

Estimated prevalence of hearing loss and provision of hearing services in Pacific Island nations

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ABSTRACT

INTRODUCTION: Hearing impairment (HI) affects an estimated 538 million people worldwide, with 80% of these living in developing countries. Untreated HI in childhood may lead to developmental delay and in adults results in social isolation, inability to find or maintain employment, and dependency. Early intervention and support programmes can significantly reduce the negative effects of HI.

AIM: To estimate HI prevalence and identify available hearing services in some Pacific countries—Cook Islands, Fiji, Niue, Samoa, Tokelau, Tonga.

METHODS: Data were collected through literature review and correspondence with service providers. Prevalence estimates were based on census data and previously published regional estimates.

RESULTS: Estimates indicate 20–23% of the population may have at least a mild HI, with up to 11% having a moderate impairment or worse. Estimated incidence of chronic otitis media in Pacific Island nations is 3–5 times greater than other Australasian countries in children under 10 years old. Permanent HI from otitis media is substantially more likely in children and adults in Pacific Island nations. Several organisations and individuals provide some limited hearing services in a few Pacific Island nations, but the majority of people with HI are largely underserved.

DISCUSSION: Although accurate information on HI prevalence is lacking, prevalence estimates of HI and ear disease suggest they are significant health conditions in Pacific Island nations. There is relatively little support for people with HI or ear disease in the Pacific region. An investment in initiatives to both identify and support people with hearing loss in the Pacific is necessary.

KEYWORDS: Health services; hearing loss; otitis media; Pacific Islands

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Introduction

Recent estimates based on World Health Organization (WHO) data indicate that about 538 million people globally have a hearing loss greater than 35 decibel hearing level (dBHL), regarded by WHO as a significant disability.¹ Adult onset hearing loss is ranked as the second greatest single contributor to years lived with disability (YLD) after unipolar depressive disorders, based on 2002 WHO estimates.² Hearing loss severity can be classified as mild (26–40 dBHL), moderate (41–55 dBHL), moderately severe (56–70 dBHL), severe (71–90 dBHL), and profound (≥ 90 dBHL).³ Disability weightings used in the calculation of

YLDs allow comparison of adult onset hearing loss with other diseases, based on published disability weighting data.⁴ It has been reported that ‘a mild hearing loss is comparable to mild asthma; a moderate hearing loss is comparable to the chronic pain associated with a slipped disc; and a severe hearing loss is comparable to having pneumonia on an ongoing basis’.⁵

Age of onset has significant implications for hearing disability. Children will have a greater disability for a given severity of loss, particularly if the loss is acquired pre-lingually, because of the dependency of speech and language development on hearing. In children, untreated hearing loss

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may result in delayed development of speech, as well as language and cognitive skills, which can relate to learning, behavioural and social problems.^{6,7} In adults, the inability to communicate, along with other factors such as the stigma of disability, can result in social isolation, inability to gain or maintain employment, dependency, and poverty.⁸ These effects are compounded in developing economies, where access to early detection and rehabilitation services is limited, and the stigma associated with hearing loss may be greater.⁹

Hearing loss also represents a significant cost to society. For example, Australian data indicates a direct financial cost of hearing loss in 2006 at A\$11.75 billion (1.4% of GDP), with productivity loss accounting for 57% of this figure.⁵ Given that hearing loss has a greater prevalence among the elderly, a growing demographic group, the prevalence of hearing loss is set to rise substantially. Hearing loss has been estimated to rise within the Australian population from approximately 17% to about 28% of the population by 2050.⁵ Currently there are no estimates of the financial cost of hearing loss in developing economies.¹⁰

The main aetiology of hearing loss ordered by proportion of total burden (disability adjusted life years or DALYs) are genetic, otitis media (middle ear disease), presbycusis (age-related), noise exposure, ototoxic drugs and chemicals, pre- and perinatal problems, infectious causes, wax and foreign bodies, nutrition related, trauma related, Ménière's disease, tumours, and cerebrovascular disease.^{10,11} The WHO suggests that, with appropriate interventions, up to 50% of hearing loss is thought to be preventable.¹² Congenital or other non-preventable hearing loss is managed effectively through early intervention (e.g. hearing aids, cochlear implants) to reduce the negative impact of the impairment.

The provision of, and access to, specialist health services remain a challenge for many low-to-middle income countries; the Pacific Islands are no exception. The WHO has acknowledged the need for services and resources to treat and prevent hearing loss and ear disease within low- and middle-income countries (LMIC).

Given New Zealand's proximity and long-established connections, the Pacific region remains a priority for our research. A review of published and grey literature, as well as census data for the Cook Islands, Fiji, Niue, Samoa, Tokelau and Tonga revealed a lack of reliable country-specific prevalence data related to hearing loss and middle ear disease. Peer reviewed, published studies on hearing loss in the Pacific Islands are scarce, although some of the governments have collected data on disability and hearing loss. A sample of two local schools in Samoa reported peak rates of otitis media with effusion in children aged 6–7 years, with 19.4% testing positive.¹³ In the Cook Islands, a deafness and hearing impairment (HI) prevalence rate for the overall population of 0.74% has been reported,¹⁴ compared with 0.6% in Tonga,¹⁵ and 0.28% in Samoa.¹⁶ These reports are most likely a gross underestimate of the proportion of the prevalence of hearing impairment, given that the estimated prevalence of hearing loss in New Zealand is 10.3%,¹⁷ in Australia and the UK 17%,^{5,18} and the WHO reports HI to be as high as 8.8% in the South East Asian Region.¹⁹

Two Bayesian modelled regional estimates have recently been published for hearing loss prevalence¹ and middle ear disease incidence,²⁰ and these provide some indication of the probable extent of hearing loss and middle ear disease in the Pacific region. The Stevens et al.¹ paper models regional hearing loss prevalence for over five-year-olds by gender, age, and hearing loss severity for the year 2008, based on Bayesian hierarchical modelling, from 42 studies in 29 countries. Relative to their higher income neighbours, estimates for the Asia-Pacific region indicate a much higher prevalence for all degrees of hearing loss from an earlier age (Figure 1). For example, the prevalence of hearing loss representing significant disability (>35 dBHL) among school-aged children (5–19 years of age) is estimated at 1.8% within the Asia-Pacific Region and 0.4% within Australasia.¹

Monasta et al.²⁰ modelled global regional middle ear disease (acute otitis media [AOM] and chronic suppurative otitis media [CSOM]) incidence, associated hearing loss prevalence, and mortality by age and hearing loss severity for the year 2005. The data were generated via a two-stage approach based on risk factors and regression modelling.²⁰

The results for Oceania suggest a very high incidence of AOM of 28.56%, and CSOM of 0.937%, with a high estimated prevalence of associated hearing loss (>25 dBHL better ear; 51.23/10 000). These estimates are significantly higher than estimates for Australian and New Zealand (Australasian) populations, with AOM (7.25%), CSOM (0.341%), HI >25 dBHL better ear (1.36/10 000). Age-related data in these models suggests that the overall burden of otitis media (OM) and its sequelae is greatest in younger children globally.

The purpose of this current study is to provide country-specific estimates for a group of Pacific Island nations, by extending the estimated regional prevalence data from the Stevens et al.¹ and Monasta et al.²⁰ datasets. This information can potentially be then used to guide policy and planning responses. The study also examines the extent and nature of hearing services that currently exist or are being developed in these nations. Hearing services are defined here in the broadest sense, comprising community education (prevention and awareness), identification (newborn and school screening), rehabilitative (audiological), medical (preventive and curative), education and support services. A further analysis of the availability of hearing services within Pacific nations enables a deeper understanding of the extent of the problem, as a basis for the development of initiatives to address the burden of hearing loss within small Pacific Island nations.

Methods

Country-specific estimates for prevalence of hearing loss and middle ear disease

Due to the lack of reliable country-specific data, two Bayesian-modelled regional prevalence datasets for hearing loss¹ and middle ear disease²⁰ were extended, using country census data, to provide country-specific prevalence estimates.

The country-specific models were generated by multiplying the specific prevalence for each age group (and gender)¹ by the number of people within that age range (and gender),¹ for the Cook Islands,¹⁴ Fiji,²¹ Samoa,¹⁶ Tokelau,²² and Tonga.²³ Data used for the population breakdown by age groups came from the respective national census

WHAT GAP THIS FILLS

What we already know: Pacific peoples within New Zealand have a higher incidence and prevalence of middle ear disease and associated hearing loss than New Zealand Europeans. Prevalence data relating to hearing loss and middle ear disease within the Pacific Islands is scarce.

What this study adds: The prevalence of ear disease and hearing loss were estimated within selected eastern Pacific Island nations and compared with available services identified. The findings highlight a need for the development of hearing and ear health services within these nations.

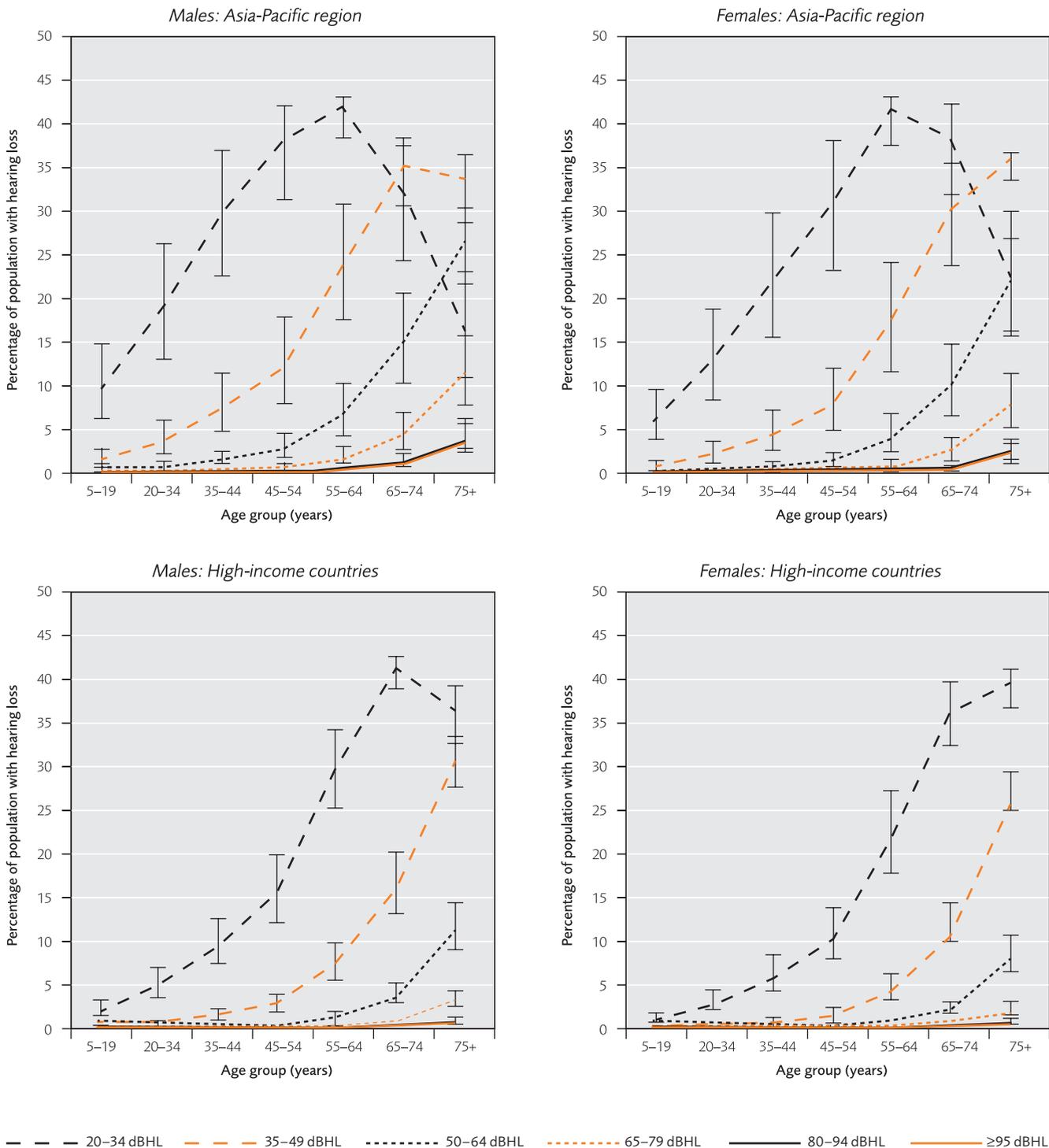
of each country. The census collection year used was 2006 for all of the countries apart from Fiji, whose census was conducted in 2007 (see the Appendix Table A1 in the online version of this paper for census dates). These data were then combined to find an estimate of the total number of people with HI in each population and then collapsed into a single prevalence estimate (Tables 1 and 2). As Stevens et al.¹ only reports hearing loss for populations over four years of age, to estimate permanent hearing loss prevalence for children less than five years of age, we used the prevalence of congenital deafness and HI acquired from meningitis, the two greatest causes of permanent hearing loss in young children. This was calculated using the congenital deafness rate in New Zealand of 3 per 1000 live births,²⁴ assuming low mortality, and a rate of 1 per 1000 cases of HI acquired from meningitis infections where there is no immunisation²⁵ (see Appendix Table A2 in the online version of this paper for the model data).

Service provision

A review was completed that aimed to identify hearing services currently available in the Pacific countries, as defined in the introduction.

Information on service provision was collected in two parts: a review of literature (limited to English language articles in Medline, Scopus, PubMed and Embase) and an extensive online search for grey literature (using Google). Terms relating to HI (otitis media, glue ear, deaf, deafness, hearing loss, hearing impaired, hearing aid, cochlear implant, and Phonak and Oticon—two hearing aid companies known to be providing intermit-

Figure 1. Estimated prevalence (%) of hearing loss by age group, hearing impairment, and region for 2008*



* Figure generated from data of Stevens et al.¹—supplementary Table S3.1

Error bars represent 95% uncertainty levels

Table 1. Estimates of hearing loss prevalence by country for population five years of age and older*

Country	Population ≥5 yrs	20–34 dBHL	35–49 dBHL	50–64 dBHL	65–79 dBHL	80–94 dBHL	≥95 dBHL	All (≥5 yrs)
Cook Islands	15 339	20.2% (15.3%, 25.4%)	7.3% (5.3%, 10.0%)	2.2% (1.5%, 3.3%)	0.6% (0.4%, 1.0%)	0.2% (0.1%, 0.3%)	0.2% (0.1%, 0.3%)	30.7% (22.7%, 40.3%)
Fiji	754 553	19.9% (14.9%, 25.3%)	6.7% (4.7%, 9.3%)	2.0% (1.3%, 2.9%)	0.6% (0.3%, 0.9%)	0.2% (0.1%, 0.3%)	0.1% (0.1%, 0.2%)	29.5% (21.4%, 39.0%)
Samoa	160 981	18.5% (13.8%, 23.8%)	6.4% (4.6%, 8.7%)	2.0% (1.3%, 2.9%)	0.6% (0.3%, 0.9%)	0.2% (0.1%, 0.3%)	0.1% (0.1%, 0.3%)	27.8% (20.2%, 36.9%)
Tokelau	1300	18.9% (14.1%, 24.1%)	7.2% (5.2%, 9.6%)	2.4% (1.6%, 3.4%)	0.7% (0.5%, 1.1%)	0.2% (0.1%, 0.4%)	0.2% (0.1%, 0.3%)	29.6% (21.6%, 38.9%)
Tonga	87 301	18.1% (13.4%, 23.4%)	6.5% (4.7%, 8.7%)	2.1% (1.4%, 3.0%)	0.6% (0.4%, 0.9%)	0.2% (0.1%, 0.3%)	0.2% (0.1%, 0.3%)	27.7% (20.1%, 36.6%)
New Zealand	3 752 859	12.4% (10.5%, 14.9%)	4.1% (3.4%, 5.1%)	1.1% (0.8%, 1.5%)	0.3% (0.2%, 0.4%)	0.1% (0.1%, 0.1%)	0.1% (0.0%, 0.1%)	18.1% (15.0%, 22.1%)

* Based on Stevens et al.¹ and collapsed by age and gender for the year 2008

Values in brackets represent 95% confidence levels

Table 2. Country estimates for AOM and CSOM incidence, prevalence of hearing impairment (HI) and mortality (proportions) for the year 2005*

Country	Population (total)	AOM incidence (%)	CSOM incidence (‰)	HI better ear (‰/0000)				Deaths (‰/000000)
				25 dBHL > HI ≤ 40 dBHL	40 dBHL > HI ≤ 60 dBHL	60 dBHL > HI ≤ 80 dBHL	80 dBHL > HI	
Cook Islands	16 996	31.7 (30.9, 32.4)	11.2 (10.6, 11.7)	364.8 (358.5, 371.1)	167.4 (166.8, 168.1)	59.3 (59.1, 59.6)	20.9 (20.8, 21.0)	161.5 (141.4, 173.6)
Fiji	837 271	30.7 (29.9, 31.5)	11.1 (10.5, 11.6)	356.8 (350.4, 363.1)	163.7 (163.1, 164.4)	58.0 (57.7, 58.3)	20.5 (20.4, 20.6)	149.1 (130.6, 161.0)
Samoa	187 820	41.0 (40.2, 41.8)	14.1 (13.5, 15.0)	346.5 (339.9, 353.1)	159.0 (158.3, 159.7)	56.3 (56.1, 56.6)	19.9 (19.8, 20.0)	175.8 (151.1, 186.0)
Tokelau	1466	35.4 (34.6, 36.2)	12.3 (11.7, 12.9)	371.2 (364.7, 377.8)	170.4 (169.7, 171.1)	60.4 (60.1, 60.6)	21.3 (21.2, 21.4)	207.6 (185.0, 222.3)
Tonga	101 028	40.1 (39.3, 40.9)	13.8 (13.2, 14.4)	350.0 (343.4, 356.6)	160.6 (159.9, 161.3)	56.9 (56.7, 57.2)	20.1 (20.0, 20.2)	184.0 (161.8, 197.8)
New Zealand	4 027 938	10.6 (10.1, 11.0)	3.6 (2.7, 4.4)	9.5 (4.2, 15.1)	1.5 (0.9, 2.1)	0.1 (0.1, 0.2)	0.0 (0.0, 0.0)	3.0 (0.0, 9.9)

AOM Acute otitis media

CSOM Chronic suppurative otitis media

* Calculated from Monasta et al.²⁰ data—Tables S26, S48, and country census data (Table 1)^{14,16,21–23,26}

Values in brackets represent 99% confidence levels

tent services in Pacific countries) were coupled with country names and regional terms (Cook Islands, Fiji, Niue, Samoa, Tokelau and Tonga, Pacific, Pacific Islands) and service provision descriptors (services, education, rehabilitation, special needs). A second search was performed using the same country and geographic search terms, coupled with hearing service providers (audiology, otolaryngology, audiologist, otolaryngologist, ENT, ORL, speech language therapist). Information on services was collected through direct communication with service providers,

either by email or telephone interview. Twenty-seven service providers or organisations were identified and contacted, and responses were received from 15.

Results

Estimates of hearing loss prevalence in the Pacific

Extending the data of Stevens et al.,¹ the prevalence of hearing loss within the Asia-Pacific region is far greater than in high-income countries

(Figure 1). Using these prevalence estimates and country census data,^{14,16,21–23,26} country-specific estimates of hearing loss prevalence were generated for individuals five years of age and older, and collapsed by age and gender (see Table 1 for mean prevalence and 95% uncertainty values). It is estimated that over 27% of the Pacific Island population over five years of age have a hearing loss greater than 20 dBHL and that over 10% have a hearing loss that represents a significant disability according to the WHO (>35 dBHL). Estimates of the number of children (0–19 years of age) with congenital deafness and acquired HI from childhood meningitis are shown in the Appendix (see Table A2 in the online version of this paper).

Estimated otitis media prevalence

The estimated incidence of acute (ASOM) and chronic (CSOM) suppurative otitis media in Pacific Island countries is very high in comparison with New Zealand. Table 2 shows estimated incidence and prevalence values with 99% confidence levels. These middle ear conditions, particularly CSOM, can cause significant hearing loss if untreated, and our estimates of the prevalence of hearing loss are very high at 35–36/1000 in Pacific Island nations when compared to New Zealand at 0.36/1000. The estimated incidence of CSOM in Pacific Island nations is 3–5 times greater than other Australasian countries in children less than 10 years old, but becomes more similar in older children and adults. Similarly, significant permanent disabling hearing loss (>40 dBHL in the better ear) from otitis media is substantially more likely in children and adults in Pacific Island nations. Estimates of CSOM incidence and disabling hearing loss prevalence by age and by region are shown in the Appendix (see Table A3 in the online version of this paper).

Service provision

Once identified, services were categorised according to whether they provided prevention, identification or (re)habilitation services. No services or initiatives specific to prevention of hearing loss were identified within these countries. A list of the services and contact details are provided in the Appendix (see Table A4 in the online version of this paper).

Identification of medical or audiological services

Population-based or specialist hearing loss identification initiatives are scarce in the Pacific. A programme run by the Christoffel Blind Mission (CBM), an international non-governmental organisation (NGO), called Project HEAVEN (Project Hearing and Vision Enhancement) was identified in Fiji. This programme employs 20 vision/hearing screeners and coordinates with local schools to carry out vision and hearing testing. Children identified with an HI are referred to the local hospital or clinic where available. The primary method of screening uses an ‘audioscope’, which combines otoscopy and a screening audiometer. Screening tympanometry is not performed. In 2011, Project HEAVEN screened 21 886 children and 1265 (5.78%) were referred on to the local medical officer for medical treatment or a screening audiometric assessment, which is undertaken by the screener in charge of the programme. Children thought to have significant hearing loss are referred to the Bayly Clinic described later in this section. Project HEAVEN also attempts to provide very basic, non-programmable, analogue hearing aids where possible, fitted by the screener in charge of the programme.

Other identification services are dependent on overseas teams of visiting specialists, primarily from New Zealand and Australia. These teams vary in size and composition, but may include audiologists, technicians, ear nurses and otolaryngologists. Such initiatives include the Pacific Aid Hearing Programme run by Bay Audiology and the New Zealand Lions Club (a charity organisation) who have undertaken projects to identify hearing impaired adults and children and to fit hearing aids in the Cook Islands and Fiji. Phonak NZ (a hearing aid company) has also been working in Fiji, regularly sending teams to coordinate with local special schools to carry out hearing testing and to fit hearing aids (personal communication: K Emerson—Phonak NZ; February 2012), but this has changed recently. A local inclusive education organisation in Samoa, SENESE, coordinates with the Royal Institute for Deaf and Blind Children in Australia for teams of audiologists to visit and test hearing and fit hearing aids that are donated.

Audiological (re)habilitation services in these Pacific nations are also minimal. Citizens of the Cook Islands, Niue and Tokelau are entitled to New Zealand citizenship and therefore are eligible for New Zealand Ministry of Health-funded services. However, the reality is that most of these services are inaccessible to the majority of the population as they are provided only in New Zealand.

The Carabez Alliance, an NGO dedicated to providing audiological services in the Pacific, opened the Bayly Clinic in Suva, Fiji in 2008. The service consists of an assessment unit and a therapy unit, which is staffed by a teacher of the deaf trained in screening audiometry, basic hearing aid repair, and supported by the Royal Institute of Deaf and Blind Children in Sydney through a teleconferencing facility. The Carabez Alliance provides free audiological services to children aged 0–18 years, and hearing aids with the support of the hearing aid manufacturing companies Phonak and Unitron. They also partner with the Royal Institute of Deaf and Blind Children to provide a teleschool service for ongoing speech and language therapy. The Carabez Alliance also partners with the Sydney Cochlear Implant Centre (SCIC), with whom they have undertaken several projects in Fiji and Samoa to help give profoundly deaf children access to cochlear implants. SENESE (Samoa) also runs a habilitation service; they currently employ two teacher aids employed as hearing aid technicians, who are supported by a volunteer audiologist from Australia.

The remainder of rehabilitation services in the Pacific region are provided by visiting specialists. The Pacific Islands Program (PIP) run by the Royal Australasian College of Surgeons (RACS) and funded by the Australian Agency for International Development (AUSAID) has provided ENT services to the Solomon Islands, Vanuatu, Fiji, Tonga, Samoa, Federated States of Micronesia, Marshall Islands, Cook Islands, Kiribati and Tuvalu. There have been 42 visits to the Pacific by this group between 2004 and 2010. Visits are usually about a week in length and average 171 consultations and 34 operations. The New Zealand Agency for International Development (NZAID) also supports visiting medical specialist programmes, as well as an overseas referral

scheme for select countries. For example, ENT specialists have made at least five visits to a number of the Cook Islands between 2004 and 2011, sometimes accompanied by audiologists.²⁷ Despite the admirable efforts of visiting specialists, the rehabilitation services provided are still insufficient to address the needs of the population.

Education and support services

Education and support services for people with special needs, including HI, are established in the Pacific. Organisations such as SENESE or Loto Tamaufai in Samoa focus on providing information, breaking down barriers to inclusion in schools and the community, and supporting deaf individuals and their families, as well as assisting them with access to services. SENESE provides some audiometry and hearing aid services to children, with support from visiting specialists and contact with the Royal Institute for Deaf and Blind Children in Sydney. They are also providing considerable leadership in the development of a National Plan for Hearing Services in Samoa (sponsored by the Ministries of Education and Health and AusAID).

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Other groups emphasise the importance of integrating the deaf community through strengthening sign language. These include the Fiji Gospel School for the Deaf and the Tongan Red Cross School for Speech and Hearing Impaired. There is also a strong voice for Pacific people with disabilities provided by advocacy and support organisations, such as the Fiji Association for the Deaf, the Nuanua O Le Alofa Inc (NOLA) in Samoa, the Samoan Deaf Club and The Naunau 'o e 'Alamaite Tonga Association Incorporated (NATA) in Tonga. There is also a Deaf organisa-

tion in the Cook Islands associated with the Cook Islands Disability Action Team, although limited information was available on this organisation.

Discussion

Reliable epidemiological data for hearing loss in the Pacific Islands is currently lacking; existing national datasets likely underestimate the country-specific burden of hearing loss. Epidemiological data on population health and disability is vital for planning and policy responses. The impact of this data is far-reaching—from policy decisions to the availability and accessibility of hearing services offered to individuals. Epidemiological models based on risk factors and regression analysis using data from non-Pacific countries suggest a very high prevalence of otitis media and HI within the five Pacific Islands nations investigated. These are estimates based on models and need to be verified by epidemiological studies. However, both models provide estimates of their validity and reliability.^{1,20} Stevens et al. report that cross-validation analysis shows that there was good external validity for their model, with 87% of the survey estimates falling within the 95% uncertainty intervals.¹ A high prevalence of otitis media and its sequelae in these Pacific Island nations is also supported by anecdotal evidence through discussions with local medical and hearing health care professionals. Our estimates of hearing loss prevalence suggest that existing hearing services within the Pacific Islands investigated are poorly resourced to meet current needs.

Data obtained from the Fiji-based Project HEAVEN²⁸ suggest a 5.78% referral rate for all school-aged children, based on hearing screening and otoscopy. However, Project HEAVEN does not have access to screening tympanometry, which may result in an under-representation of otitis media in their statistics. Of the screened children, 2.18% were referred to medical officers for treatment of otitis media and its sequelae, and a further 3.52% were seen for impacted wax and foreign body removal; only 0.06% were referred for audiological assessment, which likely reflects the lack of available services. For reference, prior to the advent of newborn hearing screening, screening audiometry referral rates for school

new entrants in 2005/06 in New Zealand were estimated at 6.6%, with Pacific children having the highest fail rate of 11.2%.²⁹

A significant cause of acquired hearing loss in childhood is Otitis Media with Effusion (OME), which can result in a fluctuating hearing loss of up to 50 dBHL.³⁰ It was not possible to determine from the literature or from the estimates the extent of OME in Pacific Island children compared with CSOM or AOM. The only report of peak rates of OME in Samoan schoolchildren (6–7 years old) of 19.4%¹³ compares with 25.4% of Pacific two-year-olds living in New Zealand.³⁰ The Dunedin Multidisciplinary Study found a 9.0% prevalence rate of OME in a cohort of mainly NZ European five-year-olds;³¹ suggesting that the rates of OME in Pacific children in New Zealand or in Pacific Island countries may be higher than for NZ Europeans.

Although there are a number of organisations active in this field in the Pacific region, it appears there are no clear systematic initiatives to address the broader health needs of people in the Pacific with HI. Based on information available to the researchers, the exception is Samoa, where a National Hearing Service plan has been developed under the local leadership provided by SENESE. Also, there are initiatives in the broader disability area, such as the research on Disabled Persons Organisations in Pacific Island Countries funded by AusAID,³² and the WHO overall initiative on disability in developing countries, which will have flow-on effects for people with hearing disability in the Pacific. A comprehensive description of the extent of hearing loss and ear disease in the Pacific nations is a vital next step towards developing (integrated) services for the prevention, identification and rehabilitation of HI. Further, with a sound knowledge of the epidemiology and cultural appreciations of hearing health, there is more likelihood that tailored audiological services can be effectively designed to interface with medical, educational, and disability support services in Pacific communities.

Population health outcomes are one of the core equity distinctions between high- and low/middle-income countries; hearing health is one

such indicator.³³ An analysis of the number of hearing health care professionals is a way to compare provision of hearing health care across high- and low/middle-income countries (See Appendix Table A5 in the online version of this paper). Countries were selected for comparison because of either their proximity to the Pacific, or their use of differing hearing health care models. Norway, for example, has no audiologists, but a high number of ear, nose and throat specialists and technicians.³³ There is a stark difference between the number of specialists per capita in high-income countries and Pacific Island nations. A significant challenge in developing a comprehensive hearing health programme relates to the difference in the Per Capita Gross National Income (See Appendix Table A6 in the online version of this paper). Affordability is key to access for health services in LMICs; adapting models used elsewhere in high-income settings may not translate as well as locally developed solutions. This may mean the development and training of hearing professionals, adept at working at the community health level and employing strategies aligned with the WHO community-based rehabilitation (CBR) approach. It may also mean the development of a regional approach (a Pacific hearing health alliance) to allow bulk purchase of diagnostic and rehabilitation equipment, which could draw on the guidelines for hearing aids and service delivery developed by the WHO.^{34,35}

Hearing service development represents a significant challenge considering the constrained resources, diverse geography, and current shortage in local expertise. Emergent technologies such as e-Health and tele-audiology, as well as hearing testing devices for working in challenging environments, and the commitment and vision of individuals and organisations working in the field, could form the necessary bridge to overcome these obstacles. Excellent information resources exist in the form of service delivery guidelines and comprehensive ear health publications produced by the WHO,³⁴⁻³⁸ and from pioneering groups working in other regions.³⁹ These resources are fundamental for both training and ongoing support to health professionals in the region. It is probable that such services could incorporate e-Health or m-Health technologies,^{40,41} mobile clinics,⁴² and be delivered

by a workforce with region-specific qualifications delivered by e-Learning. Such a large health programme would require government investment in terms of mandate, legislation, and funding. However, in order to responsibly advocate the need for these services, a crucial next step is the gathering of region-specific epidemiological evidence.

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Recent reviews of the burden of disease due to otitis media in the Asia-Pacific region identifies a significant disease burden and economic cost.⁴³ Public health intervention such as vaccinations, including the pneumococcal conjugate vaccines,⁴⁴ may play an important preventive role.⁴³

There were several limitations to the current study. The lack of prevalence data meant that we were obliged to create hypothetical models. For example, for the child <5-year-old estimates, we assumed that the rates of congenital deafness and meningitis-acquired HI are the same in the Pacific Islands as they are in New Zealand; however, this is likely to be an underestimate in developing countries.⁴⁵ Thus, the estimates presented here are approximate values only.

The identification of services was limited by a reliance on online data. Given that internet use is limited in many of these countries, our search may have failed to identify local community-based initiatives or visiting specialist programmes, which were not recorded online. The relatively low response rate to our direct inquiries for information should also be noted; of the 27 possible service providers who were contacted, we received 15 responses. We were not expecting to survey all providers, but rather capture the available and accessible data. This study should therefore be considered as a foundation, and one that has identified the overall service gaps and

provided an indication through prevalence estimates of what could be the extent of HI in these countries. Further epidemiological studies are needed and more focused approaches involving discussions with health and disability authorities and local communities within the Pacific countries to establish the true extent of the services and support to people with HI in these Pacific nations.

A strength of this report was the input that it received from several sources (including organisations working directly within Pacific Island settings). This process allowed us to collate work being done by independent organisations into a larger picture of the situation for hearing-impaired populations in the Pacific. This may act as a useful resource for future researchers and service providers in this field, allowing them easy access to information on what is available and to identify the gaps in current services.

Final comments

Despite the best efforts of dedicated organisations and individuals, hearing loss remains an enormous burden on populations living in the Pacific Islands. The establishment of holistic services to address not only the audiological, but also the medical, educational and support needs of Pacific people with HI should be a development priority. However, a collaborative effort by researchers and health professionals, as well as local organisations and the governments of these nations, will be required to achieve this. It is essential that Pacific peoples, particularly those with HI, take a leading role in the development and establishment of these services. They are best positioned to recognise their most important needs and to have their voices heard by their governments.

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COMPETING INTERESTS

None declared.

APPENDIX

Table A1. Census collection dates for census data used in modelled country estimates^{18,20,24–26,28}

Country	Census collection date
Cook Islands	1 December 2006
Fiji	16 September 2007
Samoa	6 November 2006
Tokelau	19 October 2006
Tonga	30 November 2006
New Zealand	7 March 2006

Table A2. Estimated number of children with a congenital hearing loss or an acquired hearing loss from meningitis by country

	No. of congenital deaf aged 0–4 years	No. of congenital and meningitis-acquired deaf aged 5–19 Years	Number of congenital and meningitis-acquired deaf aged 0–19 years
Cook Islands	5	22	27
Fiji	248	960	1208
Samoa	81	260	341
Tokelau	1	2	3
Tonga	41	141	182

Table A3. Estimated incidence of CSOM and significant disabling hearing loss (>40 dBHL in the better ear) prevalence in the population by region for the year 2005*

Region	CSOM incidence (%)				HI (≥40 dBHL) in better ear prevalence (%)			
	< 5yrs	5–9yrs	10–19yrs	Adults	< 5yrs	5–9yrs	10–19yrs	Adults
Pacific Island nations	5.995	2.015	0.519	0.366	0.171	0.146	0.164	0.306
Australasia	0.500	0.334	0.307	0.356	0.000	0.00%	0.001	0.002

CSOM Chronic suppurative otitis media

* Calculated from Monasta et al.²⁰—Tables S26, S48

Table A4. List of services identified and information sources

Name	Reference
Christoffel Blind Mission (CBM) Project HEAVEN	CBM. Pacific and South East Asia, Fiji. Ear and Eye Screening for Primary Schools. Available from: http://www.cbm.org/programmes/-Project-HEAVEN-HEaring-and-Vision-ENhancement--351546.php . Accessed 12 December 2011.
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The Cook Islands Disability Action Team	Gallaudet University. Research Support and International Affairs—Deaf Organisations—Cook Islands. Available from: http://www.gallaudet.edu/Cook_Islands.xml . Accessed July 2014.

Table A5. Estimated numbers of hearing health care professionals in selected high-income countries*

Country	Per capita GNI (\$Int)	Population (in 1000s)	Audiologists/million population	ENT specialists/million population	Techs [†] /million of population	Total [‡] /million population
New Zealand	26470	3875	45	17	0	61
Australia	31860	19731	66	18	20	104
UK	35690	59251	38	9	29	76
Norway	43920	4533	0	66	33	99
USA	44260	294043	51	41	0	92

GNI Gross national income

\$Int International dollars

* Data from Goulios and Patuzzi³³—Chapter 4, Table 1

† Audiology and hearing aid technicians

‡ Number of hearing health care professionals

Table A6. Estimated numbers of hearing health care professionals within the Pacific Islands (nations without hearing health professionals not included in Table)*

Country	Per capita GNI (\$Int)	Population (in 1000s)	Audiologists/million of population	ENT specialists/million of population	Techs [†] /million of population	Total [‡] /million population
Fiji	4880	837	0	1	2	4
Samoa	4270	188	0	5	16	21

GNI Gross national income

\$Int International dollars

* Data from Goulios and Patuzzi³³—Chapter 4, Table 1

† Audiology and hearing aid technicians

‡ Number of hearing health care professionals