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Changing Patient Profile, Hearing Aid Use and Disability among First-time Hearing Aid Users in Singapore over a Decade

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List of Abbreviations:

BTE	Behind the ear
CIC	Completely in the canal
HAE	Hearing aid evaluation
HAF	Hearing aid fitting
ITC	In the canal
ITE	In the ear
PHAF	Post hearing aid fitting
RIC	Receiver in canal

Abstract

Objectives

To examine the time trends in demographics, hearing characteristics, hearing aid (HA) choices, usage and patient-reported disability among first-time HA users in Singapore over a decade.

Design

Cross-sectional study.

Study Sample

1052 subjects issued with HAs at a tertiary hospital from 2004 to 2013

Results

An increase in number of first time HA users were seen from 2004 to 2013. Although mean age did not change significantly, the proportion of older adults (> 80 years) being fitted increased (p for trend = 0.033). Inflation adjusted cost of HAs rose over time (p < 0.001 for trend). Bilateral HA uptake increased (Adjusted odds ratio [AOR] = 1.58 (95% Confidence Interval [CI] 1.35–1.85) while use of customisable HAs decreased (AOR = 0.74, 95% CI 0.66–0.84) over the period. A decrease in the proportion of subjects reporting 5 or more disabilities (AOR = 0.45, 95% CI 0.34–0.59) and using their HAs > 7 hours daily (AOR = 0.45, 95% CI 0.34–0.59) was seen.

Conclusion

From 2004 to 2013, there was a positive trend towards HA uptake in Singapore. Bilateral HA uptake increased while customizable in ear type of HA use decreased. While hearing disability showed a decreasing trend, HA usage remained suboptimal.

Article

Background

The 2016 Global Burden of Disease study found hearing loss (HL) to be the third leading cause of years-lived-with-disability (YLDs) globally. Over 1.27 billion people with varying degrees of HL worldwide share 36.3 million YLDs which accounts for 4.5% of all YLDs (Vos et al., 2017).

The World Health Organisation defines adult disabling HL as having a pure tone audiogram (PTA) 4-frequency (0.5 kHz, 1 kHz, 2 kHz & 4 kHz) threshold average > 40 dB in the better hearing ear (World Health Organization, 2020). Over 5% of the world's population or 466 million people suffer from disabling HL (World Health Organization, 2020). rising sharply to 30% among older adults with the majority from South Asia, Asia Pacific and Sub-Saharan Africa (World Health Organization, 2018).

Untreated HL is associated with impaired communication (Hallam, Ashton, Sherbourne, & Gailey, 2008; Kamil & Lin, 2015), negative physical status (F. R. Lin & Ferrucci, 2012), depression (Li et al., 2014), social isolation (Mick, Kawachi, & Lin, 2014), negative effects on caregivers (Kamil & Lin, 2015; Wu, Chin, & Tong, 2004) and increased risk of accidental injuries (H. W. Lin, Mahboubi, & Bhattacharyya, 2018). The global annual social-economic costs of disability and handicap from untreated HL is estimated to be USD 750 billion (World Health Organization, 2018).

The 2017 Lancet Commission into dementia found that HL was the single most important modifiable risk factor for dementia. Treating HL can potentially reduce new dementia cases by one quarter (Livingston et al., 2017). Another study found that those with mild, moderate and severe HL were up to 2, 3 and 5 times more likely than normal individual to develop

dementia respectively (F. R. Lin et al., 2011).

Hearing Aid (HA) use can reduce hearing disability; improve social functioning and employment opportunities (Joore, Brunenberg, Chenault, & Anteunis, 2003), improve cognition (Dawes et al., 2015), and lower the risk of depression (Choi et al., 2016; Mener, Betz, Genther, Chen, & Lin, 2013).

Singapore is a multi-ethnic South East Asian country with a population of 5.6 million and a median age of 40 years (Singapore Department of Statistics, 2018). Despite being a high income nation by WHO criteria (World Health Organisation, 2012), HA uptake and usage in Singapore are suboptimal. The 2010 Singapore National Health survey found that only 3.3% of adults with disabling HL wore a HA (Ministry of Health Singapore, 2011). This was low compared to 11% in Australia (Hartley, Rochtchina, Newall, Golding, & Mitchell, 2010) 14.1% in Japan (EHIMA, 2012), 14.3% in the US (Chien & Lin, 2012), and 18.4% in Taiwan (for patients with HL ≥ 55 dB) (Chang & Chou, 2007), to 38.6% in the UK (EHIMA, 2009).

A recent study found Singapore residents first sought help for their HL at a mean age of 70 years and over half of them had already developed moderately-severe HL at first presentation (> 55 dB). Even though more than 85% used their HAs more than 4 days a week, only a third used their HAs for more than 7 hours per day (Ho, Zhang, et al., 2018). Age, ethnicity and type of HL were important determinants for more severe HL at first HA fitting while younger age and worse hearing were determinants of regular HA use. Nearly a third of subjects of Malay ethnicity already had severe HL (> 70 dB) at first presentation and were twice as likely as Chinese, and thrice as likely as Indian subjects to present with severe HL of their better ear. Even though 98.0% of patients had bilateral HL, only 18% were fitted with bilateral

HAs, with younger patients more likely to opt for them. (Ho, Ong, et al., 2018).

Similar to many developed countries, Singapore's population is fast ageing while fertility rates are declining. The proportion of elderly (> 65 years) is projected to rise from 14% in 2015, to 32% in 2035, and a sobering 47% by 2050 (United Nations, 2013). Not only will there be a dramatic increase in the number of individuals with HL, but the number of people with dementia will increase by more than 5 fold (from 2015 to 2050) to hit a quarter of a million people (Alzheimer's Disease International, 2015). Prevalence of dementia increases rapidly above the age of 65, with population prevalence in Europe hitting 22.5% in those aged ≥ 85 years (Niu, Álvarez-Álvarez, Guillén-Grima, & Aguinaga-Ontoso, 2017). A study from Singapore also found that individuals with HL were 2.3 times more likely to develop dementia or mild cognitive impairment. The same study also found that those already with dementia were 3.6 times more likely to have hearing impairment (Heywood et al., 2017).

Demographic shifts, evolving health care policies, socio-economic changes and, better awareness of hearing impairment and associated disability are likely to influence profile of HA users, hearing disability and HA usage over time. Understanding temporal trends in hearing can help guide policy makers plan strategic interventions to improve hearing health. To the best of our knowledge, there have been no previous studies examining such time trends in the South East Asian region.

Aims

This study sought to examine the time trends in demographics, hearing characteristics, HA choices, usage, and patient-reported disability among first-time HA users in Singapore from 2004 to 2013.

Methodology

A cross-sectional study was conducted on consecutive subjects who had their first HA fitted at the audiology unit in Tan Tock Seng Hospital between 2004 and 2013. A comprehensive search for physical and electronic hospital records was undertaken to extract demographic and audiological data. Tan Tock Seng Hospital is the anchor tertiary public hospital of the National Healthcare Group cluster of healthcare providers which serves the population of central and northern Singapore. The ethnic breakdown of patients in our study compared to the Ear Nose and Throat (ENT) clinic patients and the national ethnic composition is; Chinese 87.0% vs. 79.9% vs. 74.3%, Malay 4.5% vs. 5.0% vs. 13.4%, Indian 6.1% vs. 7.6% vs. 9.0%, and 'Others' 2.4% vs. 7.5% vs. 3.2% respectively (Singapore Department of Statistics, 2019).

Patients with hearing impairment receive an ENT assessment followed by a diagnostic PTA. HL levels, independently tested for each ear, were determined by the four-tone average PTA calculated from the hearing thresholds at 0.5, 1, 2, and 4 kHz. The severity of HL was classified as mild (≤ 40 dB), moderate (> 40 –55 dB), moderate-severe (> 55 –70 dB), and severe (> 70 dB). PTA of the aided ear and better ear were analysed independently to account for possible differences, important since $> 80\%$ of subjects had unilateral HA fitting. For subjects with bilateral HA fitting, the average of both ears was taken as their aided ear PTA.

Hearing aid evaluation (HAE) appointments are offered to those who are motivated to improve their hearing. Patients who decide to proceed are given a hearing aid fitting (HAF)

appointment and a face-to-face ‘post hearing aid fitting’ (PHAF) appointment 1 to 2 months after, to evaluate their HA usage. The HAE sessions were aimed at educating and counselling patients on their HL and treatment options, including the use of HAs. To achieve this, our audiologists tried to understand each patient’s unique hearing disabilities by getting them to self-grade 8 hearing difficulties or disabilities. These 8 questions were compiled over time as being the most common and most relevant hearing disabilities in our local population. (Table 1)

[t] Table 1 here [/t]

Subjects were instructed to indicate the level of difficulty as either ‘Always’, ‘Sometimes’ or ‘Never’ for questions 1 to 7. For Question 8, ‘Hearing loss limits social life’, the level of difficulty could be indicated as either ‘Severe’, ‘Moderate’, ‘Slightly’, or ‘Never’. In Table 1, Baseline disability records, ‘Never’ as ‘No’ whilst all other answers were recorded as ‘Yes’. This response scale captures a finer granularity of individual disability, useful for clinical evaluation but recorded than a binary ‘Yes’ or ‘No’ answer.

Subjects who chose not to answer were categorized as a ‘non-responder’ for that question. Subjects had the option of answering ‘Not applicable’ to ‘Hearing loss affects job’ and ‘Family member feels frustrated’ (Questions 6 and 7) and these responses were excluded from analysis.

These questions were routinely administered before (at HAE appointment) and after (at PHAF appointment) fitting of HAs. It was then possible to evaluate the number of disabilities that had improved. The questions were interviewer administered as most of our subjects prefer not to self-fill any forms. When analyzing the change of hearing disability, an

improvement was defined as a change in response on the scale toward improvement at PHAF (e.g. Always to Sometimes or Moderate to Slightly).

The audiology unit offers a range of HAs, including behind the ear (BTE) types of HAs (standard BTE and newer ‘receiver in canal’ (RIC)) and customizable in ear types including ‘in the ear’ (ITE), ‘in the canal’ (ITC) and ‘completely in the canal’ (CIC) HAs.

The costs of HAs were analysed in two ways. ‘Total HA cost’ was derived by adding the total cost of all HAs fitted while ‘HA cost per unit’ was derived by dividing the total HA cost by the total number of HAs fitted. The HA costs have been inflation adjusted using the Consumer Price Indices (CPI) under the medical device category with CPI 2014 = 100 as the base (Singapore Department of Statistics, 2019). All costs are presented in Singapore dollars [1 SGD = 0.73 USD]. Patients pay full cost of the HAs as there was no Government subsidy during the study period.

The study was approved by the Institutional Review Board. Waiver of consent was granted as data were anonymised and aggregated. The research team, led by the first author, had independence and autonomy from the grant provider in the data analysis and interpretation.

Statistical analyses were performed using Stata (version 13.1, StataCorp LP, College Station, TX). Significance tests were two-sided at the 5% significance level. The time trends were evaluated using the Mantel-Haenszel Chi-square test (dichotomous) (Mantel & Haenszel, 1959) or nonparametric test for trend (ordered groups) (Cuzick, 1985) for categorical data and simple linear regression for continuous data (Yin, Wu, & Hong, 2016). Results are reported as count (n) and percentage for categorical data and mean, standard deviation (SD) or median, interquartile range (IQR) for continuous data.

Multivariable logistic regression models were used to assess whether temporal shifts in patient characteristics could explain trends in HA usage, bilateral HA uptake, HA choice, self-reported disability before HA fitting and improvement in disability after HA fitting. Models were adjusted for variables chosen a priori, based on previous published studies (Ho, Ong, et al., 2018; Ho, Zhang, et al., 2018). The crude and adjusted odds ratios (OR) are reported with 95% confidence intervals (CI).

Results

A total of 1062 subjects were identified as having had their first HA fitted at the audiology unit at Tan Tock Seng Hospital between 2004 and 2013. After excluding 10 subjects (0.9%) with missing data, 1052 subjects were included in final analysis. An electronic medical records system was adopted by the hospital in 2009, but earlier paper records were fragmented. Therefore, the number of missing records prior to 2009 could not be ascertained.

Comparing 2009 and 2013, the number of patients fitted with HAs in our hospital had increased from 143 to 207, representing a 44.7% increase compared with the population growth of 8.25% in Singapore (United Nations, 2018). The subjects were stratified into 5 cohorts for trend analysis. As the cohorts were progressively larger every year, the first cohort consists of subjects from 3 years, while the last cohort was taken on its own.

Patient Characteristics

Although the mean age of first time HA users has remained stable over time, the proportion of those aged > 80 years has increased significantly. Ethnicity, gender and degree of HL for both aided and better hearing ear remained unchanged over the study period (Table 2).

[t] Table 2 here [/t]

HA costs and waiting time

A trend towards increasing waiting time from HA evaluation to HA fitting was observed.

After accounting for inflation, HA cost per unit increased by 50%, while total HA cost almost doubled over the study period.

HA usage

The proportion of patients using their HAs for 4–7 hrs. per day increased but the proportion using their HAs for > 7 hrs. actually decreased over time (Table 2). Compared to ≤ 7 hrs. of daily HA use, the unadjusted OR for time trend for > 7 hrs. of daily HA use was 0.66 (95% CI 0.56–0.78). In multivariable analysis, after adjusting for age, better ear PTA, number of baseline disabilities, cost of HA, and type of HA, the adjusted OR was 0.73 (95% CI 0.60–0.88) indicating a decrease in daily usage > 7 hrs. over the study period (Supplementary Table 1).

Laterality of HA fitting & HA type

The proportion of patients having bilateral HAs fitted increased over the study period (Table 2). The unadjusted OR for time trend for bilateral HA uptake was 1.55 (95% CI 1.33–1.81). In multivariable analysis, after adjusting for age, symmetry of HL, aided ear PTA, and type of HL, the adjusted OR was 1.58 (95% CI 1.35–1.85) indicating an improved bilateral HA uptake over the study period (Supplementary Table 2).

There was also a trend towards more patients opting for BTE type HAs, with the RIC type of BTE gaining popularity. For those who opted for the customizable HAs, there was a trend towards choosing ITC and CIC HAs. Compared to BTE HA, the unadjusted OR for time trend for customizable HA uptake was 0.75 (95% CI 0.67–0.85). After adjusting for age,

symmetry of HL, aided ear PTA, better ear PTA, and type of HL, the adjusted OR was 0.74 (95% CI 0.66–0.84) indicating reduced customisable HA uptake, and increased BTE HA uptake over the study period (Supplementary Table 3).

Hearing disability

There was a trend towards higher proportion of subjects presenting with fewer disabilities and a corresponding lower proportion of subjects presenting with more disabilities. Hence, it was not surprising that there was a significant increase in the proportion of subjects reporting improvement in fewer disabilities and a corresponding decrease in the proportion of subjects reporting improvement in more disabilities (Table 2).

Compared to subjects reporting 4 or less disabilities at HAE, the unadjusted OR for time trend for reporting 5 or more disabilities, was 0.45 (95% CI 0.35–0.58). After adjusting for age, ethnicity, aided ear PTA, and better ear PTA, the adjusted OR was 0.45 (95% CI 0.34–0.59), indicating an improvement in hearing disability over the study period (Supplementary Table 4). Compared to subjects reporting reduction in 4 or less disabilities at PHAF, the unadjusted OR for time trend for improvement in 5 or more disabilities was 0.55 (95% CI 0.46–0.67). After adjusting for age, better ear PTA, type of HL, number of disabilities at HAE, regularity of HA use, and daily HA usage the adjusted OR was 0.82 (95% CI 0.67–1.02), indicating that the reduction of disabilities was primarily explained by the number of disabilities subjects had prior to their HA fitting, which decreased over the study period (Supplementary Table 5).

The types of hearing disabilities were analysed to examine time trends in individual domains (Table 1). There was a decreasing trend in proportion of subjects reporting difficulties in the following 5 disability domains; ‘Difficulty with 1:1 Conversation in quiet’, ‘Difficulty hearing

over the telephone', 'Needs to increase volume of TV/radio', 'Family member feels frustrated' and 'Hearing loss limits social life'. There was a decreasing trend in proportion of subjects reporting improvements in their hearing disability following HA fitting for the following 4 domains; 'Difficulty with group conversation in quiet', 'Difficulty hearing in noise', 'Difficulty hearing over the telephone', and 'Needs to increase volume of TV/radio', while a trend towards increase in proportion reporting improvement in 'Family member feels frustrated' was seen.

Discussion

In this study we observed a steady increase in number of first time HA users from 2004 to 2013. Although mean age did not change significantly, the proportion of adults aged > 80 years being fitted with HAs increased, in keeping with our ageing population phenomenon. There is an acceleration in HL especially in low frequencies for individuals in their 10th decade of life compared to those in their 9th decade (Wattamwar et al., 2017).

It was interesting to note a decline in customizable HA use over the study period. This could in part be explained by the higher proportion of subjects above 80 years of age in later cohorts who may prefer BTE over in ear type HAs. Elderly subjects, especially those with visual impairment and arthritis, may prefer the standard BTE for ease of handling and reduced risk of being misplaced, mirroring trends in Western cohorts (Dillon, 2001). A study from the UK found cosmetic acceptability, perceived benefit and sound quality to also be important factors in choosing HAs (Brooks, 2009). These could be potential explanations for the observed time trends in HA choice.

An increase in bilateral HA uptake was seen over the study period. However, even the 30% bilateral uptake of the final cohort is suboptimal, given that 98.0% of the subjects had bilateral HL. We have previously reported that younger age and symmetrical HL were independent predictors of bilateral HA uptake (Ho, Zhang, et al., 2018). However, in our analysis the variations in these factors were not able to fully explain the observed trends. Taken together with the finding that HA users paid more for their HAs over the decade, improved willingness to spend on HA may be a reason.

Patients are more likely to seek help for their hearing loss when they perceive communication and social difficulties from their hearing loss (Duijvestijn et al., 2003). The decrease in self-perception of hearing disability at HAE despite no significant changes in the PTA thresholds for both better and aided ear may indicate an increased readiness for HAs over the study period. This is reinforced by the decline in subjects reporting 'Family member feels frustrated' and 'Hearing loss limits social life' meaning they are less likely to wait for these negative social consequences of hearing loss before taking action.

We have previously reported that younger age and higher PTA thresholds of better hearing ear were independent predictors of frequent daily HA use (Ho, Ong, et al., 2018). Even after adjusting for potential confounders including the number of baseline disabilities, daily HA use > 7 hours showed a decreasing trend over the study period and remained suboptimal. Studies from the Netherlands, USA, and Australia have shown a positive correlation between self-reported hearing difficulties, and HA use and satisfaction (Duijvestijn et al., 2003; Hosford-Dunn & Halpern, 2001; Mulrow, Tuley, & Aguilar, 1992; Uriarte, Denzin, Dunstan, Sellars, & Hickson, 2005). Similarly, in our study, one possible explanation for declining daily HA usage could in part be lower self-perceived disability and better methods of coping over the years. An example may be the increased use of smartphone messaging for

communication. A review in 2015 found that patient-related factors such as self-perception of hearing problems, expectations, self-perceived benefit, and satisfaction could influence HA usage (Ng & Loke, 2015). Although we were unable to assess these directly in the current study, they are potential explanations for the observed time trends in HA use.

The management of HL should not be limited to HA fitting alone. There is a need for comprehensive approaches, focusing on improved access to diagnostic audiology, better education on the negative consequences of untreated HL, and management of expectations prior to HA fitting (The data on hearing disability from this study can be useful for managing patients' expectations about HAs and counselling them on which aspects of their hearing difficulties are more likely to improve with the use of HAs). And in the early days after they start using HAs, they may report lesser improvement in their social life despite better 1:1 communication in quiet, as they may still have difficulties with group conversation and difficulty hearing in noise as our data would suggest. (Table1) In fact, HA fitting is only the beginning of the hearing rehabilitation journey, after which, improved follow up care, speech-in-noise training and continued engagement with HA users need to continue after HAs are fitted. Hearing rehabilitation in adults is primarily performed by audiologists in Singapore with one to one session being the norm. A pilot programme demonstrated that it is possible to increase HA usage through better engagement and training of HA users and their family members (Nieman et al., 2017).

There are several study limitations to keep in mind when drawing conclusions from this study. The cross-sectional design of the study limits the ability to conclude possible causality, because the risk factors and outcomes were measured simultaneously. Our findings should ideally be corroborated with a longitudinal cohort study. Building on the experience gained

from the current study, the study team is constructing a prospective cohort which is better suited to assess temporal relationships.

Due to incomplete record capture prior to 2009, we are unable to comment regarding the proportion of records unavailable for assessment. However, we believe that this data was missing completely at random and unlikely to cause any bias. Lastly, this study does not extend to those who buy their HA from private providers. However, as there was no government subsidy through public or private providers, hearing aid fitting practices may not vary greatly.

Despite the mentioned limitations, the study has important strengths that deserve mention. This is the first study in Singapore and, to the best of our knowledge, in the South East Asian region studying a large consecutive cohort of patients fitted with HAs. After careful and meticulous extraction was performed to ensure all variables were collated, only 10 (0.9%) subjects were excluded from the study due to missing data. As our audiology unit sees one of the largest numbers of patients in Singapore, we are confident the study population is representative of the general population seeking HAs in Singapore and the findings have wide implications for practice and policy.

Conclusion

A steady increase in the number of first time HA users was seen from 2004 to 2013. The proportion of older adults being fitted with HAs increased and HA users were willing to spend more. Bilateral HA uptake increased while customizable in ear type of HA use decreased over

time. A decline in hearing disabilities was seen at presentation. However, daily HA use remained suboptimal and showed a decreasing trend over the study period. Hence, strategies for hearing health need to go beyond improving HA uptake but to help patients optimize their HA usage with a comprehensive hearing rehabilitation process.

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The authors report no conflicts of interest.

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