<85	24.0	19.2
85+	5.1	5.7
Marital status		
Married	67.4	63.0
Divorced/separated	11.4	9.2
Widowed	14.1	22.3
Never married	7.1	5.5
Ethnicity		
Born outside Australia	30.5	35.4
Non-English speaking background	12.2	19.4
Occupations		
Manager/administrator	16.2	18.2
Professionals	22.7	16.3
Para-professionals	9.4	11.7
Trades people	11.6	11.6
Clerk/sales/service workers	29.4	23.2
Plant & machine operator	4.7	9.4
Labourers	6.0	9.6

were minimally affected by age and were similar for women and men. The HHIE-S performed better for younger than older female subjects. It was more sensitive but less specific in men compared with women. The single question performed slightly better than the HHIE-S for mild hearing impairment. The HHIE-S performed better for moderate hearing impairment.

For comparison with the HHIE-S, sensitivity and specificity were calculated for different score cut-points from 0 to 40. For each level of hearing loss, ROC curves were generated and the AUC (with 95% CI) calculated. True and false positive rates for selected cut-point scores (>6, >8, >10, >12 and >14) for mild, moderate and marked hearing loss are shown in Table 4. The ROC curves prepared from these data are shown in Figure 1. These analyses confirmed the usefulness of an HHIE-S score >8 for moderate hearing loss (reasonably high true positive rate with an acceptable false positive rate). It was somewhat less useful for identifying mild hearing loss (low true positives) and marked hearing loss (high false positives).

Previous studies reporting the validation of self-reported hearing loss are compared with findings from our study and shown in Table 5.

Discussion

The EHLS assessed the accuracy of four questions, in addition to the HHIE-S, in identifying individuals with hearing loss from an older community.[17] These questions were: 'Do you feel you have a hearing loss?'; 'In general, would you say your hearing

Table 2 Screening performance characteristics for a single question and the Hearing Handicap Inventory for the Elderly-screening version (HHIE-S). Results indicate per cent (95% CI) at different levels of hearing impairment, using the ear with better hearing

Analysable data		Mild	Moderate	Marked
Measured hearing impairment (audiometry)				
Question	(N_1 = 1931)	n_1 = 767	n_1 = 268	n_1 = 45
	prevalence	p_1 = 39.7%	p_1 = 13.9%	p_1 = 2.3%
HHIE-S	(N_2 = 1807)	n_2 = 704	n_2 = 235	n_2 = 35
	prevalence	p_2 = 39.0%	p_2 = 13.0%	p_2 = 1.9%
Single question: 'Do you feel you have a hearing loss?'				
Sensitivity		78 (75–81)	93 (89–96)	100 (91–100)
Specificity		67 (64–70)	56 (53–58)	50 (48–53)
Positive predictive value		61 (57–64)	25 (22–28)	5 (3–6)
Negative predictive value		82 (80–85)	98 (97–99)	100 (99–100)
Measured (audiometry) less estimated prevalence (question)		–11.4 ($P < 0.01$)	–37.3 ($P < 0.01$)	–48.7 ($P < 0.01$)
HHIE-S				
Sensitivity		58 (53–61)	80 (74–85)	100 (89–100)
Specificity		85 (83–87)	76 (73–78)	70 (68–72)
Positive predictive value		71 (67–74)	33 (29–36)	6 (4–8)
Negative predictive value		76 (73–78)	96 (95–97)	100 (99–100)
Measured (audiometry) less estimated prevalence (HHIE-S)		7.3 ($P < 0.01$)	–18.7 ($P < 0.01$)	–29.7 ($P < 0.01$)

is: excellent, very good, good, fair, poor?'; 'Have you ever worn a hearing aid or amplifying device?'; 'Do your friends and relatives think you have a hearing problem?' The question, 'Do you feel you have a hearing loss?' was the most sensitive (sensitivity, specificity 71%) with overall and gender-specific prevalence estimates within 3.2% of the audiometric estimates in the EHLS.[17] This question is the same as that used to identify self-reported hearing loss in our study. Its screening performance characteristics in both studies were similar. Slightly higher sensitivity but lower specificity was found in our study, with this question giving an overall prevalence estimate for mild hearing impairment within 11.4% of the measured rate, somewhat higher than the EHLS finding of 1.9%.

This is not surprising given the similarities between the EHLS and BMHS. Both are large population-based hearing studies in older communities of predominantly northern European heritage, which have a similar age range. Both studies yielded high sensitivity, specificity, PPV and NPV rates of 78%, 67%, 61% and 82% (BMHS) compared with 71%, 71%, 68% and 74% (EHLS). The difference (11.4%, 1.9%) between measured (from audiometry) and estimated prevalence (from the question), could reflect differences in the definition of hearing impairment. In our study, hearing impairment was defined as present from audiometric thresholds in the better ear, in keeping with the convention for most previous studies.[2,4,14,22] The EHLS chose the worse ear 'to assess the ability of the questions to detect a *person* with hearing loss in one or both ears'. When we used the worse ear EHLS definition, this question yielded sensitivity (71%), specificity (72%), PPV (71%), NPV (69%) and difference between measured and estimated prevalence (2.3%). These rates are indistinguishable from the EHLS findings.

Some previous studies have reported lower sensitivity for single questions in identifying mild hearing impairment. The study of rural Iowa women reported sensitivity of 56% and specificity 82%.[14] The study of 2278 people, aged 40–64 years, attending two practices in the South-East of England reported sensitivity and specificity of a single question 'Do you have difficulty hearing and understanding most things people say, without seeing their face and lips?' as 58.3% and of 91.8% respectively.[23] However, this could reflect its overall lower prevalence of hearing impairment, and also minor differences in definition and question used.

Our HHIE-S findings demonstrate that for this instrument, a score >8 performed reasonably in identifying hearing impairment, particularly at moderate levels of hearing loss. It had the same sensitivity as our single question, but had higher specificity. The HHIE-S also performed better in younger than in older subjects, and was more sensitive, but less specific, among men.

The better performance of the HHIE-S in men may be partly explained by poorer hearing sensitivity (higher PTA) in men than in women. Men had significantly higher PTA than women in both younger ($P < 0.0001$) and older age groups ($P = 0.004$). The age effect on the HHIE-S performance found in this study has been reported in previous investigations.[17,24] This may be explained, in part, by greater demand on communication abilities and less acceptability of hearing loss as an ageing process by younger than older subjects. Younger subjects may view hearing loss as a more significant health concern as reflected by their higher scores on the HHIE.

The EHLS also compared measured hearing impairment with an HHIE-S score >8.[17] In that study, surprisingly, the sensitivity of the HHIE-S was only 34% (37% in younger and 32% in older subgroups). Although the HHIE-S questionnaire has been evaluated for its utility in identifying hearing loss[15,25] and may also correlate with other measures of global age-related dysfunction,[26] the EHLS authors commented that the HHIE-S is an inventory of hearing handicap, not of hearing impairment. The relationship between these two is imperfect.[27] This may explain the relatively poorer performance in terms of sensitivity, overall accuracy and estimated prevalence in the EHLS. The better performance of the HHIE-S than the EHLS may be, in part,

Table 3 Screening performance characteristics for the question 'Do you feel you have a hearing loss?' and the Hearing Handicap Inventory for the Elderly-screening version (HHIE-S) by age in men and women. Results indicate per cent (95% CI) at different levels of bilateral hearing impairment, using the ear with better hearing

Analysable data		Mild	Moderate	Marked
Measured hearing impairment (audiometry)				
Question	(N_1 = 1931)	n = 767	n = 268	n = 45
	Prevalence	p_1 = 39.7%	p_1 = 13.9%	p_1 = 2.3%
HHIE-S	(N_2 = 1807)	n = 704	n = 235	n = 35
	Prevalence	p_2 = 39.0%	p_2 = 13.0%	p_2 = 1.9%
Women aged <70 years (n_1 = 556 – n_2 = 525)				
Sensitivity	question	79 (69–87)	95 (73–99)	100 (29–100)
	HHIE-S	57 (45–67)	84 (59–96)	100 (29–100)
Specificity	question	72 (68–76)	65 (62–70)	64 (60–68)
	HHIE-S	88 (85–91)	83 (80–87)	81 (78–85)
Women aged 70+ years (n_1 = 549 – n_2 = 501)				
Sensitivity	question	76 (70–80)	90 (82–95)	100 (74–100)
	HHIE-S	47 (41–53)	74 (63–83)	100 (59–100)
Specificity	question	71 (65–77)	54 (49–59)	46 (42–51)
	HHIE-S	88 (83–92)	78 (74–82)	70 (66–74)
All women (n_1 = 1105, n_2 = 1026)				
Sensitivity	question	77 (71–80)	91 (84–95)	100 (78–100)
	HHIE-S	49 (44–54)	76 (66–83)	100 (69–100)
Specificity	question	71 (68–75)	60 (57–64)	55 (52–59)
	HHIE-S	88 (86–91)	81 (79–84)	76 (73–79)
Men aged <70 years (n_1 = 406, n_2 = 389)				
Sensitivity	question	84 (76–90)	97 (84–100)	100 (54–100)
	HHIE-S	71 (60–79)	84 (65–94)	100 (40–100)
Specificity	question	58 (53–64)	51 (46–56)	48 (43–53)
	HHIE-S	79 (73–83)	70 (65–75)	67 (62–71)
Men aged 70+ years (n_1 = 420, n_2 = 392)				
Sensitivity	question	79 (73–83)	94 (88–98)	100 (82–100)
	HHIE-S	64 (57–70)	85 (76–91)	100 (80–100)
Specificity	question	61 (53–69)	46 (41–52)	38 (33–43)
	HHIE-S	81 (75–88)	65 (60–71)	56 (51–61)
All men (n_1 = 826, n_2 = 781)				
Sensitivity	question	80 (76–84)	95 (90–98)	100 (86–100)
	HHIE-S	66 (60–71)	85 (77–90)	100 (84–100)
Specificity	question	59 (55–64)	49 (45–53)	43 (40–47)
	HHIE-S	80 (76,83)	68 (64,72)	61 (58,65)

explained by our definition of bilateral hearing impairment (using better ear measures) rather than the EHLS definition of hearing impairment present in one or both ears. Attempts were made by our audiologists to reduce bias and misleading effects on participants' responses by administering the HHIE-S before the single question 'Do you feel you have a hearing loss?'. The order of administering the HHIE-S and single question in the EHLS was not documented.

The ROC curves confirmed the usefulness of an HHIE-S score >8 in identifying moderate hearing loss. However, our findings suggested that a lower HHIE-S cut-point score (e.g. >6) might be more useful in screening for mild hearing loss and a higher cut-point score (e.g. >14) for marked hearing loss.

The relative importance of sensitivity and specificity depends upon the prevalence of any given condition and judgements about the consequences of screening error. In this study where the prevalence of hearing loss is relatively high and a positive test could lead to consideration of need for hearing aid provision, sensitivity may be judged more relevant. A relatively large number of subjects with hearing loss will be correctly classified if the sensitivity is high. As sensitivity and specificity are inversely related, one measure will increase as the other decreases. The higher NPV and lower PPV for moderate and marked hearing loss assessed by both tools (question and HHIE-S) could be partly explained by the lower prevalence rates found for moderate and marked hearing loss.

A slightly different problem arises if the aim of collecting data on hearing impairment is not for prevalence estimates alone. If the reason for measuring hearing loss is to assess associations between hearing loss and other factors, or to adjust for presence of hearing loss in a multivariate model, then some knowledge of the measurement error characteristics of a

Table 4 True positive rate (sensitivity) and false positive rate (1-specificity) and 95% CI for mild, moderate and marked hearing loss at selected Hearing Handicap Inventory for the Elderly-screening version (HHIE-S) cut-points with the area under the curves with 95% CI

Area under Receiver Operating Characteristics (ROC) curve	HHIE-S cut points	True positive rate (sensitivity)	False positive rate (1-specificity)
0.79 (0.77–0.81) mild	6	65.6 (62.0–69.1)	20.5 (18.2–23.0)
	8	57.5 (53.8–61.2)	15.3 (13.3–17.6)
	10	51.6 (47.8–55.3)	11.9 (10.1–14.0)
	12	44.9 (41.2–48.6)	9.8 (7.2–10.7)
	14	38.9 (35.3–42.6)	6.7 (5.4–8.4)
0.86 (0.84–0.89) moderate	6	85.5 (80.4–89.8)	31.0 (28.7–33.4)
	8	80.4 (74.8–85.3)	24.5 (22.4–26.7)
	10	76.2 (70.2–81.5)	20.0 (18.1–22.2)
	12	70.2 (63.9–76.0)	15.8 (14.1–17.7)
	14	61.7 (55.2–67.9)	12.9 (11.3–14.7)
0.93 (0.90–0.95) marked	6	100.0 (90.0–100)	36.9 (34.6–39.2)
	8	100.0 (90.0–100)	30.4 (28.3–32.7)
	10	94.3 (80.8–99.3)	26.0 (24.0–28.2)
	12	94.3 (80.8–99.3)	21.4 (19.6–23.5)
	14	94.3 (80.8–99.3)	17.8 (16.1–19.7)

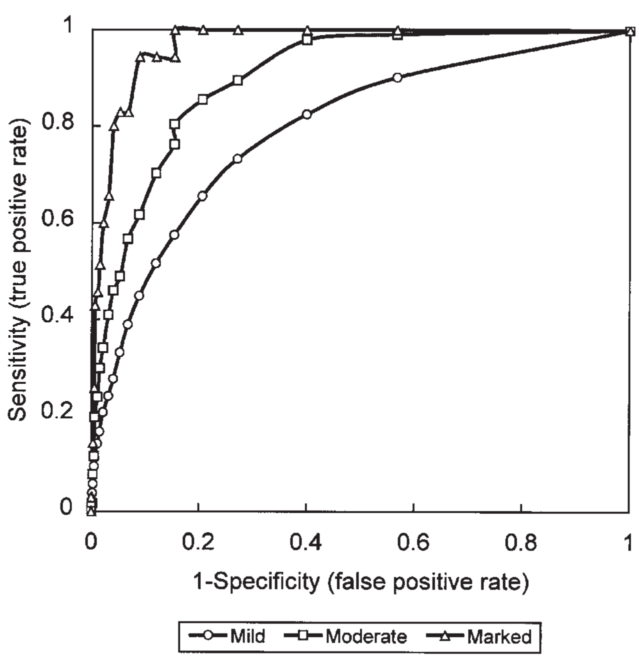

Figure 1 Receiver operating characteristic curve for HHIE-S score, for mild, moderate and marked hearing impairment

questionnaire approach compared to audiometric measurement is necessary. In particular, if the aim is to assess attributable risks (as when estimating the possible reduction in cases following an intervention), then some estimate of measurement error is required. In such circumstances, given available funds, a validation study would provide some benefit if the population examined is likely to be systematically different from the BMHS or the EHLS populations. However, given the very similar findings in EHLS to BMHS (for worse ear), the measurement error characteristics determined by these studies may be a reasonable default when funding is not available to perform the relatively large and expensive validation studies that would be required.

In summary, in this older population with a high prevalence of hearing loss (39.4%), both a single question: 'Do you feel you have a hearing loss?' and the HHIE-S questionnaire (using a score >8) performed reasonably in identifying subjects with hearing impairment. The single question performed relatively better than the HHIE-S for mild hearing loss while the HHIE-S was more effective in identifying subjects with moderate hearing loss. The performance of the question was minimally affected by gender or age. The HHIE-S, on the other hand, performed better in younger male subjects. Both could be recommended for use in epidemiological studies that aim to include questions about age-related sensory impairment but cannot perform audiometric measures. However, we recommend validation studies be undertaken if it is intended that hearing loss be used as a co-variable in multivariate models, so that an assessment of the impact of measurement error on the model can be made.

KEY MESSAGES

- A single question: 'Do you feel you have a hearing loss?' appeared sufficiently sensitive and specific to provide a reasonable estimate of hearing loss prevalence.
- A Hearing Handicap Inventory for the Elderly score >8 was shown to provide a similar prevalence estimate.
- Both could be recommended for use in epidemiological studies that aim to assess the magnitude of the burden from age-related hearing impairment.

Table 5 Selected previous studies reporting validation of self-reported hearing loss

Authors	Year	Sample	Question used	Gold standard	Outcome
Moscicki *et al.*[4]	1985	Framingham cohort (USA)	Do you have a hearing	pure-tone audiometry	hearing loss prevalence 47%
		2293 people aged 57–89	problem now?	0.5–4K Hz; >25 dBHL	true-estimated prev = 6.2%
				better ear	
Gates *et al.*[2]	1990	Framingham cohort (USA)	Do you have a hearing	pure-tone audiometry	hearing loss prevalence 42%
		1662 people aged 63–95	problem now?	0.5–3K Hz; >25 dBHL	
				better ear	
Clark *et al.*[14]	1988	267 women from rural Iowa	Would you say that you	pure-tone audiometry	hearing loss prevalence 11 to 60%
		(USA) aged 60–85	have any difficulty hearing?	1–2K Hz; >25 dBHL	sensitivity 66%, specificity 80%
				1–2K Hz; >40 dBHL	sensitivity 90%, specificity 71%
				1–4K Hz; >25 dBHL	sensitivity 56%, specificity 82%
				better ear	
Voeks *et al.*[22]	1992	198 nursing home residents,	Do you have trouble	pure-tone audiometry	hearing loss prevalence 54%
		(USA); mean age 72	hearing?	0.5–2K Hz; >25db HL	sensitivity 69%
				better ear	
Nondahl *et al.*[17]	1993	Epidemiology of Hearing	Do you feel you have a	pure-tone audiometry	hearing loss prevalence 45.9%
		Loss Study (USA)	hearing loss?	0.5–4K kHz; >25 dB HL	sensitivity 71%, specificity 71%
		3556 people aged 48–92		worse ear	true-estimated –1.9% (worse ear)
					true-estimated –14.8% (better ear)
Sindhusake *et al.*	2000	Blue Mountains Hearing	Do you feel you have a	pure-tone audiometry	hearing loss prevalence 39.4%
(current study)		Study (Australia)	hearing loss?	0.5–4K Hz; >25 dBHL	sensitivity 78%, specificity 67%
		2015 people aged 55–100		0.5–4K Hz; >40 dBHL	sensitivity 93%, specificity 56%
				better ear	true-estimated +2.3% (worse ear)
					true-estimated –11.4% (better ear)

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