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Original Article

The Prevalence of Hearing Impairment by Age and Gender in a Population-based Study

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Abstract

Background: This study aimed to determine the prevalence of hearing impairment (HI) by age and gender in a population aged 5 yr and older residing in Tehran, Iran.

Methods: In this cross-sectional study, 140 clusters each including 10 households from Tehran, Iran were sampled between 2012 and 2013 using cluster random sampling. Trained audiologists examined the participants during face-to-face interviews. The hearing of the participants was evaluated before the removal of wax or other foreign bodies. In this study, HI was categorized as mild (grade 1, 26-40 db), moderate (grade 2, 41-60 db), severe (grade 3, 61-80 db), and deaf (grade 5, 81 db or more). All participants signed informed consent forms. The SATA software was used for data analysis.

Results: Of 6521 individuals, 4370 (67%) were interviewed. The prevalence of HI (auditory threshold of 0.5, 1, 2, 4 KHz and more than 25 db in the better ear) was 14.27 (11.53-17.91) of whom 9.52 (7.07-11.98) had grade 1, 4.04 (3.02-5.06) had grade 2, 0.67 (0.33-1.02) had grade 3 HI and 0.48 (0.16-0.8) were deaf. About 5.19% of the participants had disabling hearing impairment. All HI grades increased significantly with age but no significant difference was observed between men and women.

Conclusion: The considerable prevalence of HI in Iran in comparison with other developing countries, with regards to the trend of aging in the population, seems concerning. The results of the study could be used as a treatment and research guideline for future works in the area of policymaking and plan to decrease these disorders.

Keywords: Prevalence, Hearing impairment, Epidemiology, Iran

Introduction

The three-fold increase in the elderly population of the world by the year 2050 has made hearing impairment (HI) the third most common disability in the elderly according to the statistics of the WHO (1-3). On the other hand, HI, in addition to comprising 4.7% of the total causes of years lived with disability (YLD) in the world, imposes a great disease burden on the health system due to long-term social, functional, and psychological complications (4, 5). Moreover, the prevalence of HI has been on the rise in all age groups across the world (6). In the USA, the prevalence of HI increased from 14.9% in 1994-1998 to 19.5% in 2005-2006. In another report, its prevalence increased by two times from 1965 to 1994 in the USA (7, 8). Furthermore, HI has affected two-

thirds of the 70-year-old Americans and one-third of the Japanese population in the 4th decade of life and half of the Japanese population above 60 yr of age (9, 10). In addition, 14.9% of the American children (more than seven million children) suffer from different types of HI (11). Despite the importance of this issue, few studies were performed on the prevalence of HI and the associated disorders in Iranian children in the late 1990s and as a result, our knowledge of the total prevalence of the different levels of HI in the Iranian population is very limited.

However, a broad spectrum of environmental and genetic factors can contribute to the development of HI in different societies (12). The most important causes of HI are noise-induced hearing loss (13, 14) diabetes (15, 16) and heavy metals (15, 16) in association with genetic and congenital diseases, infectious diseases before and after birth, and drugs (17-19). HI has a great impact on health through overlapping with or causing other diseases like increasing the frequency of depression (20), communication problems, dementia (21) and cognitive disorders (22); therefore, it has a deep impact on the quality of life (23). According to the reports from the US, despite the high prevalence of HI, 36% of the people never undergo hearing evaluation (24). Therefore, WHO intends to prevent the long-term complications of the HI in countries with low and middle-income countries through screening programs (25). Iran is the second most populated country in the Middle East with an aging population; however, few population-based studies have been conducted on hearing disorders in Iran but each one has its own limitation like the study population, sample size, or measurement method (26, 27).

The aim of the present study was to determine the prevalence of HI and deafness in an Iranian population based on the WHO definitions.

Materials and Methods

This cross-sectional study was performed by the ENT and Head and Neck Research Center of Iran University of Medical Sciences and Iran National Science Foundation between 2012 and 2013 in Tehran, Iran. This study had 2 phases. In the first phase, 140 clusters each including 10 households in individuals above 6 months were sampled using cluster random sampling. Head clusters were also selected randomly according to the 10-digit postal code. In each cluster, sampling was performed for up to 10 households. First, the head cluster household was visited. Then, using a systematic method, 10 nearby households joined the study in a clockwise manner. All examiners were audiometrists that had mastery overhearing tests and were capable of communicating with the participants. In the second phase, after coordination with all households in each cluster, the trained audiometrists attended the participants' houses and conducted the interviews and audiometric tests. All audiology and ambient noise devices were calibrated with reference devices.

A questionnaire including some demographic and specialized data was completed. This questionnaire was designed by the WHO Ear and Hearing Disorders Survey protocol whose validity and reliability was previously confirmed. All the participants signed informed consent forms.

This study was approved by the Medical Ethics Committee of ENT Research Center.

Examinations

Preliminary evaluations included the assessment of 1) otalgia, 2) auricle shape (normal or abnormal), 3) the presence of inflammatory factors, wax, foreign body, fungal infection, and otorrhea in the external auditory canal, 4) the presence of tympanic perforation, opacity, protrusion, or inflammation, 5) the presence of otorrhea in the middle ear.

The audiometrists first examined adult participants to reduce the fear of children and younger adults during the examinations. If any foreign body or wax was observed in the external canal, auditory evaluations were performed without their removal in order to assess their effects on hearing. The second set of examinations and audiometry were performed after wax removal at the discretion of the audiometrists.

In individuals above the age of 5 yr, audiometry was performed after the participant received

complete explanations. Before audiometry started, a rather quiet room was chosen, the ambient noise was measured, and its level was recorded in the relevant section of the questionnaire. The ambient noise should be preferably less than 40 db according to the WHO protocol. If the ambient noise was more than 40 db, its measurement was done and the result was recorded. On the other hand, the auditory threshold of the participants was measured in the frequencies of 1, 2, 4, and again 1 kHz. At the beginning, hearing in each ear was evaluated in 1 KHz by 60 dB sound level.
If no response was observed, the sound level was increased in 10-dB increments until the desired response was achieved. When the participant responded, the auditory threshold was determined by reducing the intensity by 10 dB and then increasing it by 5 dB with no correcting factor. All these thresholds were examined at the frequencies of 2 and 4 kHz, as well. In the end, the auditory threshold was again examined at 1 kHz; all the steps were repeated if the final threshold measurement at 1 KHz had a difference of more than 5 dB with the primary measurement. The classification of hearing impairment by dB is presented in Table 1. Hearing impairment grade 2 to 4 was categorized as disabling hearing impairment.
After data collection was completed, the participants were divided into the following age groups: 5-10 yr, 11-20 yr, 21-30 yr, 31-40 yr, 41-50 yr, 51-60 yr, 61-70 yr, and more than 70 yr.

Table 1: Classification of hearing impairment according to WHO criteria

Grade of impairment	Corresponding audiometric ISO value	Performance	Recommendations
0 - No impairment	25 dB or better (better ear)	No or very slight hearing problems. Able to hear whispers.	
1 - Slight impairment	26-40 dB (better ear)	Able to hear and repeat words spoken in normal voice at 1 meter.	Counselling. Hearing aids may be needed.
2 - Moderate impairment	41-60 dB (better ear)	Able to hear and repeat words spoken in raised voice at 1 meter	Hearing aids usually recommended.
3 - Severe impairment	61-80 dB (better ear)	Able to hear some words when shouted into better ear.	Hearing aids needed. If no hearing aids available, lip-reading and signing should be taught.
4 - Profound impairment including deafness	81 dB or greater (better ear)	Unable to hear and understand even a shouted voice.	Hearing aids may help understanding words. Additional rehabilitation needed. Lip-reading and sometimes signing essentially.

Data Analysis

The SATA software was used for data analysis. We reported the prevalence of HI as percentage with a 95% confidence interval (CI). To calculate CI, the effect of cluster sampling was regarded. Logistic regression was used to evaluate the correlation of HI with age and gender and the odds ratios were reported.

Results

Of the 6521 selected individuals, 4370 (67.0%) participated in the study of whom 4213 were 5 yr and older and 2280 (54.1%) were female.

The total prevalence of HI was 14.72% (95% CI 11.53-17.91). Moreover, 64.71%, 27.45%, 4.58%, and 3.27% of the hearing impairment participants had HI grade 1, 2, and 3 and 4 (deafness), respectively. Table 2 presents the prevalence of different HI grades by gender. The prevalence of deafness was 0.48% (95% CI 0.16-0.8) in the present study and 5.19% of the participants had to disable HI. Evaluation of the correlation between the prevalence of HI between male and female participants using logistic regression showed that the total prevalence of HI and the prevalence of HI grade 1 and 2 were significantly higher in males. The results of logistic regression are presented in Table 1.

Table 2: The prevalence of hearing impairment by grade according to gender

	Total	Female	Male	OR(95%CI), *P*-value
Hearing impairment	14.72(11.53 -7.91)	12.6(9.55-5.66)	17.74(13.83 -1.65)	1.5(1.24 -1.8),<0.001
Grade 1=slight	9.52(7.07 -11.98)	8.1(5.57 -10.63)	11.55(8.63 -14.48)	1.48(1.14 -1.93), 0.004
Grade 2=moderate	4.04(3.02 -5.06)	3.36(2.32 -4.39)	5.02(3.41 -6.63)	1.52(1.03 -2.24), 0.035
Grade 3=severe	0.67(0.33 -1.02)	0.65(0.19 -1.12)	0.7(0.16 -1.24)	1.07(0.36 -3.14),0.901
Grade 4=deaf	0.48(0.16 -0.8)	0.49(0.09 -0.89)	0.47(0.03 -0.91)	0.95(0.3 -3.04),0.931
Disabling hearing impairment(grad 2,3 and 4)	5.19(4.05 -6.34)	4.5(3.29 -5.71)	6.18(4.4 -7.96)	1.4(0.98 -2),0.065

Table 3 shows the prevalence of HI in different age groups. According to Table 2, the prevalence of HI increased in all levels by aging. Table 4 presents the association of HI with age and gender in a multiple models. In this model, the prevalence of hearing impairment had no significant association with gender while all grades of HI increased significantly with age. Fig. 1 shows the prevalence of HI according to the educational level. The prevalence of HI decreased significantly from 41.3% in illiterate participants to 8.9% in participants with university education (*P*<0.001).

Table 3: The prevalence (%) of hearing impairment in different age groups

	Hearing impairment	Grade 1=slight	Grade 2=moderate	Grade 3=severe	Grade 4=deaf	Disabling hearing impairment(grad 2,3 and 4)
5-10	0.6	0.0	0.6	0.0	0.0	0.6
11-20	1.9	1.7	0.0	0.0	0.3	0.3
21-30	3.3	2.4	0.6	0.3	0.0	0.9
31-40	3.6	2.9	0.7	0.0	0.0	0.7
41-50	7.4	6.8	0.3	0.0	0.3	0.6
51-60	20.1	14.0	5.0	0.7	0.4	6.1
61-70	42.6	31.2	9.9	1.0	0.5	11.4
>= 71	70.4	33.3	27.7	5.7	3.8	37.1

Table 4: The association of hearing impairment with age and gender in a multiple logistic regression model

		OR(95%CI)	*P*-value
Hearing impairment	Sex	1.16(0.89 -1.5)	0.264
	Age	1.09(1.07 -1.12)	<0.001
Grade 1=slight	Sex	1.21(0.89 -1.64)	0.218
	Age	1.06(1.04 -1.09)	<0.001
Grade 2=moderate	Sex	1(0.62 -1.62)	0.988
	Age	1.1(1.08 -1.12)	<0.001
Grade 3=severe	Sex	0.67(0.2 -2.3)	0.525
	Age	1.1(1.04 -1.15)	<0.001
Grade 4=deaf	Sex	0.67(0.21 -2.1)	0.489
	Age	1.07(1.02 -1.13)	0.01
Disabling hearing impairment(grad 2,3 and 4)	Sex	0.9(0.58 -1.41)	0.651
	Age	1.1(1.08 -1.12)	<0.001

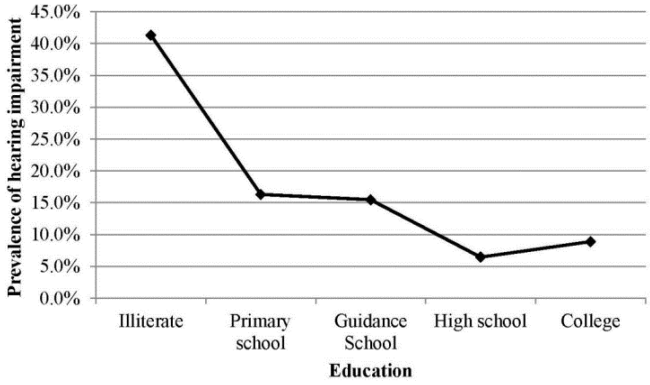

Fig. 1: The prevalence of hearing impairment according to the educational level

Discussion

The WHO has provided executive protocols for the collection of the data of hearing disorders in regional and provincial level, for epidemiologic studies on hearing and other ear disorders. In this study, for the first time in Iran and as the second country in the Middle East, we used the WHO protocol to evaluate the prevalence and causes of HI in an Iranian population.

According to our results, 14.7% of the society experienced some levels of HI and about two-thirds of them (9.9%) had mild HI (grade 1). Table 5 presents the prevalence of HI in different countries. For the first time in the Middle East, the prevalence of hearing impairment was reported 5.5% and 36.06 in 1000 population in Oman in 2004. Despite the two-fold prevalence of hearing impairment in our country, only one-third of the participants had mild HI in Oman (28).

In another research on 4000 participants in different parts of Egypt in the Middle East, the prevalence of hearing loss was reported about 16%; considering the social texture and population of Iran and Egypt, a rather similar prevalence of HI was expected (29). The prevalence of HI is higher in Taiwan and Brazil than Iran (21.4 and 26.1%, respectively) (30, 31). The reports from developed countries are very different; for example, the prevalence of hearing impairment has been reported 16.9%, 16%, 26.7%, 4%, and 15.06% in Sweden (6), England (32), Norway (33), Canada (34), and the US (35), respectively. On average, the prevalence of HI in developed countries (4.9%) is much lower than its prevalence in Africa (15.7%) and South Asia (17.0%) (25). A broad spectrum of diseases including genetic factors (6), pre and postnatal infections (36), otitis media (28), and foreign body (37) cause hearing disorders in children and adults. However, most studies have eliminated the children age group and defined their target population as adults. The sampling method is also important when evaluating HI in different societies; in our study, hearing evaluation was performed prior to the removal of wax or foreign body while this process has been performed after wax removal in many studies. Moreover, the type of the target population (urban, rural, developed, and developing) and other factors such as level of health care and lifestyle should also be considered when evaluating hearing problems.

In the present study, the prevalence of the level of HI increased in both sexes with age; 1% of the participants aged 5-10 yr had HI while more than two-thirds of the people above the age of 70 experienced auditory disorders. Other studies have also reported similar findings (38, 39); for example in China, the prevalence of HI is 3.28% in the society and 12.8% at the age of 60 yr (6). Sixty percent of the people with hearing loss had a mean age of 75.5 yr (40).

The trend of exacerbation of hearing disorders with age can be explained by personal and environmental factors. Presbycusis, exposure to Environmental factors as ototoxic materials and

drugs (41) and noise pollution (42) increase the incidence of hearing loss at older ages. On the other hand, according to our findings and the findings of other studies (43) the lower prevalence of HI in the educated people and in the young population versus the elderly population, due to higher levels of education in the young, is expected. However, HI might have resulted in the lack of academic progress. Nevertheless, the prevalence of hearing disorders was higher in our elderly participants when compared to other studies, which may be due to environmental factors although the age cohort effect may also play a role in this regard.

Table 5: The prevalence of hearing impairment and deafness in different countries

Country	Year	n	Age	Prevalence of Deafness (or profound hearing loss)	Prevalence of Hearing Impairment
				Total	
USA (35)	2015	16415	18-74	-	15.06%
Brazil (31)	2007	2427	4<	-	26.1%
Bangladesh (44)	2014	3707	>18		0.3/1000
China (45)	1993	-	-	0.186	-
USA (46)	1998	-	3-10	1.1/1000	-
France (47)	1996	-	<9	.54/1000	-
Australia (48)	2011	3258	21-84	-	14.1%
USA (49)	1998	3753	48-92	45.9%	-
USA (7)	2010	2005-2006=1771 1988-1994=2928	12-19	19.5% 14.9%	-
Italy (50)	1998	2398	>65	-	19%
Australia (51)	2007	2431	Mean= 67.0	-	44.6%
USA (11)	1998	6166	6-19	14.9%	-
USA (52)	2004	White= 107100 African-American= 17904	>18	- -	11.0%-12.7% 5.9%-8.5%
USA (53)	2005	2052	73-84	59.9%	-
Oman (54)	2010	1639	>60	3.6%	33.5%
Oman (55)	2004	12400	-	-	-
USA (56)	2006	>5 y/o population	>5	4.1%(41 per 1000 or 11,000,00)	-
Egypt (29)	2007	4000	-	16.0%	-
Uganda (57)	2008	6041	-	-	Child=10.2% Adult=11.7%
Global(57)	2013	-	5-14 y/o Female >15 y/o Male >15 y/o	-	1.4% 9.8% 12.2%
China(58)	2006	1261	>60	1.3%	58.1%
Korea(59)	2014	18650	-	-	22.73%

In spite of the fact that no association was found between gender and HI in our study and a study performed in Italy (60), previous studies have published different reports indicating an increase

in the prevalence of these disorders in men (33, 61-63) and women (64-66).
This study had some weak and strong points mentioned. The most important strong point of the study was determining the prevalence of visual disorders in a population-based study with a large sample size using cluster sampling. The limitations of this study was an attrition of about 33% during sampling and a response rate of 67%, resulted in selection bias. Therefore, attention should be paid to the bias.

Conclusion

The considerable prevalence of HI in Iran in comparison with other developing countries, with regards to the trend of aging in the population, seems concerning. This study is the first epidemiologic study of hearing loss in the national level and its results could be used as a baseline for other researches and evaluation of burden of HI in our country.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interests

The authors declare that there is no conflict of interest.

References

1. Timmer BH, Hickson L, Launer S (2015). Adults with mild hearing impairment: Are we meeting the challenge? *Int J Audiol*,54(11):786-95.
2. Organization WH. Global tuberculosis control: WHO report 2010: WHO; 2010.
3. Kiely KM, Gopinath B, Mitchell P, et al. (2012). Cognitive, health, and sociodemographic predictors of longitudinal decline in hearing acuity among older adults. *J Gerontol A Biol Sci Med Sci*,67(9):997-1003.
4. Mathers C, Smith A, Concha M (2000). Global burden of hearing loss in the year 2000. Global burden of Disease,18(1-30).
5. Mathers CD, Bernard C, Iburg KM, et al. (2003). Global burden of disease in 2002: data sources, methods and results. Bull World Health Organ.
6. Liu XZ, Xu LR, Sismanis A, et al. (2001). Epidemiological studies on hearing impairment with reference to genetic factors in Sichuan, China. *Ann Otol Rhinol Laryngol*,110(4):356-63.
7. Shargorodsky J, Curhan SG, Curhan GC, et al. (2010). Change in prevalence of hearing loss in US adolescents. *JAMA*, 304(7):772-8.
8. Wallhagen MI, Strawbridge WJ, Cohen RD, et al. (1997). An increasing prevalence of hearing impairment and associated risk factors over three decades of the Alameda County Study. *Am J Public Health*,87(3):440-2.
9. Uchida Y, Nakashima T, Ando F, et al. (2003). Prevalence of self-perceived auditory problems and their relation to audiometric thresholds in a middle-aged to elderly population. *Acta Otolaryngol*,123(5):618-26.
10. Lin FR, Thorpe R, Gordon-Salant S, et al. (2011). Hearing loss prevalence and risk factors among older adults in the United States. *J Gerontol A Biol Sci Med Sci*,66(5):582-90.
11. Niskar AS, Kieszak SM, Holmes A, et al. (1998). Prevalence of hearing loss among children 6 to 19 years of age: The Third National Health and Nutrition Examination Survey. *Jama*,279(14):1071-5.
12. Momi SK, Wolber LE, Fabiane SM, et al. (2015). Genetic and Environmental Factors in Age-Related Hearing Impairment. *Twin Res Hum Genet*,1-10.
13. Agrawal Y, Platz EA, Niparko JK (2009). Risk factors for hearing loss in US adults: data from the National Health and Nutrition Examination Survey, 1999 to 2002. *Otol Neurotol*,30(2):139-45.
14. Ahmed HO, Dennis JH, Ballal SG (2004). The accuracy of self-reported high noise exposure

level and hearing loss in a working population in Eastern Saudi Arabia. *Int J Hyg Environ Health*,207(3):227-34.
15. Horikawa C, Kodama S, Tanaka S, et al. (2012). Diabetes and risk of hearing impairment in adults: a meta-analysis. *J Clin Endocrinol Metab*,98(1):51-8.
16. Cheng YJ, Gregg EW, Saaddine JB, et al. (2009). Three decade change in the prevalence of hearing impairment and its association with diabetes in the United States. *Prev Med Rep*,49(5):360-4.
17. Agrawal Y, Platz EA, Niparko JK (2008). Prevalence of hearing loss and differences by demographic characteristics among US adults: data from the National Health and Nutrition Examination Survey, 1999-2004. *Arch Intern Med*,168(14):1522-30.
18. Katbamna B, Crumpton T, Patel DR (2008). Hearing impairment in children. *Pediatr Clin North Am*,55(5):1175-88.
19. Lieu JE, Tye-Murray N, Fu Q (2012). Longitudinal study of children with unilateral hearing loss.*Laryngoscope*,122(9):2088-95.
20. Li C-M, Zhang X, Hoffman HJ, et al. (2014). Hearing impairment associated with depression in US adults, National Health and Nutrition Examination Survey 2005-2010. *JAMA Otolaryngol Head Neck Surg*,140(4):293-302.
21. Gurgel RK, Ward PD, Schwartz S, et al. (2014). Relationship of hearing loss and dementia: a prospective, population-based study. *Otol Neurotol*,35(5):775-81.
22. Lin FR, Ferrucci L, Metter EJ, et al. (2011). Hearing loss and cognition in the Baltimore Longitudinal Study of Aging. *Neuropsychology*,25(6):763.
23. Ciorba A, Bianchini C, Pelucchi S, et al. (2012). The impact of hearing loss on the quality of life of elderly adults. *Clin Interv Aging*,7(159.
24. Cruickshanks KJ, Wiley TL, Tweed TS, et al. (1998). Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin the epidemiology of hearing loss study. *Am J Epidemiol*,148(9):879-86.
25. Stevens G, Flaxman S, Brunskill E, et al. (2013). Global and regional hearing impairment prevalence: an analysis of 42 studies in 29 countries. *Eur J Public Health*,23(1):146-52.
26. Islami Z, Baradaranfar MH, Mehrparvar AH, et al. (2013). Frequency of Hearing Impairment among Full-term Newborns in Yazd, Iran. *Iran J Pediatr*,23(3):349-52.
27. Absalan A, Pirasteh I, Dashti Khavidaki GA, et al. (2013). A Prevalence Study of Hearing Loss among Primary School Children in the South East of Iran. *Int J Otolaryngol*,2013(138935.
28. Al Khabori M, Khandekar R (2007). Unilateral hearing impairment in Oman: a community-based cross-sectional study. *Ear Nose Throat J*,86(5):274.
29. Abdel-Hamid O, Khatib OM, Aly A, et al. (2007). Prevalence and patterns of hearing impairment in Egypt: a national household survey. *East Mediterr Health J*,13(5):1170-80.
30. Lin C-Y, Yang Y-C, Leon Guo Y, et al. (2007). Prevalence of hearing impairment in an adult population in southern Taiwan. *Int J Audiol*,46(12):732-7.
31. Béria JU, Raymann BCW, Gigante LP, et al. (2007). Hearing impairment and socioeconomic factors: a population-based survey of an urban locality in southern Brazil. Rev. Panam. *Salud Públ*,21(6):381-7.
32. DAvIs AC (1989). The prevalence of hearing impairment and reported hearing disability among adults in Great Britain. *Int J Epidemiol*,18(4):911-7.
33. Hannula S, Mäki-Torkko E, Majamaa K, et al. (2010). Hearing in a 54-to 66-year-old population in northern Finland. *Int J Audiol*,49(12):920-7.
34. Woodcock K, Pole JD (2008). Educational attainment, labour force status and injury: a comparison of Canadians with and without deafness and hearing loss. *Int J Rehabil Res*,31(4):297-304.
35. Cruickshanks KJ, Dhar S, Dinces E, et al. (2015). Hearing Impairment Prevalence and Associated Risk Factors in the Hispanic Community Health Study/Study of Latinos. *JAMA Otolaryngol Head Neck Surg*. 141(7):641-8.
36. Ross DS, Visser SN, Holstrum WJ, et al. (2010). Highly variable population-based prevalence rates of unilateral hearing loss after the application of common case definitions. *Ear and hearing*,31(1):126-33.
37. Olusanya B, Okolo A, Adeosun A (2004). Predictors of hearing loss in school entrants in a developing country. *J Postgrad Med*,50(3):173.

38. Sorri M, Roine R (2000). Age-adjusted prevalence of hearing impairment has significantly increased during the last two decades. *Scand Audiol Suppl*,54):5-7.
39. Parving A, Hein H, Suadicani P, et al. (1993). Epidemiology of Hearing Disorders Some Factors Affecting Hearing. The Copenhagen Male Study. *Scand Audiol*,22(2):101-7.
40. Davis A (1995). The prevalence and distribution of hearing impairment and reported hearing disability in the MRC Institute of Hearing Research's National Study of Hearing. Hearing in adults London: Whurr Publishers Ltd.
41. Tucci DL, Merson MH, Wilson BS (2010). A summary of the literature on global hearing impairment: current status and priorities for action. *Otol Neurotol*,31(1):31-41.
42. Nelson DI, Nelson RY, Concha-Barrientos M, et al. (2005). The global burden of occupational noise-induced hearing loss. *Am J Ind Med*,48(6):446-58.
43. Mehra S, Eavey RD, Keamy DG (2009). The epidemiology of hearing impairment in the United States: newborns, children, and adolescents. *Otolaryngol Head Neck Surg*,140(4):461-72.
44. Murthy GVS, Mactaggart I, Mohammad M, et al. (2014). Assessing the prevalence of sensory and motor impairments in childhood in Bangladesh using key informants. *Arch Dis Child*,99(12):1103-8.
45. Liu X, Xu L, Zhang S, et al. (1993). Prevalence and aetiology of profound deafness in the general population of Sichuan, China. *J Laryngol Otol*,107(11):990-3.
46. Van Naarden K, Decouflé P, Caldwell K (1999). Prevalence and characteristics of children with serious hearing impairment in metropolitan Atlanta, 1991–1993. *Pediatrics*,103(3):570-5.
47. Baille M-F, Arnaud C, Cans C, et al. (1996). Prevalence, aetiology, and care of severe and profound hearing loss. *Arch Dis Child*,75(2):129-32.
48. Nash SD, Cruickshanks KJ, Klein R, et al. (2011). The prevalence of hearing impairment and associated risk factors: the Beaver Dam Offspring Study. *Arch Otolaryngol Head Neck Surg*,137(5):432-9.
49. Cruickshanks KJ, Wiley TL, Tweed TS, et al. (1998). Prevalence of hearing loss in older adults in Beaver Dam, Wisconsin. The Epidemiology of Hearing Loss Study. *Am J Epidemiol*,148(9):879-86.
50. Maggi S, Minicuci N, Martini A, et al. (1998). Prevalence rates of hearing impairment and comorbid conditions in older people: the Veneto Study. *J Am Geriatr Soc*,46(9):1069-74.
51. Chia EM, Wang JJ, Rochtchina E, et al. (2007). Hearing impairment and health-related quality of life: the Blue Mountains Hearing Study. *Ear Hear*,28(2):187-95.
52. Lee DJ, Gomez-Marin O, Lam BL, et al. (2004). Trends in hearing impairment in United States adults: the national health interview survey, 1986-1995. *J Gerontol A Biol Sci Med Sci*,59(11):1186-90.
53. Helzner EP, Cauley JA, Pratt SR, et al. (2005). Race and sex differences in age-related hearing loss: The Health, Aging and Body Composition Study. *J Am Geriatr Soc*,53(12):2119-27.
54. Khandekar R, Al Riyami A, Attiya M, et al. (2010). Prevalence and determinants of blindness, low vision, deafness and major bone fractures among elderly Omani population of Nizwa Wilayat (Nizwa elderly population study–2005). *Indian J Ophthalmol*,58(4):313.
55. Al Khabori M, Khandekar R (2004). The prevalence and causes of hearing impairment in Oman: a community-based cross-sectional study. *Int J Audiol*,43(8):486-92.
56. Mitchell RE (2006). How many deaf people are there in the United States? Estimates from the Survey of Income and Program Participation. *J Deaf Stud Deaf Educ*,11(1):112-9.
57. Westerberg BD, Lee PK, Lukwago L, et al. (2008). Cross-sectional survey of hearing impairment and ear disease in Uganda. *J Otolaryngol Head Neck Surg*,37(6):753-8.
58. Liu C, Bu X, Xing G, et al. (2006). [Epidemiologic study on hearing impairment and ear diseases in old people]. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*,41(9):661-4.
59. Jun HJ, Hwang SY, Lee SH, et al. (2015). The prevalence of hearing loss in South Korea: Data from a population-based study. *Laryngoscope*,125(3):690-4.
60. Quaranta A, Assennato G, Sallustio V (1995). Epidemiology of hearing problems among adults in Italy. *Scand Audiol Suppl*,42(9-13.

61. Mattos LC, Veras RP (2007). The prevalence of hearing loss in an elderly population in Rio de Janeiro: a cross-sectional study. Rev Bras *Otorrinolaringol*,73(5):654-9.
62. Wilson D, Walsh P, Sanchez L, et al. (1999). The epidemiology of hearing impairment in an Australian adult population. *Int J Epidemiol*,28(2):247-52.
63. Wilson P, Fleming D, Donaldson I (1993). Prevalence of hearing loss among people aged 65 years and over: screening and hearing aid provision. *Br J Gen Pract*,43(406-9).
64. Karlsmose B, Lauritzen T, Parving A (1999). Prevalence of hearing impairment and subjective hearing problems in a rural Danish population aged 31–50 years. *Br J Audiol*,33(6):395-402.
65. Borchgrevink H, Tambs K, Hoffman H (2005). The Nord-Trondelag Norway audiometric survey 1996-98: unscreened thresholds and prevalence of hearing impairment for adults> 20 years. *Noise Health*,7(28):1.
66. Amedofu GK, Ocansey G, Antwi BB (2006). Characteristics of hearing-impairment among patients in Ghana. *Afr J Health Sci*,12(3):87-93.