

Does This Patient Have Hearing Impairment?

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CLINICAL SCENARIOS

Case 1

A 77-year-old previously healthy woman in your primary care practice comes to your office for a routine medical examination. She feels well, has no complaints, and remains active. During a routine functional inquiry, you inquire whether she feels she has any difficulty hearing. She tells you yes. She says that her husband occasionally complains that she is not hearing him very well. With further questioning, she also reports that she sometimes has difficulty understanding people at work. In social situations, she often has to ask others to repeat themselves. What do you do next?

Case 2

You have been treating a 69-year-old man in your primary care practice for hypertension and diabetes for the last 10 years. He comes to see you in your office for a routine annual checkup. You decide to screen him for hearing impairment and ask him whether he feels that he has difficulty hearing. He replies no. What do you do next?

WHY IS THIS QUESTION IMPORTANT?

Hearing impairment, a common chronic condition in the older Ameri-

See also Patient Page.

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Context Hearing impairment is prevalent among the elderly population but commonly underdiagnosed.

Objective To review the accuracy and precision of bedside clinical maneuvers for diagnosing hearing impairment.

Data Sources MEDLINE and EMBASE databases (1966 to April 2005) were searched for English-language articles related to screening for hearing impairment.

Study Selection Original studies on the accuracy or precision of screening questions and tests were included. Articles that used unaccepted reference standards or contained insufficient data were excluded. Medical Subject Headings or keywords used in the search included *hearing loss, hearing handicap, hearing tests, tuning fork, deafness, physical examination, sensitivity, specificity, audiometry, tuning fork tests, Rinne, Weber, audioscope, Hearing Handicap Inventory for the Elderly—Screening version, whispered voice test, sensorineural, and conductive*.

Data Extraction One author screened all potential articles and 2 authors independently abstracted data. Differences were resolved by consensus. Each included study (n=24) was assigned a methodological grade.

Data Synthesis A yes response when asking individuals whether they have hearing impairment has a summary likelihood ratio (LR) of 2.5 (95% confidence interval [CI], 1.7-3.6); a no response has an LR of 0.13 (95% CI, 0.09-0.19). A score of 8 or greater on the screening version of the Hearing Handicap Inventory for the Elderly (HHIE-S) has an LR of 3.8 (95% CI, 3.0-4.8); a score less than 8 has an LR of 0.38 (95% CI, 0.29-0.51). An abnormal Weber tuning fork test response has an LR of 1.6 (95% CI, 1.0-2.3); a normal response has an LR of 0.70 (95% CI, 0.48-1.0). An abnormal Rinne tuning fork test response has LRs ranging from 2.7 to 62; a normal response has LRs from 0.01 to 0.85. Inability to perceive a whispered voice has an LR of 6.1 (95% CI, 4.5-8.4); normal perception has an LR of 0.03 (95% CI, 0-0.24). Not passing the audioscope test has an LR of 2.4 (95% CI, 1.4-4.1); passing has an LR of 0.07 (95% CI, 0.03-0.17).

Conclusions Elderly individuals who acknowledge they have hearing impairment require audiometry, while those who reply no should be screened with the whispered-voice test. Individuals who perceive the whispered voice require no further testing, while those unable to perceive the voice require audiometry. The Weber and Rinne tests should not be used for general screening.

JAMA. 2006;295:416-428

www.jama.com

can population, affects between 25% and 40% of the population aged 65 years or older.¹⁻⁵ The prevalence increases dramatically with age, affecting 40% to 66% of patients older than 75 years and more than 80% of patients older than 85 years.⁶⁻⁸ Several studies highlight the negative social and emotional effects of hearing impairment. Hearing-impaired elderly indi-

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viduals who do not use hearing aids are more likely to report sadness and depression, worry and anxiety, paranoia, decreased social activity, emotional turmoil, and insecurity compared with their hearing-impaired peers who use hearing aids.⁹⁻¹⁴

Formal audiological tests are required to diagnose hearing impairment. These involve testing the patient's ability to hear sound tones in a soundproof room with standardized equipment. While these tests are not invasive and are easy to conduct, they require expensive equipment that is not widely available for mass screening, require dedicated staff, and are time consuming. Therefore, tests that are readily performed by clinicians as part of a general physical examination are useful to minimize the number of patients who require these formal tests. The objective of this article is to inform clinicians which bedside tests are useful for this purpose and to pro-

vide estimates of their accuracy and precision.

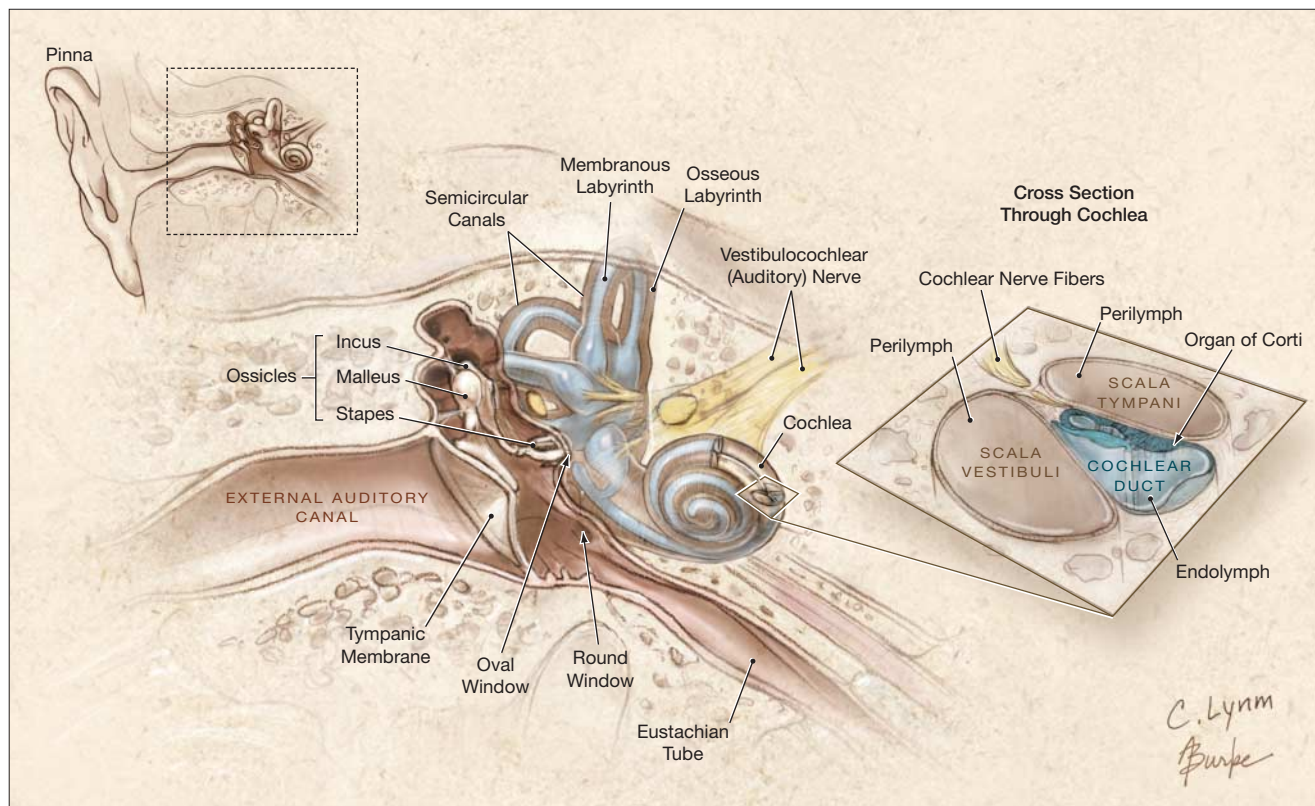
ANATOMY AND PHYSIOLOGY OF HEARING

The ear is divided into 3 structural parts: external, middle, and internal (FIGURE 1). The external ear consists of the pinna, or auricle, located on the head surface, and extends through the external auditory canal to the tympanic membrane (eardrum). It functions to capture sound waves for conduction to deeper ear components. In addition, the external ear protects the air-filled space of the middle ear, which contains the medial side of the tympanic membrane, the proximal end of the eustachian tube, and 3 bony ossicles (malleus, incus, and stapes). The ossicles convert sound vibrations from the air into mechanical waves for the inner ear.

The inner ear, or labyrinth, begins where the footplate of the stapes fits

into the oval window and includes the cochlea, the semicircular canals, and the distal end of the auditory nerve (cranial nerve VIII). As part of the cochlea, the organ of Corti is composed of hair cells (sensory transducers) and a complex assortment of supporting cells and is the end-organ of hearing. Perilymph fluid surrounds the membranous labyrinth of the semicircular canals and the cochlea. Located within the cochlea are the cochlear ducts, which contain endolymphatic fluid. Movement of the footplate of the stapes causes vibrations of the perilymph and endolymph, thus transmitting mechanical energy from the footplate at the oval window to the organ of Corti. Movement of the hair cells in the organ of Corti allows for the conversion of mechanical waves into electrical potential. This electrical potential is transmitted via the auditory nerve to the brain for interpretation.

Figure 1. Anatomy of Ear



HEARING IMPAIRMENT

Pathophysiology

Disruption of the auditory pathway anywhere from the pinna to the brain may result in hearing loss. Hearing loss is typically classified as conductive, sensorineural, or mixed. Conductive hearing loss results from pathologic changes of either the external or the middle ear structures, preventing the sound waves from reaching the fluids of the inner ear. Common causes include cerumen or foreign-body impaction, perforated tympanic membrane, otitis media, otosclerosis, cholesteatoma, tumor, or disarticulation of the ossicular chain due to trauma.

Sensorineural hearing loss results from pathologic changes of inner ear structures such as the cochlea or the auditory nerve and prevents neural impulses from being transmitted to the auditory cortex of the brain. Sensorineural hearing loss can be genetic, resulting from a mutation in a single gene or from a combination of mutations in several genes, or acquired, due to prolonged exposure to loud noises, exposure to ototoxic substances such as aminoglycosides, inner ear infections, Meniere disease, and other systemic disease such as diabetes mellitus. Patients with sensorineural hearing loss typically have difficulty filtering background noise, which makes listening especially challenging in common social settings. Degeneration of the hair cells in the organ of Corti causes sensorineural hearing loss related to aging (presbycusis). Presbycusis is the most common cause of hearing loss in the United States and is typically gradual, bilateral, and characterized by high-frequency hearing loss. Mixed hearing loss comprises elements of both conductive and sensorineural hearing loss.

Definition of Hearing Impairment and Hearing Handicap

Sound is described in terms of frequency (or pitch, measured in Hertz) and intensity (or loudness, measured in decibels). Conversational speech usually occurs between 500 and 3000

Hz and between 45 and 60 dB. A person with normal hearing perceives sounds that have frequencies between 20 and 20 000 Hz.

Impairments in hearing can involve impairments of sensitivity to frequency, intensity, or both. Since hearing impairment is not a “yes or no” phenomenon but rather a matter of type and degree, there is no universally accepted case definition for hearing impairment.¹⁵⁻¹⁸ However, all case definitions require formal audiometric testing that includes pure-tone assessment, speech audiometry, and impedance studies. In pure-tone audiometry, individual tones of different frequencies (ranging from 250 to 8000 Hz) are presented in a soundproof room at various intensities (ranging from 5 to 120 dB) to each ear. Air conduction thresholds, which are a measure of both conductive and sensorineural hearing, are determined by presenting pure tones (using headphones) that must travel via the outer and middle ear before getting to the cochlea and auditory nerve. Bone conduction thresholds, which test only sensorineural hearing, are determined by placing a bone oscillator on the mastoid bone; this stimulates the skull, which in turn stimulates the cochlea directly, bypassing the outer and middle ear. The threshold for each tone frequency is determined by finding the intensity level (in decibels) at which the individual can detect the tone 50% of the time. An audiogram graphically displays the threshold for each frequency. In presbycusis, the pure-tone audiogram characteristically shows hearing impairment for higher-frequency sounds (1000 to 8000 Hz).

Sensorineural Hearing Impairment

The traditional definition used to classify sensorineural hearing impairment is a pure-tone average, called the speech frequency pure-tone average, greater than 25 dB in the better ear at 500 Hz, 1000 Hz, and 2000 Hz.^{17,18} In other words, an individual has sensorineural hearing impairment if the bone

threshold average at 500 Hz, 1000 Hz, and 2000 Hz is greater than 25 dB. Numerous variations to this standard criterion have been proposed. For example, a definition proposed by Ventry and Weinstein¹⁶ and widely accepted by physicians and audiologists defines hearing impairment as the inability to hear a 40-dB tone at 1000 or 2000 Hz in both ears, or a 40-dB tone at 1000 and 2000 Hz in one ear. Clinically, a 25-dB threshold is usually considered mild sensorineural hearing impairment; a 40-dB threshold, moderate; and a greater than 60-dB threshold, severe.

Conductive Hearing Impairment

To diagnose conductive hearing impairment, an air-bone gap is calculated by subtracting the bone conduction threshold (in decibels) from the air conduction threshold at each tested frequency. When the air conduction threshold is greater than the bone conduction threshold, conductive hearing impairment exists. The greater the air-bone gap, the greater the magnitude of conductive hearing impairment. Clinically, an air-bone gap of 25 dB is considered mild conductive hearing impairment; of 40 dB, moderate; and of greater than 60 dB, severe.

Hearing Handicap

While audiometric tests provide a quantitative measure of hearing loss, they do not reflect the impact of such a loss on an individual's life. *Hearing handicap* is used to denote a change in hearing that interferes with performing activities of daily living.^{15,16} Some individuals with mild hearing loss experience a substantial disability and handicap, whereas others with moderate hearing loss may not exhibit any form of disability or hearing handicap. The most commonly used test to quantify hearing handicap is the screening version of the Hearing Handicap Inventory for the Elderly (HHIE-S).¹⁹ Although initially designed to identify hearing handicap, this test has also been used to screen individuals for hearing impairment.

HOW TO PERFORM SCREENING TESTS FOR HEARING IMPAIRMENT

Self-reported Hearing Loss Screening Question

Self-reported data to assess presence of diseases and disorders have been used frequently in large-scale epidemiologic survey studies, such as the Health Interview Survey²⁰ or the National Health and Nutrition Examination Survey.²¹ Similarly, screening patients for hearing impairment using self-reported screening questions involves asking the patient whether they feel they have hearing impairment. Numerous variations in the wording of the sentence exist, including "Do you feel you have a hearing loss?" or "Do you have a hearing problem now?" or "Would you say you have any difficulty hearing?" A yes or equivocal response to this question is considered a positive screen for hearing impairment.

The HHIE-S

The HHIE-S (Box)¹⁹ is a 10-item, self-administered questionnaire developed to measure social and emotional handicap secondary to hearing impairment. The HHIE-S can be administered easily in a primary care office setting.

Individual questions are scored as yes (4 points), sometimes (2 points), or no (0 points). Scores on the HHIE-S range from 0 (no handicap) to 40 (maximum handicap). Different scores have been proposed as a cutoff above which individuals are identified as hearing handicapped.

Tuning Fork Tests: Weber and Rinne

Clinical textbooks describe several tuning fork tests, including the Weber, Rinne, Bing, and Schwaback. Over the years, the Bing and Schwaback tests have gone out of favor due to inadequate evidence of their performance. The Weber and Rinne tests, on the other hand, are still widely taught. To perform both tests, the tuning fork (256 or 512 Hz) is struck gently on a hard rubber pad, the elbow, or the knee about two thirds of the way along the tine.²²

Box. Hearing Handicap Inventory for the Elderly (Screening Version)

Item No./Question

E-1. Does a hearing problem cause you to feel embarrassed when meeting new people?	Yes (4)	Sometimes (2)	No (0)
E-2. Does a hearing problem cause you to feel frustrated when talking to members of your family?	Yes (4)	Sometimes (2)	No (0)
S-1. Do you have difficulty hearing when someone speaks in a whisper?	Yes (4)	Sometimes (2)	No (0)
E-3. Do you feel handicapped by a hearing problem?	Yes (4)	Sometimes (2)	No (0)
S-2. Does a hearing problem cause you difficulty when visiting friends, relatives, or neighbors?	Yes (4)	Sometimes (2)	No (0)
S-3. Does a hearing problem cause you to attend religious services less often than you would like?	Yes (4)	Sometimes (2)	No (0)
E-4. Does a hearing problem cause you to have arguments with family members?	Yes (4)	Sometimes (2)	No (0)
S-4. Does a hearing problem cause you difficulty when listening to television or radio?	Yes (4)	Sometimes (2)	No (0)
E-5. Do you feel that any difficulty with your hearing limits or hampers your personal or social life?	Yes (4)	Sometimes (2)	No (0)
S-5. Does a hearing problem cause you difficulty when in a restaurant with relatives and friends?	Yes (4)	Sometimes (2)	No (0)

Total Score _____

Weber Test. To conduct the Weber test, the base of the vibrating fork is placed on the vertex (top or crown of the head). Alternative locations are the bridge of the nose, upper incisors, or forehead.²³ The patient is asked if the sound is heard and whether it is heard in the middle of the head (or in both ears equally), toward the left, or toward the right. In a patient with normal hearing, the tone is heard centrally. In asymmetric/unilateral hearing impairment, the tone lateralizes to one side. Lateralization indicates an element of conductive impairment in the ear in which the sound localizes, a sensorineural impairment in the contralateral ear, or both.

The Weber test detects differences in air and bone conduction thresholds in

one ear compared with those in the other. Therefore, individuals with bilateral conductive or bilateral sensorineural hearing impairment should, like individuals with normal hearing, have a Weber test result that does not demonstrate lateralization, as these individuals have no difference in air and bone conduction thresholds between the 2 ears. Thus, the Weber test is not useful to identify individuals with bilateral conductive hearing impairment or bilateral sensorineural hearing impairment.

Rinne Test. The Rinne test can be performed in 2 ways to detect conductive hearing impairment.

Loudness Comparison Technique. The base of the vibrating fork is placed on the mastoid bone, behind the ear and

level with the canal, to assess bone conduction. To assess air conduction, the fork is then quickly placed close to the ear canal with the "U" of the fork facing forward to maximize the sound for the patient. The patient is asked if the sound is louder by bone conduction or by air conduction. Normally, the air conduction is louder than bone conduction (often abbreviated in written records as AC>BC).

Threshold Technique. The base of the vibrating fork is placed on the mastoid bone, behind the ear and level with the canal, to assess bone conduction. To assess air conduction, the patient is asked to tell the examiner as soon as he or she can no longer hear the sound, then the fork is quickly placed close to the ear canal with the "U" of the fork facing forward. The patient is asked if he or she can hear the sound again. Normally, the sound is heard longer through air conduction than through bone conduction.

In conductive hearing loss, sound is heard through bone as long as or longer than (by threshold technique) or as loud as or louder than (by loudness comparison technique) it is through air (written in records as BC>AC). In sensorineural hearing loss, the Rinne test result is the same as that achieved in normal hearing, with sound heard longer (by threshold technique) or louder (by loudness comparison technique) through air.

Whispered-Voice Test

The examiner stands 2 ft (0.6 m; arm's length) behind the patient's field of vision (to prevent lipreading); the examiner then whispers while gently using the end of his or her finger to occlude and rub the external auditory canal of the patient's nontested ear. It is imperative to rub, as occlusion alone does not provide sufficient masking. The examiner should take in a full breath, exhale, and then whisper a set of 3 random numbers and letters (eg, "5, B, 6"). To confirm that the patient understands the instructions, a trial run using a loud voice and a simple number such as 99 is often worthwhile.

Patients with normal hearing will repeat back all 3 numbers/letters correctly. If they respond incorrectly or not at all, the test should be repeated once more using a different combination of 3 numbers/letters. It is important to use a different combination each time to exclude the effect of learning. Overall, the patient is considered to have passed the screening test if they repeat at least 3 out of a possible total of 6 letters/numbers correctly. The other ear should be then assessed in a similar manner, again using a different combination of numbers/letters.²⁴

Audioscope

An audioscope is a rechargeable battery-powered, lightweight, handheld instrument that combines a pure-tone screening audiometer and otoscope into a single unit. It contains built-in integrated circuitry for producing pure tones at 500, 1000, 2000, and 4000 Hz, at loudness levels of 20, 25, and 40 dB, as well as a halogen fiber optic otoscope for otoscopic examination. The cost of this apparatus is approximately US \$550.

The patient sits with an elbow propped on the armrest of a chair and with the hand in the form of a gentle fist.²⁵ The patient is then instructed that he or she will hear faint tones of different pitches and should raise a finger as soon as a tone is heard and then lower the finger as soon as the tone is no longer heard. The patient should repeat back the instructions to ensure that they have been completely understood. Patients who are not able to respond with arm or finger movements due to physical disability should be instructed to answer yes when they hear the test tone.

The patient's ear canal and tympanic membrane should first be visualized with an appropriately fitting speculum attached to the audioscope. The speculum should be inserted into the ear canal to get a tight seal between the speculum and the ear canal. The audioscope is then used to present pure tones of random loudness (in decibels) to prevent patients from an-

ticipating the loudness of the next presented tone (each tone has an on-time of 1.5 seconds and an off-time of 1.5 seconds). The results for that ear should be recorded and the contralateral ear should be tested in the same fashion.²⁶ The audioscope screening can be performed in less than 90 seconds in office settings.

METHODS

Literature Search and Quality Assessment of Included Articles

A structured MEDLINE and EMBASE database search including the years 1966 through April 2005 was conducted to identify English-language articles examining the accuracy or precision of bedside screening tests for hearing impairment. Medical Subject Headings or keywords used in the search included *hearing loss*, *hearing handicap*, *hearing tests*, *tuning fork*, *deafness*, *physical examination*, *sensitivity*, *specificity*, *audiometry*, *tuning fork tests*, *Rinne*, *Weber*, *audioscope*, *Hearing Handicap Inventory for the Elderly—Screening version*, *whispered voice test*, *sensorineural*, and *conductive*. This computerized search was supplemented with a manual review of the bibliographies of all identified articles, additional "core" articles (identified a priori as articles used to develop recent guidelines for the screening of elderly patients for hearing impairment), a commonly used clinical skills textbook,²⁷ and contact with experts in the field.

One of the authors (A.B.) screened all potential articles and then reviewed and abstracted data from all articles that were identified as relevant. A second author (P.T.) independently reviewed and abstracted data from the same articles. Both authors together reviewed these extracted data for inclusion; differences were resolved by consensus. Articles were included if they were original studies on the accuracy and/or precision of bedside screening questions or physical examination maneuvers for hearing impairment. Studies on screening of both symptomatic and asymptomatic individuals were included. Articles were excluded if they

evaluated individuals younger than 16 years, used another screening test evaluated in this article (eg, audioscope) as a reference standard, or contained insufficient or incomplete data to allow calculation of likelihood ratios (LRs).

Study quality was assigned based on a grading scheme previously used for this series.²⁸ Level 1 studies were blind independent comparisons of a test with a valid reference standard in a large number (≥ 200) of consecutive patients. Level 2 studies were similar to level 1 studies, but with fewer than 200 patients. Level 3 studies were also blind independent comparisons of the test with a reference standard, but the patients were enrolled in a nonconsecutive fashion using a subset or smaller group who may have had the condition, and the studies generated results on both the test and the reference standard. Level 4 studies were nonindependent comparisons of a test with a valid reference standard among a “grab” sample of patients believed to have the condition in question. Level 5 studies were nonindependent comparisons of a test with a reference standard of uncertain validity.

We included studies of the self-reported screening question and HHIE-S that were level 1 or level 2 in quality. For other screening tests, we included the best available studies, which consisted of several studies having quality levels of 3 or 4.

Data Analysis

All analyses were performed using Comprehensive Meta-analysis version 2.023 (Biostat Inc, Englewood, NJ). We used the raw data in the articles to calculate the LR and diagnostic odds ratios (DORs) associated with test results. Likelihood ratios are a method of converting pretest probability into posttest probability.²⁹ A positive LR is the ratio of the chance of an abnormal test result in people who have the disease condition relative to people who do not have the disease. Similarly, a negative LR is the ratio of the chance of a normal test result in people who have the disease condition relative to people who do not have the disease. The pretest

probability is the prevalence of hearing impairment in the general adult population. For a hearing loss prevalence or pretest probability of 25%, a positive LR of 10 raises the posttest probability to 77%, a positive LR of 5 raises it to 63%, and a positive LR of 3 raises it to 50%. Similarly, negative LR of 0.15 and 0.10 lower the posttest probabilities to 5% and 3%, respectively.

The DORs are a global measure of test performance that tell examiners how likely they are to correctly identify hearing impairment or normal hearing. Several studies determined test characteristics (sensitivity, specificity, positive and negative LR) for each test against varying hearing impairment definitions of the reference standard. For hearing impairment definition at a particular intensity level (in decibels), the testing frequency that provided the best DOR was included in the accuracy tables presented herein and used to calculate the summary LR.

When there were at least 2 studies with similar definitions of hearing impairment and similar screening tests, we used random-effects measures to calculate the summary LR. For most studies, despite statistical heterogeneity, the confidence interval around the point estimate for the LR was sufficiently narrow that we could make appropriate inferences about the usefulness of the test.

Most studies reported precision (intraobserver and interobserver) as either a κ statistic or Pearson r coefficient. There were insufficient data for each test to combine results and provide summary precision scores.

RESULTS

Study Characteristics

A total of 924 studies were identified by the search strategy, of which 24 met the inclusion and exclusion criteria (TABLE 1). The included studies accounted for a total of 12 645 patients. The studies were published between 1966 and 2004 and involved patients both with and without ear symptoms who were seen at outpatient otolaryngology or primary care clinics as well as geriatric medicine inpatient settings.

Most studies used pure-tone thresholds from an audiometer alone or in combination with speech reception and speech recognition thresholds as the reference standard; however, the case definitions differed. The differences were in both the tone frequencies used for testing and the decibel threshold used to classify someone as hearing impaired. For most tests, the testing frequencies used had small nonsignificant effects on the calculated LR. Therefore, in studies that evaluated the screening test against varying hearing test frequencies, only the frequency definition that provided the best DOR is presented in the corresponding screening-test table and used to calculate the likelihood summary estimate.

Precision Studies

No studies reported the precision of the self-reported single-question screening test, though it seems likely that patients would provide consistent results given the test's simplicity and ease of administration. The HHIE-S is a standardized test with preset questions that is assumed to have high reproducibility and precision. The HHIE-S performed at 6-week intervals displays high test-retest reliability (Pearson $r=0.84$ when completed on paper and $r=0.96$ when conducted face-to-face⁵⁰). Similarly, the HHIE-S performed at a physician's office and then repeated at a hearing center shows high test-retest reliability ($r=0.84$, $P<.001$).⁴⁰

No studies evaluating the precision of the Weber test were identified. The reproducibility of the Weber test may be limited by the lack of a standardized force used to strike the tuning fork, the tuning fork frequency used, and the precise location at which the base of the fork is placed.

Only 1 study evaluated the reliability of the Rinne test. Burkey et al⁴⁸ showed that the sensitivity improved considerably when the test was performed by an otolaryngologist as compared to an otolaryngology postgraduate trainee. The variability in the test accuracy when performed by 2 different examiners on the same patient

DOES THIS PATIENT HAVE HEARING IMPAIRMENT?

Table 1. Hearing Impairment Accuracy Studies

Source	Clinical Setting	Study Dates	Design	No. of Patients	Age, Mean (SD) or Mean (Range) or Range, y	Tests Evaluated	Reference Standard	Quality Level*
Clark et al, ³³ 1991	Two communities in rural Iowa	1988	Prospective evaluation of women in a longitudinal bone density study alive in 1988	267	60-85	Self-reported question	Audiogram	1
Nondahl et al, ³⁰ 1998	Population-based study of residents of Beaver Dam Township, Wis	1993-1995	Prospective evaluation of Beaver Dam Eye Study patients alive as of March 1, 1993	3556	65.8 (48-92)	HHIE-S, self-reported question	Audiogram	1
Wiley et al, ³¹ 2000	Population-based study of residents of Beaver Dam Township, Wis	1993-1995	Prospective evaluation of Beaver Dam Eye Study patients alive as of March 1, 1993	3471	48-92	HHIE-S	Audiogram	1
Sindhusake et al, ³² 2001	Population-based study of residents living in the west of Sydney, Australia	1997-1999	Prospective evaluation of individuals who participated in the Blue Mountains Eye Study	2003	55-99	HHIE-S, self-reported question	Audiogram	1
Dalton et al, ¹⁴ 2003	Population-based study of residents of Beaver Dam Township, Wis	1998-2000	Prospective evaluation of individuals who participated in EHLS-1 study	2688	69 (53-97)	HHIE-S	Audiogram	1
Okamoto et al, ³⁴ 2004	Settsu City Health Center, Osaka, Japan	July to December 2001	Prospective evaluation of consecutive participants who were given health checkups	918	40-85	Self-reported question	Audiogram	1
Lichtenstein et al, ⁴⁰ 1988	Four university-based and 2 community-based internist practices in Nashville, Tenn	NA	Prospective evaluation of consecutive patients >65 y	178	74.2 (6.4)	HHIE-S, audioscope	Audiogram	2
Lichtenstein et al, ⁴¹ 1988	Four university-based and 2 community-based internist practices in Nashville, Tenn	NA	Prospective evaluation of consecutive patients >65 y	178	74.2 (6.4)	HHIE-S	Audiogram	2
MacPhee et al, ³⁵ 1988	Acute rehabilitation wards in Victoria Geriatric Unit, Glasgow, Scotland	January and February 1987	Prospective evaluation of all patients at the unit during study period	62	80.8 (66-96)	Whispered voice	Audiogram	2
Voeks et al, ³⁷ 1993	Nursing home residents over 2-y period	NA	Prospective evaluation of consecutive admissions during study period	198	72.4 (11.4)	Self-reported question	Audiogram	2
McBride et al, ⁴² 1994	Primary care clinics at community health center and a Veterans Affairs Medical Center	1989	Prospective evaluation of consecutive patients >60 y	185	70 (5)	HHIE-S, audioscope	Audiogram	2
Eekhof et al, ³⁶ 1996	Outpatient ENT clinic over 6-wk period	NA	Prospective evaluation of consecutive patients aged 55 years and older attending the clinic for an audiogram	62	≥55	Audioscope-3, whispered voice	Audiogram	2
Abyad, ³⁹ 2004	Community academic nursing home in Lebanon	1998-1999	Prospective evaluation	68	79 (4.6)	HHIE-S	Audiogram	2
Wu et al, ³⁸ 2004	Geriatric medicine outpatient clinic and inpatients in Tan Tock Seng Hospital, Singapore, over 6 mo	NA	Prospective evaluation of consecutive outpatients to the clinic and all patients admitted on the last Saturday of the month for the 6-mo period	63	62-90	Self-reported question	Audiogram	2
Stankiewicz and Mowry, ⁴⁴ 1979	ENT clinic	NA	Prospective evaluation of random clinic patients reporting of hearing loss, tinnitus, and/or vertigo; patients with normal hearing used as control	122	NA	Weber, Rinne	Audiologic examination, audiometry	3

(continued)

Table 1. Hearing Impairment Accuracy Studies (cont)

Source	Clinical Setting	Study Dates	Design	No. of Patients	Age, Mean (SD) or Mean (Range) or Range, y	Tests Evaluated	Reference Standard	Quality Level*
Swan and Browning, ²⁴ 1985	Audiology clinic over 2-mo period	NA	Prospective evaluation of all patients with aural symptoms over 2 mo	101	57 (17-89)	Whispered voice	Audiogram	3
Frank and Peterson, ⁴⁵ 1987	Hiram G. Andrews Rehabilitation Center, The Pennsylvania State University Speech and Hearing Clinic, senior citizen groups, central Pennsylvania	NA	Prospective evaluation	678	20-96	Audioscope	Audiogram	3
Browning et al, ⁴³ 1989	Otology clinic	NA	Prospective evaluation of consecutive patients referred with ear symptoms	101	NA	Whispered voice	Audiogram	3
Ciurlia-Guy et al, ⁹ 1993	Veterans chronic care facility	NA	Prospective evaluation	104	79 (10.0) 60-99	Audioscope-3	Audiogram	3
Crowley and Kaufman, ⁴⁹ 1966	Columbia-Presbyterian Medical Center, New York, NY	NA	Prospective evaluation of patients with air-bone threshold gaps ≥ 10 dB	100	NA	Rinne	Audiogram	4
Bienvenue et al, ²⁵ 1985	Speech and Hearing Clinics at The Pennsylvania State University and the State University College	NA	Prospective evaluation of clients at the clinics	30	51-81	Audioscope	Audiogram	4
Burkey et al, ⁴⁸ 1988	Private otology practice	1994-1995	Retrospective chart review	1000	NA	Rinne	Audiogram	4
Chole and Cook, ⁴⁶ 1988	Otolaryngology clinic, Davis Medical Center, University of California	NA	Prospective evaluation of individuals suspected of having conductive hearing loss	200	NA	Rinne	Audiogram	4
Johnston, ⁴⁷ 1992	Guy's Hospital Medical School, London, England	NA	Prospective evaluation of consecutive patients with conductive hearing loss	62	32	Rinne	Audiogram	4

Abbreviations: EHLS-1, Epidemiology of Hearing Loss Study 1; ENT, ear, nose, and throat; HHIE-S, Hearing Handicap Inventory for the Elderly—Screening version; NA, not available. *See "Methods" section for definition.

population suggests that the test may not be reliably reproduced. Furthermore, the variability in other test factors similar to the Weber test limits the expected reproducibility.

Several studies examined the precision of the whispered-voice test. Macphee et al³⁵ compared the results of a geriatrician and an otolaryngologist and found an agreement of 88%, while Uhlmann et al³¹ compared the results of an audiologist with those of an otolaryngologist and found a correlation of 0.67. However, in the study by Eekhof et al,³⁶ in which the results of 6 examiners were compared with those of the first examiner, the interobserver reliability (measured by the Cohen κ) ranged from 0.16 (poor) to 1.0 (perfect). The authors attributed the

large variation between examiners' outcomes to the differences in loudness of the whispering. A systematic review of the whispered-voice test⁵² reinforced the fact that standardizing the loudness of the whisper is the greatest challenge. Few studies state that the whispered sequence occurred after a full expiration. In addition, they suggest that the most appropriate letters, numbers, or words for testing also need further investigation. Furthermore, presbycusis in older patients results in difficulty hearing high-frequency sounds such as consonants; hence, using different consonants and vowels could also alter the reproducibility of the test.⁵³

Two studies examined the precision of the audioscope. In the study by Lichtenstein et al,⁴⁰ in which the re-

sults of the audiologist in the hearing center were compared with those of the internist in the office, the interobserver reliability measured by the κ score ranged from 0.41 (poor) at 500 Hz to 0.74 (very good) at 2000 Hz. Bienvenue et al²⁵ showed that the correlations between repeated audiometric screenings taken about one-half hour to 1 hour apart were 0.996 at 500 Hz, 0.988 at 1000 Hz, 0.998 at 2000 Hz, and 0.989 at 4000 Hz. Since these correlations were quite high, the authors concluded that the results of the audioscope test are reliable.

Accuracy of History Taking for the Diagnosis of Hearing Impairment

Self-reported Screening Question. Six studies assessed the accuracy of a self-

reported screening question against a reference standard of pure-tone average threshold across a broad range of patients (TABLE 2). The studies were similar in design but differed slightly in the wording of the self-reported question. The screening question is only moderately useful to detect subtle hearing impairment (≥ 25 dB). Patients who report difficulty hearing have a summary LR of 2.2 (95% confidence interval [CI], 1.8-2.8), while those who claim no problem have a summary LR of 0.45 (95% CI, 0.36-0.56). Patients who report normal hearing are much less likely to have moderate to severe hearing impairment (≥ 40 dB), with a summary LR of 0.13 (95% CI, 0.09-0.19). A family member's assertion that the patient has difficulty hearing may be as important as, or more important than, the patient's own recognition of hearing loss. Although we found no evidence that addresses this issue in the studies we reviewed, we suggest that clinicians should decide individually on how to incorporate a family member's

perception of their relative's decreased hearing when deciding on formal audiology testing.

The HHIE-S. Seven studies met our study criteria, and all used pure-tone average as the reference standard (TABLE 3). The presence of hearing handicap (ie, an HHIE-S score >8) increases the probability of a hearing impairment of at least 40 dB (summary LR, 3.8; 95% CI, 3.0-4.8). However, a more severe hearing handicap (ie, an HHIE-S score >24) does not further improve the probability of detecting hearing impairment (summary LR, 4.0; 95% CI, 2.6-6.2). The absence of a hearing handicap, defined as an HHIE-S score of 8 or less, marginally lowers the probability of hearing impairment (summary LR, 0.38; 95% CI, 0.29-0.51).

Accuracy of the Physical Examination for Diagnosis of Hearing Impairment

Weber Tuning Fork Test. In the only study of the Weber test that met the study criteria,⁴⁴ the reference standard test and

definition of hearing impairment were not explicitly described in terms of air-bone thresholds. Neither the tests performed using the 256-Hz tuning fork nor those performed using the 512-Hz tuning fork are useful to either increase or decrease the probability of identifying individuals with unilateral sensorineural or unilateral conductive hearing loss. An abnormal Weber test result has an LR of only 1.6 (95% CI, 1.0-2.3) to 1.7 (95% CI, 1.0-2.9), while a normal result lowers the probability, with an LR of 0.70 (95% CI, 0.48-1.0) to 0.76 (95% CI, 0.57-1.0), making it an inaccurate test for screening purposes.

Rinne Tuning Fork Test. Although numerous studies have evaluated the Rinne tuning fork test for assessing conductive hearing loss, only 5 studies met the study criteria (TABLE 4). All 5 studies were of lower quality (level 3 or 4). Although Chole et al⁴⁶ found better characteristics with the 512-Hz tuning fork, most studies found that a 256-Hz tuning fork is more accurate either alone or in combination with

Table 2. Accuracy of the Self-reported Single Question to Detect Hearing Impairment

Source	Self-reported Single Question	Definition of Hearing Impairment	Reference Standard Definition of Hearing Impairment*		LR (95% CI)	
			Pure-Tone Average Threshold, dB	Pure-Tone Frequencies, kHz, and Ear Tested	Positive	Negative
Clark et al, ³³ 1991	Would you say that you have any difficulty hearing?	Yes	>25	1, 2, 3, and 4 in poorer ear	4.2 (2.5-7.2)	0.55 (0.47-0.66)
Voeks et al, ³⁷ 1993	Do you have trouble hearing?	Yes or equivocal response	>25	0.5, 1, and 2 in better ear	1.4 (1.1-1.8)	0.61 (0.43-0.87)
Nondahl et al, ³⁰ 1998	Do you feel you have a hearing loss?	Yes	>25	0.5, 1, 2, and 4 in poorer ear	2.5 (2.3-2.7)	0.41 (0.38-0.44)
Sindhusake et al, ³² 2001	Do you feel you have a hearing loss?	Yes	>25	0.5, 1, 2, and 4 in better ear	2.4 (2.2-2.6)	0.33 (0.29-0.38)
Summary estimate			>25		2.2 (1.8-2.8)	0.45 (0.36-0.56)
Okamoto et al, ³⁴ 2004	Do you have any difficulty with your hearing?	Yes	>30	1 in worse ear	2.3 (2.0-2.7)	0.50 (0.41-0.61)
Wu et al, ³⁸ 2004	Do you think you have a hearing problem?	Yes	>30	1 or 3	6.3 (1.0-41.7)	0.47 (0.32-0.67)
Summary estimate			>30		2.4 (1.6-3.8)	0.49 (0.41-0.59)
Clark et al, ³³ 1991	Would you say that you have any difficulty hearing?	Yes	>40	1 and 2 in better ear	3.1 (2.4-3.9)	0.15 (0.05-0.43)
Sindhusake et al, ³² 2001	Do you feel you have a hearing loss?	Yes	>40	0.5, 1, 2, and 4 in better ear	2.1 (2.0-2.2)	0.13 (0.08-0.20)
Summary estimate			>40		2.5 (1.7-3.6)	0.13 (0.09-0.19)

Abbreviations: CI, confidence interval; LR, likelihood ratio.
*Hearing impairment definition based on audiometry.

Table 3. Accuracy of the HHIE-S to Detect Hearing Impairment

Source	HHIE-S Definition of Hearing Impairment	Reference Standard Definition of Hearing Impairment		LR (95% CI)	
		Pure-Tone Average Threshold, dB	Pure-Tone Frequencies, kHz, and Ear Tested	Positive	Negative
Lichtenstein et al, ⁴¹ 1988	>8	≥25	0.5, 1, and 2 in better ear	3.2 (2.1-4.7)	0.43 (0.30-0.60)
McBride et al, ⁴² 1994	>8	>25	1, 2, and 4 in better ear	3.6 (2.0-6.6)	0.60*
Nondahl et al ³⁰ 1998	>8	>25	0.5, 1, 2, and 4 in worse ear	6.8 (5.5-8.3)	0.70 (0.67-0.72)
Sindhusake et al, ³² 2001	>8	>25	0.5, 1, 2, and 4 in better ear	3.9 (3.3-4.5)	0.49 (0.45-0.54)
Dalton et al, ¹⁴ 2003	>8	>25	0.5, 1, 2, and 4 in either ear	7.9 (6.1-10.1)	0.66 (0.64-0.69)
Abyad ³⁹ 2004	>8	>25	0.5, 1, and 2 in better ear	2.4 (1.4-4.2)	0.25 (0.12-0.53)
Summary estimate	>8	>25		4.5 (3.1-6.6)	0.55 (0.45-0.67)
Lichtenstein et al, ⁴¹ 1988	>8	>40	1 or 2 in both ears or 1 and 2 in one ear	3.1 (2.2-4.4)	0.37 (0.24-0.57)
McBride et al, ⁴² 1994	>8	>40	1 or 2 in both ears or 1 and 2 in one ear	2.5 (1.7-3.7)	0.49*
Wiley et al, ³¹ 2000	>8	>40	0.5, 1, 2, and 4 in worse ear	5.0 (4.4-5.6)	0.40 (0.35-0.46)
Sindhusake et al, ³² 2001	>8	>40	0.5, 1, 2, and 4 in better ear	3.3 (3.0-3.7)	0.26 (0.20-0.34)
Dalton et al, ¹⁴ 2003	>8	>40	0.5, 1, 2, and 4 in either ear	5.0 (4.3-5.8)	0.52 (0.47-0.56)
Summary estimate	>8	>40		3.8 (3.0-4.8)	0.38 (0.29-0.51)
McBride et al, ⁴² 1994	>24	>25	1, 2, and 4 in better ear	4.3 (1.7-10.4)	0.76*
Summary estimate	>24	>25		4.3 (1.7-10.4)	0.76
Lichtenstein et al, ⁴⁰ 1988	>24	>40	1 or 2 in both ears or 1 and 2 in one ear	5.2 (2.6-10.2)	0.64 (0.50-0.80)
McBride et al, ⁴² 1994	>24	>40	1 and 2 in one ear or 1 or 2 in both ears	3.4 (1.9-5.9)	0.66*
Summary estimate	>24	>40		4.0 (2.6-6.2)	0.64 (0.50-0.80)

Abbreviations: CI, confidence interval; LR, likelihood ratio.

*Data not provided to calculate confidence intervals around negative LR; not included in calculation of summary estimate.

other tuning forks.^{43,44,49,54,55} The reference standard was air-bone threshold gaps determined using pure-tone audiometry. Variability in the degree of air-bone threshold gaps used to define conductive hearing impairment prohibits the combination of data across studies to calculate summary estimates. An abnormal Rinne test result increases the probability of conductive hearing loss but has a wide range of LRs (2.7 [95% CI, 2.0-3.5] to 62 [95% CI, 3.9-970]), with a majority of the studies showing LRs greater than 15. On the other hand, a normal Rinne test result may be less useful in dismissing hearing impairment, as indicated by the LR range from 0.01 (95% CI, 0-0.15) to 0.85 (95% CI, 0.76-0.95), with the majority of the LRs greater than 0.30. Several studies have attempted to report the minimal air-bone threshold gap required for the Rinne test result to change from normal to abnormal (results range from from 17 dB to 40 dB^{23,49,54,56-59}). Again, the large variance in the results precludes using the Rinne test as an accurate screening tool.

Table 4. Accuracy of the Rinne Tuning Fork Test to Detect Conductive Hearing Impairment

Source	Tuning Fork Frequency, Hz	Reference Standard Definition of Hearing Impairment: Air-Bone Threshold Gap, dB*	LR (95% CI)	
			Positive	Negative
Chole and Cook, ⁴⁶ 1988	256	≥10	2.8 (1.8-4.3)	0.30 (0.21-0.42)
	512	≥10	44 (2.8-696)	0.56 (0.48-0.65)
Johnston, ⁴⁷ 1992	512	>10	15 (1.0-236)	0.47 (0.36-0.60)
Burkey et al, ⁴⁸ 1998	512	≥10	24 (18-30)	0.21 (0.16-0.27)
Crowley and Kaufman, ⁴⁹ 1966	256	>15	48 (3.0-746)	0.26 (0.19-0.35)
		>15	62 (3.9-970)	0.21 (0.15-0.30)
	512	>25	12 (5.1-27)	0.06 (0.03-0.14)
		>25	11 (4.7-25)	0.09 (0.05-0.18)
	256	>30	3.9 (2.7-5.6)	0.01 (0-0.15)
		512	>30	2.7 (2.0-3.5)
Stankiewicz and Mowry, ⁴⁴ 1979†	256	NA‡	30 (9.3-95)	0.58 (0.46-0.73)
	512	NA‡	17 (3.7-75)	0.85 (0.76-0.95)

Abbreviations: CI, confidence interval; LR, likelihood ratio; NA, not available.

*Definition based on audiometry; air-bone threshold gap calculated by subtracting the bone conduction threshold in decibels from air conduction threshold in decibels.

†Rinne test performed using threshold technique; in remaining studies, Rinne test performed using loudness technique.

‡Conductive hearing loss not defined in terms of air-bone gap.

Whispered-Voice Test. Four studies met our study criteria (TABLE 5). Pure-tone threshold audiometry was the reference standard in all 4 studies. The prevalence of hearing impairment ranged from 26% to 61%. Inability to

repeat back a letter/number combination whispered at a distance of 2 ft (0.6 m) increases the probability of a 30-dB or greater hearing impairment (summary LR, 6.1; 95% CI, 4.5-8.4). However, normal perception of the whis-

pered voice dramatically lowers the likelihood of hearing impairment (summary LR, 0.03; 95% CI, 0-0.24). Inability to perceive the whispered voice when the test is performed at 6 in (15 cm) from the patient, instead of the more commonly used distance of 2 ft, sharply increases the likelihood of hearing impairment (LR, 67; 95% CI, 4.3-1062); however, accurate perception of the whispered voice at 6 in only marginally reduces the likelihood of hearing impairment (LR, 0.27; 95% CI, 0.19-0.39).³⁵ Thus, screening for hearing loss with the whispered voice test

at 6 in will more likely fail to detect affected patients than will performing the test at 2 ft.

Audioscope Test

Six studies evaluating the accuracy of the audioscope test were identified (TABLE 6). Three of the studies were quality level 1 or 2, while the remaining 3 studies were level 3 or 4. The prevalence of hearing impairment ranged from 26% to 69%. Four studies^{8,36,40,42} used a 40-dB pure-tone average threshold (reference standard), while the remaining 2 studies used a

30-dB²⁵ and a 45-dB⁴⁵ threshold, respectively.

Despite slight differences in the definition of hearing impairment, the sensitivity to detect hearing impairment was consistently high, ranging from 87% to 100%. On the other hand, the specificity was variable, ranging from 42% to 90%. Thus, normal hearing perception on audioscope screening makes hearing impairment very unlikely (summary LR, 0.07; 95% CI, 0.03-0.17). Patients with abnormal hearing perception on audioscope screening have a moderately increased probability of

Table 5. Accuracy of the Whispered-Voice Test to Detect Hearing Impairment*

Source	Whispered-Voice Definition of Hearing Impairment	Reference Standard Definition of Hearing Impairment†		LR (95% CI)	
		Pure-Tone Average Threshold, dB	Pure-Tone Frequencies, kHz	Positive	Negative
Swan and Browning, ²⁴ 1985	Unable to repeat >3/6 letter/number combination	>30	0.5, 1, and 2	7.4 (4.7-11.8)	0.01 (0-0.10)
MacPhee et al, ³⁵ 1988	Unable to repeat 50% of 3 triplet sets of numbers	>30	0.5, 1, and 2	6.1 (3.2-11.7)	0.01 (0-0.12)
Browning et al, ⁴³ 1989	Failure to repeat 2 of 3 digit/letter combination on 2 occasions	>30	0.5, 1, and 2	9.5‡	0.06‡
Eekhof et al, ³⁶ 1996	Inability to repeat 2 or more combinations	>30	NA	4.6 (2.6-8.1)	0.12 (0.06-0.24)
Summary estimate		>30		6.1 (4.5-8.4)	0.03 (0-0.24)

Abbreviations: CI, confidence interval; LR, likelihood ratio; NA, not available.

*Distance from examiner to patient was 2 ft (0.6 m) in all 4 studies.

†Definition based on audiometry.

‡Data not provided to calculate confidence intervals around LR; not included in calculation of summary estimate.

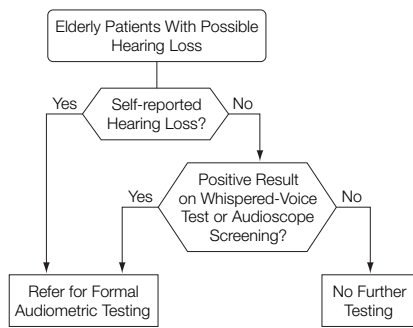
Table 6. Accuracy of the Audioscope to Detect Hearing Impairment

Source	Audioscope Definition of Hearing Impairment	Reference Standard Definition of Hearing Impairment*	LR (95% CI)	
			Positive	Negative
Bienvenue et al, ²⁵ 1985	Pure-tone average ≥ 30 dB at 0.5, 1, 2, and 4 kHz	Pure-tone average ≥ 30 dB at 0.5, 1, 2, and 4 kHz	3.1†	0.10†
Frank and Peterson, ⁴⁵ 1987	Threshold ≥ 45 dB at ≥ 1 of the 0.5-, 1-, 2-, or 4-kHz frequencies (each ear separate)	Pure-tone threshold ≥ 45 dB at ≥ 1 of 0.5-, 1-, 2-, or 4-kHz frequencies (each ear separate)	14.1†	0.09†
Lichtenstein et al, ⁴⁰ 1988	40-dB loss at 1- or 2-kHz frequency in both ears or at 1- and 2-kHz frequencies in one ear	40-dB loss at 1- or 2-kHz frequency in both ears or at 1- and 2-kHz frequencies in one ear	3.4 (2.5-4.5)	0.08 (0.03-0.24)
Ciurlia-Guy et al, ⁸ 1993	Unable to hear a 40-dB tone at any 1 frequency of 1 or 2 kHz in either ear	Unable to hear a 40-dB tone at any 1 frequency of 1 or 2 kHz in either ear	1.3 (1.1-1.5)	0.07 (0.01-0.51)
McBride et al, ⁴² 1994	Better-ear threshold of ≥ 40 dB at 2 kHz	40-dB loss at 1- or 2-kHz frequency in both ears or at 1- and 2-kHz frequencies in one ear	4.9 (3.4-6.8)	0.05†
Eekhof et al, ³⁶ 1996	Unable to hear all 4 tones (0.5, 1, 2, and 4 kHz) at 40 dB	Pure-tone average threshold >40 dB	1.7 (1.4-2.1)	0.03 (0.0-0.45)
Summary estimate			2.4 (1.4-4.1)	0.07 (0.03-0.17)

Abbreviations: CI, confidence interval; LR, likelihood ratio.

*Definition based on audiometry.

†Data not provided to calculate confidence intervals; not used to calculate summary estimate.

Figure 2. Algorithm for Determining Need for Formal Audiometric Testing

hearing impairment (summary LR, 2.4; 95% CI, 1.4-4.1).

CASE RESOLUTION

Case 1

Given this woman's age, her pretest probability of hearing impairment is between 40% and 66%. Her yes reply to the question as to whether she feels she has hearing impairment indicates that she is symptomatic and hence increases the probability of her having significant hearing impairment (summary LR, 2.5; 95% CI, 1.7-3.6) to more than 80%. This patient should be referred both for formal audiological testing to determine the degree and type of hearing impairment and for planning for hearing amplification. No further bedside testing is required in this patient, since even a pass on the whispered-voice test (summary LR, 0.03; 95% CI, 0-0.24) only lowers the post-test probability to approximately 10%.

Case 2

If we assume this patient's pretest probability for hearing impairment is approximately 50%, his no response to the single screening question (LR, 0.45) only reduces his chance of greater than 25-dB impairment to about 30%. Since the single question has not confidently ruled out hearing impairment, a screening whispered-voice test will be very useful in this patient. A passing result on this test makes hearing impairment much less likely (summary LR, 0.03; 95% CI, 0-0.24), and no further testing will be required. However, not

passing the test suggests hearing impairment (summary LR, 6.1; 95% CI, 4.5-8.4), and the patient should then be referred for formal audiometric testing. Although the audioscope and whispered-voice tests both have similar accuracy test characteristics, the whispered-voice test has a better DOR compared with the audioscope test. Clinicians who are concerned about the reliability of using their own whispered voice might opt to screen with an audioscope.

BOTTOM LINE

To screen elderly individuals for hearing impairment in general practice, they should first be asked whether they feel they have hearing impairment (FIGURE 2). Patients who provide a yes or equivocal response should be referred directly for formal audiometric testing. If the reply is no, then they should be further screened with a whispered-voice test. Accurate perception of a whispered letter/number combination significantly lowers the likelihood of hearing impairment, and these individuals do not require further evaluation. Patients unable to perceive the whispered combination should be referred for formal testing. The audioscope has diagnostic accuracy characteristics similar to those of the whispered-voice test and may be preferable to clinicians who are unsure of their ability to perform the whispered-voice test reliably. Further research is required to improve standardization of the technique of conducting the whispered-voice test, including ensuring that it is performed after full expiration and determining a set of letters and numbers that will most reliably screen for hearing impairment. Both the Rinne and Weber tuning fork tests, which are limited by inaccuracy and lack of precision data, are not recommended for routine screening and should no longer be part of the medical curriculum.

Author Contributions: Drs Bagai and Detsky had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

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Acquisition of data: Bagai, Thavendiranathan, Detsky.

Analysis and interpretation of data: Bagai, Thavendiranathan, Detsky.

Drafting of the manuscript: Bagai, Detsky.

Critical revision of the manuscript for important intellectual content: Bagai, Thavendiranathan, Detsky.

Statistical analysis: Bagai, Thavendiranathan, Detsky.

Administrative, technical, or material support: Detsky.

Study supervision: Detsky.

Financial Disclosures: None reported.

Acknowledgment: We thank David Simel, MD, Duke University, Durham, NC, for his valuable guidance during the course of the study. We also thank George Tomlinson, PhD, University of Toronto, Toronto, Ontario, for his statistical help with data analysis. In addition, we are thankful to Heather Whitson, MD, Duke University, and Jay Piccirillo, MD, Washington University, St Louis, Mo, for their comments and review of the manuscript.

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In every child who is born, under no matter what circumstances, and of no matter what parents, the potentiality of the human race is born again.

—James Agee (1909-1959)