

Hearing and Balance Disorders in the State of Hawai'i: Demographics and Demand for Services

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Abstract

Hearing and balance disorders affect people of all ages. Among children, hearing loss affects speech and language development, academic performance, and psychosocial development. Hearing loss in adults negatively impacts work productivity, cognitive function, and psychosocial status. Prevalence of hearing loss in children in Hawai'i is higher than the national average. Research indicates that hearing loss is a prevalent condition among veterans and advanced age adults. This is of particular concern in Hawai'i as the state is home to many military training facilities and has a large elderly population. In contrast to the higher than average prevalence of hearing loss in Hawai'i, there is a relatively small number of practicing audiologists in the state. Audiologists are independent doctoral level professionals responsible for the assessment and non-medical management of hearing impairment, vestibular disorders, auditory processing disorder, auditory neuropathy, tinnitus, and related disorders. Currently, there is no formal audiology training program in Hawai'i to meet the needs for current or future hearing health professionals. The Department of Communication Sciences and Disorders at the University of Hawai'i at Mānoa is developing a proposal for a Doctor of Audiology (Au.D.) program to provide a comprehensive doctoral-level audiology curriculum and clinical training in order to graduate audiologists with knowledge and skills needed to serve people with hearing and balance disorders in Hawai'i. This review article describes the current status of hearing and balance disorders and services in Hawai'i and stresses the importance of early identification and intervention in remediating their effects in all ages, with a focus on the need for expanding hearing health services in Hawai'i.

Keywords

Audiology, Doctor of Audiology (Au.D.), Hawai'i, hearing loss, prevalence, screening

Abbreviations

*Au.D. = Doctor of Audiology
NHSP = Newborn Hearing Screening Program
SRP = School Readiness Project
PACT = Parents and Children Together
AAA = American Academy of Audiology
ABA = American Board of Audiology
ASHA = American Speech-Language and Hearing Association
CSD = Communication Sciences and Disorders
UHSHC = University of Hawai'i Speech and Hearing Clinic
JABSOM = John A. Burns School of Medicine*

Introduction

Hearing disorders can affect people across the lifespan from infancy to advanced age. Damage or dysfunction in various parts of the hearing system leads to temporary or permanent hearing loss of varying types and degrees. If hearing loss is not identified and treated early, it can have long-term effects on the cognitive, emotional, social, and educational development of an individual.¹

Hearing loss not only affects the individual but also impacts family, and friends, as well as co-workers, and is associated with complex communication consequences such as difficulty in conversations with loved ones, speech understanding problems in educational, work, and social situations, and frustration using the phone and watching television. Because of the difficulties in communication due to their hearing loss, people often withdraw and may become socially isolated.² Hearing loss can also be associated with physical consequences such as fatigue, headache, tiredness, vertigo, and stress.² Recent evidence from multiple studies of large numbers of persons ranging from young adults to the geriatric population suggests a link between untreated hearing loss and cognitive impairment,^{3,4} and diminished quality of life.⁴

Around 40 million Americans including children and adults, approximately 16% of the population, suffer from hearing loss severe enough to affect communication abilities.⁵ In the United States, at least 2 children out of 1000 births have hearing related disorders.⁶ In the State of Hawai'i, approximately 3 per 1000 children are born annually with permanent hearing loss.⁷ Hearing loss can occur at any age from infancy to old age and considering the higher prevalence of hearing loss and the population of Hawai'i, there are relatively few licensed practicing audiologists. The main purpose of this paper is to review the importance of early identification and intervention for hearing loss in all ages, with a focus on the need for expanding hearing health services in Hawai'i.

Hearing Loss in Children

Infant Hearing Loss

Even a mild degree of hearing loss in infants can be associated with difficulties in speech and language development, learning, reading, and interpersonal and social skills necessary to augment self-esteem and success in life.⁹ Children with hearing and listening difficulties are an under-served population across the country.^{10,11} The earlier hearing loss occurs in a child's life, the more severe the effects on the child's development.⁹

In 1990, Hawai'i became the first state to mandate universal newborn hearing screening for all infants born in the state. Audiologists are primarily responsible for early identification, diagnosis, and management of hearing loss in children, and for minimizing the impact of hearing loss on overall development of children. Unfortunately, a high proportion of children who do not pass hearing screening test may not receive a necessary follow-up diagnostic assessment or adequate early intervention

services due to an insufficient number of audiologists.⁷ The serious shortage of audiologists in the state, parental refusal, lack of accessibility, and other reasons contribute to a breakdown in the provision of necessary diagnostic and intervention services for children with hearing impairment.

Hearing-Related Programs in Hawai'i for Newborns

Programs are available to infants in Hawai'i for detection, diagnosis, and habilitation or rehabilitation of pediatric hearing loss. The Hawai'i Department of Health Newborn Hearing Screening Program (NHSP) coordinates hospital screening activities statewide and helps families to set up diagnostic evaluation for babies who fail hearing screening. Newborn hearing screening data from 2007 to 2013 published by the State of Hawai'i, Department of Health (Table 1)⁷ shows that in 2013, 3.3 children in every 1000 births were diagnosed with a hearing loss, and 65.6% received early intervention services. Among children who failed newborn hearing screening, 18.0% were lost to follow up. In Table 2, 63.93% of the infants were diagnosed with permanent sensorineural hearing loss, 32.78% with a mixed (conductive and sensorineural) hearing loss, and 3.27% with a conductive hearing loss.

Sensorineural and mixed hearing losses can be managed by prescribing hearing aids, cochlear implants, assistive devices, and/or other implants. Audiologists play a role in determining candidacy, prescribing hearing devices, programming and

fitting hearing devices, and aural rehabilitation. Conductive hearing losses are the result of trauma, ear infection (otitis media), foreign bodies, ear-wax, malformation of ear, etc, and can be treated medically by otolaryngologist and other professionals. Persistent untreated conductive hearing loss can lead to language delay, poor school performance, and auditory processing disorders. According to the American Academy of Audiology's (AAA) "Audiologic Guidelines for the Diagnosis and Treatment of Otitis Media in Children,"¹² the identification, assessment, and management of hearing loss as a result of otitis media falls within the scope of practice of the audiologist.¹² Children with fluctuating hearing loss due to recurrent otitis media experience developmental deficits in communication, attention, and behavior that are primarily auditory based. These children should be referred for a complete audiology evaluation to include: air and bone threshold testing, speech threshold and discrimination testing, and immittance audiometry. Due to the fluctuating nature of the hearing loss, children should continue to be monitored at least at the beginning of the school year and once during the winter months.¹² Audiology intervention should also include an education component for the caregivers regarding the implications of hearing loss on communication as well as information on how to optimize auditory based communication and the classroom environment.¹² Therefore, the audiologist plays a crucial role in the screening, evaluation, treatment, and monitoring of these children.

| Year | %Screened | % Not Passed Screening | % Lost to Follow-Up/Lost to Documentation (LTF/LTD) | % Confirmed Hearing Loss* | Hearing Loss Prevalence per 1000 screened | % Enrolled in Early Intervention (EI)** |
|------|-----------|------------------------|---|---------------------------|---|---|
| 2007 | 98.6 | 1.4 | 33.6 | 25.5 | 3.7 | 82.6 |
| 2008 | 99.0 | 1.2 | 23.1 | 31.0 | 3.7 | 80.3 |
| 2009 | 97.6 | 1.1 | 11.7 | 28.2 | 3.2 | 75.9 |
| 2010 | 98.0 | 1.5 | 32.2 | 22.3 | 3.3 | 77.0 |
| 2011 | 98.5 | 1.1 | 24.6 | 26.1 | 2.8 | 63.2 |
| 2012 | 98.5 | 1.2 | 15.0 | 24.4 | 2.9 | 72.2 |
| 2013 | 99.2 | 1.0 | 18.0 | 31.3 | 3.3 | 65.6 |

- Children who failed the hearing screening were referred for the diagnostic hearing test
- Children who failed diagnostic hearing test were referred for early intervention
- *% Confirmed Hearing Loss = (Total number of children who failed diagnostic hearing test)/(Total number of children who failed hearing screening) X100
- **% Enrolled in EI = (Total number of children enrolled in early intervention)/(Total number of children who failed diagnostic hearing test) X100

| Data Item | Number |
|-----------------------------------|--|
| Total Number of Births | 18,930 |
| Total Documented as Not Screened | 214 |
| Total Documented as Screened | 18,716 |
| Total Pass Screening | 18,521 |
| Total Not Pass Screening | 195 |
| Total with Permanent Hearing Loss | Out of 61, 39 (63.93%) reported sensorineural hearing loss; 2 (3.27%) reported conductive hearing loss; 20 (32.78%) reported mixed hearing loss. |

Out of 195 children who failed the screening, 49 children had no diagnosis and 85 had no hearing loss.

Hearing Loss in Pre-School and School-Aged Children

Middle ear infection is the most common cause of hearing loss in pre-school and school-age children in Hawai'i. Middle ear disorders may be more prevalent in Hawaiian preschoolers than typical preschool populations.¹³ Ear infections can lead to conductive hearing loss and negatively affect communication. Hearing loss not detected and treated early can have a negative impact on educational development as well as the development of speech, language, and interpersonal skills. Until 1995, the Hawai'i Department of Health conducted the School Health Hearing and Vision Program that included hearing screening. The program was discontinued due to budgetary constraints. Data for the 1994-95 school year showed out of 72,896 students screened statewide, 5.8% failed the hearing screening and 3.1% showed some type of hearing deficit. Otitis media (ear infection) was the major cause of hearing loss followed by cerumen or foreign body impaction. About 145 children were identified with permanent sensorineural hearing loss.¹⁴

The Hawai'i State Department of Education reports that about 1.5% to 2% of students receiving special-education services are identified with hearing-related problems. Studies confirm an increased prevalence of permanent hearing loss in school age children, particularly adolescents, presumably secondary to recreational exposure to sound.¹⁵ Also, auditory processing disorders in children with normal hearing sensitivity can have a markedly adverse impact on communication, reading, and academic performance.¹⁶ School audiologists are key members of the educational team when it comes to reducing the negative impact of hearing loss and other auditory disorders on children. In Hawai'i, at present there are school screening programs such as School Readiness Project (SRP), Parents and Children Together (PACT), and Hawai'i Lions Hearing Screening. These school screening programs reach few schools in the state and not all school-aged children receive the screening services.

Hearing Loss in Adults Noise-Induced Hearing Loss

One of the most common causes of hearing loss in adults is exposure to loud levels of sound. Adults are at risk for noise-induced hearing loss in the work environment and also as a result of recreational activities such as hunting, motor sports, and listening to or performing loud music. The Hawai'i Department of Labor and Industrial Relations¹⁷ reports annual data about the number of individuals with occupation/employment-related

hearing loss. The reported cases had a wide range of occupational backgrounds such as construction, manufacturing, mining, and transportation. In Table 3, data from 2010-2014 showed that slightly less than 0.5% of total reported cases had hearing loss. This number is an under-representation of total adult cases in Hawai'i since all cases are not reported.

Hawai'i is home to one of the largest military bases and naval installations. Soldiers, marines, sailors, and airmen are exposed to loud sounds from blasts, gunfire, and jet engine noise which not only cause hearing loss but can also cause tinnitus, which is ringing in the ear. Hearing loss is the most common service-connected disability in military veterans.¹⁸ In addition, severe hearing loss for relatively younger veterans who served from 2001 to 2010 is four times higher compared to non-veterans.¹⁹ There are 112,625 veterans living in the Hawai'i, which is approximately 11% of Hawai'i's adult population.²⁰ The veteran population in Hawai'i is in need of more accessible audiology services for the management of hearing loss and tinnitus.

Hearing Loss Related to Aging

In the United States, more than 60% of people above age 70 reported a permanent hearing loss requiring immediate audiology intervention.²¹ Hawai'i witnessed a growth in the elderly population within the last two decades. Roughly 14.5% of the state's population is within the age range of 65 years and above. Hearing loss is a common health problem among the aging population, especially if the clients had noise exposure during their military service.

Related Disorders

In addition to assessment, treatment, and management of hearing loss, audiologists provide clinical services to persons with other related disorders. Tinnitus is the perception of ringing or other sounds in the absence of external sound. Approximately one-in-five persons with hearing impairment have persistent tinnitus, which can be debilitating. Bothersome tinnitus has a major effect on sleep, work, and quality of life. Tinnitus is also one of the most common health problems in military personnel and veterans.

Audiologists are also responsible for evaluation and management of vestibular and balance disorders. Impaired balance and fall disorders among the elderly population are a major health problem with serious financial implications.

| Table 3. Number of Reported Hearing Loss Cases at the Hawai'i Department of Labor and Industrial Relations. Data from Workers' Compensation Annual Database. | | | | |
|---|---|-----------------------------|----------------------------------|----------|
| Year | Total Reported Cases with Hearing Loss* | Total (%) with Hearing Loss | Reported Cases with Hearing Loss | |
| | | | New | Existing |
| 2010 | 20,654 | 100 (0.48) | 32 | 68 |
| 2011 | 20,515 | 91 (0.44) | 22 | 69 |
| 2012 | 21,052 | 87 (0.41) | 18 | 69 |
| 2013 | 20,721 | 83 (0.40) | 22 | 61 |
| 2014 | 20,693 | 71 (0.34) | 16 | 55 |

*Total reported cases: All injuries and illnesses reported to the disability compensation division. These reported injuries or illnesses may not have occurred during the reported year.

Other causes of hearing loss include head trauma, vestibular schwannoma affecting the auditory system, neural degeneration, ototoxic medications, cardiovascular disease, diabetes, and hypertension. Prompt audiology monitoring and early intervention of hearing loss in adults is important to reduce the impact on the individual's quality of life.

During the process of assessment and management of various hearing and balance related disorders, audiologists often work closely with other professionals such as otolaryngologists, ear-nose-throat specialists, neurologists, family physicians, psychologists, teachers, social service professionals, and speech-language pathologists.

Need for Audiologists in Hawai'i

Despite the high prevalence of hearing and balance disorders in Hawai'i, only 76 audiologists hold a license to practice, some of whom are listed as living on the mainland.²² The need for audiology services is outpacing the supply of new audiologists. There is a need for a formal doctoral level educational program to produce an adequate number of competent audiologists in the state.

Audiologists are doctoral level licensed professionals who identify, diagnose, and manage hearing and balance disorders in children and adults. Management of hearing loss involves selection and fitting of hearing aids and other assistive devices, programming cochlear implants, instruction on communication strategies, hearing conservation, environmental modifications, and personal and information counseling. Audiologists also perform intra-operative neurophysiology surgical monitoring, newborn hearing screening, school-based services, tinnitus management, and implementation of hearing conservation programs. Assessment and non-medical management of auditory processing disorders, vestibular disorders, and auditory neuropathy falls under the audiologist's scope of practice.²³

Doctor of Audiology Degree

In the United States, the Doctor of Audiology degree (AuD) has replaced the Masters-level degree to become the new entry-level academic credential, since 2007. The AuD is a clinical doctorate degree that can lead to state licensure and other professional credentials. Professional organizations such as the American Academy of Audiology (AAA), American Board of Audiology (ABA) and American Speech-Language and Hearing Association (ASHA) offer educational activities and credentialing to assure the high standard of practice, clinical certification, and code of conduct for the profession of audiology.

The Accreditation Commission for Audiology Education provides accreditation to new audiology programs. At present, there are 74 accredited AuD programs in the United States but only 4 programs are on the West Coast. Programs generally accept between 10 and 20 students a year. In comparison to other health professions such as medicine, optometry, and dentistry, audiology programs combined have the lowest number of students

and the fewest graduates annually. There is considerable and growing demand for more audiology graduates in the country, but little has been done to increase the number of audiology professionals as compared to other allied health professions.

Tele-Audiology

The term "tele-audiology" was coined to refer to audiology applications of tele-health.^{24,25} Peer-reviewed publications describe validation of the feasibility and quality of diverse audiology services delivered via tele-health technology and techniques in newborn hearing screening, diagnosis of childhood hearing loss, hearing screening of school age children, hearing aid fitting, cochlear implant programming, counseling, and rehabilitation of persons with bothersome tinnitus.²⁴ The tele-audiology approach to hearing health care is now relied upon in the Veterans Administration Audiology clinics, rural regions of the United States, and also in developing regions of the world. Legislation related to tele-health was recently enacted in the state of Hawai'i, including 2013 statutes §432D 23.5, §431:10A-116.3, and the 2016 Legislative Session Act 226 mandating Medicaid coverage for tele-health services and removing originating site restrictions. Research confirms that tele-audiology increases access to high quality hearing health care while decreasing patient wait times and costs. The unique geographical features of Hawai'i present challenges to patients attempting to access hearing health care. Patients with hearing loss and related disorders are scattered among multiple islands yet diagnostic and rehabilitative audiology services are available only in major population centers. Transportation to these centers is often time-consuming and costly. There is a strong rationale for the development of a systematic tele-audiology program for expansion of various hearing health care services in the state of Hawai'i.

Department of Communication Sciences and Disorders at the University of Hawai'i at Manoa

The Department of Communications Sciences and Disorders (CSD) at the University of Hawai'i at Manoa is located in the John A. Burns School of Medicine (JABSOM). The department currently offers a Master of Science degree in CSD with an emphasis in speech-language pathology. The CSD department proposes to eventually establish a Doctor of Audiology program, which will complement the current Master of Science in Communication Sciences and Disorders, as well as provide a much-needed service to the community. The University of Hawai'i Speech and Hearing Clinic (UHSHC) is a state of the art clinic and has been providing speech, language, and hearing services for more than 30 years. UHSHC is affiliated with United Health Partners which is the faculty practice organization created to support clinical, academic, and research activities of faculty at JABSOM. Services provided by UHSHC include:

- Aural rehabilitation
- Comprehensive hearing evaluation
- Auditory processing evaluation
- Dispensing hearing aids and assistive hearing technologies
- Comprehensive speech, language, and cognitive-communicative evaluation and therapy

The department's vision is to collaborate with professional experts through local, national, and international partnerships (especially in Asian-Pacific countries), to establish and maintain a dynamic, productive and cost effective program in the field of communication sciences and disorders.

Conclusion

There is a shortage of audiologists in Hawai'i available to provide much needed hearing health care to the community. Although competent audiologists are urgently needed, there is no professional training program available in the state. The prospective AuD program at the University of Hawai'i at Manoa would provide a high-quality educational opportunity for students interested in a career in audiology who wish to remain in their home state. It is also anticipated that an AuD program in Hawai'i would attract students from across the country and throughout the Pacific.

The University of Hawai'i at Manoa, Department of Communication Sciences and Disorders is aiming to build an audiology graduate program that will prepare professionals to serve a diverse group of individuals who require diagnosis, counseling, and assistance with hearing and speech problems. A new AuD program will help to increase the number of highly qualified audiologists in Hawai'i who will be able to serve the needs of the veteran population, school screening, newborn hearing screening, people with traumatic brain injury, and all children and adults with communication disorders. Hawai'i has a strategic location to connect the United States, Pacific region and Asian countries, which could be an advantage in bringing students from multicultural backgrounds.

Conflict of Interest

None of the authors identify any conflicts of interest.

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References

1. Johnson CE. *Introduction to Auditory Rehabilitation: A Contemporary Issues Approach*. Upper Saddle River, NJ: Pearson Higher Ed; 2011.
2. Hall JW III. *Introduction to Audiology Today*. Boston: Pearson Education Inc; 2014.
3. Lin FR, Metter EJ, O'Brien RJ, Resnick SM, Zonderman AB, Ferrucci L. Hearing loss and incident dementia. *Archives of neurology*. 2011;68(2):214-220.
4. Li-Korotky H-S. Age-related hearing loss: quality of care for quality of life. *The Gerontologist*. 2012;52(2):265-271.
5. Blackwell DL, Lucas JW, Clarke TC. Summary health statistics for US adults: national health interview survey, 2012. *Vital and health statistics. Series 10, Data from the National Health Survey*. 2014(260):1-161.
6. National Institute of Deafness and Other Communication Disorders. Quick Statistics About Hearing. 2015. <http://www.nidcd.nih.gov/health/statistics/pages/quick.aspx>. Accessed April 20, 2016.
7. State of Hawai'i, Department of Health. Newborn Hearing Screening Program. 2014. <http://health.hawaii.gov/genetics/programs/nhsp/>. Accessed April 20, 2016.
8. United States Census Bureau. Population Demographics for Hawai'i 2016 and 2015. 2016. <https://suburbanstats.org/population/how-many-people-live-in-hawaii>. Accessed April 20, 2016.
9. American Speech-Language-Hearing Association. Effect of Hearing Loss on Development. Audiology Information Series. 2015. <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0ahUKEwiisTu1ZHLhVCNT4KHyoEAFaQFggkMAE&url=http%3A%2F%2Fwww.asha.org%2FuploadedFiles%2FAIS-Hearing-Loss-Development-Effects.pdf&usq=AFQjCNGmUsKbiZLpLlSuvZpgFd-BO4GYCw&cad=rja>. Accessed April 20, 2016.
10. Madell, Jane R., and CertAVT LSLs. "The challenges ahead in pediatric audiology." *ENT News* 18.1;(2009):66-68.
11. Eiserman, William D., et al. "Using otoacoustic emissions to screen for hearing loss in early childhood care settings." *International journal of pediatric otorhinolaryngology* 72.4;(2008):475-482.
12. American Academy of Audiology Guidelines (1992). <http://www.audiology.org/publications-resources/document-library/audiologic-guidelines-diagnosis-treatment-otitis-media>. Accessed October 28, 2016.
13. Pang-Ching G, Robb M, Heath R & Takumi M. Middle ear disorders and hearing loss in native Hawai'ian preschoolers. *Language, Speech, and Hearing Services in Schools*. 1995; 26:33-38.
14. Statewide Hearing Screening Data, Department of Health, School Health Hearing and Vision Program (1994-1995).
15. Shargorodsky J, Curhan SG, Curhan GC, Eavey R. Change in prevalence of hearing loss in US adolescents. *JAMA*. 2010;304(7):772-778.
16. American Academy of Audiology. Clinical Practice Guidelines. Diagnosis, Treatment, and Management of Children and Adults with Central Auditory Processing Disorder. 2010. www.audiology.org. Accessed April 20, 2016.
17. State of Hawai'i, Department of Labor and Industrial Relations. Occupation or Employment Related Hearing Loss. 2016. <http://labor.hawaii.gov/2014-dlir-annual-report/>. Accessed April 20, 2016.
18. US Government Accountability Office. Hearing loss prevention: improvements to DOD hearing conservation programs could lead to better outcomes. Washington, DC: US Government Accountability Office; 2011. Available at <http://www.gao.gov/new.items/d11114.pdf>. Accessed July 20, 2011.
19. Centers for Disease Control and Prevention. Severe hearing impairment among military veterans — United States., 2010. *Weekly*, 60, 955-958 (July 22, 2011).
20. Supporting Veterans In Hawai'i. <http://www.veteransdata.info/states/2150000/HAWAII.pdf>. Last accessed on August 8, 2016.
21. Lin FR, Thorpe R, Gordon-Salant S, Ferrucci L. Hearing loss prevalence and risk factors among older adults in the United States. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*. 2011;66(5):582-590.
22. State of Hawai'i, Department of Commerce and Consumer Affairs. Professional and Vocational Licensing Division, Current Licenses as of April 14, 2016. 2016. <http://cca.hawaii.gov/pvl/reports/>. Accessed April 20, 2016.
23. American Speech-Language-Hearing Association. (2004). *Scope of practice in audiology* [Scope of Practice]. Available from www.asha.org/policy.
24. Swanepoel DW, Hall III JW. A systematic review of telehealth applications in audiology. *Telemedicine and e-Health*. 2010;16(2):181-200.
25. Swanepoel DW, Clark JL, Koekemoer D, et al. Telehealth in audiology: The need and potential to reach underserved communities. *International Journal of Audiology*. 2010;49(3):195-202.