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# Screening of hearing in elderly people: assessment of accuracy and reproducibility of the whispered voice test

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**Abstract** *Given the high prevalence of presbycusis and its detrimental effect on quality of life, screening tests can be useful tools for detecting hearing loss in primary care settings. This study therefore aimed to determine the accuracy and reproducibility of the whispered voice test as a screening method for detecting hearing impairment in older people. This cross-sectional study was carried out with 210 older adults aged between 60 and 97 years who underwent the whispered voice test employing ten different phrases and using audiometry as a reference test. Sensitivity, specificity and positive and negative predictive values were calculated and accuracy was measured by calculating the area under the ROC curve. The test was repeated on 20% of the ears by a second examiner to assess inter-examiner reproducibility (IER). The words and phrases that showed the highest area under the curve (AUC) and IER values were: "shoe" (AUC = 0.918; IER = 0.877), "window" (AUC = 0.917; IER = 0.869), "it looks like it's going to rain" (AUC = 0.911; IER = 0.810), and "the bus is late" (AUC = 0.900; IER = 0.810), demonstrating that the whispered voice test is a useful screening tool for detecting hearing loss among older people. It is proposed that these words and phrases should be incorporated into the whispered voice test protocol.*

**Key words** *Older persons, Screening, Hearing loss, Senior health care services, Primary health care*

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## Introduction

Population ageing due to rising life expectancy is a global phenomenon. Brazil is no exception to this trend and, according to current projections, the total number of people aged 60 years or over is expected to reach 32 million by 2020[1]. Aging is a natural process of human development whereby individuals undergo gradual physiological changes[2,3].

Presbycusis is an age-related change in auditory acuity characterized by symmetrical, downward sloping high-frequency, bilateral, sensorineural hearing loss[2,4,5]. The prevalence of age-related hearing loss ranges between 30% and 90%[2,4,6]. Presbycusis causes major communication difficulties, particularly in understanding speech and conservations in noisy environments[7-9]. The diagnosis of hearing loss is made through pure-tone audiometry and vocal audiometry to determine auditory sensitivity and the quality of peripheral auditory information based on sound frequency hearing and speech recognition index[2,5]. These tests, together with acoustic immittance testing, are used to determine the type and degree of hearing loss and help doctors to diagnose presbycusis. Pure-tone audiometry is the gold-standard for hearing evaluation and requires an acoustically treated environment and equipment[10]. Given the operational complexities involved in performing pure-tone audiometry, this test has limited use as a method for the universal hearing screening of older people. As a result, other hearing screening methods that can be easily used and applied by trained practitioners are emerging as an alternative in the public health arena[11].

The whispered voice test has been recommended as a screening test for detecting hearing impairment among elderly persons suspected of having presbycusis[6,12-14]. It is considered a low-cost, simple-to-use and fast test for detecting moderate hearing loss among adults who do not need to use hearing aids[14].

The health care guidance note produced by the Ministry of Health, Aging and the Health and Care of Older People (*Envelhecimento e saúde da pessoa idosa*)[15] recommends the whispered voice test as a screening instrument for testing auditory acuity among older people. According to the recommendations, the examiner should stand outside the patient's field of vision at a distance of 33 cm from each ear and whisper at each side a simple brief question such as "what is your name?". If the patient does not respond, the external auditory canal should be inspected for any obstruction that may cause a reduction in auditory acuity. In the absence of obstruction, the patient should be referred to specialized health center for audiometric testing[15].

The whispered voice test has been used in senior health care centers and in the Unified Health System by geriatric health practitioners and a range of other health professinoals[16,17]. However, everyday questions such as "what is your name?" may contain cognitive clues, whereby hearing only the word "what" or "name", for example, may lead to the correct answer even though the patient has hearing loss and needs intervention. In Brazil, the current lack of research on the sensitivity, specificity, inter-examiner reproducibility and positive and negative predictive values of the whispered voice test raises difficulties to the standardization and validation of this technique as a screening tool for detecting hearing loss among the aged population.

In Brazil, until now there is no standardization and validation of this technique, due to there are not studies in which sensitivity, specificity, inter-examiner reproducibility and positive and negative predictive values of the whispered voice test are stablish as a screening tool for detecting hearing loss among aged Brazilian population.

The present study therefore aims to determine the reproducibility and accuracy of the whispered voice test as a screening tool for detecting hearing loss among older people by employing different phrases and using pure-tone threshold audiometry as the reference test. Based on the findings of this study, we propose a set of different speech stimuli as part of the whispered voice test protocol.

## Methodology

A cross-sectional accuracy study was undertaken whereby hearing evaluations were performed with a group of older people attending a senior health care center at a public university hospital in Brazil.

The study sample comprised all patients aged 60 years or over referred by the geriatric services who underwent an audiological evaluation in the center between February and November 2013 and who agreed to take part in the study by signing an informed consent form. Those patients who did not complete the proposed evaluation were excluded from the study, resulting in 210 patients with an average age of 76 years

(standard deviation: 8, minimum of 60 years and maximum of 97 years) and 420 tested ears.

The data collection process involved the following steps: inspection of the external auditory canal; the whispered voice test; and pure-tone and vocal audiometry.

The inspection of the external auditory canal was undertaken using a Omni 3000 otoscope to determine whether there was total or partial obstruction of the external acoustic meatus. Patients with an obstruction that was likely to impede the detection of hearing thresholds were informed and referred for assessment and otorhinolaryngological procedures and subsequent evaluation[18,19].

The whispered voice test was conducted by specialized professionals in a silent room with minimal internal and external noise and with the patient sitting in a chair in the presence only of the examiner. Despite the fact that the room had an acoustic booth, we opted to carry out the test in an untreated environment so that the findings would reflect the reliability of the tool for use in typical medical consulting rooms, including those found in primary health care facilities. The stimuli were presented via the whispered speech of the examiner, who was careful to speak at a uniform level of loudness throughout the tests. The examiner stood behind each ear at arm's length (measured as the distance between the elbow and clenched fist and equivalent to a distance of approximately 33 centimeters from the tested ear) at an angle of zero and outside the patient's field of vision[14,15].

Verbal stimuli were previously selected considering the following linguistic aspects: word size, commonly used phrases and words in Portuguese, and the presence of common speech sounds in Portuguese. To cater for the audiometric characteristics of presbycusis[5], we were careful to ensure that the speech material contained a phonemic repertoire that included different points of articulation, emphasizing fricatives, which have lower peak acoustic energy and a wider frequency spectrum[20]. All words and phrases were selected from speech lists used in audiological evaluation[21,22], considering size, ease of reproduction, and suitable content for older people.

A set of different whispered phrases and words was presented to both ears. The nontest ear was occluded by the examiner by rubbing the tragus in a circular motion to minimize the participation of the opposite auditory canal. For the right ear, the patient was requested to answer the question "what is your name?" and repeat the phrase "it looks like it's going to rain", the word "shoe", the word "Key", and the word "does". For the left ear, the patient was requested to answer the question "how old are you?" and repeat the phrase "the bus is late", the word "window", the word "rain", and the word "chalk". For each whispered stimulus, the result was expressed as a fail, where the patient was unable to correctly repeat the phrase or word (tested positive for possible hearing loss), or a pass (tested negative for hearing loss).

To test inter-examiner reproducibility, 42 participants were randomly selected and underwent the test again. This time, the test was conducted by a less experienced examiner who was a multiprofessional resident in the field of geriatric medicine and trained to conduct the test. The test was conducted in a room with similar features to the one used in the first test and appropriate care was taken to control internal and external noise. Reproducibility was tested by comparing the level of agreement between the results obtained by the first and second examiners for each stimulus. The level of agreement was determined using the Kappa coefficient (k) using the following categories[23]: 0 – 0.2: very poor; 0.21–0.4: poor; 0.41 – 0.6: moderate; 0.61 – 0.8: good; 0.81 – 100: very good.

The intrinsic quality of the whispered voice test was assessed by calculating sensitivity, specificity, and positive and negative predictive values, using audiometry as a reference test. Receiver operating characteristic (ROC) analysis was performed using the sensitivity and specificity values. The area under the curve (AUC) was calculated to assess the accuracy of the whispered voice test for each of the phrases used[23].

Pure-tone audiometry was performed after the whispered voice test to determine bone-conduction and air-conduction thresholds. This was done using an appropriately calibrated AVS-500 audiometer and acoustic booth, both manufactured by Vibrasom. Initially, air-conducted hearing thresholds were determined at 250Hz, 500Hz, 1000Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz, and 8000Hz. When these thresholds exceeded 20dB HL, bone-conducted thresholds were determined at 500Hz, 1000Hz, 2000Hz, 3000Hz, and 4000Hz[19]. In accordance with the BIAP classification, hearing loss was confirmed when hearing thresholds were higher than 20dB HL at the following frequencies: 500Hz, 1000Hz, 2000Hz, and 4000Hz[18,24].

The data was analyzed using the software program OpenEpi version 3.03[25].

The study was approved by the Ethics Committee at the Federal University of Minas Gerais and was conducted in accordance with National Health Council guidelines.

## Results

### General characteristics of the study participants

The general characteristics of the study participants are presented in Table 1. A total of 420 individual ears were tested. Based on the results of pure-tone audiometry as a reference test, the prevalence of hearing loss was 68.8% (Table 1).

### Sensitivity, specificity, and negative and positive predictive values of the whispered voice test

Table 2 shows the comparison between the results of the whispered voice test and tone audiometry and the sensitivity, specificity and negative and positive predictive values for each stimulus presented.

### Accuracy of the whispered voice test

Figure 1 shows the ROC curves produced using the sensitivity and specificity values from the whispered voice test for each stimulus. A visual analysis of the curves shows that the AUC of the stimulus "shoe" was 0.918, followed by "window" (AUC = 0.917), "it looks like it's going to rain" (AUC = 0.911), "the bus is late" (AUC = 0.900), "what is your name?" (AUC = 0.886), "key" (AUC = 0.886), "how old are you?" (AUC = 0,837), "rain" (AUC = 0.880), "does" (AUC = 0.696), and "chalk" (AUC = 0.687) (Figure 1).

### Reproducibility of the whispered voice test

The reproducibility of the whispered voice test varied according to the stimulus. Table 3 shows the level of agreement between the answers obtained by the first examiner and those obtained by the second examiner.

### Proposed application of the whispered voice test

Based on the results of the tests of accuracy and reproducibility, Figure 2 shows the proposed application of the whispered voice test as a screening tool for detecting hearing loss among older people.

## Discussion

The search for an efficient and effective screening test for detecting hearing loss among the geriatric population is important, particularly given the prevalence of hearing impairment among older people and the detrimental effect it can have on quality of life if left undetected and untreated[6]. In view of the important contribution of hearing to communication among older people and the limited access to audiological services, primary care services are expected to provide auditory acuity screening of the geriatric population and refer patients to secondary care services as and when necessary[26]. Hearing screening should be simple enough to be conducted in primary care settings and sensitive enough to identify patients with possible risk of hearing loss[3].

Hearing screening to detect hearing impairment is currently recommended as a fundamental component of any general evaluation of an older individual in national health care guidelines not only in Brazil, but also in other countries such as the United Kingdom and Austrelia[27-30]. The present study tested the whispered voice test, recommended by the Ministry of Health for screening older people in primary health care settings[15], standardized the questions using phonetically balanced words and phrases, and suggested a new test protocol (Chart 1).

The technique used for the whispered voice test varies between studies[27-29,31]. For example, the appropriate distance between the examiner's mouth and tested ear ranges between 33[15-17,28] and 60 centimeters [6,28-30], while other studies use digits, letters and words as stimuli[6,28-31]. In the present study, the examiner stood 33 cm to the side of the tested ear[15,28] and whispered phrases and different sized words in an attempt to identify the most sensitive types of verbal stimuli specifically capable of determining possible hearing loss, using audiometry as a reference test. The phrases and words were chosen bearing in mind that presbycusis is characterized by hearing loss at high frequencies[5] and therefore the test should contain words and phrases with sounds in this frequency band, such as fricatives.

The findings showed varying sensitivity and specificity values according to the verbal stimulus used (Table 2): the larger the phrase or word, the higher the specificity of the test, while the smaller

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**Table 1.** General characteristics of the study participants (n = 210).

| Characteristics | | n | % |
|---|---|---|---|
| Gender (n = 210) | Women | 135 | 64.3 |
| | Men | 75 | 35.7 |
| Complaint of hearing loss (n = 210) | Yes | 167 | 79.5 |
| | No | 43 | 20.5 |
| Complaint of tinnitus (n = 210) | Yes | 158 | 75.2 |
| | No | 52 | 24.8 |
| Complaint of dizziness (n = 210) | Yes | 123 | 58.6 |
| | No | 87 | 41.4 |
| Presence of hearing loss (n = 420 ears) | Yes | 289 | 68.8 |
| | No | 131 | 31.2 |
| Degree of hearing loss (n = 289 ears with presence of de hearing loss) | Mild | 92 | 31.8 |
| | Moderate | 130 | 45.0 |
| | Moderately severe | 49 | 17.0 |
| | Severe | 13 | 4.5 |
| | Profound | 5 | 1.7 |
| Type of hearing loss (n = 289 ears com presence of hearing loss) | Sensorineural | 255 | 88.2 |
| | Conductive | 2 | 0.7 |
| | Mixed | 32 | 11.1 |

n: number

**Table 2.** Sensitivity, specificity and negative and positive predictive values of the whispered voice test by words and phrases used, using audiometry as a reference test.

| Ear | Words/phrases | Whispered voice test | Audiometry | | S (%) (CI 95%) | E (%) (CI 95%) | VPP % (CI 95%) | VPN % (CI 95%) |
|---|---|---|---|---|---|---|---|---|
| | | | A | N (%) | | | | |
| Right (n = 210 ears) | What is your name? | F | 116 (55.2) | 4 (1.9) | 82.9 | 94.3 | 96.7 | 73.3 |
| | | P | 24 (11.4) | 66 (31.4) | (75.8-88.2) | (86.2-97.8) | (91.7-98.7) | (63.4-81.4) |
| | It looks like it's going to rain | F | 125 (59.5) | 5 (2.4) | 89.3 | 92.9 | 96.1 | 81.2 |
| | | P | 15 (7.1) | 65 (31.0) | (83.1-93.4) | (84.3-96.9) | (91.3-98.3) | (71.3-88.3) |
| | Shoe | F | 131 (62.4) | 7 (3.3) | 93.6 | 90.0 | 94.9 | 87.5 |
| | | P | 9 (4.3) | 63 (30.0) | (88.2-96.6) | (80.8-95.1) | (89.9-97.5) | (77.9-93.3) |
| | Key | F | 134 (63.8) | 13 (6.2) | 95.7 | 81.4 | 91.2 | 90.5 |
| | | P | 6 (2.9) | 57 (27.1) | (90.9-98.0) | (70.8-88.8) | (85.5-94.8) | (80.7-95.6) |
| | Does | F | 139 (66.2) | 42 (20.0) | 99.3 | 40.0 | 76.8 | 96.5 |
| | | | 1 (0.5) | 28 (13.3) | (96.1-99.9) | (29.3-51.7) | (70.1-82.3) | (82.8-99.4) |
| Left (n = 210 ears) | How old are you? | F | 115 (54.8) | 6 (2.9) | 77.2 | 90.2 | 95.0 | 61.8 |
| | | P | 34 (16.2) | 55 (26.2) | (69.8-83.2) | (80.2-95.4) | (89.6-97.7) | (51.4-71.2) |
| | The bus is late | F | 129 (61.4) | 4 (1.9) | 86.6 | 93.4 | 96.9 | 74.0 |
| | | P | 20 (9.5) | 57 (27.1) | (80.2-91.1) | (84.3-97.4) | (92.5-98.8) | (63.3-82.5) |
| | Window | F | 139 (66.2) | 6 (2.9) | 93.3 | 90.2 | 95.8 | 84.6 |
| | | P | 10 (4.8) | 55 (26.2) | (88.1-96.3) | (80.2-95.4) | (91.3-98.1) | (73.9-91.4) |
| | Rain | F | 140 (66.7) | 11 (5.2) | 93.9 | 81.9 | 92.7 | 84.7 |
| | | P | 9 (4.3) | 50 (23.8) | (88.9-96.8) | (70.5-89.6) | (87.4-95.9) | (73.5-91.8) |
| | Chalk | F | 146 (69.5) | 37 (17.6) | 98.0 | 39.3 | 79.8 | 88.9 |
| | | | 3 (1.4) | 24 (11.4) | (94.2-99.3) | (28.1-51.9) | (73.4-85.0) | (71.9-96.2) |

A: altered; N: normal; P: pass; F: fail; S: sensitivity; E: specificity; VPP: positive predictive value; VPN: negative predictive value; CI: Confidence Interval; n: number.

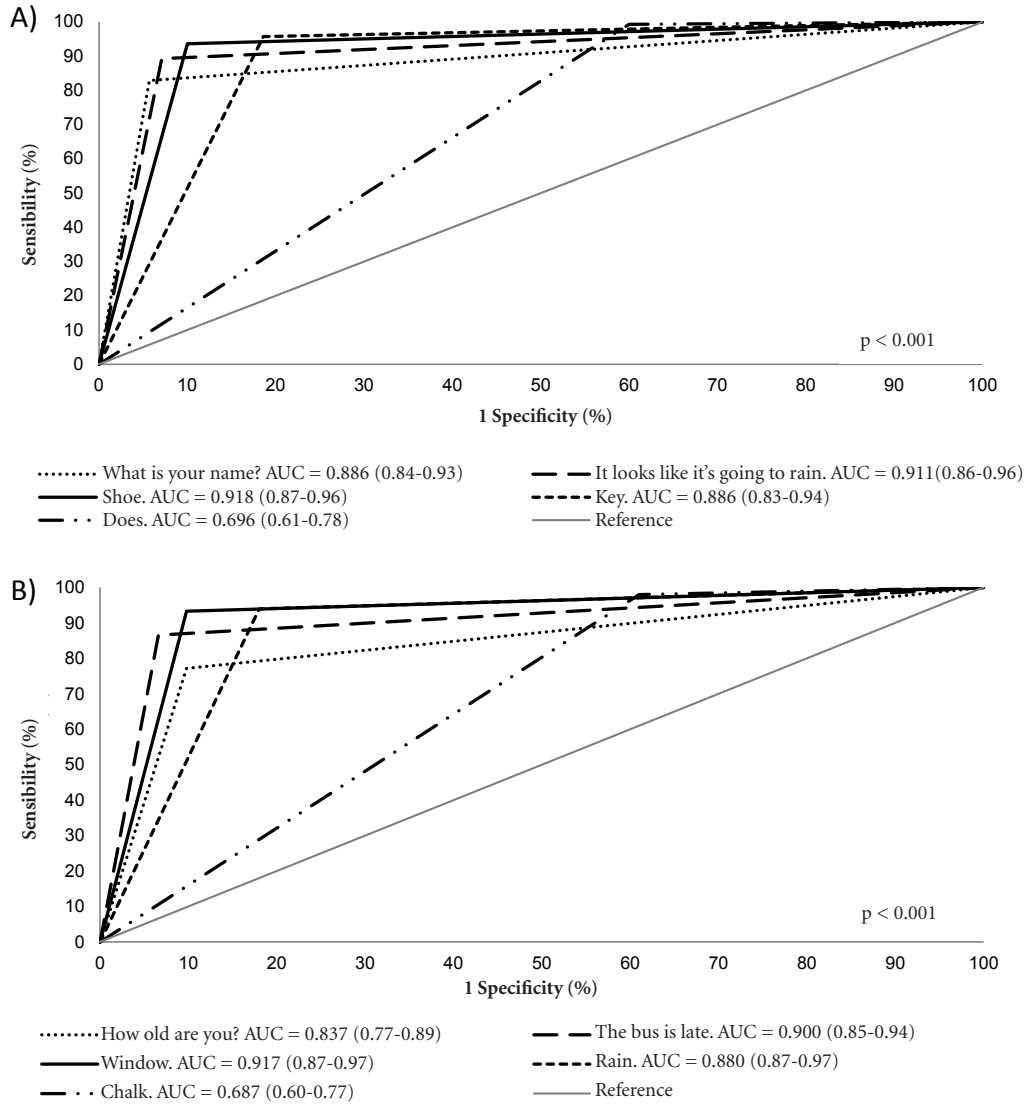


**Figura 1**. ROC curves of the whispered voice test for different stimuli. A) ROC curve for the right ear. B) ROC curve for the left ear.

ROC: receiver operating characteristics; AUC: area under the ROC curve (95% Confidence Interval – lower and upper).

the word size the higher the sensitivity. For the phrase "what is your name?" sensitivity and specificity were 82.9% and 94.3%, respectively. This question is predictable and commonly used on a day-to-day basis, thus increasing redundancy and the likelihood of guessing the correct answer. This in turn means that the number of false negatives was higher than that found for words such as "shoe" or "window". The same occurs with the phrase "how old are you?", suggesting that both phrases should not be used for hearing screening. Previous studies that determined the sensitivity and specificity of the whispered voice test conducted in other countries found that sensitivity and specificity values ranged between 80% and 100% and 80% and 90%, respectively[27-31].

To demonstrate the relationship between sensitivity and specificity, ROC analysis was performed to reveal phrases for which there was greater optimization of sensitivity as a function of specificity (Figure 1). The results showed that the AUC value was greatest for the words

**Table 3**. Agreement degrees of inter-examiners in whisper test performances.

| Word/phrase | Inter-examiner agreement (kappa) | Classification of agreement degrees |
|---|---|---|
| What is your name | 0,754 | Good |
| How old are you | 0,769 | Good |
| The bus is late | 0,810 | Great |
| It looks like it's going to rain | 0,810 | Great |
| Shoe | 0,877 | Great |
| Window | 0,869 | Great |
| Rain | 0,683 | Good |
| Key | 0,683 | Good |
| Does | 0,701 | Good |
| Chalk | 0,754 | Good |

**Chart 1.** Proposed application of the whispered voice test as a screening tool for detecting hearing loss among older people.

| |
|---|
| **Step 1:** The whispered voice test should be conducted in a quiet room with the patient sitting on a chair. The examiner should instruct the patient as follows: "you should keep your eyes closed and at your side I am going to whisper a word and/or a phrase; if you hear the word and/or phrase please repeat it". |
| **Step 2:** The examiner should stand outside the patient's field of vision at a distance of approximately 33 centimeters and at the same level as the tested ear and whisper the word "*shoe*" or the phrase "*the bus is late*" and wait for a response. In the other ear, the examiner should whisper the word "*window*" or the phrase "*It looks like it's going to rain*" and wait for a response. |
| **Step 3:** If the patient correctly repeats the words or phrases, he/she is considered to have PASSED the test. If the patient does not correctly repeat the words or phrases, he/she is considered to have FAILED the test. |
| **Step 4:** Patients who fail the test should have their external auditory canal inspected and in the case of ear wax blockage should be referred for removal and retested. In the absence of ear wax blockage, patients should be referred for audiometry. |

"shoe" (AUC = 0.918) and "window" (AUC = 0.917), followed by "it looks like it's going to rain" (AUC = 0.911), "the bus is late" (AUC = 0.900), "what is your name?" (AUC = 0.886), "key" (AUC = 0.886), "how old are you?" (AUC = 0.837), "rain" (AUC = 0.880), "does" (0.696), and "chalk" (0.687) (Figure 1). Thus, the words that showed highest accuracy were "shoe" and "window". These words begin with fricatives within the frequency band 3000Hz to 8000Hz, showing that speech discrimination is influenced by high frequencies and that the whispered voice test should therefore include words with speech sounds in this frequency band in order to make it more sensitive to sloping hearing loss, which is a major characteristic of presbycusis[5].

Some studies report that the whispered voice test may be influenced by variables related to the presentation of stimuli by the examiner, such as voice intensity and experience[14,29]. In the present study, the whispered voice test was initially conducted by an experienced examiner who was careful to speak at a uniform level of loudness throughout the tests. To test inter-examiner variability, the same procedure was repeated by a second examiner with 20% of the individual ears. The results show that the level of agreement between the examiners varied according to the stimulus presented. The phrases that showed best inter-examiner reproducibility where the trisyllabic words "shoe" (k = 0.877) and "window" (k = 0.869), followed by the phrases "the bus is late" (k = 0.810) and "it looks like it's going to rain" (k = 0.810). For the phrase "what is your name?" inter-examiner reproducibility was 75%.

The reproducibility values of the whispered voice test described in the literature vary. A study carried out in Washington that compared the

results of the whispered voice test conducted by an otolaryngologist with those obtained by a speech therapist found that level of agreement was 67%[31], while a study that compared the results of the test performed by a geriatrician and otolaryngologist showed a rate of 88%[30]. Despite the variability among reproducibility values, our findings show that the whispered voice test is reproducible, since, depending on the stimulus presented, the level of agreement remained between good and very good even after changing the examiner. This shows that a properly trained practitioner is capable of conducting the test in a primary health care setting. The most important benefit of this test is that it offers greater efficiency without reducing screening quality, meaning that only patients who really need specialized hearing evaluations will be referred to secondary care services.

Despite being a simple test of hearing ability, the whispered voice test does have some limitations, since it should be conducted carefully by an experienced examiner in a quite setting. Furthermore, mild degrees of hearing loss (up to 40 dB) may go undetected by the test. However, from a public health perspective, this type of hearing loss has little detrimental impact on the quality of life and independence of older patients[18,24]. On the other hand, moderate hearing loss may go unnoticed by older people, which can have a detrimental effect on cognition, independence and quality of life[9,18,24].

Presbycusis is progressive and can be treated and rehabilitated using electronic sound amplification devices available through the auditory health care services provided under Brazil's public health care system[32,33]. It is important to highlight that early diagnosis and intervention is crucial to ensure successful rehabilitation and use of these devices among the geriatric population, since the longer the period of auditory deprivation, the more difficult it is for an older individual to become readapted to the world of sound[9,33]. In light of the above, the whispered voice test is an important screening tool for detecting hearing loss among the geriatric population.

The findings of the present study reveal that, for the phrase "what is your name?", suggested by the guidance note Aging and the Health and Care of Older People[15], inter-examiner reproducibility, sensitivity, specificity, and positive and negative predictive values were 75%, 83%, 94%, 97%, and 73%, respectively, while accuracy, expressed by area under the ROC curve, was 89%, using audiometry as a reference test. The words "shoe" and "window" showed the highest accuracy. For the word "shoe", AUC, inter-examiner reproducibility, sensitivity, specificity, positive and negative predictive values were 92%, 88%, 94%, 90%, 95%, and 87%, respectively, whereas for the word "window" AUC, sensitivity, specificity, positive and negative predictive values were 92%, 93%, 90%, 96%, and 85%, respectively. Thus, although the use of the phrase "what is your name?" is suggested for screening, the present study reveals that other words and phrases showed higher sensitivity and reproducibility. In light of this, it is suggested that the whispered voice test should be conducted as outlined in Chart 1.

## Conclusion

The findings suggest that the whispered voice test is an acceptable screening test to detect hearing loss in the geriatric population. The speech stimuli that showed greatest accuracy and reproducibility were the words "shoe" and "window" and the phrases "the bus is late" and "it looks like it's going to rain". It is therefore suggested that these stimuli should be included in the whispered voice test protocol. The suggested expressions are phonetically balanced and highly used in the speeches. They also include high frequency sounds, which are the most affected by presbycusis.

## Collaborations

L Labanca, LPC Guarisco and DU Gonçalves worked on the conception, design, data analysis, data interpretation, approval of the manuscript content, and in the writing of the present study; FS Guimarães e EAB Couto worked on data analysis, data interpretation, approval of the manuscript content, and in the writing of the present study.

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