Original Article

Hearing Loss amongst the Elderly in a Southeast Asian Population – A Community-based Study

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Abstract

Introduction: The aim of this study was to determine the prevalence of hearing loss amongst the elderly population attending community services in Singapore. The usefulness of the Hearing Handicap Inventory for the Elderly Screening version (HHIE-S) in detecting hearing loss was also investigated. Materials and Methods: Pure-tone audiometry was carried out on a randomly recruited cohort of people (n = 338) over 60 years old and who were attending rehabilitation and social day care services for senior citizens at St Luke's Elder Care centres located throughout the city. Prior to the hearing test, subjects were administered the HHIE-S questionnaire, which was translated into the language they were most conversant in. Results: The study cohort showed mean pure-tone average at speech frequencies (0.5, 1, 2 and 4 kHz; 4-frequency average hearing level [4FA HL]) of the subjects' better hearing ear that has worsened with age. The percentage of the elderly with disabling hearing impairment (4FA >40 dB HL) was 9.1% (60 to 69 years old), 22.0% (70 to 79 years old), 35.7% (80 years old and above). Across all age groups, males had significantly poorer thresholds at 4 kHz than females. When adjusted for the demographic profile of the country, the prevalence of hearing loss (4FA >25 dB HL) and disabling hearing impairment (4FA >40 dB HL) amongst the elderly in Singapore was 63.7% and 16.2%, respectively. We estimate that there are currently 422,000 elderly with hearing loss greater than 25dB HL and over 100,000 elderly with disabling hearing loss of over 40 dB HL. Of subjects with a disabling hearing impairment, only 7.5% used hearing aids. The use of self-reporting HHIE-S showed poor sensitivity in detecting hearing loss of various severities amongst the elderly. Conclusion: These data provide estimates of the prevalence and severity of hearing loss in older persons in Singapore and suggest that more can be done to help the elderly recognise, acknowledge and address hearing loss in the country.

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Key words: Audiology, Epidemiology, Geriatric, Hearing Aids, Singapore

Introduction

Presbycusis, or age-related hearing loss, is a common condition among the elderly and a burgeoning problem in societies with ageing populations such as Singapore. In the last 2 decades, the percentage of the elderly (aged 60 years and above) in Singapore's resident population has risen from 9.7% in 1995 to 17.9% in 2015.[1] The increase in life expectancy due to improvements in healthcare and standard of living means that there is a growing number of people with chronic conditions such as presbycusis. Presbycusis can impact quality of life by impairing communication, leading to poorer psychosocial functioning.[2] Additionally, epidemiologic research in the United States (US) has found an association between presbycusis and dementia.[3] This growing burden of presbycusis in the elderly is of concern, and it is imperative that countries facing ageing populations find ways to respond to these challenges.

Amongst Singapore's elderly population, there is only 1 published study carried out at a public hospital in 2004 which found that among 63 elderly patients of the geriatric medicine unit, 52 (83%) had hearing impairment worse than 30 dB HL.[4] There is no study that looks at hearing

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loss in the whole elderly population at a larger scale. Thus, the first aim of this study was to estimate the prevalence of hearing loss among the elderly in Singapore from a larger, non-hospital setting.

Standardised audiometric assessment is largely considered the gold standard in determining hearing loss in individuals. In prevalence studies however, standard testing may be difficult to carry out on a large scale, due to logistical and financial reasons. Another method utilised in epidemiological studies of disease prevalence is the use of self-report measures. Self-report measures, often in the form of questionnaires, can be reliable indicators of handicap. They are also quick and inexpensive to administer to a large group of study participants. The Hearing Handicap Inventory for the Elderly: Screening version (HHIE-S)[5,6] is one such instrument that assesses hearing loss. This questionnaire is a shortened version of the HHIE, and contains 10 questions regarding the effects of hearing impairment on emotional and social adjustments. The questionnaire has been shown to be a robust screening tool[7-9] in identifying elderly people who might benefit from audiological intervention. It has also been translated and used in different culture groups and countries.[10-13] In Singapore, the Health Promotion Board introduced the Functional Screening for Older Adults in the Community, a community health programme to detect and manage functional decline in the elderly population. As part of the screening protocol, the HHIE-S is used together with a Single Global Screening Question, "Do you or your family think that you may have hearing loss?" and audioscope testing to detect hearing loss in the elderly population.[14] However, the robustness of the HHIE-S has yet to be validated in the local population. The second aim of this study was to examine the sensitivity and specificity of this questionnaire in detecting hearing loss among the Singaporean elderly population.

Materials and Methods

Study Setting

St Luke's ElderCare Ltd is a non-profit organisation which provides rehabilitation and day care services for senior citizens. Since 2011, the organisation has been running 10 geographically dispersed centres across Singapore, with a diverse client pool of 1200 senior citizens. These clients live in their own homes but attend activities organised by the centres. The demographics of these clients form a representative sample of the elderly population in Singapore. The study was part of a community project organised by Temasek Polytechnic's School of Engineering and St Luke's ElderCare that offered hearing tests to senior citizens served by the respective ElderCare centres.

Participants

Nine out of 10 St Luke's ElderCare centres participated in the project. One centre (St Luke's Golden Years Centre) declined to participate. Written informed consent was obtained from all participants and the purpose of the study was explained to them. Participants (or their caregivers) had to fill in a form which screened for factors that might hinder their ability to provide accurate information, such as clinical dementia, neurological diseases or an inability to understand instructions. Individuals with any of the above conditions were excluded from the study. Only participants aged 60 years and above on the day of the hearing test were included in prevalence results analysis. The study was carried out over 2 days and participants consisted of the elderly who were attending the ElderCare centres during the study period.

Procedure

Pure-Tone Audiometry

Pure-tone audiometry was conducted on each participant using 3 Siemens SD28 diagnostic audiometers. The audiometers had undergone acoustic calibration by an external vendor 1 month prior to the study to ensure that the accuracy of the audiometers are within the tolerances permitted by American Standard Specification for Audiometers, S3.6-1969. As soundproof booths were not available at the centres, EARTONE 3A insert earphones were used for testing and were covered by 3M Peltor supra-aural earmuffs to attenuate ambient noise. This method allows for accurate threshold determination down to 0dB HL for 125-8000 Hz,[15] provided that ambient noise is not more than 40 dBA. The hearing tests were carried out in a quiet room and an Integrating Class 1 sound level meter (Model 1900; 3M Quest Technologies, Wisconsin, USA) was used to ensure that the ambient noise level was less than 40 dBA. The tests were performed by 3 students from Temasek Polytechnic, who had completed training equivalent to the Ministry of Manpower-accredited basic industrial audiometry course. The audiometers' proper functions were confirmed at the start of each day before audiometry was carried out. Air conduction thresholds were obtained for both ears at 0.5, 1, 2, and 4 kHz. These 4 frequencies were chosen as they covered the range of speech sounds. The average of the thresholds at these 4 frequencies was then calculated for each ear, and the better hearing ear (the ear with the lower average thresholds) was chosen for the final analysis. The average threshold for 0.5, 1, 2 and 4 kHz in the better hearing ear is referred to as the 4-frequency average (4FA).

Hearing levels of 25 dB and 40 dB are often used as screening criteria for mild and moderate hearing losses.[16] For the purposes of this analysis, we defined hearing

Table 1. Breakdown of Study Subjects by Centre Location

No.	ElderCare Centre (n = 338)	Male (n = 125)	Female (n = 213)	Min. Age (Years)	Max. Age (Years)
1	Serangoon	21	44	60	90
2	Yishun	8	24	60	90
3	Bukit Timah	3	15	61	88
4	Hougang	19	34	61	91
5	Tampines	26	37	61	94
6	Ayer Rajah	5	8	63	81
7	Jurong East	12	20	63	96
8	Whampoa	15	11	61	96
9	Telok Blangah	16	20	61	93

Table 2. Comparison between Study Subjects and Target Population

Age (Years)	*P* Value		Population		*P* Value for χ^2 Test
	For χ^2 Test (n = 338)	%	No. ('000)	%	
60 – 64					
Male	15	41.7%	110.2	49.6%	0.87
Female	21	58.3%	111.9	50.4%	
65 – 69					
Male	12	40.0%	70.5	48.4%	0.87
Female	18	60.0%	75.3	51.6%	
70 – 74					
Male	22	40.0%	48.7	46.0%	0.90
Female	33	60.0%	57.1	54.0%	
75 – 79					
Male	24	38.1%	31.2	44.1%	0.90
Female	39	61.9%	39.5	55.9%	
80 – 84					
Male	32	38.1%	18.6	40.3%	0.96
Female	52	61.9%	27.6	59.7%	
≥85					
Male	20	28.6%	11.9	33.1%	0.92
Female	50	71.4%	24.1	66.9%	

impairment as having a 4FA of >25 dB HL. Disabling hearing impairment was defined as having a 4FA of greater or equal to 40 dB HL.

Questionnaire

The questionnaire administered consisted of 2 parts and was administered verbally. The first contained questions from the HHIE-S. Developed as a diagnostic tool to identify older people with hearing difficulties, the HHIE-S consists of 10 questions designed to assess perceived emotional and social problems associated with impaired hearing (e.g. frustration, embarrassment or difficulty in certain situations). One of 3 responses ("yes", "sometimes" or "no") was recorded for each question and scored as 4, 2, or 0, respectively. Missing values were excluded and scores from the 10 questions were totalled for a minimum score of 0 and a maximum score of 40. According to guidelines by the American Speech-Language Hearing Association (ASHA), scores of >8 indicate the presence of a hearing handicap.[15] This cutoff point was used to validate the usefulness of the HHIE-S instrument in predicting hearing loss measured using pure-tone audiometry measurements. For non-English speakers, the HHIE was translated to Chinese[11] as well as various Chinese dialects and Malay. The second part of the questionnaire pertained to the use of hearing aids.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) Version 12.0 for Windows (SPSS Inc., 2003), with a *P* value of <0.05 taken to be significant for all tests. In addition to descriptive statistics, analysis of variance (ANOVA) was used to analyse the results of the pure-tone audiometry. The screening performance of the HHIE-S was separately assessed for sensitivity, specificity, positive and negative predictive values. The difference between measured and estimated prevalence was also obtained.

Results

A total of 366 people aged above 60 participated in the hearing tests at the various centres; 28 of them were excluded either due to suspected or confirmed clinical dementia, or neurological disorders. A breakdown of the 338 subjects included in the final analysis is shown in Table 1.

Comparison of Study Cohort to Local Population

A comparison of this study cohort to the local population over 60 years of age is shown in Table 2. The proportion of males and females in the study cohort was not significantly different to that of the local population for all age groups.

Prevalence of Hearing Loss

The 4FA of the participants stratified by age and gender is shown in Table 3. The mean 4FA for the whole cohort ranged from 20.5 dB HL to 52.4 dB HL. One-way ANOVA showed

Table 3. Pure-Tone Threshold Average (4FA) Stratified by Age Groups and Sex

Age (Years)	n = 338	4FA (dB HL)			
		Mean	SD	Min.	Max.
60 – 64					
Male	15	29.7	15.1	13.75	62.5
Female	21	20.5	9.6	5.0	42.5
Total	50.1	24.3	12.8	5.0	62.5
65 – 69					
Male	12	32.9	9.8	21.25	55.0
Female	18	23.4	8.4	8.75	38.8
Total	56.3	27.2	10.0	8.75	55.0
70 – 74					
Male	22	37.6	14.8	15	65.0
Female	33	35.7	12.6	15.0	66.3
Total	73.3	36.5	13.4	15.0	66.3
75 – 79					
Male	24	40.7	16.8	21.25	82.5
Female	39	37.5	13.5	8.75	73.8
Total	78.2	38.7	14.8	8.75	82.5
80 – 84					
Male	32	45.0	15.7	20	101.3
Female	52	41.2	15.5	21.3	90.0
Total	86.2	42.6	15.6	20.0	101.3
≥85					
Male	20	52.4	13.0	22.5	83.8
Female	50	45.9	11.4	23.75	71.3
Total	98.2	47.7	12.1	22.5	83.8
All					
Male	238.3	41.1	16.1	13.75	101.3
Female	204.1	37.2	15.0	5	90.0
Total	78.3	38.6	15.5	5	101.3

4FA: Four-frequency average of 0.5, 1, 2 and 4 kHz; SD: Standard deviation

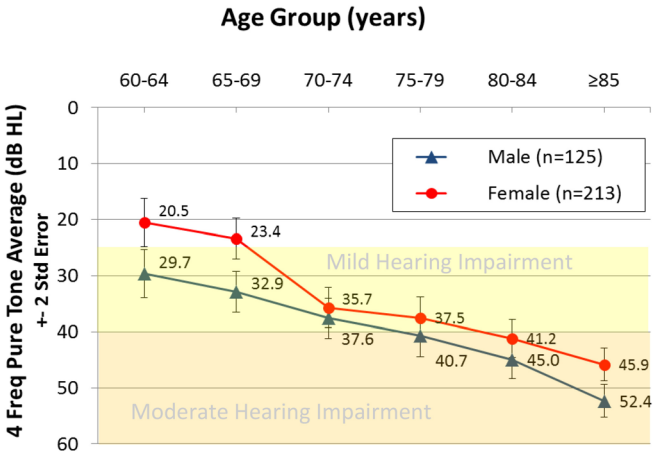

Fig. 1. The difference in 4FA thresholds between genders at various age groups.

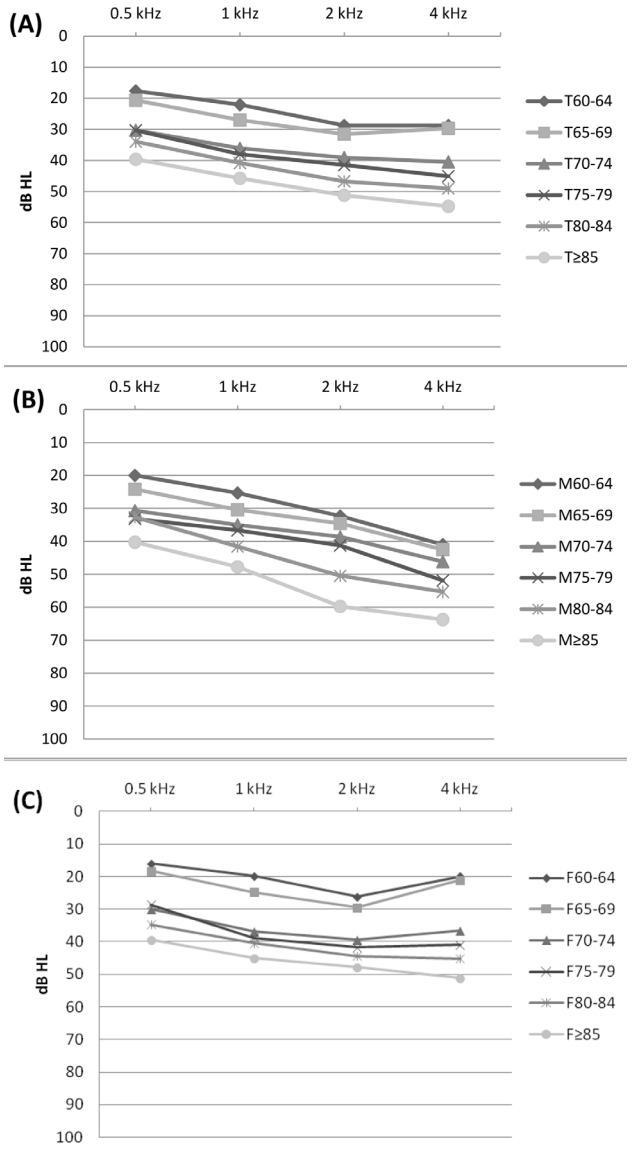

Fig. 2. Average threshold at each frequency, stratified by age groups, for A) total study cohort, B) males, and C) females.

that the mean hearing thresholds increased significantly with age in the total study cohort, as well as for both males and females. The mean hearing thresholds for male subjects was also poorer than that of female subjects. This difference is significant in the all age groups (with the exception of the 70 to 74 age group). The mean 4FA thresholds between genders at various age groups are illustrated in Figure 1.

Table 4 shows the mean pure-tone thresholds for each of the 4 frequencies, grouped by gender and age. At 4 kHz, the male subjects had significantly higher thresholds than female subjects (P <0.0001). There was no statistically significant difference in mean thresholds between the genders at other frequencies. As illustrated in Figure 2, the

Table 4. Comparison of Mean Pure-Tone Thresholds (dB HL) in the Better Ear for Males, Females and Total Subjects

Age (years)	n = 338	0.5 kHz			1 kHz			2 kHz			4 kHz		
		Mean	SD	*P* Value	Mean	SD	*P* Value	Mean	SD	*P* Value	Mean	SD	*P* Value
60 – 64													
Male	15	20.0	15.4	0.210	25.3	11.7	0.121	32.3	18.0	0.226	41.0	28.7	0.010*
Female	21	16.0	10.3		19.8	9.3		26.2	11.9		20.0	17.7	
Total	36	17.6	9.4		22.1	10.6		28.8	14.9		28.8	24.9	
65 – 69													
Male	12	24.2	9.7	0.108	30.4	10.5	0.151	34.6	13.2	0.232	42.5	12.3	0.001*
Female	18	18.3	9.2		24.7	10.2		29.4	9.8		21.1	18.3	
Total	30	20.7	9.7		27.0	10.6		31.5	11.4		29.7	19.2	
70 – 74													
Male	22	30.7	17.7	0.875	35.0	15.1	0.643	38.6	16.0	0.849	46.1	18.8	0.065
Female	33	30.0	14.3		36.8	13.5		39.4	13.2		36.7	17.9	
Total	55	30.3	15.6		36.1	14.1		39.1	14.2		40.5	18.7	
75 – 79													
Male	24	33.1	18.4	0.269	36.7	17.5	0.605	41.3	18.7	0.922	51.9	18.3	0.018*
Female	39	28.6	13.8		38.8	15.3		41.7	14.8		40.9	16.7	
Total	63	30.3	15.7		38.0	16.1		41.5	16.3		45.1	18.0	
80 – 84													
Male	32	32.7	12.8	0.551	41.6	15.4	0.749	50.5	20.6	0.166	55.3	21.0	0.021*
Female	52	34.7	16.6		40.4	16.9		44.4	18.4		45.1	18.0	
Total	84	33.9	15.2		40.8	16.3		46.7	19.4		49.0	19.7	
≥85													
Male	20	40.3	14.5	0.811	47.8	12.0	0.405	59.8	21.2	0.008*	63.8	14.3	0.001*
Female	50	39.4	13.0		45.0	12.6		47.8	14.1		51.2	13.4	
Total	70	39.6	13.3		45.8	12.4		51.2	17.2		54.8	14.7	
All													
Male	125	31.3	15.4	0.753	37.4	15.7	0.927	44.4	20.4	0.080	51.4	20.6	0.000*
Female	213	30.7	15.6		37.3	15.9		40.9	16.2		40.0	19.6	
Total	338	30.9	15.5		37.3	15.8		42.2	17.9		44.2	20.7	

SD: Standard deviation

*Indicates statistically significant difference between the mean hearing thresholds of males and females within each category.

male participants of this study cohort showed a worsening of thresholds with increasing frequency, a trend which was not observed in the female participants.

The prevalence of hearing loss in the study cohort, stratified by age groups, is shown in Table 5. Overall, the prevalence of each category of hearing loss increased with age. The percentage of subjects with a hearing impairment (4FA >25 dB HL) was 48.5% for subjects aged 60 to 69 years, 82.2% for subjects aged 70 to 79 years and 93.5% for subjects aged 80 years and above. The percentage with a disabling hearing impairment (4FA >40 dB HL) for subjects aged 60 to 69 years, 70 to 79 years and above 80 years were 9.1%, 22.0% and 35.7%, respectively. Among subjects with a disabling hearing impairment, only 7.5% (10 out of 133 subjects) used hearing aids.

After adjusting for the demographic profile of the population, the prevalence of hearing loss (4FA >25 dB HL) and disabling hearing impairment (4FA >40 dB HL) among Singapore residents aged 60 and older was found to be 63.7% and 16.2%, respectively. Although there was a larger cohort of over 80-year-olds in our study than the general population, it is clear from our study that there is a significant hearing impairment problem in our elderly, even for those aged below 80. For example, just the group of 70 to 79 year olds alone had a 82.2% rate of hearing loss >25 dB and 22% rate of hearing loss >40 dB.

Table 5. Prevalence of Hearing Loss amongst the Elderly in Singapore

Age (Years)	% of Singapore's Elderly Population (a)	No. of Subjects Screened	Hearing Loss 4FA >25 dB HL		Disabling HL 4FA >40 dB HL		Marked HL 4FA >60 dB HL	
			No. of Subjects	Prevalence (b)	No. of Subjects	Prevalence (b)	No. of Subjects	Prevalence (b)
60 – 69	59.22%	66	32	48.5%	6	9.1%	2	3.0%
70 – 79	27.61%	118	97	82.2%	26	22.0%	7	5.9%
>80	13.16%	154	144	93.5%	55	35.7%	15	9.7%
All		338	273	80.8%	132	39.1%	30	8.9%
	Estimated National Prevalence = Σ(ai)x(bi)		63.7%		16.2%		4.7%	
	Estimated Number of Elderly		422,547		107,222		31,265	

4FA: Four-frequency average of 0.5, 1, 2 and 4 kHz

HHIE-S

The findings of the HHIE-S are summarised in Table 6, which shows the performance of each tool in detecting any hearing loss (4FA >25 dB), disabling hearing impairment (4FA >40 dB HL) and marked hearing impairment (4FA >60 dB) in the study cohort. In summary, the HHIE-S was found to be a poor predictor of hearing loss. However, the HHIE was a good predictor of hearing aid use (Table 7).

Discussion

Across the world, the prevalence of hearing loss in the elderly varies depending on the country, sample size, age definition of elderly and the audiometric criteria for hearing loss employed. The type of society one lives in also affects hearing loss, as industrialised societies have been shown to accelerate hearing loss with age compared to agrarian societies.[17,18] Such differences make the rates of hearing loss somewhat difficult to compare. Nevertheless, it is clear that across the world, a significant proportion of elderly people suffer from hearing loss. Table 8 displays the estimated prevalence of hearing loss for several different studies around the world.

Our study attempted to estimate the prevalence of hearing loss amongst the elderly population in Singapore. Based on the randomly-recruited cohort of the elderly living outside institutionalised care, a high percentage of them had some form of hearing impairment. When adjusted for the demographic profile of the country, the prevalence of hearing loss (4FA >25 dB HL) and disabling hearing impairment (4FA >40 dB HL) amongst the elderly in Singapore was 63.7% and 16.2%, respectively.

Table 6. Sensitivity, Specificity, PPV and NPV Values of the HHIE-S Questionnaire in Predicting Hearing Loss

Measured Hearing Impairment (Audiometry)	Hearing Loss PTA >25 dB HL	Disabling Hearing Loss PTA >40 dB HL	Marked Hearing Loss PTA >60 dB HL
Quantity (%)	273 (80.8%)	132 (39.1%)	30 (8.9%)
HHIE-S (≤8 or >8)			
PPV	94.3%	37.3%	10.1%
NPV	25.4%	77.1%	96.5%
Sensitivity	36.6%	47.7%	63.3%
Specificity	90.8%	68.6%	64.0%

HHIE-S: Hearing Handicap Inventory for the Elderly Screening version (HHIE-S); NPV: Negative predictive value; PTA: Pure-tone average; PPV: Positive predictive value

Table 7. Sensitivity, Specificity, PPV and NPV Values of the HHIE-S Questionnaire in Predicting Hearing Aid Use

	Wearing Hearing Aid (n = 132)
Quantity (%)	10 (7.5%)
HHIE-S (≤8 or >8)	
PPV	13%
NPV	97%
Sensitivity	80%
Specificity	56%

HHIE-S: Hearing Handicap Inventory for the Elderly Screening version (HHIE-S); NPV: Negative predictive value; PPV: Positive predictive value

Table 8. The Prevalence of Hearing Loss in the Elderly in Different Countries

Authors	Year	Country	Sample	n	Age Criteria (Years)	Frequencies (kHz) Measured	PTA Criteria	Percentage of Hearing Loss (>25 dB HL)	Percentage of Disabling Hearing Loss (>40 dB HL)
Gates GA et al*	1990	United States of America	Framingham Cohort	1662	63 – 95	0.5, 1, 2, 3	Better ear	42%	-
Lin FR et al†	2011	United States of America	National Health and Nutritional Exam Survey 2005 – 2006	717	48 – 92	0.5, 1, 2, 4	Better ear	44.80%	16.50%
Sindhusake D et al‡	2000	Australia	Blue Mountains	2015	55 – 100	0.5, 1, 2, 4	Better ear	39.10%	13.40%
Davis A§	1995	United Kingdom	National Study of Hearing (1980s)	2663	65 – 74	0.5, 1, 2, 4	Better ear	60%* (>20 dB)	20%* (>35 dB)
Hong JW et al‖	2015	Korea	2010 – 2012 Korea National Health and Nutrition Exam Survey	3562	>65	0.5, 1, 2, 3, 4, 6	Better ear	69.70%	35.1
Rosdina A et al¶	2010	Malaysia	Patients attending a primary care facility	111	>60	0.25, 0.5, 1, 2, 4	Better ear	36.90%	10.80%
Chang HP et al#	2007	Taiwan	Randomly-recruited cohort in Taipei	1221	>65	0.5, 1, 2, 4	Better ear	99.00%	52.70%
Lee GJC et al**	2017	Singapore	The elderly attending community aged care services	338	>60	0.5, 1, 2, 4	Better ear	63.70%	16.20%

PTA: Pure-tone audiometry

*Gates GA, Cooper JC Jr, Kannel WB, Miller NJ. Hearing in the elderly: the Framingham cohort, 1983-1985. Part I. Basic audiometric test results. Ear Hear 1990;11:247-56.

†Lin FR, Thorpe R, Gordon-Salant S, Ferrucci L. Hearing loss prevalence and risk factors among older adults in the United States. J Gerontol A Biol Sci Med Sci 2011;66:582-90.

‡Sindhusake D, Mitchell P, Smith W, Golding M, Newall P, Hartley D, et al. Validation of self-reported hearing loss. The Blue Mountains Hearing Study. Int J Epidemiol 2001;30:1371-8.

§Davis A. Hearing in adults: the prevalence and distribution of hearing impairment and reported hearing disability in the MRC Institute of Hearing Research's National Study of Hearing. London: Whurr Publishers Limited; 1995.

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When compared to other large scale epidemiological studies done around the world, the local findings for the measured prevalence of hearing loss (4FA >25 dB HL) was higher than the US and Australia but lower than that of the Asian countries of Korea and Taiwan.

When we compared the prevalence of hearing loss >40 dB HL, our estimates of about 16.2% was quite consistent with the findings of other large scale studies carried out in developed countries (Table 8). When an individual's pure-tone average (PTA) is greater than 40 dB HL, his/her hearing is outside the audible range of some speech sounds. Such a hearing loss is significant enough to impact day-to-day communication. The World Health Organization (WHO) termed PTA >40dB HL as disabling hearing loss. In 2012, WHO released estimates on the magnitude of disabling hearing loss among the elderly aged 65 years and above based on 42 population-based studies.[19] Their estimates ranged from 32.8% for global average and 18.4% for high income nations. The prevalence found in our study puts us at the lower end of the range.

To put into perspective the magnitude of the health problem affecting our nation, based on the recent population data of Singapore, we estimated that there are currently 422,000 elderly with hearing loss greater than 25 dB HL and over 100,000 elderly people with disabling hearing loss of over 40 dB HL. According to current demographic projections, the numbers are expected to double in 15 years by 2030.[1] These numbers confront the challenges currently existing in

developing countries in providing affordable and accessible hearing healthcare. Given the prevalence of hearing loss in older adults, the growing demands for quality audiological services need to be adequately managed.

When comparing hearing levels between male and female participants, we found that the 4FA of male subjects were poorer than that of female subjects in all age groups. In particular, at 4 kHz, male subjects showed significantly higher thresholds than female subjects. Diminished hearing at 4 kHz is commonly associated with noise exposure. In addition to presbycusis, it is likely that there is an occupational noise-induced hearing loss (NIHL) component in males of our study cohort. Studies have shown that noise exposure alters the way ears age, and can accelerate the rate of ageing of the cochlea.[20,21] Even after the noise exposure ceases, there can be subsequent neurodegeneration that contributes to a variety of abnormal auditory perceptions. NIHL has been found to affect males at a higher rate than females, at a 3:1 ratio in the general population.[22] This could be due to men who have traditionally participated in higher noise risk activities and held occupations that had higher noise risk. The significant difference between the male and female hearing thresholds suggests the cumulative long-term effects of excessive noise. Despite the stringent laws put in place to protect the hearing of our workers, noise-induced deafness has been the top reportable occupational health disease each year since the 1970s.[23] Besides occupational noise, the use of firearms during mandatory military service, as well as recreational activities such as listening to music from portable music players, are other sources of noise risks in our population. Recently, it was found that 1 in 6 youths in Singapore are at risk of developing noise-induced deafness due to the use of portable music players.[24] Noise-induced hearing loss is entirely preventable. More efforts can be directed to educate and protect the hearing of our population.

As the study did not include an examination of the ears before the hearing test, it is conceivable that conditions such as accumulated ear wax may have contributed to an overestimation of the severity of the hearing loss. However, this study still reflects the actual hearing loss rate of the elderly in the community, whether due to presbyacusis or other reversible conditions.

Despite the fact that hearing impairment can have significant adverse effects on the emotional and social well-being of older persons,[2,25] not all elderly subjects are willing to take up hearing aids. In our study, among subjects with a disabling hearing impairment, only 7.5% (10 out of 132 subjects) used hearing aids. It is not clear from our study whether this was due to subjects being unaware of such intervention or if this was due to an outright rejection of hearing aids. It would be important to further analyse the reason for this low usage in future studies.

Nonetheless, the hearing aid ownership percentage is far lower than that found in other studies. In Taiwan, a community-based study showed that of subjects with a clinically evident hearing impairment (≥55 dB HL), only 18.4% used hearing aids.[26] In the US, only about 10% of people with mild hearing impairment and 40% of people with moderate to severe hearing impairment used hearing aids.[27] An Australian study[28] showed that of the 33% of elderly that had hearing impairment, only 11% owned a hearing aid.

A study carried out in Singapore looked into the attitudes of the elderly towards hearing aids, and found that only 33.3% responded positively to the suggestion of hearing aid use. The reasons given by the rest who were not keen to consider using hearing aids were that hearing aids were inconvenient (34%), expensive (34%), difficult to use (10%), they did not need them since they were already old (10%), or could still cope without them (23%).[4] A study conducted in Australia[29] found that multiple factors could influence a person's willingness to take up hearing aids. These include age (in this study, older people were more likely to use hearing aids), perceived severity of hearing loss and the level of support from their significant other. The participants were more likely to consider hearing aids when they found that there were more benefits than barriers to amplification, and when they were convinced that hearing aids would not be negatively perceived by others.

The cost of hearing aids can be a major deterrent, given that many of the senior citizens are retirees. In Asian populations where the elderly are often cared for by their children, it is common for them to refuse hearing aids because they do not want to trouble their children with additional financial burden. At the time of this study, hearing aid subsidies for senior citizens were not yet available. In March 2013, the Senior Mobility Fund was reviewed and expanded to provide a 90% subsidy for hearing aids to eligible seniors. This has significantly reduced the cost of hearing aid ownership and helped improve accessibility for the financially needy elderly. However, the impact of this hearing aid subsidy has yet to be assessed.

Over the last 4 years, there is growing evidence that hearing impairment is independently associated with a 30% to 40% rate of accelerated cognitive decline.[30] Individuals with mild, moderate and severe hearing impairment have a 2-, 3- and 5-fold increased risk of dementia over a 10-year follow-up period.[3] The use of hearing devices can provide increased auditory stimulation, promote social engagement and lessen cognitive load;[31] the risk of cognitive decline and dementia could potentially be reduced through the use of hearing devices, as demonstrated by the results of observational epidemiologic studies.

Our data suggests that more can be done to educate our population on hearing loss and hearing aid use. A challenge pertaining to current primary care remains. For the general practitioner who may be confronted with an older adult patient in clinic, hearing impairment is seen as secondary in the face of more pressing clinical issues. Many doctors will only address the patient's hearing difficulty when the patient or family member is persistent in bringing it to the clinician's attention. A more proactive approach needs to adopted, given that most patients do not understand the importance of hearing, unless spurred by their doctor. While the benefits of using a hearing aid should be carefully explained so that people can have a good appreciation of its benefits, the consequences of going without it should also be explained, for instance, the social and emotional impact of hearing loss and its association with cognitive decline in the elderly. Ideally, all those with hearing impairment (regardless of their initial feelings towards a hearing aid), should have a trial run of using a hearing aid to determine if they find it useful.

The HHIE-S is a well validated instrument for hearing loss screening. Studies testing the accuracy of this screening questionnaire have found that the sensitivity ranges from 36% to 72% and the specificity ranges from 78% to 92% [32,33] depending on the population. In the Blue Mountains Hearing Study conducted in Australia, researchers did a population study of 2015 elderly living in the west of Sydney. This study aimed to validate the HHIE-S against hearing loss measured by pure-tone audiometry. They found that the questionnaire yielded a sensitivity and specificity of 80% and 76%, respectively, in detecting disabling hearing loss. The study concluded that the HHIE-S was sensitive and specific enough to provide reasonable estimates of hearing loss prevalence in older adults. Interestingly, in another study by Rosis et al[34] the HHIE-S questionnaire showed low sensitivity (23.5%) and high specificity (73.7%) when the study population consisted of subjects who attended the audiological clinic. However, when the HHIE-S was administered to patients from the Geriatrics Clinic, the sensitivity was 94.7% and specificity was 75%. The study concluded that the HHIE-S questionnaire is a screening instrument that has high sensitivity and specificity in identifying hearing loss in elderly people who seek healthcare services not related to hearing disorders. In this study, the clinical setting in which the questionnaire was administered influenced the accuracy of the screening test. Self-report measures can be accurate and cost-effective screening tools for hearing loss in place of audiometric tests.

Although the HHIE-S has been accepted internationally as a useful tool for hearing loss screening in the elderly, its use in an Asian context such as Singapore has not been well validated. The accuracy of the HHIE-S may also be affected by societal differences. In our study, the sensitivity and specificity of the HHIE-S questionnaire for hearing loss >25dB HL are 36.6% and 90.8%, respectively. When tested against its performance in screening for disabling hearing impairment >40dB HL, the HHIE-S showed a sensitivity and specificity of 48% and 69%, respectively. In contrast, the Blue Mountains Hearing Study found that the questionnaire was 80% sensitive and 78% specific in detecting 4FA >45 dB HL.

The low sensitivity suggests that HHIE-S may not be the best hearing screening questionnaire for the elderly in our population. It is possible that many elderly in our society lack insight into their hearing impairment. They belong to a generation born pre-World War II or pre-independence. With more than 80% of Singapore's elderly having below secondary education, many of them had lived through difficult economic situations and thus, developed a stoic but resilient attitude towards life, resulting in a tendency to play down their inconveniences. For example, when asked, "Does your hearing difficulty make you embarrassed when you talk to strangers?" and "Does your hearing difficulty make it frustrating to talk to others in your family?", many of the elderly subjects answered in the negative despite having 4FA >40 dB HL. Cultural differences may also limit the usefulness of this questionnaire in the local Asian population. For example, a question in the HHIE-S, "Does a hearing problem cause you to attend religious services less often than you would like?", may not be applicable to a typical family.

In fact, the study by Wu et al employed a differently designed questionnaire because the researchers felt that the HHIE-S was not appropriate for local elderly patients, many of whom lead sedentary lifestyles. Their questionnaire reported a higher sensitivity (73%) but a lower specificity (64%).[4] However, it must be noted that this study looked specifically at outpatient and inpatient elderly patients, rather than in a community setting. It is interesting however, when the HHIE-S was analysed to predict hearing aid usage amongst those with disabling hearing impairment, the HHIE-S showed a 80% sensitivity and 97% NPV (Table 7). This seems to suggest that an individual's perception of his/her own hearing difficulty is a good indicator of eventual hearing aid use and benefit. It is clear that further work needs to be done in designing a questionnaire that may be reliably employed as a screening instrument for hearing impairment in Singapore's elderly population.

Conclusion

This study provides estimates on the prevalence and severity of hearing loss in older persons in Singapore. The numbers reinforce the need to develop affordable and

accessible approaches toward hearing healthcare. General practitioners and other healthcare providers can play an important role in educating the elderly and their families on the benefits of hearing aids. The HHIE-S demonstrates high specificity but low sensitivity for hearing impairment in our local community and further studies have to be done to identify a reliable screening instrument for hearing impairment in our local aged population.

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