

Hearing, Cognition, and Healthy Aging: Social and Public Health Implications of the Links between Age-Related Declines in Hearing and Cognition

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ABSTRACT

Sensory input provides the signals used by the brain when listeners understand speech and participate in social activities with other people in a range of everyday situations. When sensory inputs are diminished, there can be short-term consequences to brain functioning, and long-term deprivation can affect brain neuroplasticity. Indeed, the association between hearing loss and cognitive declines in older adults is supported by experimental and epidemiologic evidence, although the causal mechanisms remain unknown. These interactions of auditory and cognitive aging play out in the challenges confronted by people with age-related hearing problems when understanding speech and engaging in social interactions. In the present article, we use the World Health Organization's International Classification of Functioning, Disability and Health and the Selective Optimization with Compensation models to highlight the importance of adopting a healthy aging perspective that focuses on facilitating active social participation by older adults. First, we examine epidemiologic evidence linking ARHL to cognitive declines and other health issues. Next, we examine how social factors influence and are influenced by auditory and cognitive aging and if they may provide a possible explanation for the association between ARHL and cognitive decline. Finally, we outline how audiologists could reposition hearing health care within the broader context of healthy aging.

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Learning Outcomes: As a result of this activity, the participant will be able to (1) discuss the evidence regarding the associations between age-related hearing loss (ARHL) and other age-related health issues, and (2) describe how social factors influence and are influenced by ARHL to guide new approaches to audiology practice.

HEALTH, HEALTHY AGING, AND THE IMPORTANCE OF SOCIAL FUNCTIONING

All too often, old age is associated with difficulties such as multiple health problems, including declines in auditory and cognitive abilities, and social isolation. Sensory input provides the signals used by the brain when listeners understand speech, enjoy music, detect warning signals, react to environmental sounds, and participate in social activities with other people in a range of everyday situations. When sensory inputs are diminished, there can be short-term consequences to brain functioning, and long-term deprivation can affect brain neuroplasticity. Importantly, the interactions of auditory and cognitive aging play out in everyday life as people with age-related hearing problems communicate, participate in social activities, and maintain social roles and relationships.

In the present article, we consider how age-related sensory, cognitive, and social functioning may be interrelated and the implications of such interrelationships for rehabilitative audiology. In particular, we use the World Health Organization's International Classification of Functioning, Disability and Health (WHO ICF) and the Selective Optimization with Compensation (SOC) model of Baltes and Baltes to highlight the importance of adopting a healthy aging perspective that focuses on facilitating active social participation by older adults.^{1,2}

The WHO ICF provides a familiar framework that has been used by audiologists.³ Two key features of the WHO ICF are that functioning is conceptualized with bidirectional influences across a trio of levels (impairment, activity, and participation) spanning biological to social factors and that functioning occurs in

context and can be modulated by personal and environmental factors. All components of the system are linked to each other such that change in one will yield changes in others. Importantly, modifying contextual factors by removing barriers and/or enhancing supports can facilitate healthy functioning for an individual. Ideally, healthy functioning would result if personal resources and supportive physical and social environments were optimized to offset the potentially negative consequences of biological impairments. From an ecological perspective, an optimized person-context fit would promote healthy adaptation,⁴ enabling the person to cope successfully and achieve their goals without stress.

According to the SOC model, "successful" aging involves modifying the balance between losses and gains such that, as older adults continue to develop in their later life, it remains possible to have a positive balance. The SOC model assumes that as adults age there is intra-individual plasticity and interindividual variability (i.e., all individuals can change with age, but they may differ in how they change). The model describes three key processes involved in successful aging: (1) selection and prioritization of goals to be achieved with limited resources; (2) optimization of how limited resources are deployed to achieve selected goals (e.g., developing new skills can improve the efficiency of resource use); (3) compensation by drawing on relatively intact abilities (or using assistive technologies) to offset declining abilities so that selected goals can be achieved in new ways. The SOC model can be applied in rehabilitation to understand how older adults cope successfully with declines and various disabilities (e.g., recovery from stroke).⁵ The model can also be used to understand how younger and middle-aged people can prevent

declines and prepare for successful aging by engaging proactively in health-promoting lifestyles.⁶

Health has been defined as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity,⁷ but from the perspective of health promotion, health has been redefined as the capacity of people to adapt to, respond to, or control life's challenges and changes.⁸ Importantly, hearing health needs to be thought of as part of this capacity for people to live their lives optimally. We are poised to reinvent hearing health care for older adults by adopting a healthy aging approach.

LINKS BETWEEN HEARING LOSS, COGNITIVE DECLINE, AND THE HEALTH OF OLDER ADULTS

The population is aging rapidly; a historically unprecedented large proportion of the population is becoming seniors as those in the "baby boomer" generation turn 65 years old. Another reason is that longevity has increased, with more people living to older ages, including many who are centenarians.⁹⁻¹¹ Indeed, the most rapid reductions in mortality are occurring in the "oldest old" age group of octogenarians and nonagenarians.¹² Accordingly, in the coming years, audiologists should expect to see more people who are living to older ages and whose needs differ from those of younger adults.

In general, as the population ages, the burden of disease and mortality is shifting with increases in chronic, noncommunicable, and geriatric illnesses; specifically, a recent study of projected global disease burden, using estimates based on trends in demographic and socioeconomic factors, suggested that dementias and adult-onset hearing loss will be among the top 10 causes of total disability in high-income countries by the year 2030.¹³ Not surprisingly, given the increasing prevalence of hearing loss, dementia, and other chronic health conditions, it is becoming more common for older adults to have multiple comorbidities. Indeed, there is growing awareness that hearing loss must be factored into social policies to promote healthy aging and programs to provide a wide range of health services to older adults.¹⁴

Nonauditory age-related health conditions may influence hearing loss and hearing health care. For example, hearing loss has been linked to other major chronic health conditions that may be risk factors for hearing loss, including diabetes,¹⁵ cardiovascular disease,¹⁶ and hypertension.¹⁷ Furthermore, hearing rehabilitation, including use of hearing aids, may be complicated by nonauditory age-related conditions, such as visual impairment or loss of manual dexterity due to arthritis.¹⁸⁻²⁰ Conversely, hearing loss and hearing health care may influence other age-related health conditions. Clearly, the association between hearing loss and incident dementia has become a concern. However, like many geriatric health conditions, dementia rarely has a single cause; although various types of dementia have been identified, their etiologies are not yet well understood and likely involve a complex interaction of many genetic, lifestyle, and environmental factors.²¹ Furthermore, hearing loss is associated with and may precede a broad range of other age-related mental and physical health issues besides dementia, including depression,²² difficulties walking,²³ falls,^{24,25} poorer physical functioning and increased risk in women of incident nursing care requirements,²⁶ frailty,²⁷ and even mortality.²⁸⁻³² Similar to hearing loss, dementia and cognitive dysfunction also contribute to falls,³³ length of stay in hospital,³⁴ more intensive nursing care,³⁵ and poorer recovery after surgery,³⁶ and hospital stays and surgery may increase rates of cognitive declines in older individuals with and without dementia on admission.³⁷ In addition, provocative findings indicate that hearing loss may undermine the quality and costs of health care, and that hospital costs for patients with dementia are higher compared to costs for peers without dementia,^{38,39} even in analyses that control for severity of medical illness, functional impairment, and other potentially confounding variables. Thus, the implications of hearing loss in older adults, especially in those who have or may develop dementia, extend to many aspects of health and health care.

Of course, many older people with hearing loss are cognitively normal, and not all people with dementia have hearing loss. Nevertheless, the increasingly common co-occurrence of

declines in sensory loss and cognitive loss as people get older does not seem to be merely a result of increasing prevalence in unrelated conditions, but rather that these conditions are interrelated.⁴⁰ Convincing evidence has emerged suggesting that cognitive loss is more prevalent or may progress more quickly in people with hearing loss than in their peers with good hearing. Audiologists will need to be prepared to help an increasing number of older adults who are living with hearing loss in combination with other chronic health issues, but especially those who have both hearing loss and dementia.⁴¹

The strongest epidemiologic evidence linking pure tone hearing loss to accelerated cognitive decline and dementia comes from two large, population-based cohort studies with long follow-up periods. The first study included a cohort of 639 dementia-free older individuals who underwent audiometric pure tone threshold testing in the early 1990s.⁴² The participants returned for follow-up every 2 years with a median follow up of over 11 years. Whether or not the time to incident all-cause dementia depended on the severity of hearing loss was investigated using Cox proportional hazards regression models adjusted for age, sex, race, education, diabetes, smoking, and hypertension. Strikingly, the risk of incident dementia increased by 1.27 times per 10-dB increase in hearing thresholds. Relative to people with normal hearing, the incidence of all-cause dementia was 1.89 times higher in people with mild hearing loss, 3 times higher in people with moderate hearing loss, and 4.94 times higher in people with severe hearing loss. To put the effect size into context, the authors calculated that the cognitive reduction associated with a 25-dB loss in hearing was equivalent to the reduction associated with an increase of 7 years in age. Similar results were found in the second study of nearly 2,000 people in the Health ABC cohort who were 70 to 79 years old.⁴³ In that study, participants from Pittsburgh and Memphis with mild to severe hearing loss had faster rates of cognitive decline compared with normal hearing participants, even after adjusting for possible confounders due to demographic or health factors. Furthermore, at least two earlier studies conducted by other researchers have

shown faster rates of cognitive declines among patients who already had dementia with hearing loss compared with those with normal hearing.^{44,45} In addition to associations between pure tone hearing loss and dementia, other studies have also demonstrated that performance on tests of central auditory processing (e.g., dichotic tests of speech in noise) are associated with cognitive status and incident dementia.⁴⁶⁻⁴⁹ Taken together, these studies establish that there is a link between auditory and cognitive aging, but further research is required to determine why there is a link or if the link can be modified by intervention. The explanations for the link may be based on biological, cognitive, and/or social mechanisms. In the present article, the biological and cognitive mechanisms are mentioned briefly, but there is greater focus is on the possible social mechanisms that may be associated with the link between auditory and cognitive aging.

Possible Biological Mechanisms

A common neurodegenerative pathology could conceivably lead to both hearing loss and dementia. The pathognomonic β -amyloid plaques, neurofibrillary tangles, and neuronal atrophy of Alzheimer disease have been observed in the peripheral visual neural and olfactory sensory systems at autopsy, and reduced smell is an early clinical symptom of the disease; however, Alzheimer pathology, although affecting the central auditory system,⁵⁰ has not been demonstrated in peripheral structures like the cochlea or cochlear nerve.⁴⁰ Other possible biological risk factors common to both hearing loss and dementia could be a variety of genetic, inflammatory, or immunologic and/or other health conditions (e.g., cardiovascular disease, hypertension, diabetes, stress) that are often controlled in epidemiologic studies as possible confounders.^{43,51}

Possible Cognitive Mechanisms

Cognitive mechanisms may contribute to the link between hearing and dementia. Evidence for cognitive mechanisms comes from research on age-related changes in brain structure,

functional brain networks, and behavioral performance.

A link between hearing loss and changes in brain structure is suggested by recent radiographic evidence from a brain imaging study of participants in the Baltimore Longitudinal Study of Aging.⁵² Among a cohort of 126 dementia-free individuals, the mean rate of brain volume reduction over a 6.4-year follow-up was greater among participants with hearing loss. The size of this effect was approximately equivalent to the average difference seen between people with normal cognition and people with mild cognitive impairment. In particular, hearing loss was related to greater changes in the temporal lobe structures, which are important for spoken language processing, semantic memory, and sensory integration, and atrophy in the medial temporal lobe is found in the early stages of Alzheimer's disease.⁵³⁻⁵⁸

Beyond changes in brain structures, it is even more important to understand more about changes in brain function and associated behaviors. Notably, in addition to biological changes in the brain and reduced performance on behavioral tests of memory, a necessary condition of dementia diagnosis is loss of ability to function independently in everyday life.^{59,60} Building on what has been learned about age-related changes in functional brain networks,⁶¹ further research using functional brain measures is needed to determine how sensory-cognitive brain networks may change over time and how these changes relate to functioning in different everyday communication situations.⁶² Two main themes that have emerged in research on the cognitive neuroscience of aging are that there are individual differences in cognitive reserve and that there is cognitive compensation such that patterns of brain activation for a given individual vary depending on the cognitive load demanded by a task.

The concept of cognitive reserve refers to individual differences in cognition that seem to moderate the extent to which dementia pathology manifests in symptoms of disease.⁶³ People with greater cognitive reserve are thought to have neural networks that are less susceptible to disruption such that they can compensate better for pathologic changes in the brain and thereby maintain functioning in everyday life.⁶⁴ At a

certain point, however, even individuals who have greater cognitive or brain reserves can no longer compensate for neural degeneration and the clinical manifestation of disease becomes apparent, even though symptoms have been delayed relative to others who have less reserve. Cognitive reserve is thought to be greater for those who are more educated, have higher IQs, work in occupations or engage in activities with rich opportunities for mental and social engagement, and adopt healthy lifestyles in terms of diet and physical activity.^{65,66} Thus, there may be interindividual differences insofar as older adults may begin the process of adjusting to hearing loss having accumulated more or less cognitive reserve over their lifetimes. In the long term, if hearing loss compromises an individual's ongoing lifestyle choices, resulting in reduced engagement in physical, mental, and social activity, then the maintenance of the person's cognitive reserve may be compromised. In this way, over many years, hearing loss may accelerate the depletion of cognitive reserve as dementia progresses. For a given person at a given point in time, there are also intraindividual differences in how brain networks are activated depending on the cognitive load demanded by various tasks. In studies of brain function, increasing brain activation as the cognitive load demanded by a task increases has been interpreted as evidence of cognitive compensation.⁶¹

The notions of cognitive reserve and cognitive compensation are compatible with behavioral findings concerning interindividual and intraindividual differences in listening performance.^{67,68} The cognitive demands encountered by a listener performing tasks in everyday life vary depending on a variety of interacting factors related to the characteristics of the listener and the signal(s) produced by one or more sources in a context.⁶⁹ Listener characteristics, including cognitive reserve, contribute to interindividual differences in performance. Individuals of the same age can differ in their auditory and cognitive processing abilities, and in their linguistic and world knowledge; however, in general, processing abilities decline whereas knowledge increases or is maintained as adults get older.⁷⁰ Finally, consistent with the SOC model, listeners may differ in their goals

or selection of priorities for allocating cognitive resources, especially when there are multiple competing tasks. These listener characteristics interact with signal and context factors that contribute to situation-specific intraindividual differences in performance. In the terms of the SOC model, optimization could reduce and/or compensation could offset-increased cognitive load. The signal properties affecting the cognitive load demanded in a specific listening situation may include not only the acoustic (with or without optimization by the use of listening technologies) and the linguistic properties of a target speech signal, but also the properties of energetic and informational maskers, and converging or competing information from other sensory modalities. In addition, the cognitive load of a listening task will depend on many aspects of the context that may facilitate the use of semantic, social, and interpersonal knowledge and expectancies to interpret incoming signals.

In general, congruent or supportive contexts make the task easier and lessen cognitive load, and incongruent contexts make the task more difficult and increase cognitive load. Even if the acoustical conditions are the same, increased cognitive load (e.g., by increasing task demands) causes listeners to rely more on lexical knowledge and less on phonetic detail.⁷¹ Notably, younger adults rely relatively more on bottom-up processing of signal cues, whereas older adults rely relatively more on top-down processing of context cues.⁷² In effect, compared with younger listeners, older listeners may be chronically operating with more cognitive load and more frequently engaging compensatory patterns of brain activation.⁷³ Over many decades, the compensatory shift in the use of different types of information during everyday listening may accompany permanent changes in patterns of activation in brain networks, such as changes in hemispheric asymmetry or shifts to more frontal lobe activation.^{74,75} In addition, converging evidence suggests that the hippocampus is involved not only in memory but also in associative memory or the binding of information about items and contexts during the perception of complex stimuli.^{76,77} Experimental studies demonstrated age-related declines in

item-item and item-context associative memory, with diminished ability to compensate by using context when information is encoded and with disruptions of auditory associations that are temporally defined.^{78,79} Insofar as those with age-related hearing loss (ARHL) may habitually experience even greater cognitive loads in typical listening situations, which might accelerate changes in brain networks, it is possible that they could show sooner or faster cognitive declines than peers with better hearing.

HOW SOCIAL FACTORS INFLUENCE AND ARE INFLUENCED BY AUDITORY AND COGNITIVE AGING

Social factors affect many aspects of health, including how people live with age-related auditory and cognitive declines; conversely, health and age-related auditory and cognitive declines affect social interactions and quality of life. The connections between auditory, cognitive, and social factors are illustrated by the comment of a doctor who summed up his experience with hearing loss as follows: "It affected me meeting girls and having girlfriends. Being made fun of for not hearing things, where people were making light of it. It hurt, but you'd never admit to it. People would say, 'You can hear, you just didn't pay attention.' And that was partly accurate. I stopped paying attention because I couldn't hear."⁸⁰ How successfully an older adult selects, optimizes, and compensates in everyday life may depend on several relevant social factors, including stigma, self-efficacy, social support, social networks, and participation in social activities.

Stigma, Stereotypes, and Self-Perceptions

Stigma involves the (self-)identification of a person as having a characteristic that is devalued in a social context.⁸¹ Negative stereotypes of aging, as well as negative self-perceptions, may affect the health of older adults and how they function in everyday activities, such as communication and social interaction, which depend

on both hearing and memory.⁸²⁻⁸⁴ Notably, memory and hearing are two domains in which older people are often negatively stereotyped.⁸⁵⁻⁹⁰ Age-related declines in memory and hearing may be exacerbated when older adults fall prey to negative stereotypes of aging, and negative views of aging may be one reason why older people's self-perceptions of ability do not always accurately reflect their actual function.^{91,92} The stigma associated with hearing loss is entangled with ageism,⁹³ and perceptions of stigmatization can fuel the denial of hearing problems and nonadherence to rehabilitative treatments.^{94,95} The perception of stigma seems to differ between men and women, to vary with age, and to be associated more with hearing loss than with hearing-aid use.⁹⁶ Importantly, age per se is not correlated with negative views of aging,⁹⁷ and responses to stigma can vary depending on context such that some individuals are vulnerable while others are resilient to stigma.⁸¹ Thus, there is potential to tailor interventions according to the individual's responses to stigma.

Self-Efficacy

Self-efficacy refers to domain-specific "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments."^{98(p.3)} In general, individuals with high self-efficacy put forth greater effort in achieving a behavior, persevere when difficulties arise or failures occur, have self-aiding thoughts for achieving the behavior, and cope better with emotional, social, and environmental demands surrounding the behavior.⁹⁸ Numerous studies have demonstrated that domain-specific self-efficacy plays an important role in the successful management of a various chronic health conditions; for example, patients with high self-efficacy for managing diabetes have more positive outcomes, higher health-related quality of life, increased compliance with treatment recommendations, and better long-term maintenance of the modified behavior compared with patients with low self-efficacy.⁹⁸⁻¹⁰⁰ Thus, it seems that sufficient self-efficacy is critical if older adults are to seek help, take action, and modify and maintain the behavior changes required for successfully

adaptation to ARHL. Importantly, audiologists could use techniques to increase the self-efficacy of older adults at various stages of the rehabilitative process.¹⁰¹

Social Support

Social support refers to the perceived quality, rather than the quantity, of relationships providing emotional or affective support (e.g., empathy), instrumental support (e.g., financial aid), and/or informational support (e.g., advice).^{102,103} Social support can have a powerful effect on outcomes for various health conditions by promoting the use of effective coping strategies and counteracting negative interpretations of adverse events.^{104,105} The importance of social support is demonstrated in the role played by significant others in hearing rehabilitation and by caregivers in dementia care.¹⁰⁶ Significant others can act as a source of motivation and support for those using hearing aids,^{107,108} by encouraging the person who is hard-of-hearing to pursue and adhere to treatment,^{109,110} by acting as a facilitator for communication, and by providing information and instruction on the proper use and operation of hearing aids¹¹¹⁻¹¹³; however, the negative attitudes of significant others may contribute to delaying help-seeking or rejecting treatment.^{114,115} The availability of the social support seems to differentiate successful from unsuccessful and satisfied from unsatisfied hearing aid users.^{116,117} Furthermore, social support is a strong predictor of adjustment to the psychological distress associated with hearing loss.¹¹⁸

Social support provided by significant others and caregivers may be beneficial to the person who has the impairment(s), but unfortunately, providing social support may strain relationships, increase stress, and compromise the health and quality of life of those who provide the support. Hearing loss affects not only the person who has hearing loss but also significant others,¹¹⁹⁻¹³⁰ reducing their physical, psychological, and social well-being. In particular, third-party disability manifests in wide-ranging effects on the spouses of persons with hearing impairment,¹³¹ including communication difficulties, emotional sequelae, and effects on relationships and everyday

activities.^{127,129} Similarly, the well-known burden of caregiving for an individual with dementia can result in changes in caregivers' own physical health, mental health, financial resources, and social participation.^{132,133} Dementia can result in difficulties with language and cognition,^{134,135} and hearing loss in this population can also lead to communication breakdowns. Importantly, breakdowns in communication increase caregiver burden and have been identified as one of the most distressing problems for caregivers of people with dementia.^{136–139} For example, many of the behavioral symptoms of AD and other dementias, such as frequent requests for repetition and difficulty following conversations, can lead to withdrawal from social situations and increased feelings of caregiver burden. The combination of declines in hearing and cognition may be overwhelming for caregivers,⁴¹ but audiologic rehabilitation of older adults with cognitive impairment and their significant others may help alleviate burden, increasing the efficiency of home care and delaying the client's move to institutional care.¹⁴⁰

Social Networks

Significant others and caregivers are the core of an older person's social network. Indeed, as people age, their socioemotional priorities shift toward a focus on emotional regulation and having fewer, high-quality close relationships and away from a focus on knowledge acquisition and having larger social networks.¹⁴¹ Importantly, maintaining social connections is critical to healthy aging. Indeed, social isolation and loneliness are particularly common in older adults and increase their risks of mortality, mental and physical health issues, disabilities, and difficulty in making life-course transitions.^{142,143} Stronger social networks may reduce mortality, cardiovascular disease, depression, and anxiety,^{144–147} with the risk of mortality associated with social isolation being as great as that of other notorious clinical risk factors such as cigarette smoking and hypertension.^{148,149} Hearing loss in cognitively normal older adults has been related to reduced quality of life and increased social isolation and emotional distress,¹⁵⁰ as well as reductions in

physical capabilities and instrumental activities of daily living, such as managing medication.¹⁵¹ A recent population-based study conducted using nationally representative data for the United States confirmed that older people with hearing loss, especially women, had smaller social networks compared with people with normal hearing.¹⁵² Isolation may increase the risks of dementia onset and progression. Epidemiologic studies indicate that weaker social networks, reduced social support and loneliness increase the risk of incident dementia among those who are initially free of the disease,^{153,154} after controlling for potentially confounding variables. Again, age-related declines in hearing and cognition both increase risk of social isolation and in combination the risk is likely to be even greater. Preventing social isolation must be a target for audiologic rehabilitation designed to promote healthy aging.

PARTICIPATION IN SOCIAL ACTIVITIES

Beyond merely preventing social isolation, effective selection, optimization, and compensation would enable a person who is aging successfully to participate actively in enriching activities in everyday life. In models based on population data, there are significant paths from age to hearing to intelligence to participation in activities of daily living.¹⁵⁵ In samples of people with hearing impairment (or vision impairment), relationships have been found between cognition and everyday functioning.¹⁵⁶ Again, there are reciprocal issues insofar as not only do auditory and cognitive declines compromise active participation in everyday life, but reduced opportunities for social participation may accelerate further declines. Animal studies showed that social and sensory stimulation can strengthen the structure and function of the central nervous system at the cellular and molecular levels; for example, compared with controls isolated in sensory-deprived conditions, rats randomized to live among their peers in cages containing abundant sensory stimuli had lower concentrations of inflammatory cytokines and higher levels of protective neurotrophic factors in the hippocampus, with greater numbers of synapses per dendrite, larger neurons,

and greater neurogenesis, as well as better spatial memory and learning behaviors.¹⁵⁷ Similar molecular and cellular changes have been observed in animals exposed to greater levels of physical activity¹⁵⁸ or reduced caloric intake,¹⁵⁹ and these changes may mediate a path between healthy lifestyles and cognitive resilience. Of many studies conducted in humans, one of the most intriguing evaluated the Experience Corps,¹⁶⁰ a social intervention in which at-risk older adults are trained and work as volunteers with children in classrooms; compelling evidence suggests that increasing meaningful social participation for the volunteers resulted in numerous positive outcomes, including improved physical performance (walking speed), improved cognitive performance (memory), and increased size of social networks. Furthermore, functional brain imaging provided evidence of intervention-specific increases in brain activity in the left prefrontal cortex and anterior cingulate cortex over the 6-month interval relative to matched controls, with matched gains in executive inhibitory ability.¹⁶¹ In general, longitudinal population-based studies suggest that greater participation by older adults in social activities may be associated with better cognition.¹⁶² These findings point to active and meaningful social participation as another target for audiologic rehabilitation designed to promote healthy aging.

IMPLICATIONS FOR AUDIOLOGIC PRACTICE

As described above, across time and at any given point in time, the health and everyday social functioning of older adults can affect and be affected by age-related declines in hearing and cognition. Consistent with the WHO ICF framework, there is a pressing need to reinvent hearing health care for older adults by adopting a healthy aging approach that emphasizes social participation. The processes for achieving successful aging described in the SOC model could be used as a basis for designing new approaches to rehabilitative audiology and for designing other health-related programs delivered to older adults who have hearing problems. The WHO ICF and SOC model could be applied in

programs to prevent, assess, treat, and increase accessibility for older adults who have ARHL.

Prevention

Fortunately, over the past 20 to 30 years, total disability among Americans 65 years and older has declined by ~25%, possibly in response to rising levels of education and standards of living, better treatment of cardiovascular diseases, reduced rates of smoking, greater availability of assistive devices, and less physically demanding jobs.¹⁶³ Similarly, risk of ARHL decreased throughout the 20th century in North America, possibly in response to lower levels of industrial noise and better control of cardiovascular disease.¹⁶⁴ Prevention of ARHL may be achieved by addressing risk factors like cardiovascular disease and noise exposure, particularly among young people whose ears may be particularly susceptible to subclinical noise damage.¹⁶⁵ These findings are inspiring public health researchers to find more ways to slow or prevent age-related health issues, especially cognitive impairment and dementia, and to improve the independence and well-being of older adults. On the one hand, health promotion initiatives that help older adults to maintain good health and active social participation could moderate some of the negative consequences of age-related declines in hearing and cognition. On the other hand, if hearing loss is a modifiable risk factor, especially for dementias and cognitive decline, then sooner and better hearing health care could moderate some of the negative consequences of several age-related health issues.

Assessment

Audiometric threshold testing has been the cornerstone of traditional audiologic assessment, and hearing aid fitting has been the cornerstone of traditional audiologic rehabilitation. Going beyond the information gathered in a traditional audiologic assessment, information about nonaudiometric factors concerning relevant aspects of an individual's physical, mental, and social health would be needed to plan effective hearing health care in the broader context of healthy aging. Relevant aspects of

physical health would include background on other sensory modalities (e.g., vision, balance, touch), motor functioning (e.g., dexterity, mobility, falls), and chronic health conditions (e.g., diabetes, cardiovascular disease, hypertension). Relevant aspects of mental health would include background on cognitive functioning (e.g., screening or history of diagnosis of mild cognitive impairment or dementia) and mood (e.g., depression) or other psychological or psychiatric disorders (e.g., anxiety). Audiologists would not typically gather information about physical and mental health issues, and other health professionals, even those diagnosing dementia, seldom gather information about hearing,¹⁶⁶ even though hearing problems could affect the results of testing.¹⁶⁷ However, in the context of interprofessional teams, those involved in the care of older adults with multiple health issues could benefit from cooperating and sharing relevant information to ensure that the best quality of health care is provided.

In addition to information about physical and mental health, information about relevant aspects of social functioning would be needed to plan hearing health care designed to promote successful aging. Rehabilitation planning could be greatly enhanced if audiologists had information about the social factors that are most likely to influence an older adult's readiness to seek help, take action, and maintain behavior change to live successfully with hearing loss. These measures would provide insights into the stigma, self-efficacy, social support, social isolation, and social participation issues of the individual with hearing loss. Planning rehabilitation designed to help an older adult achieve a good person-environment fit would also require information about the contextual barriers and facilitators specific to the individual's physical and social communication ecologies. Such information would be used to assess the accessibility needs of the person, in particular communication situations, as well as to characterize the availability of social support and possible concerns regarding third-party disability or caregiver burden. Fortunately, there has been a recent increase in research on applying the principles of health and social psychology in audiologic rehabilitation.¹⁶⁸

Rehabilitation

Current rehabilitation options for individuals with ARHL include technologies (e.g., hearing aids, assistive devices, cochlear implants), auditory or communication training, counseling, and group programs. Unfortunately, there is no simple, one-size-fits-all solution for adults with normal cognition, and more specialized interventions for those at various stages of cognitive decline are rarely implemented in typical audiology clinical settings.^{41,169} Some barriers to successful rehabilitation are related to technology that falls short of user expectations or is expensive and/or ergonomically suboptimal. However, there are many other barriers to successful rehabilitation that are primarily related to social factors.

Many older adults delay seeking help for hearing problems and, by the time they first try a hearing aid, they are already affected by multiple physical and cognitive health issues. For decades, hearing health professionals have advocated for fitting hearing aids as soon as possible and certainly while older adults are physically and psychologically able to learn to use the technology.^{170,171} Although some health professionals have questioned the value of hearing rehabilitation for older adults with dementia, it seems that hearing rehabilitation may be of extreme importance in helping these individuals and their family caregivers.^{43,170,172} There is strong evidence that hearing aids and auditory rehabilitation improve communication and hearing-related quality of life.^{173,174} If poorer communication increases risk for social isolation and withdrawal from social participation, which in turn contribute to the link between hearing loss and cognitive decline, then it is possible that improving communication by using hearing aids might weaken the link. In epidemiologic studies, cognitive declines were associated with hearing loss but did not differ between participants who reported using hearing aids and those who did not^{42,43}; however, minimal information on hearing aid use was available. High-quality, long-duration randomized controlled trials are needed to determine if older adults with clinically significant cognitive declines benefit as much as peers with normal cognition from current best practices in

audiologic rehabilitation and if such rehabilitation can slow cognitive declines.¹⁴

Some older adults are successful in adapting to hearing loss. They identify and accept that they have hearing-related problems; they select the situations and relationships where communication has the most value for them; they optimize by learning new listening skills (e.g., through auditory training and practice), using technologies (e.g., hearing aids and assistive devices), and modifying environments (e.g., by reducing background noise); and they compensate by speech-reading and using communication strategies in conversation (e.g., asking communication partners to speak clearly). But other people have more difficulty making changes to adjust to life as a person with hearing loss. They may not recognize or might deny that they have hearing problems; they might never have their hearing tested; they might avoid social situations out of fear of embarrassment, or take out their frustrations in ways that may damage relationships with friends or family, jeopardize social support, and/or reduce opportunities for interaction.¹³⁰

New approaches may be needed to overcome barriers arising from social factors such as stigma and negative views of aging, poor self-efficacy, lack of social support, and social isolation and/or withdrawal from social interaction. For example, Internet screening may provide an opportunity to reach those who would not come to a clinic for a hearing test. However, the identification of hearing loss by screening may be insufficient to predispose further action; new approaches to increase readiness for hearing rehabilitation will likely be needed to predispose uptake of hearing aids and other changes in behavior to improve hearing-related quality of life.^{175,176} Other new approaches, especially those involving social support, may be needed to reinforce and maintain new behaviors and coping; for example, in one study, harnessing social support by including significant others in rehabilitation classes for individuals with hearing loss resulted in larger reductions in hearing handicap scores for those who attended with a significant other compared with those who attended alone.¹⁷⁷ The Internet may also provide new opportunities to overcome these barriers; for example, lack of social support

predicted the frequency of participation in and subjective benefit from an online self-help group for hearing loss.¹⁷⁸ Finally, new rehabilitative approaches to address the effects of hearing loss on significant others could also help to predispose uptake and reinforce outcomes of audiologic rehabilitation, especially for caregivers of older adults who have hearing loss and clinically significant cognitive declines.

Accessibility

Reduction of the risk of developing dementias may depend on lifestyle changes and improved treatment or prevention of chronic health conditions, including hearing loss, that confer additional risk. The most important modifiable lifestyle factors include cognitive reserve, physical activity and exercise, dietary factors, alcohol intake, and smoking. The most obvious treatable chronic health conditions include cardiovascular diseases, stroke, midlife hypertension, diabetes, and midlife hypercholesterolemia.¹⁷⁹ Sadly, many of the potentially modifiable risk factors for dementia, such as socialization, physical activity, and prevention or treatment of chronic health conditions, including hearing loss as a recent addition, are poorly addressed at the population level. Too many people are isolated, sedentary, and do not do anything about hearing impairment. There may be important opportunities to reduce the incidence of cognitive loss if these factors, and others, are addressed in a comprehensive manner in communities, hospitals, and clinics. The current model of health care, however, which is subjugated to the "tyranny of the acute" and divided into professional silos, is not an ideal platform upon which to build a holistic program that aims to prevent chronic illness.

New interprofessional and public health approaches to population health are needed. In particular, such approaches could increase awareness of the importance of hearing health, better integrate hearing health care into the larger health care picture, increase uptake of amplification devices and other forms of audiologic rehabilitation, and mandate public policies and environmental accommodations such as ambient noise controls and access to written information in public

spaces. At the level of global health policy, within the last decade, the World Health Organization 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.¹⁸⁰ A challenge to audiologists is to begin to contribute to such initiatives.¹⁸¹

CONCLUSION

Greater attention to improving lifestyle and medical risk factors for cognitive declines is urgently needed across adulthood. Prevention and mitigation of hearing loss may play a significant role in these efforts, in combination with other ways to promote healthy physical, mental, and social aging. Even if dementias cannot be entirely prevented by sooner and better hearing health care, simply delaying the onset of disease would result in significant benefits to individuals and society. It is estimated that a 1-year delay would lead to a 10% reduction in prevalence by 2050,¹⁸² and there would likely be additional, noncognitive benefits to the health and well-being of older adults. The alternative of doing nothing will almost certainly result in growing strains on families, health care systems, and aging societies. Audiologists have a valuable contribution to make by reinventing hearing care in the context of healthy and successful aging.

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