Sensitivity and Specificity of Self-Assessment of Hearing Handicap and Pure tones in Screening: A Comparison

(REGISTER NO. 02SH0013)

An independent project submitted in part fulfillment of the first year M.Sc (Speech and Hearing), University of Mysore, Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING
MANASAGANGOTHRI, MYSORE-570 006

JUNE 2003

Certificate

This is to certify that this independent project entitled *"Sensitivity and Specificity of Self-Assessment of Hearing Handicap and Pure tones in Screening: A Comparison" is a* bonafide work done in part fulfillment of the degree of Master of Science (Speech and Hearing) of the student (Register No. 02SH0013).

Mysore

June, 2003

Director
All India Institute of
Speech & Hearing
Mysore-570 006

Certificate

This is to certify that this independent project entitled *"Sensitivity and Specificity of Self-Assessment of Hearing Handicap and Pure tones in Screening: A Comparison"* has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

GUIDE

Mysore

June, 2003

(Dr. C. S. Vanaja)
Lecturer in Audiology
All India Institute of
Speech & Hearing
Mysore-570 006

Declaration

This independent project entitled *"Sensitivity and Specificity of Self-Assessment of Hearing Handicap and Pure tones in Screening: A Comparison"* is the result of my own study under the guidance of Dr. C. S. Vanaja, Lecturer in Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any other University for the award of any Diploma or Degree.

Mysore

June, 2003 Register No. 02SH0013

वक्रतुंड महाकाय सूर्यकोटि समप्रभ ।
निर्विघ्नं कुरु मे देव सर्व कार्येषु सर्वदा ।।

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CONTENTS

		Page No.
I	Introduction	1 - 4
II	Review of Literature	5 - 16
III	Methodology	17 - 19
IV	Results	20 - 25
V	Discussion	26 - 29
VI	Summary and Conclusion	30 - 31
	References	32 - 34
	Appendix	35 - 36

LIST OF TABLES

NO.	Title	Page No.
1	Response Matrix for sensitivity and specificity of criterion I	22
2	Response Matrix for sensitivity and specificity of criterion II	23
3	Response Matrix for sensitivity and specificity of criterion in	23
4	Response Matrix for sensitivity and specificity of criterion IV	24
5	Response Matrix for sensitivity and specificity of criterion V	24
6	Comparison of sensitivity, specificity and predictive efficiency of different criteria	25
7	Sensitivities for different criteria for different degrees of hearing loss	25

INTRODUCTION

Hearing impairment is one of the most prevalent chronic conditions affecting a substantial part of the population. The extent to which a hearing impairment represents a handicap in the medico legal terms and in sociopersonal terms is not straightforward (Matthews, Lee, Mills & Schum, 1990). The former can be computed by specific test frequencies as in pure tone testing where some arbitrary fence is used to decide the amount of handicap. Handicap in terms of socio-personal aspects can be measured using a self-assessment questionnaire.

As mentioned earlier, hearing impairment is a widely prevalent condition, so it is very difficult for the audiologists to assess in details each and every individual who may have hearing handicap. This is true especially in the case of a very large population, when the manpower and the resources available are scarce. In such situations, screening is done to identify the clients with hearing impairment and only those who require a detailed assessment are referred for a further investigation.

Screening using the pure tones has been the traditional method for years. However to use pure tone screening, equipment like a screening audiometer is required. So, the cost of the screening program increases with the use of pure tone screening. Also, it can be time consuming when a large population needs to be screened for the presence of hearing impairment. Only a professional can do this type of screening.

Self-assessment questionnaires can be another option. Self-assessment has been employed for various purposes, namely, diagnostic interview/counseling (Sturmak, 1987; as cited in Schow & Gatehouse, 1990), rehabilitation evaluation (Schow & Nerbonne, 1989), amplification benefit measures (Schow & Tannhill, 1977; Oja & Schow, 1984; Smedley, 1990; Birk-Neilson; 1976; as cited in Schow & Gatehouse, 1990). They have also been used for compensation purposes (Schow, Brockett, Sturmak & Longhurst 1989), demographic and research uses (Schien et al, 1970; as cited in Schow & Gatehouse, 1990), etc. One of the major applications of self-assessment is screening (Schow & Nerbonne, 1982). The screening questionnaires help to form the basis of hearing evaluation identification, identification of hearing loss. They give preliminary information about the problems due to hearing loss. They can be effectively used with case history and pure tones in screening programs.

The self-assessment questionnaires used for audiological screening purposes contain specific questionnaires pertaining to everyday listening situations. Consequently, the clients' own perception of handicap is obtained. Since questions regarding only the most probable problem areas are included, the screening can be carried out for a large number of subjects at a time.

Self-report instruments are easy to use and do not require a professional to administer. Thus anganwadi and health workers can use them and a large population can be covered. Also as these questionnaires are inexpensive, the cost of screening program reduces considerably.

Need for the study:

In order to use any self report instrument for screening purposes, it is vital to establish data that show accuracy in identifying impaired subjects, i.e., sensitivity and in properly classifying the normal subjects, i.e., specificity. In this way it is possible to see the percent of false positives and false negatives that may occur when self-assessment procedure is used. (Ibrahim, 1985; as cited in Schow& Gatehouse, 1990).

The sensitivity and specificity of a self-report instrument varies with different populations and content of the scale used. An instrument, which appears to be very sensitive in one population, may not be so in some other population. The self-report instrument cannot be directly applied for two different groups of people. This difference may be attributed to the criteria used, the definition of hearing loss, the demographic characteristics of the population under study, etc (Schow & Gatehouse, 1990).

One scale has been developed in the Indian context for the "Self-assessment of hearing handicap" (Vanaja, 2000). The short form of the scale consists often questions pertaining to different listening situations. The psychometric measures of this scale need to be evaluated. The sensitivity and specificity of this scale needs to be compared to that of pure tone screening so as to determine its independent screening efficacy. A comparison of pure tone screening with the short form of the "Self assessment of hearing handicap scale" will throw light on the pros and cons of using each of these methods, independently or in combination for screening purposes. If the self-assessment scale is found to be sensitive enough for independent use, it could be

used for mass screening such as health fair screening, online assessment. This kind of instrument will be especially useful in India where manpower is less.

Aim of the Study:

To compare the sensitivity and specificity of the following screening programs:

- Pure tone screening
- Screening based on self-report of hearing handicap
- Screening program using the combination of the above two.

REVIEW OF LITERATURE

Self-assessment of hearing was introduced in 1930's (USPHS, 1938). Standard audiological sensitivity and speech recognition (discrimination) scores give us useful information about basic hearing abilities but making inferences from this data to predict the effect upon daily life is difficult. Audiometric tests do not assess the non-sensory variables that contribute to actual communication performance. So, they provide only partial and indirect information about communication handicap. It was an effort to bridge this gap that Davis (1948, as cited in Schow & Nerbonne, 1990) proposed Social Adequacy Index (SAI). This idea of combining pure tone averages and speech discrimination loss to derive a measure of social adequacy was an early effort to achieve relevancy from traditional data.

Later, High, Fairbanks and Glorig (1964) developed a "Scale for Self assessment of Hearing Handicap" to tap the individual's perception of his handicap. The results were compared to those of a battery of standard audiological tests. Following this various other self assessment scales were developed, some of them being: Social Hearing Handicap Scale (Ewerston & Birk-Nielson, 1973), the Hearing Performance Inventory (Giolas, Owens, Lamb & Schubert, 1979), Communication Screening Profile (Schow & Nerbonne, 1982), the Hearing Handicap Inventory for the Elderly (Ventry & Weinstein, 1982), etc. However the efficacy of the self-assessment scales, their sensitivity, specificity, comparison to traditional measures, was not evaluated for all the above-mentioned scales. The results of the studies,

which compared the self-assessment scales to the traditional audiometric measures, are discussed here.

High, Fairbanks & Glorig (1964) compared the scores of the Scale for Self Assessment of Hearing Handicap with those of a battery of standard audiological tests. Significant correlation coefficients (about 0.70) were obtained between the scores of the hearing handicap scale and all measures of auditory sensitivity for better ears but not for speech discrimination measures. A self assessment scale used by the Social Survey (1948) for screening of hearing impairment in the US was also used in England by Ward, Tucker, Tudor and Morgan (1975). The questionnaire was sensitive to hearing loss (in better ear) above 20 dB HL. The percentage of false negatives was reported to be less than 17%, which is a fairly satisfactory sensitivity.

Ewerston & Birk-Nielson constructed "Social Hearing Handicap Index" in 1973. It consists of twenty-one questions including different listening situations. The results of this scale were compared with those of the speech recognition thresholds. They concluded that the social index is 90% of quantitative hearing impairment. In other words a heavy hearing impairment can be but does not have to be the cause for a heavy social handicap and slight hearing loss can cause a heavy social handicap.

The "Hearing Performance Inventory"(Giolas, Owens& Schubert, 1979) was modified by Lamb, Owens & Schubert in 1983. Hawes and Niswander (1985) correlated the scores of this inventory with sensitivity measures, discrimination measures as well as sensitivity and discrimination measures. The sensitivity measures

were pure tone averages using five different frequency combinations and spondee thresholds. The scores of the inventory correlated significantly higher with pure tone averages (1000 Hz, 2000 Hz, 3000 Hz.) than with spondees. The correlation with discrimination in noise showed a small but consistent trend to be higher than . correlations of Hearing Performance Inventory (HPI) scores with most comfortable level discrimination in quiet. However, this difference was not statistically significant. The audiometric variables accounted for less than half of the variance in HPI. Hence, they concluded that the HPI was inadequate in predicting the amount of self-perceived hearing handicap.

Schow & Nerbonne developed Self Assessment of Communication for the assessment of hearing handicap in 1982. The scale measures the communication difficulties in various listening situations and the clients' general feelings about the handicap. Schow & Nerbonne (1982) also developed "Communication Screening Profile" for elderly clients. It measures both audiometric and non-audiometric aspects. The first part deals with the audiometric aspects related to communication i.e. pure tone thresholds, spondee thresholds, speech identification at 40 dB HL and 50 dB HL, SPIN in "auditory only" and "auditory visual" modes and the next part consists of the self assessment questionnaire. The test-retest correlations of the questionnaire ranged from 0.58 to 0.78 (Demorest & Erdman, 1988). However, the correlation of the scale with audiometric data was not assessed.

The Hearing Handicap Inventory for the Elderly (HHIE) was developed by Ventry and Weinstein in 1982, to assess the effect of hearing impairment on emotional and social adjustment of elderly people. A 13-item subscale for emotional and 1 -item for social and situational effects is used. The reliability through Chronbach's Alpha was high (0.95). The.split half reliabilities were equally high. The relationship between pure tone sensitivity, word recognition and self-assessed hearing handicap was studied. It was found that pure tone sensitivity shows a better correlation with hearing handicap (0.58-0.62) than the speech reception thresholds (0.56-0.59). The correlations with pure tone sensitivity were of the same magnitude for both emotional and social subscales. The self- perceived handicap increased with increase in impairment. Elderly individuals with greater than 40 dB HL pure tone averages in better ear can nearly all be categorized as having some degree of hearing handicap (Weinstein & Ventry, 1983). The test-retest reliability was high for both the face-to-face and paper pencil administration, suggesting that HHIE has the potential as a measure of change due to rehabilitation. (Weinstein, Spitzer & Ventry, 1986). In 1989, Newman and Weinstein checked the test-retest reliability using a face-to-face administration followed by a paper pencil technique. They found that the reliability was high. Weinstein (1986) studied the sensitivity and specificity of the screening program when HHTE-screening version was used alone and when used along with pure tone screening. A complete audiological battery was administered irrespective of the screening results. It was found that the sensitivity of the combined procedure was 85% and its specificity was 51%. To improve the sensitivity and specificity, the pass-fail criteria were modified. According to the new criteria, 0-10 was considered

as pass, 10-24 as mild handicap, 26-40 as significant handicap. This revised criteria improved the specificity to 64% and sensitivity did not improve. In general, specificity was highest (83%) when HHIE-S was used alone and sensitivity was highest when a combined procedure was used.

In a study by Garestecki (1987), 200 subjects were screened at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. The pure tone screening procedure used by Ventry and Weinstein, was criticized, as it did not screen beyond 2000 Hz. Here, different criteria were used for different frequencies. A criterion of 25 dB HL was used for 500 Hz and 1000 Hz, 45 dB HL for 2000 Hz and 50 dB HL for 4000 Hz. The HHIE-S (Ventry and Weinstein, 1983) was used for the self-assessment of hearing handicap. The results obtained were similar to those obtained by Ventry and Weinstein i.e. specificity was 71% and the sensitivity was 73%. Thus irrespective of the pass-fail criteria used, approximately 30%of those experiencing hearing handicap will go undetected and 20-25% of those who fail the test may not feel handicapped due to their loss.

Bess, Lichenstein & Logan, (1988) studied the screening version of HHIE-S. They evaluated the diagnostic performance of the screening version against the five definitions of hearing loss .The definitions of hearing loss used for the study were:

1) Criterion given by Ventry & Weinstein (1982, 1983): The subject is considered impaired if one fails to hear at 40 dB HL for 1000 Hz or 2000 Hz in both ears or fails to hear at 40 dB HL for 1000 Hz and 2000 Hz in one ear.

2) Speech frequency pure tone average. The subject is considered impaired if the loss at 500 Hz, 1000 Hz and 2000 Hz is greater than or equal to 25 dB HL in better ear.

3) High frequency Pure Tone Average. The subject is considered impaired if the average hearing loss at 1000 Hz, 2000 Hz and 4000 Hz was greater than or equal to 25 dB HL in the better ear.

4) Speech Reception Threshold. The subject is considered impaired if SRT was greater than or equal to 25 dB HL in better ear.

5) Speech Recognition. The subject is considered impaired if speech recognition score (NU-6) in quiet is less than 90% in the better ear.

It was found that the sensitivity ranged from 53% (for HFPTA) to 72% (for the Ventry Weinstein criterion). The specificity varied from 72% to 84% with the maximum being for the HFPTA and minimum for the SRT and the speech recognition. This shows that HHIE-S performed in a similar manner against five definitions of hearing loss. They concluded that HHIE-S was a valid test for identifying hearing impairment in the elderly.

Bess, Lichenstein, Logan and Burger (1989) compared the four criteria (criteria of Ventry and Weinstein, SFPTA, HFPTA and SRT) with two functional outcome measures in the elderly. Sickness impact profile (SIP) and HHDE-S (Ventry and Weinstein, 1983) were the self-assessment scales used. It was observed that

prevalence of hearing loss mainly depended upon the criterion used. Using HFPTA, 62% were considered as hearing impaired while only 35% were considered impaired using SFPTA. The prevalence was much lower with SRT (30%) and Ventry and Weinstein criterion (29%). It was found that the HHIE-S correlated best with Ventry and Weinstein criterion (1982,1983) followed by HFPTA whereas SIP correlated better with SFPTA. It was also observed that functional impairment increased with increase in the number of criteria on which the subjects failed.

Lichenstein, Bess, Logan and Burger (1990) carried out a further study using the same scales, the SIP and the HHIE-S to develop specific criteria of hearing impairment for the elderly population. Using functional scales as standards, receiver-operating curves were constructed for each frequency. Analysis of the results showed that poorer ear thresholds were more closely related with the functional measures than the better ear thresholds. Therefore the poorer ear thresholds were used to determine whether an individual was handicapped or not.

Poltl & Hickson (1990) studied the hearing status and self-reported hearing handicap using HHIE-S (Ventry & Weinstein, 1983) in the elderly clients. They observed a significant correlation between audiologically assessed hearing loss and the self reported handicap ($r = 0.38$). It was seen that the prevalence of hearing loss as measured with audiometry was 80% and that with self-report was 41%. Based on this, they concluded that pure tone testing is necessary as many clients may deny their hearing loss. As a strict criterion was used (25 dB HL), they also concluded that hearing handicap was perceived only when hearing loss was more than 40 dB HL.

This supports the criteria used by Ventry & Weinstein (1983) for identifying a subject with hearing loss.

Matthews, Lee, Mills & Schum (1990) evaluated subjects by traditional audiometric tests, speech perception in Noise test and the Hearing Handicap Inventory for Elderly (HHEE). A low correspondence between audiometric measures of hearing handicap (pure tone thresholds) and self-assessment of hearing handicap was observed (range 0.39 to 0.63). An arithmetic formula was used to compute the hearing handicap. The correlation between the total score of HHIE and 1979 AAO percent hearing handicap score was 0.55. This correlation was not significantly better than the correlation between the HHIE total scores and individual pure tone thresholds. The magnitude of correlations between the SPIN percent hearing scores and total score of HHIE were 0.63 for right ear and 0.47 for the left. Though the correlations between the HHIE and the SPIN scores were consistently higher in right ear than in left, the differences between the right and left ears were not statistically significant.

The HHIE was modified for use with younger hearing-impaired adults below 65 years of age. The Hearing Handicap Inventory for Adults (HHIA) is composed of 25 items. It demonstrated high internal consistency reliability. Audiometric correlates revealed weak yet statistically significant relationships with pure tone sensitivity and suprathresholds word recognition ability. These findings support the use of self-report with adult clients (Newman, Weinstein, Jacobson & Hug; 1990). In 1986, Lutman, Brown and Coles studied the self-reported disability and handicap in population in

relation to pure tone thresholds, age, sex and type of hearing loss. The questionnaire was administered and four components identified were, disability for everyday speech disability for speech in quiet, localization and hearing handicap. Results of audiometry were described by a two parameter characterized by low mid-frequency loss and high frequency slope. The results revealed that the scores for all four components of the scale increased progressively with increasing low-mid frequency loss, independent of high frequency slope. They were best correlated with a binaural average over 0.5 kHz, 1 kHz, and 2 kHz weighed 4:1 in favor of better ear. Sex and socio-economic group did not affect the disability. But people of similar hearing impairment reported less disability and handicap as age increased, interpreted as over-compensation for the effects of age in self-report. They further reported that conductive hearing losses in the better ear were more disabling than sensory neural hearing loss of same magnitude. Localisation and general hearing handicap were more highly correlated with measures of impairment in the poor ear than a better ear. Little variance was observed for the concept of the low fence in relationship between impairment and disability.

Jupiter (1989) evaluated the efficacy of administering the HHIE-S and pure tone screening in order to determine if an elderly person is more likely to proceed with a recommendation for hearing tests and further use a hearing aid when both the hearing sensitivity and hearing handicap was screened. The results showed that it does not make significant difference but slightly more number of subjects purchased the hearing aids when both pure tone screening and handicap screening was used.

Hearing screening has also been carried out in a dental office using self-assessment (Schow, Reese & Smedley, 1990). "The Rating Scale for Each Ear"(RSEE) was used for this purpose. The clients who failed on this scale were evaluated using standard pure tone audiometric procedures. 79% of the adult clients passed the RSEE. The failure rate was 21% using RSEE but 29% using pure tone screening.

The sensitivity and specificity of three different self-assessment scales in hearing screening was compared by Schow, et al (1990). The data was compared from hearing screening at health fairs over a period of four years. Pure tone screening was done & the scales administered were "rating scale for each ear" (Schien, Gentile & Haase, 1970'as cited in Schow, et al, 1990) "Hearing Handicap Inventory for the Elderly-Screening version" (Ventry & Weinstein, 1983) and "Self Assessment of communication" (Schow & Nerbonne, 1982). The highest sensitivity and specificity was obtained for RSEE. They suggested that RSEE could be used to substitute hearing screening, but to find the amount of handicap HHIE-S should be used.

In 1992, Erickson-Mangold, Hallberg and Erlandsson translated the Communication strategies Scale of Communication Screening Profile for the Hearing Impaired into Swedish and used it for study of people with hearing impairment. The scale was evaluated in terms of descriptive statistics, corrected item total correlations, principal component analysis & internal consistency reliability. The results showed

that handicap scores correlated with degree of hearing loss as measured with pure tones.

Vanaja (2000) developed a self-assessment questionnaire consisting of 50 questions pertaining to hearing loss in the Indian context. This scale also has a short form consisting of 10 items, scored on a three-point scale. The correlation co-efficient between the pure tone thresholds and the self-perceived handicap was found to be significantly high (>0.6). She suggested that the short form of the scale can be used for hearing screening with a cut off score of three.

Gomez, Hwang, Sobotova, Stark and May (2001) compared the self-reported hearing loss with audiometry in a cohort of New York farmers. They found that using a cut off of >25 dB the lowest prevalence of hearing impairment is 9% for the binaural low frequency average followed by 23% for the better ear mid frequency average, 37% for the worse ear mid frequency average and 47% for the binaural high frequency average. The agreement between self reported hearing loss and audiometric hearing impairment was evaluated, the results were as follows:

Binaural low frequency average had the lowest agreement (21%), Binaural High Frequency average and Binaural Mid Frequency average had 55% and 48% agreement respectively, followed by the Worse ear mid-frequency average, which had 52% agreement. The sensitivity and specificity of the binaural mid frequency average were 77% and 82% respectively, similar to the better ear mid frequency average.

Thus, a review of the literature indicates that self-assessment of hearing handicap is an important parameter in the test battery of audiological assessment. Since it measures the effect of hearing loss on daily activities, the communication abilities can be assessed in a better way. However the variance in the results of these scales cannot be completely accounted for by audiological or non-audiological factors. Inspite of this, results of a few investigations indicate that Self-assessment Scales can be effective screening tools.

METHOD

Subjects:

A total of 100 subjects, 54 males and 46 females, were taken for the study. Among them, 75 subjects were in the age range of 18-50 years and 25 subjects were in the age range of 51-70 years. All the subjects were well versed with spoken and written Kannada.

II. Instrumentation & Material:

- Screening audiometer: Calibrated screening audiometer, GSI17 with TDH 50 earphones was used for pure tone screening.
- Clinical audiometer: A calibrated clinical audiometer was used for the detailed audiologic evaluation.
- Immittance meter: Calibrated middle ear analyzer, GSI 33 was used to carry out tympanometry and refiexometry.
- Scale for Self Assessment of Hearing handicap (Screening version) was used to obtain the self-report of hearing impairment. This scale developed by Vanaja (2000) consists of 10 questions pertaining to various everyday listening situations, rated on a three-point scale.

III. Environment:

The pure tone screening was carried out in a quiet environment.

The detailed audiological evaluation was done in an acoustically treated two-room suite.

IV. Procedure:

a) Pure tone screening: Screening was done at 4 audiometric frequencies 500Hz, lOOOHz, 2000Hz & 4000Hz at 30 dBHL for both ears.

All the subjects were instructed to raise a finger to indicate that they heard the sound.

b) The screening version of "Self Assessment of Hearing Handicap" (Vanaja, 2000) was administered following the pure tone screening. The scale consists of 10 questions related to everyday listening situations rated on three points: "Most of the times", "Sometimes" and " Seldom". The subjects were instructed to make a tick mark { }in the column, which was appropriate to their hearing status. The Kannada version of the scale was administered using the paper pencil technique. Appendix I give the Kannada version of short form of the self-assessment scale.

c) The complete audiological evaluation was carried out using a diagnostic audiometer. Air conduction thresholds were established using the modified Hughson & Westlake method at audiometric frequencies from 250 Hz to 8000 Hz for both ears. Bone conduction thresholds were established for the better ear at all octaves from 250 Hz to 4000 Hz. The subjects were instructed as follows:

> "I am going to place headphones over your ears. You will hear some tones. Some of the tones will be loud and some

soft, some in right ear and some in left. Every time you hear a sound, raise your hand and put it down when you stop hearing. Raise your hand even for the softest sound."

Pure tone average was calculated using the three frequencies, 500Hz, lOOOHz, and 2000Hz. Masked thresholds were obtained wherever required and special tests were done, if required, to rule out retro cochlear pathology.

d) Immittance evaluation was done using a calibrated GSI33. Tympanometry was done for both ears. Acoustic reflex thresholds were found at 500Hz, lOOOHz, 2000Hz, 4000Hz.Special tests were done, if required, to rule out Retro Cochlear pathologies.

The obtained data was subjected to statistical analysis.

RESULTS

A total of 100 subjects, fifty-five males and forty-four females were taken for the study. A complete audiological assessment comprising of pure tone audiometry, speech audiometry and immittance evaluation was carried out. Among the 100 subjects, fifty-eight were found to be normal and from the rest of the forty two, five were classified as having minimal hearing loss, eleven as mild, eight as moderate, ten as moderate severe, four as severe and four as profound hearing loss. Twenty-three subjects showed flat configuration of the audiogram, while fifteen exhibited a sloping configuration, one rising and three trough shaped audiograms. Most of the subjects were found to have a bilateral loss with varying types. Twelve subjects had a conductive type of hearing loss, fifteen had sensory neural and fifteen had a mixed type of hearing loss.

A subject was considered fail on pure tone screening test if there was no response at 30 dB HL at 500 Hz, 1000 Hz, 2000 Hz or 4000 Hz in any ear. Since most of the subjects failed at 500 Hz, another modified criterion was used excluding 500 Hz to increase the specificity.

The short form of the "self assessment scale for hearing handicap" (Vanaja, 2000) was administered to all the subjects. The subjects completed the questionnaire with the written instructions. For most of the subjects, however, the instructions had to be repeated orally. The scores of the scale ranged from zero to twenty for the subjects in the present study.

The sensitivity of the screening tests was calculated by the following formula (Meyer, as cited in McCarthy and Alpiner, 2000).

$$\text{Sensitivity} = \left[\frac{\text{(Hits)}}{\text{(Hits + Miss)}} \right] \times 100$$

The specificity for the screening tests was computed by using the following formula (Meyer, as cited in McCarthy and Alpiner, 2000)

$$\text{Specificity} = \left[\frac{\text{Correct rejection}}{\text{Correct rejection + false alarm}} \right] \times 100$$

The predictive efficiency was calculated by using the following formula (Meyer, as cited in McCarthy & Alpiner, 2000)

$$\text{Predictive efficiency} = \left[\frac{\text{Hits + correct rejection}}{\text{Total cases}} \right] \times 100$$

The sensitivity, specificity and predictive efficiency was calculated for the following four criteria:

Subject was considered to be "fail" if there was no response at 30 dB HL at any of the following frequencies in any ear - 500 Hz, 1000 Hz, 2000 Hz or 4000 Hz.

II Subject was considered to be "fail" if there was no response at 30 dB HL at any of the following frequencies in any ear — 1000 Hz, 2000 Hz or 4000 Hz.

HI Subject was considered to be "fail" if the score on the short form of "self assessment of hearing handicap" was more than three.

IV Subject was considered "fail' if he failed either criteria II or HI in any ear.

V Subject was considered "fail" if he failed both criteria II and III in any ear.

The results of the screening program using criterion I is as summarized in Table 1 The sensitivity was 100% which indicates that this screening procedure identified 100% subjects with hearing loss, specificity was 20.6%, means it identified around 21% of normal subjects. The predictive efficiency was 54%.

Table 1: Response Matrix for Sensitivity and specificity of criterion I

Hit rate	False Alarm
42	46
Miss rate	Correct Rejection
0	12

As shown in Table 2 for criterion II the sensitivity was 97.6%, which indicates that this screening procedure identified around 98% subjects with hearing loss. The specificity was 65.5% i.e., the procedure identified around 66% normal subjects and predictive efficiency was 79%.

Table 2: Response Matrix for - Sensitivity and specificity of criterion II

Hit rate	False Alarm
41	20
Miss rate	Correct Rejection
1	38

The results of the self-assessment questionnaire were calculated in a similar way. It can be observed from Table 3 that the sensitivity of criterion IH was 80.9% and the specificity was 96.5%. The predictive efficiency of the scale was 90%.

Table 3: Response Matrix for Sensitivity and specificity of criterion in

Hit rate	False Alarm
34	2
Miss rate	Correct Rejection
8	56

The sensitivity, specificity and predictive efficiency of a combined screening program were also computed i.e., criterion IV where a subject was considered fail if he failed either II or HI. The results are summarized in Table 4. The sensitivity of criterion was found to be 97.6% i.e., it identified 98% of subjects hearing loss. Specificity was 62.06%, which means that it identified around 62% normal subjects. The predictive efficiency was 77%.

Table 4: Response Matrix for Sensitivity and specificity of criterion IV

Hit rate	False Alarm
41	22
Miss rate	Correct rejections
1	36

Table 5 shows the results of criterion V where a subject was considered as fail if he failed in both criteria II & HI. The sensitivity, specificity and the predictive efficiency were found to be 80.9%, 98.2% and 91% respectively.

Table 5: Response matrix for Sensitivity and specificity of criterion V

Hit rate	False alarm
34	1
Miss rate	Correct rejections
8	57

The results show that criterion I showed the highest sensitivity whereas criteria III and V had the least sensitivity. However, criterion V showed the highest specificity and criterion I showed the least specificity. The predictive efficiency was found to be maximum for criterion V and least for criterion I. Table 6, summarizes the sensitivities, specificities and predictive efficiencies for all five criteria.

Table 6: Comparison of sensitivity, specificity and predictive efficiency of different criteria.

Criteria	Sensitivity	Specificity	Predictive efficiency
1	100%	20.06%	54%
II	97.6%	65.5%	79%
III	80.9%	96.5%	90%
Iv	97.6%	62.06%	77%
V	80.9%	98.2%	91%

Further, the data was categorized based on the degree of hearing loss using Clark (1981) classification. Table 7 gives a summary of the sensitivity of the different criteria with reference to the degree of hearing loss. As shown in the table, criterion I was most sensitive to all degree of hearing impairment from minimal to profound. Criterion II was comparatively less sensitive for minimal loss but equally sensitive for other categories. The criterion III was found to be most sensitive for severe and profound hearing loss and least sensitive for minimal loss. Criterion IV was, again, less sensitive for minimal hearing loss and most sensitive for the rest of the categories.

Table 7: Sensitivities for different criteria for different degrees of hearing loss.

	I	**II**	**III**	**IV**	**V**
Minimal	100%	80%	60%	**80%**	60%
Mild	100%	100%	63.6%	100%	63.65
Moderate	100%	100%	87.5%	100%	87.5%
Moderately severe	100%	100%	90%	100%	90%
Severe	100%	100%	100%	100%	100%
Profound	100%	100%	100%	100%	100%

DISCUSSION

This study aimed at evaluating the efficiency of a "self assessment questionnaire" in screening, in terms of sensitivity and specificity, as compared with the traditional pure tone testing procedure. The results of the present study showed that a change of criterion in the pure tone screening affected the sensitivity and specificity directly. When all four frequencies were used the sensitivity was high (100%) and specificity was low (20.06%). The sensitivity, however, reduced to 97.6% and specificity increased to 65.5% when the lowest frequency was excluded from the criterion. This can be due to the ambient noise levels, which is generally more at low frequencies. Probably 500Hz should be screened at a higher intensity to overcome the effects of ambient noise. The predictive efficiency was highest for the combined approach i.e. criterion V (91%), closely followed by criterion III (90%) and least for criterion I (54%). The predictive efficiency for criteria II and IV was almost similar i.e.79% and 77% respectively.

The results indicate that the specificity was highest for criterion V i.e. 98.2%. This was followed by criterionIII, criterion II, criterion IV and criterion I. These results are in harmony with the results of the previous studies (Weinstein, 1986; Garestecki, 1987; Schow, Reese & Smedley, 1990).

The sensitivity of pure tone screening procedures was higher than self-assessment scale in this study. It was 100% when all four frequencies were used and 97.6% when only the three higher frequencies were used (criterion II). The sensitivity

of a combined procedure i.e. criterion IV was found to be equal to that of criterion II (97.6%), while sensitivity using the self report procedure as well as the combined procedure criterion V was comparatively less (80.9%). The results indicate that the specificity was highest when a combined approach was used with a lenient criterion and sensitivity was highest when only pure tones or a combined approach was used. These results are in accordance with those of Weinstein (1986).

High sensitivity of self-assessment scale suggests that there was a good correlation between scores of self-assessment scale and pure tone audiometry. This supports the results of study by Vanaja (2000) which indicated significant correlation between pure tone thresholds and self-assessed handicap. Previous research also reports similar results with other scales (High, Fairbanks and Glorig, 1964; Hawes and Niswander, 1985; Garestecki, 1987; Bess, Lichenstein& Logan, 1988). All these studies report a good correlation between the pure tone findings and the self-perceived handicap. Similar results were also obtained by Ventry and Weinstein (1982) using HHIE.

It was found in the present study that the self-assessment questionnaire had a comparatively higher specificity and lower sensitivity. This has also been reported in a study done by Schow, Reese & Smedley (1990). They evaluated three different self-assessment scales and found that the specificity of these scales was consistently higher than the sensitivity. A good correlation between pure tone and self-assessment of handicap was established here also.

The self-assessment scale was highly sensitive to the higher degrees of hearing loss. The degree of hearing loss affects the self-perceived handicap. Earlier studies indicate that degree of loss has a greater effect on self-perceived handicap when the hearing loss is more than 55dBHL (Vanaja, 2000). Similar results were obtained in the present study as the scale was found to be comparatively less sensitive for minimal, mild and moderate degrees when compared to higher degrees.

Research also shows results, which are contradictory to those of the present study (Poltl & Hickson, 1990). A vast difference in sensitivity was obtained where pure tones were found to be much more sensitive than the self-assessment scale used i.e. the HHIE. This discrepancy can, however, be accounted for by the stringent criterion used for pure tone screening (pure tone average more than 25 dB HL in the better ear).

Another study by Mathews, Lee, Mills and Schum (1990) reports a low correspondence between the audiometric measures and the self-assessed hearing handicap. They have accounted for this low correspondence by variables like "exaggeration for monitory gains", "attention seeking" or "denial of hearing loss". However, most of the subjects in their study had a sloping hearing loss with mean threshold less than 55 dB HL at 4000 Hz. Therefore, the results of this study are consistent with those of the present study, which showed that the self-assessment scale is less sensitive below 55 dB HL.

Thus, it can be concluded that a self-assessment scale can be used for screening population, provided the sensitivity, and specificity of the scale in that particular population is fairly satisfactory.

SUMMARY AND CONCLUSION

Hearing impairment is a widely prevalent condition and detailed evaluation of each and every client becomes very difficult in a large population. Audiological screening has been the age-old way to overcome this problem. However, since pure tone screening requires equipment, the cost of screening program increases.

Self-reports are an answer to this. But before using any self-assessment questionnaire for screening, its sensitivity and specificity needs to be established. One self-assessment scale has been developed in the Indian context by Vanaja (2000). The present study was undertaken to find the sensitivity and specificity of a screening program using short form of this scale, pure tone screening and a combination of the two.

A total of 100 subjects were screened using the short form of the scale, pure tones at 500 Hz, 1000 Hz & 4000 Hz using 30 dB HL criterion and then a detailed audiological evaluation was carried out for each subject.

Sensitivity, specificity and predictive efficiency were calculated for each of the screening criteria. It was found that the sensitivity was the highest when pure tones were used and it was comparatively less for the self-assessment scale. However, the specificity was the highest for the self-assessment scale and comparatively lesser for the pure tone screening. Sensitivity and specificity was also calculated for a procedure, which used both pure tones and self report for screening. It was observed that the sensitivity and specificity, both were high for this procedure.

The following are the conclusions:

1) Since the self-assessment shows a good sensitivity and specificity, it can be used independently for screening.

2) However, if a combined procedure i.e. pure tone screening at 1 OOOHz, 2000Hz and 4000Hz along with the screening version of the self-assessment scale is used (criterion V), the sensitivity and specificity values increase. Hence, a combined procedure should be used wherever possible.

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APPENDIX I

ಪ್ರಶ್ನಾವಳಿ

ಕೇಸ್ ನಂ. : ತಾರೀಖು:

ಹೆಸರು : ವಯಸ್ಸು : ಲಿಂಗ:

ವಿಳಾಸ :

ವಾಸ : ಒಬ್ಬರೇ / ಕುಟುಂಬದವರೊಡನೆ / ನೌಕರಿಯಲ್ಲಿರುವವರು / ನಿವೃತ್ತಿ ಹೊಂದಿರುವವರು.

ಉದ್ಯೋಗ : ಈಗಿನ/ ನಿವೃತ್ತಿಯ ಮೊದಲು

ಮಾನ್ಯರೇ ,

ನಿಮ್ಮ ಶ್ರವಣದೋಷದಿಂದ ನಿಮಗೆ ವಿವಿಧ ಸಂದರ್ಭಗಳಲ್ಲಿ ಆಗುತ್ತಿರುವ ತೊಂದರೆಯನ್ನು ಗುರುತಿಸಲು ಈ ಪ್ರಶ್ನಾವಳಿಯನ್ನು ತಯಾರಿಸಲಾಗಿದೆ. ದಯವಿಟ್ಟು ಈ ಕೆಳಗಿನ ಸಂದರ್ಭಗಳಲ್ಲಿ ನಿಮಗೆ 'ಅನೇಕ ವೇಳೆ' (ಶೇಕಡ 75ಕ್ಕಿಂತ ಹೆಚ್ಚು ಸಮಯ) ಅಥವ 'ಕೆಲವು ವೇಳೆ' (25% - 50% ಸಮಯ) ತೊಂದರೆ ಇರುತ್ತದೆಯೋ ಅಥವಾ 'ಒಮ್ಮೊಮ್ಮೆ ಮಾತ್ರ' (25%ಕ್ಕಿಂತ ಕಡಿಮೆ ಸಮಯ) ತೊಂದರೆ ಇರುತ್ತದೆಯೋ ಎಂದು ತಿಳಿಸಿ. ಯಾವುದಾದರೂ ಸಂದರ್ಭವನ್ನು ನೀವು ಸಂಧಿಸದಿದ್ದರೆ 'ಸಂಬಂಧಪಟ್ಟಿಲ್ಲ' ಎಂದು ತಿಳಿಸಿ.

	ಅನೇಕ ವೇಳೆ	ಕೆಲವು ವೇಳೆ	ಒಮ್ಮೊಮ್ಮೆ
1. ನಿಮಗೆ ಈ ಕೆಳಕಂಡ ಸಂದರ್ಭಗಳ್ಲಿ ಮಾತು ಅರ್ಥ ಮಾಡಿಕೊಳ್ಳಲು ಕಷ್ಟವಾಗುತ್ತದೆಯೇ?			
i.6-8 ಅಡಿ ದೂರದಲ್ಲಿರುವ ಪರಿಚಿತ ವ್ಯಕ್ತಿಯೊಡನೆ ಸಂಭಾಷಿಸುತ್ತಿರುವಾಗ, ಅವರ ಮುಖ ಕಾಣದಿದ್ದರೆ			
ii.10-12 ಅಡಿ ದೂರದಲ್ಲಿರುವ ಕುಟುಂಬದ ಸದಸ್ಯರೊಬ್ಬರು ಮಾಮೂಲು ಧ್ವನಿಯಲ್ಲಿ ಮಾತನಾಡುವಾಗ (ಅವರ ಮುಖ ಗೋಚರಿಸದಿದ್ದರೆ)			
iii. ನಿಶ್ಶಬ್ದವಾದ ಕೊಠಡಿಯಲ್ಲಿ 6-8 ಅಡಿ ದೂರದಿಂದ ದೂರ ದರ್ಶನದ ಕಾರ್ಯಕ್ರಮವನ್ನು ಸಾಧಾರಣವಾದ ಧ್ವನಿಯಲ್ಲಿ ವೀಕ್ಷಿಸುವಾಗ.			
iv. ಇತರ ಶಬ್ದವಿರುವ (ಉದಾ :ಬೇರೆಯವರು ಮಾತನಾಡುತ್ತಿರುವುದು) ಕೊಠಡಿಯಲ್ಲಿ, 6-8 ಅಡಿ ದೂರದಲ್ಲಿರುವ ದೂರದರ್ಶನದ ಕಾರ್ಯಕ್ರಮವನ್ನು ಸಾಧಾರಣ ಧ್ವನಿಯಲ್ಲಿ ವೀಕ್ಷಿಸುತ್ತಿರುವಾಗ.			

	ಅನೇಕ ವೇಳೆ	ಕೆಲವು ವೇಳೆ	ಒಮ್ಮೊಮ್ಮೆ
v. ಮದುವೆ ಮನೆಯಲ್ಲಿ ನಿಮ್ಮ ಪಕ್ಕದಲ್ಲಿ ಕುಳಿತುರುವವರೊಡನೆ ಸಂಭಾಷಿಸುವಾಗ (ಅವರ ಮುಖ ಗೋಚರಿಸದಿದ್ದರೆ)			
vi. ನಿಮ್ಮ ಕಿವಿಯಿಂದ 6 ಅಂಗುಲ ದೂರದಿಂದ ಪಿಸು ಮಾತನಾಡಿದರೆ.			

2. ನಿಮಗೆ ಶ್ರವಣ ದೋಷವಿರುವುದರಿಂದ ಜನರೊಡನೆ ಮಾತನಾಡಲು ಹಿಂಜರಿಯುವಿರಾ?

3. ನಿಮಗೆ ಶ್ರವಣದೋಷವಿರುವುದರಿಂದ, ನೀವು ಜನರ ಗುಂಪಿನಲ್ಲಿರುವಾಗ ಏಕಾಂಗಿ ಎಂಬ ಭಾವನೆ ಬರುವುದೇ ?

4. ನಿಶಬ್ಧವಾದ ವಾತಾವರಣದಲ್ಲಿ 6-8 ಅಡಿ ದೂರದಿಂದ ನಿಮಗೆ ದೂರವಾಣಿಯ ಗಂಟೆ ಕೇಳಿಸುವುದೇ ?

5. ನಿಶಬ್ಧವಾದ ವಾತಾವರಣದಲ್ಲಿ 18-20 ಅಡಿ ದೂರದಿಂದ ಬಸ್ ಹಾರ್ನ್ ಕೇಳಿಸುವುದೇ?