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Literature Review

Aging and Hearing Health: The Life-course Approach

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Abstract

Sensory abilities decline with age. More than 5% of the world's population, approximately 360 million people, have disabling hearing loss. In adults, disabling hearing loss is defined by thresholds greater than 40 dBHL in the better hearing ear. Hearing disability is an important issue in geriatric medicine because it is associated with numerous health issues, including accelerated cognitive decline, depression, increased risk of dementia, poorer balance, falls, hospitalizations, and early mortality. There are also social implications, such as reduced communication function, social isolation, loss of autonomy, impaired driving ability, and financial decline. Furthermore, the onset of hearing loss is gradual and subtle, first affecting the detection of high-pitched sounds and with difficulty understanding speech in noisy but not in quiet environments. Consequently, delays in recognizing and seeking help for hearing difficulties are common. Age-related hearing loss has no known cure, and technologies (hearing aids, cochlear implants, and assistive devices) improve thresholds but do not restore hearing to normal. Therefore, health care for persons with hearing loss and people within their communication circles requires education and counseling (e.g., increasing knowledge, changing attitudes, and reducing stigma), behavior change (e.g., adapting communication strategies), and environmental modifications (e.g., reducing noise). In this article, we consider the causes, consequences, and magnitude of hearing loss from a life-course perspective. We examine the concept of "hearing health," how to achieve it, and implications for policy and practice.

Key Words: Hearing loss, Geriatrics, Hearing aids, Rehabilitation, Audiology

What Is Hearing Loss and Why Is It a Public Health Problem Worldwide?

Age-related hearing loss (ARHL), sometimes called presbycusis, is typically a progressive bilateral symmetrical sensorineural hearing loss (SNHL; ISO, 2000). ARHL can be attributed to physical and environmental insults coupled with genetic predisposition and increased vulnerability from physiological stressors and modifiable lifestyle behaviors that are sustained throughout the course of life (e.g., Agrawal, Platz, & Niparko, 2009). The hearing loss is most marked at higher frequencies and begins by interfering with the detection of high-pitched sounds (e.g., in English, /s/, /sh/). It typically begins in the fourth decade, but the sharpest rise in prevalence occurs at ages above 80 years, when 50%–80% are ultimately affected (Cruickshanks et al., 1998). There is no known cure at this time.

Hearing loss is traditionally defined by audiometric thresholds; the softest level (in decibels hearing level [dB HL]) of sound that an individual can detect, across a range of frequencies, when listening in a sound-attenuated room. In adults, a significant (or disabling) hearing loss has been defined by the World Health Organization (WHO) as a hearing loss greater than 40 dB HL (averaged over frequencies of 0.5, 1, 2, and 4 kHz) in the better hearing ear (WHO: Deafness and hearing loss, 2015). Using this definition, approximately one third of people aged 65 years and older are affected by a significant hearing loss (WHO: Prevention of blindness and deafness: Estimates, 2012), and the prevalence is greatest in South Asia, Asia Pacific, and sub-Saharan Africa, which decreases exponentially as income increases (Stevens et al., 2013; WHO: Mortality and burden of disease, 2012). Other population-based studies on hearing loss in older adults that have considered milder forms of hearing loss (>25 dB HL), where hearing disability and help seeking are also common (Hartley, Rochtchina, Newall, Golding, & Mitchell, 2010), have yielded significantly greater global prevalence rates (Cruickshanks et al., 1998; Lin, Niparko, Ferrucci, 2011).

ARHL is projected to be within the top 15 leading causes of burden of disease by 2030 (Mathers & Loncar, 2006). Not only can acquired hearing loss negatively affect mental health, participation in interpersonal relations, and health-related quality of life, it can also impact one's work possibilities and career. An increasing number of people with hearing loss are seeking help for occupational problems, and the needs of employees with hearing loss, on a personal level, are not yet fully understood or addressed (Kramer, 2008). On a more global level, the effects of hearing loss on work participation may interfere with plans to extend the retirement age in developed economies, where labor force and tax-base shortages are anticipated as their populations age (see Kramer, Goverts, van Til, & Festen, 2009; McMahon et al., 2013). Despite these consequences, hearing loss is often dismissed as a "normal" process of aging, and there are dire predictions about the inability to meet the health and communication needs of our aging society. Therefore, the objective of this article is to demonstrate the importance of ARHL within the context of geriatric health care. Further to discuss how this might be reconceptualized within a life-course health development model and a framework of health and functioning to facilitate effective and targeted opportunities for its prevention and management.

The WHO International Classification of Functioning and Disability (ICF, 2001) provides a framework for how a health condition (like hearing loss) can be understood within a broader bio-psycho-social-environmental context (Figure 1). According to this framework, hearing loss, when viewed as a health condition, can affect body functions and structures (e.g., deterioration in the ear), related activities (e.g., reduced speech understanding), and the participation of the individual in society (e.g., engaging in employment, receiving education about health issues, attending social events, or receiving health services). Importantly, the framework also incorporates the notion that personal, social, and environmental factors can facilitate (or be barriers to) successful functioning. Historically, hearing loss has largely been conceptualized as impairment within a biomedical model and managed clinically within an isolated model of care, with little consideration of comorbidities. More recently, there has been increasing discussion in the literature of how the ICF framework might be used to reconceptualize hearing loss for older adults, to enable audiologists to better manage hearing within a social-environmental context (Gagné, Jennings, & Southall, 2009).

As well as hearing loss having a direct effect on communication and quality-of-life, population-based studies suggest that hearing loss is associated with more rapid cognitive and physical aging (Lin & Ferrucci, 2012; Lin et al., 2013). Notably, the 2015 National Institute on Aging workshop "Sensory and motor dysfunction in aging and Alzheimer's disease" in the United States reported that age-related sensory loss, including hearing loss, is associated with dementia and falls (Albers et al., 2015). Lin and Albert (2014) have proposed a hypothetical model of possible mechanisms that might underpin the association between hearing loss and cognitive and physical aging (Figure 2). When a signal, poor in fidelity, is transmitted from the ear to the brain, greater cognitive resources (e.g., mental effort and attention) may be required to interpret the meaning of the sound. As such, the increased demands of auditory processing deplete the listener's limited pool of cognitive resources such that fewer resources remain available for other complex tasks such as

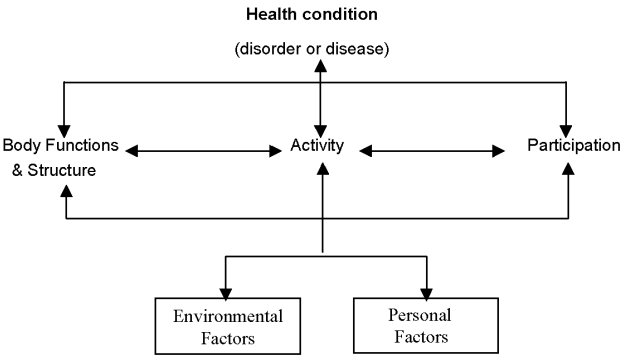


Figure 1. The International Classification of Functioning and Disability (ICF) framework [WHO (2001)].

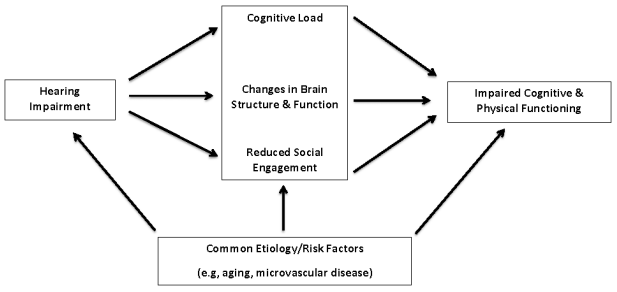


Figure 2. Possible association between hearing impairment and impaired cognitive and physical functioning in older adults (Lin & Albert, 2014).

language comprehension, memory, walking, and driving, and prolonged alterations in brain activation during listening may result in permanent neuroplastic changes in the brain (see Schneider, Pichora-Fuller, & Daneman, 2010). Alternatively, common biological processes (e.g., hypertension and diabetes) may result in degeneration and loss of both auditory and cognitive function (Helmkamp, Talbott, & Margolis, 1984; Talbott et al., 1990). A third possible explanation is that communication problems caused by hearing loss can lead to reduced social engagement and loneliness in older adults (Chen, 1994; Gopinath et al., 2012), in turn increasing the risk of cognitive decline. Poor social engagement likely contributes to impaired cognitive and physical functioning through both psychological effects (Berkman, Glass, Brissette, & Seeman, 2000; Seeman, 2000; Seeman & McEwen, 1996) and the neurobiological effects of stress and inflammation.

There are also profound consequences to the quality of life and mental and physical health of family members and caregivers. In particular, a systematic review shows that communication partners experience restricted social life, increased burden of communication, and poorer quality of life and relationship satisfaction (Kamil & Lin, 2015). Importantly, however, the review suggests that treatment of the hearing loss can improve many of these factors.

Even though ARHL is one of the top causes of burden of disease, until recently, it was largely unrecognized by policy makers as a major public health problem. Furthermore, its association with, and influence on, other age-related health issues is even less recognized and not well understood. This appears to be changing. In 2014, the Institute of Medicine (IOM) and the National Research Council in the United States hosted a workshop entitled "Hearing loss and healthy aging" (Lustig & Olson, 2014). This workshop focused on understanding how hearing loss affects healthy aging, the current deficits in and barriers to hearing health care (HHC), and how ARHL can be addressed as a public health issue. In the United Kingdom, a new Action Plan of Hearing Loss was released in March 2015 produced by the National Health Service (NHS) England and the Department of Health. The report considers different health and social issues associated with hearing loss and potential ways that HHC services can be improved for individuals of all ages. Importantly, on May 18, 2015, a technical report on hearing loss was presented to the 68th World Health Assembly in Geneva, which discussed the scarcity of services and national programs for the estimated 360 million people worldwide with disabling hearing loss. Each of these initiatives highlight the need for HHC to be reconsidered within the successful aging perspective.

The Aging Trajectory: Hearing Loss Within a Life-course Model

The life-course health development model (Halfon & Hochstein, 2002; Halfon, Larson, Lu, Tullis, & Russ, 2014) regards healthy aging as an emergent capacity of humans that dynamically develops over time, in response to multiple nested, ever changing genetic, biological, behavioral, social, and economic contexts. Adopting a life-course perspective on ARHL emphasizes the importance of considering events and experiences earlier in life that may contribute to later losses, and examining the effects of those losses in the context of each individual's biopsychosocial environment. The model views the promotion of healthy hearing as a lifelong process, an approach that has major implications for policy and practice.

Hearing Health Trajectories

Every individual, worldwide, is on a "hearing health trajectory," beginning at conception/birth and continuing throughout life. As individuals progress through childhood and adolescence, environmental conditions and experiences can become "embedded" into emerging biological systems, altering health trajectories (Brandt, Deindl, & Hank, 2012; Halfon & Hochstein, 2002). Further exposures throughout adulthood (e.g., to noise, smoking, alcohol, medications, and weight gain) continue to affect hearing health such that two individuals at age 50 years might seem to have the same hearing health because they both have identical and apparently normal audiometric thresholds, yet they could be on very different underlying hearing health trajectories. The eventual trajectories in their hearing health depend on each individual's ongoing exposures to risk and protective factors and their genetic risk or resilience (Gillespie, Phifer, Bradley, & Ressler, 2009; Pronk et al., 2013).

Comorbidities During the Life Span

The prevalence of comorbid chronic sensory, cognitive, and motor problems increases with advancing age, and it is assumed that the sum of these problems is greater than the consequences of each alone (van den Akker, Buntinx, Metsemakers, Roos, & Knottnerus, 1998). For example, compared with a single sensory loss, combined hearing and vision loss, termed dual sensory loss, further challenges cognitive functioning in older adults (Heyl & Wahl, 2012; Wahl & Heyl, 2003), and is associated with poorer quality of life, increased depression, and even increased mortality risk (Gopinath et al., 2013; Schneider et al., 2011). Tinnitus (ringing or noises heard in the head or ears that do not originate from an external stimulus) frequently co-occurs with hearing loss and can independently lead to increased risk of depression and anxiety and poorer quality of life (Bartels, Middel, van der Laan, Staal, & Albers, 2008; Shargorodsky, Curhan, & Farwell, 2010). For this reason, management of hearing loss throughout the life course must involve integrated care that considers the individual's entire health profile and provides ongoing support of each person's adaptation and self-management, so that a focus on healthy and successful aging and active participation in society is maintained.

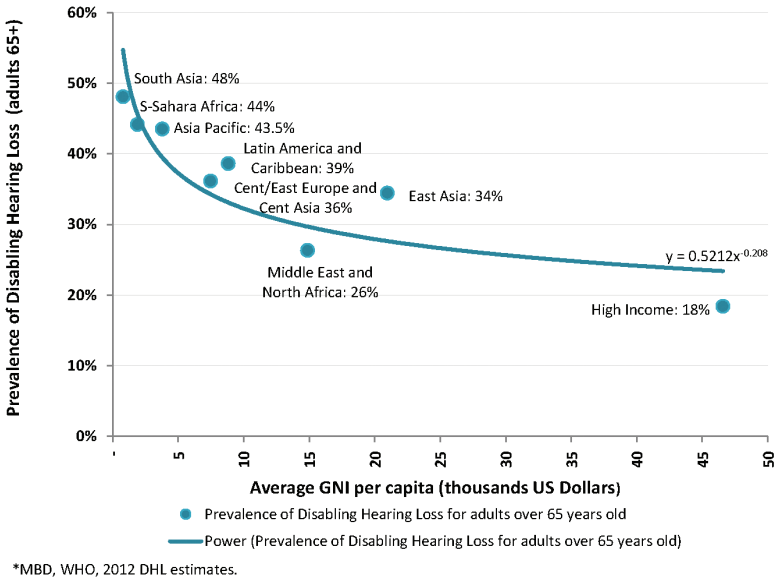
Hearing and Communication: Social Implications

The threat that hearing loss poses to an individual's ability to age successfully depends on the social and cultural context in which they live, their access to HHC and social supports, and the presence or absence of coexisting health conditions that may magnify the effects of hearing loss or make managing the loss more challenging (as demonstrated by the ICF framework; WHO, 2001). It is therefore assumed that better hearing health results from both the utilization of social support networks during stressful conditions, as well as from the benefits of regular social interaction which may reduce the risk of cognitive decline, depression, and other emotional, behavioral, and biological declines. In this respect, minimizing lifestyle risks of hearing loss (such as maintaining good nutrition and regular exercise, avoiding loud noise, and not smoking) can help to maintain good hearing and, in turn, good communication, thereby preserving independence and reducing the need for older adults to rely on community services for everyday living requirements (e.g., meals and transport; Schneider et al., 2010). In this way, both the life-course health development model and the ICF framework are intertwined; the ICF provides a framework that considers the influences of the social ecology on a person with hearing loss' ability to communicate and participate in society, and the life-course model considers how this is influenced by changes to one's social ecology as well as physical and mental health, across the life span.

Opportunities for Preventing Hearing Loss in Adults

In adults aged 65 years and older, prevalence of hearing impairment decreases exponentially as income increases (Figure 3). In developed countries, ARHL is very prevalent; however, hearing impairment or changes to the auditory system among younger and middle-aged adults is not unusual, representing an opportunity to prevent or reduce the effects of hearing loss as people age. In African and South East Asian regions, where the average life expectancy is 50 and 59 years, respectively (and as low as 32.5 years in Haiti), and in indigenous populations where considerable health disparities exist (Marmot, 2005), preventable causes of hearing impairment such as impacted cerumen (ear wax) in the outer ear, otitis media (middle ear infections), or sensorineural damage due to nutritional deficiencies, noise-induced hearing loss, ototoxicity, and genetic hearing loss from consanguinity are more commonly reported in the literature than ARHL (Girotto et al., 2014; Selvarajan, Arunachalam, Bellur, Mandke, & Nagarajan, 2013). For example, a recent study in Nigeria revealed that of 79 elderly patients presenting with tinnitus, 34 (43%) had presbycusis (Sogebi, 2013). In such countries or in remote areas, the focus of health care tends to be on primary health care and prevention rather than management of chronic sensorineural hearing loss.

The most studied environmental risk factor for hearing loss in adulthood is exposure to industrial, recreational, military, and social or community noise. The global burden of disabling noise-induced hearing loss is estimated to be as high as 16% (Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). Even though hearing loss caused by exposure to loud sound is preventable, compliance with recommendations regarding use of ear protection for those at risk of occupational exposure, or for leisure-related exposures is generally low (Bogoch, House, & Kudla, 2005; Dobie, 2008). To a certain extent, the hazards of industrial noise have been reduced over the last four decades with the introduction of hearing conservation regulations, the increasing automation of work, and the shift from noisier industrial



*MBD, WHO, 2012 DHL estimates.

Figure 3. Relationship between prevalence of hearing loss in adults aged 65 and older gross national income (WHO: Mortality and burden of disease, 2012).

to quieter information-based economies in developed countries. Nevertheless, the risk of noise-induced hearing loss depends on both the level of noise and its duration. This risk could remain high because of recreational and community noise exposures (Mostafapour, Lahargoue, & Gates, 1998), with many young people using personal music players and attending loud music concerts (Breinbauer et al., 2012) and with higher durations of exposures even if levels are moderate. Furthermore, it is now recognized that even lower levels of ongoing social or community noise can have deleterious effects on general health, with about 40% of the population in the European Union being affected (WHO: Prevention of blindness and deafness: Estimates, 2012). The broader effects of noise on general health (e.g., cardiovascular function, sleeping and mental health; Basner et al., 2014) and on workplace productivity are rarely addressed within prevention campaigns (Passchier-Vermeer & Passchier, 2000). Certainly, associations between positive attitudes about noise, increased hearing loss, and the poor use of hearing protector devices in young adults suggest that campaigns need to more effectively target attitudes and beliefs within a prevention program (Keppler, Dhooge, & Vinck, 2015).

Rehabilitation Options

To maintain good social and occupational functioning, rehabilitation programs for older adults should focus on mitigating the factors that restrict full participation in society. Without this, psychological distress and social isolation that may be associated with hearing loss could result. Aural rehabilitation therefore aims to reduce hearing loss–induced deficits of function, activity, participation, and quality of life through sensory management, instruction, perceptual training, and counseling (for a review, see Boothroyd, 2007). Sensory management can be addressed in part through the provision of technological devices (e.g., hearing aids [HAs]) to improve sound audibility. Instruction can include teaching people how to use technology and how to create optimal listening environments by reducing background noise and/or acoustic reverberation (Chisolm et al., 2007). Perceptual training can be used to improve the types of listening skills needed to enhance speech perception; and counseling can be used to encourage participation, as well as deal both emotionally and practically with residual limitations.

Current HHC practice worldwide has a primary focus on sensory management as the solution for hearing loss, particularly through the use of HAs and cochlear implants (CIs). CIs are more expensive and require surgical procedures but offer an effective solution for people whose hearing loss is too severe to benefit from conventional HAs. Both types of technology can be effective with literature reviews concluding that HAs improve a person's quality of life by reducing psychological, social, and emotional effects of SNHL (Chisolm et al., 2007; Knudsen, Öberg, Nielsen, Naylor, & Kramer, 2010). What is more, despite the limitations of HAs in certain situations, some studies in the developing world, namely South Africa and Nigeria, have revealed subjective benefit from amplification among the elderly adults (Olusanya, 2004; Pienaar, Stearn, & Swanepoel, 2010). For older adults who receive CIs, improvements in speech perception, quality of life, music perception, as well as global cognitive function have been shown (Choi et al., 2014; Mosnier et al., 2015; Sladen & Zappler, 2015). However, because of the variability in outcomes, a recent review describes how the ICF core sets can be used to better describe CI outcomes in this population (Alfakir, Hall, & Holmes, 2015).

HAs and CIs can be used in a wide range of situations, either alone or in conjunction with specialized hearing assistive technologies (HATs), and can maximize listening in specific challenging communication activities such as using the telephone, watching television, or attending events in public places (e.g., entertainment venues or places of worship). In some countries, legislation requires that HATs, such as frequency modulated systems, infrared, and inductive loop systems, be available in public places to ensure hearing accessibility. They are frequently installed in places of entertainment and are designed and often marketed for use with television listening. These basic HATs are usually less costly than HAs and have continued to become smaller, easier to use, and more acceptable to people as technology has evolved with the current widespread use of wireless technologies such as Bluetooth.

Such technological solutions are readily available and somewhat affordable in high-income countries, although the prevalence of HA use in older adults varies with reports of 21.5% in the United Kingdom (Dawes et al., 2014), 11.0% in Australia (Hartley et al., 2010), and approximately 14% in the United States (Chien & Lin, 2012; Popelka et al., 1998). However, many low-resource countries lack access to such devices, the batteries to operate them, and also to the human resources with appropriate knowledge and expertise (Olusanya, 2004, 2009). For example, in a recent study in India among adults older than 60 years, the self-reported hearing impairment rate was 63.1%, whereas the reported use of HAs was very low at only 1.47% (Thakur, Banerjee, & Nikumb, 2013). In response to these needs, HA donation programs have been implemented in several developing countries. but the effectiveness and sustainability of such programs is not yet well documented. With that said, a recent study conducted in the Philippines (Newall, Biddulph, Ramos, Swanepoel, & McMahon, 2016) suggests that the benefits for large-scale donation programs might be limited by inadequate hearing device technology, poor match to hearing loss, and poor fitting of the ear mould to the individual.

Convergence with smart phone technology has also begun. Personal sound amplifiers (PSAPs), often integrated into mobile phone technology, are also changing the landscape of hearing technology. Originally intended for people

with little to no hearing loss, mobile applications are being used for some people with hearing loss as an alternative to HAs. Unlike HAs, in countries like the United States, PSAPs are exempt from Food and Drug Administration oversight and can be sold as electronic devices directly to consumers, with no need to see a physician before buying one. However, the quality of PSAPs is yet to be standardized or evaluated. For this reason and others, the use of PSAPs is somewhat controversial. In the meantime, in developed countries, HA manufacturers are beginning to offer HAs at low costs in order to compete with the PSAP market.

Even when technology is available, a common misconception is that the amplification of sound corrects for hearing loss in the same way eyeglasses can do for correctable vision problems. Although making sounds louder to improve audibility is important, older adults may not tolerate too much amplification and they frequently describe amplified sounds as being louder, but not necessarily clearer. This complaint has not changed across the decades, despite improvements in technology (e.g., Bentler & Duve, 2000). What is more, there is an abundance of literature describing how HAs do not compensate for age-related changes in the brain. According to Tremblay and Miller (2014), the combination of biological changes in the ear and the brain may limit the amount of benefit HAs can provide to older adults given state-of-the-art signal processing engineering (for reviews see, Willott, 1996). It is for these reasons, perceptual training and counseling support are also essential components to aural rehabilitation.

Focusing on counseling and support, psychological attitudes and social support are important to optimizing functioning. A recent study suggests that the successful use of HAs is greater for people who reported more hearing difficulties in everyday life, had the support of other people such as family and friends, had more positive attitudes about using HAs, and had previous experience with HAs (Hickson, Meyer, Lovelock, Lampert, & Khan, 2014). Indeed, social support has been reported to be a stronger predictor of satisfaction with HAs than any of the audiological measures that have been evaluated as predictors (Singh, Lau, & Pichora-Fuller, 2015). This research suggests that, in addition to technological support, the communication needs of the individual and their communication partners (e.g., family) may require additional or alternative interventions, such as the provision of instructions and training on how to achieve effective communication skills to the entire family (Jerger, Chmiel, Wilson, & Luchi, 1995; Preminger, 2003). Some examples of helpful communication strategies include taking advantage of visual information, such as watching the faces and gestures of people who are speaking, to make it easier to understand what is being said. Family members, friends, coworkers, and others can also learn to adapt how they communicate. By working together, misunderstandings can be prevented or repaired quickly without disrupting conversations and without triggering perceptions of failure or stigma. For this reason, the current trend in audiologic rehabilitation is to shift to a greater emphasis on psychosocial considerations tailored to the goals of clients and their significant others and their readiness for change.

Even though there are age-related declines in hearing, listening, and remembering information, older adults can use their experience and knowledge of context to advantage when they listen (Pichora-Fuller, 2008; Wingfield & Tun, 2007). For example, being familiar with the topic being discussed can help a listener to compensate for difficulty hearing in noise. Compared with younger adults, older adults tend to rely more on their knowledge of the context and less on precisely hearing the sounds of speech (Goy, Pelletier, Coletta, & Pichora-Fuller, 2013). Given this, it becomes possible to provide perceptual training and to teach compensatory communication strategies to people with hearing loss (and their communication partners) to help them achieve their communication goals.

Barriers to Achieving Hearing Health

There is a striking lack of human resources to manage hearing loss, especially in the low- and middle-income countries (Goulios & Patuzzi, 2008), even though the prevalence of hearing loss is higher than in many other countries (WHO: Mortality and burden of disease, 2012). Reasons for these shortages in low- and middle-income countries include (i) higher priority of other health issues, (ii) lack of public awareness about deafness and hearing loss, (iii) lack of awareness about the profession of audiology, (iv) lack of audiology education programs, and (v) lack of government funding for HHC (Goulios & Patuzzi, 2008).

Manufacturing and retail costs of HAs vary widely, and the high costs of provision represent a major barrier for most populations (Borg & Östergren, 2014; McPherson, 2014). However, the increasing production of low-cost HAs and their alternatives might minimize this barrier. Cost, however, does not appear to be the only barrier that limits access to HHC. Rates of HA use among those with a hearing loss in England and Wales (where HAs are provided at little or no cost by the NHS) is around 17.3% (Taylor & Paisley, 2000b), which is only marginally higher than rates of HA use among older adults with hearing loss in the United States where HAs are not typically funded by insurance (around 14.2%; Chien & Lin, 2012; Taylor & Paisley, 2000a).

Access to HHC is another potential barrier. HHC is largely provided using a clinic-based medical model of service delivery by an audiologist or licensed HA dispenser/technician, limiting access for those in remote areas. This model also targets the person with hearing loss as the client, without effectively including family members or significant others (e.g., teachers and caregivers). Nevertheless, even when older adults discover they have hearing loss, many who could benefit from HHC services do not seek them (Chien & Lin, 2012) and a relatively large proportion

who have HAs do not wear them (Hartley et al., 2010). Those who do get HAs often do so after a delay of a decade or more, missing the opportunities for earlier intervention (Davis, Smith, Ferguson, Stephens, & Gianopoulos, 2007).

Hearing screening could overcome some of the delays in help seeking; however, there is debate over the effectiveness of screening programs for older adults because of the poor compliance to help seeking after failing the screening test and the low incidence of HA uptake after hearing loss is identified (Spiby, 2014). For example, in 2014, the U.K. National Screening Committee (U.K. NSC, Spiby, 2014) reported that hearing screening has not been shown to provide any hearing-related improvement in quality of life in comparison with hearing loss identified in other ways. They go on to say, screening for hearing loss in older people is not supported by the evidence published since 2009. Similar sentiments have been expressed in the U.S. Preventive Services Task Force recommendation statement (Chou, Dana, Bougatsos, Fleming, & Beil, 2011; Moyer, 2012). Nevertheless, many practicing clinicians appreciate the value of hearing screening, and various professional practice guidelines exist around the world. For example, the American Speech Language Hearing Association (2011) suggests adults be screened at least every decade through age 50 and at 3-year intervals thereafter, though this practice is rarely achieved ("Healthy People 2010 Hearing Health Progress Review," 2004). According to the National Center for Health Statistics (2010) only 29% of adults 20–69 years of age have had their hearing tested within the last 5 years.

There are a number of ways to approach hearing screening, from self-report survey questions to online hearing tests. Historical low-cost techniques such as the "whisper" or "finger rub" are now being superceded by cellphone and internet screening methods. For example, Hussein and colleagues (2015) showed how smartphone-based hearing screening allows community health workers to bring HHC to underserved communities at a primary care level. Active noise monitoring and data management features allow for quality control and remote monitoring for surveillance and follow-up. The telephone-based digit triplet test (digits in noise) and face-to-face computer-based internet screenings have also gained in popularity (Stenfelt, Janssen, Schirkonyer, & Grandori, 2011). Each are fast, effective, and relatively inexpensive in the detection of hearing loss in adults, with telephone and internet screening holding promise for a broader reach for individuals in rural and remote areas where shortages of health care services exist (Wilson et al., 2009). Despite this, preliminary studies find that compliance with recommendations for referral following telephone screening varies from 36% in Australia to 50% in the Netherlands, possibly reflecting cultural, social, or economic influences in help-seeking behavior (Meyer et al., 2011; Smits, Merkus, & Houtgast, 2006). A review of the literature published during 1980 to 2009 suggests that self-reported hearing disability alone is associated with help seeking and HA acquisition, use, and satisfaction in older adults (Knudsen et al., 2010). Therefore, it is yet uncertain whether measures of hearing loss or perception of digits in noise are appropriate to estimate the need for referral to HHC. In addition to this, there is a perception among some health professionals and the general community that HAs provide limited benefit, particularly in noisy environments where they are often most needed (Laplante-Lévesque et al., 2012; Meyer, Hickson, Lovelock, Lampert, & Khan, 2014), and lack of referrals by general practitioners (GPs) is a known problem (Laplante-Lévesque et al., 2012; Schneider et al., 2010).

Social and cultural factors contribute to low uptake of HAs in developed and high-income countries where HAs do not appear to be as well accepted by the population as eyeglasses. Stigma, and the threat of hearing loss and HAs to one's identity, is considered a major barrier (Hétu, 1996; Southall, Gagné, & Jennings, 2010; Wallhagen, 2010). Hearing problems may exacerbate psychosocial declines in older adults, whereas age-related psychosocial issues may aggravate hearing problems. There is no doubt that auditory and psychosocial factors are related, and the nature of the relationship can help to inform changes in rehabilitative practices (Saunders, Chisolm, & Wallhagen, 2012). Importantly, the dismissal of hearing loss as a normal part of aging either by the individual, their significant others, or other health professionals can be a barrier to seeking help (Humphrey, Herbst, & Faurqi, 1981; Kite, Wagner, & Nelson, 2002; Wallhagen, 2010). These psychosocial issues are also relevant in developing countries; for example, in Nigeria the prevailing social stigma and superstitious beliefs worsen acceptability of hearing devices. This is also relevant in other countries, such as South Africa, where concerns have been raised about culture-based ignorance and resistance toward hearing disabilities. Many still consider hearing loss to be caused by bewitchment or blood impurities (de Andrade & Ross, 2005; Swanepoel & Almec, 2008).

A barrier may also be an individual's lack of "self-efficacy," or the confidence the person has in his/her abilities to perform a domain-specific task, may influence actual performance. Self-efficacy has been shown to play an important role in the successful management of numerous health conditions; and research directly focusing on self-efficacy related to listening abilities and HA use has become a current priority (Smith & West, 2006). In many cases, poor self-efficacy for using technology and/or lack of social support create barriers toward the acquisition and effective use of HAs (Meyer, Hickson, & Fletcher, 2014).

Priorities for Future Service Delivery and Research

The development and training of all levels of HHC providers is a priority. This should be aligned with incentives to halt the current exodus of professionals from developing

to developed countries. Further, models of education for HHC providers should be designed to support the different health care systems and needs, rather than assuming a single global model of education is appropriate for all.

Affordability of hearing devices could come from the development of consumer electronic approaches toward over-the-counter style types of HAs. However, this approach runs counter to the business model of established HA companies and the HHC professionals that currently fit and dispense HAs. Low-cost HA options for developing countries (e.g., solar powered batteries; Mayers, 2013), which remains a diverse and poorly understood topic, could be introduced as part of an integrated care model rather than solely by manufacturers/market forces.

The current worldwide model of HHC relies on clinic-based testing and fitting, requiring multiple trips to a hearing health professional over several weeks. Although this may remain the gold standard model for best practices of hearing rehabilitation, clearly other patient-centered, community-delivered approaches will be necessary to reach the majority of older adults in need around the world.

The stigma associated with the use of specialized hearing devices could be reduced by applying principles of universal design. Solutions for hearing loss could be more effectively implemented in widely used communication technologies (e.g., iPads and cellphones) and as alternative modality communication methods become ubiquitous (e.g., e-mail, texting options for receiving information, and real-time captioning).

Programs that educate people with hearing loss and their communication partners about communication strategies could help them achieve their communication goals. Similarly, programs for other age-related health problems should anticipate that the majority of older adults who have hearing loss may require accommodations to ensure effective assessment and communication when health services are delivered. For example, optimal communication will ensure that older adults gain the most benefit when health-related information is provided (e.g., during diabetes education), when assessments are conducted (e.g., neuropsychological testing for dementia), or when treatments are conducted (e.g., during knee replacement surgery or subsequent physiotherapy).

Community-based solutions should be designed and supported with policies that maximize communication ability and minimize the handicapping effects of hearing loss, alone or in combination with vision loss, cognitive declines, or mobility disabilities in older adults. At the level of global health policy, the WHO has spearheaded an international "Age-Friendly Cities" agenda to foster environmental and social initiatives for "active aging," including community-level programs to promote the health, security, and the social participation of older adults in society (Fitzgerald & Caro, 2014; Jennings, Cheesman, & Laplante-Lévesque, 2014; Menec, Means, Keating, Parkhurst, & Eales, 2011). Community initiatives to accommodate the hearing and communication needs of older adults could be incorporated into the "Age-Friendly Cities" agenda; for example, background noise reduction should be undertaken in all public places and there should be more widespread use of multimodal presentations (visual and auditory) in public facilities, including in health care settings.

Finally, as worldwide access to the internet increases, greater use can and should be made of the web to provide hearing screening, assessment, and some treatments, including education about the nature of hearing loss with aging, along with tips about improving communication and information about technologies that could be used to solve hearing problems. Although these web-based services do not replace the need for trained professionals, they do provide a useful supplement (Singh, Pichora-Fuller, Malkowski, Boretzki, & Launer, 2014). What's more, they may be a solution to the dependency of GPs making referrals, a known barrier (128, 130). Now that more than 75% of the world's population is estimated to own a cell phone (World Bank), the WHO could play a leadership role in the creation of such web- and cellphone–based resources for the public and for knowledge sharing among health professionals.

There is a shortage of randomized control trials to show how educating the general public, and individuals with hearing loss, can overcome barriers and facilitators in HHC. For example, there is considerable research conducted and information available to inform policy and practice about the need for addressing vision health early in diabetes management (Javitt et al., 1994). However, more widespread recognition of the association between hearing loss and dementia has been relatively recent (Lin et al., 2011; Weinstein, 1986), despite it being identified about 20 years prior (Weinstein, 1986).

In summary, hearing health can be achieved in many ways. Through proactive communities and supportive health care initiatives and legislation, HHC could be reconceptualized within broader life course and healthy aging models. The research and service delivery priorities described here summarize some of the opportunities we have to mitigate the handicapping effects of hearing loss for the individual and their families, as well as optimize prevention, early detection, and management.

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