Hearing Loss and Healthy Aging

By Frank R. Lin, M.D., Ph.D.
Associate Professor of Otolaryngology,
Geriatric Medicine, Mental Health, and Epidemiology,
Johns Hopkins University

A white paper prepared for CaptionCall, LLC

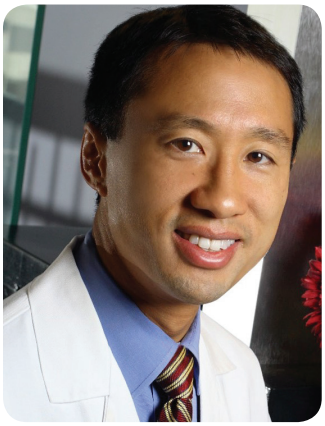
CaptionCall®

Life is Calling

Hearing Loss and Healthy Aging

By Frank R. Lin, M.D., Ph.D.

Clinicians, researchers, and policymakers increasingly understand that hearing loss can have negative effects on the cognitive, physical, and social functioning of older adults. Importantly, the mechanisms that underlie these observations may be amenable to current treatments for hearing loss. Top-down national initiatives in the U.S. are now approaching hearing loss as a public health priority to ensure the optimal health and functioning of older adults. This white paper will review how hearing loss impacts the broader functioning of older adults, the evidence for these associations, and what individuals caring for older adults can do now.



Frank R. Lin, M.D., Ph.D.
Johns Hopkins Center on Aging and Health
2024 E. Monument St.
Suite 2-700
Baltimore, MD 21287
flin1@jhmi.edu
443-287-6509

Nearly everyone has a personal story related to hearing loss. Whether it is yourself, a parent, friend, colleague, or patient, we have all personally experienced the frustrations and difficulties when communication goes awry. Unfortunately, because some loss of hearing is nearly universal with getting older, we assume that hearing loss is simply an unfortunate, and hence relatively inconsequential, aspect of aging. However, research over the past seven years on how hearing loss impacts older adults has rapidly overturned this assumption and has led to top-down national initiatives and federal legislation in the U.S. focused on addressing hearing loss in older adults as a critical public health priority. This white paper will review how hearing loss impacts the broader functioning of older adults, the evidence for these associations, and what individuals caring for older adults can do.

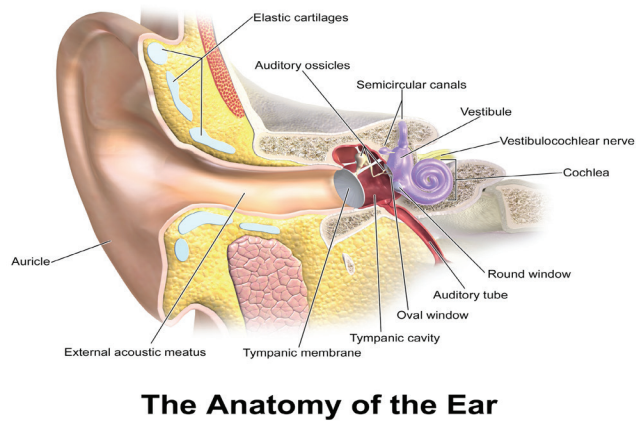
HOW WE HEAR

Our ability to hear depends on the processing of sound at three levels: 1) External & middle ear: sound is channeled through the ear canal, ear drum, and ossicles (ear bones) into the cochlea (inner ear); 2) Inner Ear: the sound transferred into the inner ear is encoded and transduced into a neural signal by the sensory hair cells of the cochlea; and 3) Brain: the auditory cortex and other regions of the brain decode the neural signal into meaning (Figure 1).

It's critical to understand that problems with hearing can occur at any of these levels. For example, if someone has a lot of occluding ear wax or an ear infection that leads to a hole in the ear drum or fluid being trapped in the middle ear, sound will not be able to get to the cochlea as efficiently. This type of hearing loss is considered a *conductive hearing loss* and is generally temporary until the underlying problem is resolved or fixed (e.g., ceru-

men removed, middle ear infection resolves).

Figure 1 Anatomy of the ear



Credit: Blausen.com staff (2014). "Medical gallery of Blausen Medical 2014". WikiJournal of Medicine 1 (2). DOI:10.15347/wjm/2014.010. ISSN 2002-4436. - Own work, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=29025009

In contrast, the hearing loss that we observe with aging is due to pathologic changes that occur in the inner ear. The sensitive sensory hair cells in the cochlea that convert sound energy into a neural signal and other parts of the cochlea that are critical for sound transduction can be damaged progressively from aging, noise exposure, genetic predisposition, etc. This type of hearing loss is termed *sensorineural hearing loss* and is what we typically are referring to when we think of older adults with hearing loss.

Finally, problems with hearing can also occur with any process that impairs the brain and hence affects the auditory decoding process. For example, individuals who experience a concussion will experience problems with hearing under challenging conditions (e.g., background noise) even when their peripheral hearing is completely normal (i.e., no problems in the external, middle, or inner ear). Likewise, individuals who have underlying cognitive difficulties from early dementia will also notice that it is harder to understand under challenging listening conditions.

Individuals with hearing problems that arise at any level (but particularly in the cochlea from sensorineural hearing loss) will notice that understanding speech under quiet conditions and when face-to-face with a speaker is often not difficult, whereas understanding speech when there are multiple talkers or with background noise (e.g., at a busy dinner table) will be very challenging. This often leads to the common refrain of, "I can hear you but can't understand you." The basis for this phenomenon is that when listening in a quiet room, the incoming auditory signal from the speaker is clear. Hence, even if the speech signal is slightly garbled by the impaired cochlea (i.e., sensorineural hearing loss) or the decoding of the signal in the brain is slightly impaired from a concurrent brain process (e.g., dementia), the overall signal is still clear enough that it can be understood. However, these individuals will struggle more in challenging listening environments (e.g., a busy restaurant, talking from a different room) where the incoming speech signal is already distorted by ambient noise and reverberation. In these cases, any distortion of the incoming signal is then further magnified by problems in the cochlea or brain.

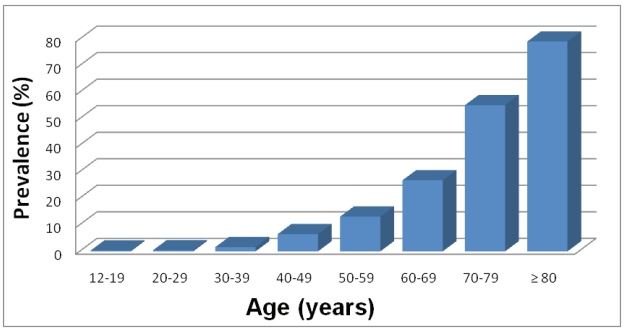
HOW COMMON IS HEARING LOSS

Sensorineural hearing loss that occurs from aging and other processes that can damage the inner ear over time is extremely common over the lifespan. When hearing loss is defined objectively using pure tone audiometry (i.e., measuring how soft sounds can be for an individual to detect them in a sound booth), we observe that the prevalence of a clinically-significant hearing loss nearly doubles with each age decade such that nearly two-thirds of all adults over 70 years has a meaningful hearing loss (Figure 2). In turn, we also know that less than 20%% of these adults with hearing loss and who could benefit from amplification currently use a hearing aid.

Because most hearing loss occurs gradually and insidiously over years, many adults are unaware of their loss. Central compensation with recruitment of other brain regions to aid in auditory processing and increased use of contextual cues allows many individuals to still decode the impoverished ascending auditory signal and to effectively "hear." As described above, any associated cogni-

tive impairment will affect the ability of individuals to effectively communicate since central decoding of sound is affected. Many older adults with cognitive impairment are, therefore, doubly challenged when trying to communicate verbally because of both age-related hearing loss in the inner ear and impaired decoding in the brain.

Figure 2 Prevalence of hearing loss in the United States 2001-2008. Hearing loss defined as the better-ear pure tone average of 0.5-4 kHz tones > 25dB. Data from Arch Intern Med. 2011 Nov 14;171(20):1851-2. doi: 10.1001/archinternmed.2011.50



HOW HEARING AFFECTS HEALTHY AGING

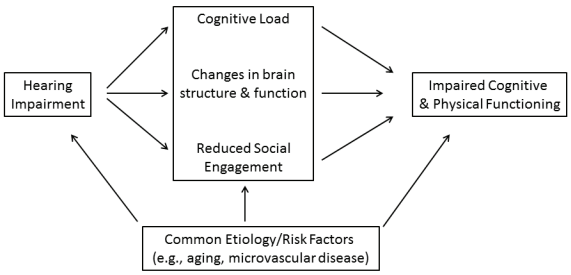
Healthy aging can broadly be defined as maintaining optimal cognitive, physical, social, and mental functioning as we age. A conceptual model (Figure 3) based on current research evidence describes the mechanisms through which hearing loss could affect these broad functional domains. This model acknowledges that a set of common etiologies could underlie a simple correlation between hearing and poor health outcomes. These include but are not limited to: age, vascular risk factors (e.g., diabetes, smoking), and social factors (e.g., education). Clearly, if these common etiologies were the only reasons underlying an association between hearing and outcomes such as dementia, this would not be interesting from the clinical or public health perspective (e.g., treating hearing loss wouldn't make a difference on helping reduce the risk of dementia). In contrast, mechanistic pathways through which hearing loss could directly contribute to poorer health include the effect of hearing loss on cognitive load, changes to brain structure, and decreased social engagement.

- *Cognitive load*: The brain has to recruit and use additional brain resources to compensate for the impoverished auditory encoding by the impaired cochlea. This process can place a "load" on the brain and rob resources that would otherwise have been dedicated to thinking, memory, and other processes.

- *Changes to brain structure*: Experimental animal studies and observational studies of older adults demonstrate that parts of the brain that handle sound processing can begin to atrophy or shrink faster with hearing loss. Importantly, these parts of the brain are also important for cognitive and other abilities which can lead to cascading effects on other areas of brain function. At present, the two most common pathologic processes that can damage the brain as we age are from microvascular disease (e.g., from high blood pressure, diabetes, etc.) and from Alzheimer's disease neuropathology, and not coincidentally, these are the two leading causes of dementia in late life. Increasingly, research is also indicating that hearing loss may act as an additional "hit" along with these other two processes to adversely affect the brain over time.

- *Social isolation*: The effects of hearing loss on someone's willingness to socially engage can often times be subtle. For example, some individuals may slowly give up going out with friends to restaurants, while others may completely withdraw and become introverted. This social isolation or loneliness is important — scientists have long known that social isolation in older adults is a direct risk factor for poorer health outcomes.

Figure 3 Conceptual model of how hearing loss impacts the functioning of older adults



Epidemiologic research over the past several years has supported the hypothesized impact of hearing loss on these broader functional areas that characterize healthy aging. The greatest amount of recent work has focused on cognitive decline and dementia in older adults. In these studies, hearing loss in older adults is consistently linked with the risk of dementia even after multiple other factors are accounted for in the analyses (e.g., effects of age, education, chronic diseases, etc.). These studies have demonstrated a direct "dose-response" wherein the greater the severity of hearing loss, the greater the risk of being diagnosed with dementia over time. In one study, the risk of developing dementia was twofold, threefold, and fivefold greater, respectively, for individuals with a mild, moderate, and severe hearing loss compared to those with normal hearing. In July 2017, the results of a major convened review of risk factors for dementia was published by the Lancet Commission and this report reviewed all the literature to date looking at risk factors that could potentially be modified to reduce dementia risk. This report concluded that among all known modifiable risk factors for dementia (e.g., obesity, smoking, diabetes, early life education), hearing loss in mid- to late-life was the single risk factor accounting for the greatest proportion of dementia risk.

"Among all known modifiable risk factors for dementia, hearing loss in mid- to late-life was the single risk factor accounting for the greatest proportion of dementia risk."

Consistent with the conceptual model, the implications and potential consequences of hearing loss also extend beyond dementia. Recent epidemiologic research has also demonstrated that hearing loss in older adults is linked with an increased risk of falls, greater risk of hospitalization and requiring institutionalization, and poorer physical functioning. In particular, for falls and physical functioning, the cognitive load imposed by hearing loss may affect the overall brain resources needed to maintain balance particularly in the setting of additional stressors that could affect balance function in older adults (e.g., visual problem, arthritis, etc.). Loss of hearing may also subtly affect our ability to monitor our auditory environment (e.g., person approaching from behind) or even hear our own footfalls with walking – both of which could affect fall risk and an individual's overall physical functioning.

IMPLICATIONS OF TREATING HEARING LOSS

The importance of hearing loss in the context of public health is that the broader functional consequences that have been associated with hearing loss may, in fact, be reduced with hearing loss treatment. The mechanistic pathways potentially linking hearing loss with impaired cognition are important because these pathways may be modifiable with existing hearing rehabilitative interventions that incorporate the use of sensory aids to maximize the clarity of speech signals and educational counseling to teach communicative strategies and the effective use of devices. Importantly, previous studies provide proof-of-principle that hearing aids and interventions that provide enhanced auditory stimuli can engage and modify the hypothesized mechanistic pathways linking hearing and cognition through reducing cognitive load, altering functional pathways and brain structure, and improving social engagement.

However, determining whether treating hearing loss could in fact reduce the risk of adverse outcomes such as cognitive decline and dementia is difficult. Intuitively, one would think that we could simply compare individuals with hearing loss who do versus do not use hearing aids in past epidemiological studies of older adults. However, individuals who use hearing aids are often also more likely to be more affluent, better educated, and healthier – all of which bias hearing aid use to appear to be associated with better outcomes when in fact the other factors associated with hearing aid use are what would explain the better results. Definitively determining whether treating hearing loss could

reduce the risk of adverse health outcomes will require a randomized trial in which a large cohort of older adults are randomized to hearing intervention versus a control intervention. Fortunately, such a trial (Aging and Cognitive Health Evaluation in Elders) has been funded by the National Institutes of Health and is currently ongoing, but definitive results will not be available until 2022.

ADDRESSING HEARING LOSS

While definitive results of the impact of treating hearing loss is not yet available, there clearly is an imperative to begin ensuring that older adults can access some form of hearing care given that there's no associated risk with treating hearing loss. For health care workers who work routinely with older adults, the presence of hearing loss is often readily apparent from personal interactions even without the need for any sort of formal screening test. In these cases, simple strategies to optimize communication can make a huge difference for the majority of individuals with hearing loss. These include:

"The importance of hearing loss in the context of public health is that the broader functional consequences that have been associated with hearing loss may, in fact, be reduced with hearing loss treatment."

- Always maintaining face-to-face communication and turning down any background noise when speaking to the individual.
- Re-wording rather than simply repeating phrases over and over again if the individual did not initially understand (e.g., if asking "what did you think of the meal?" was not understood, try repeating once and then rewording as "how was the food?"). This allows the individual to use contextual cues to understand the meaning when speech understanding is affected by hearing loss.
- Having available portable assistive listening devices for those individuals with marked difficulty understanding. Devices such as the Super Ear SE9000 by Sonic Technology Products can be tremendously helpful on a situational basis to any individual with hearing loss.

HEARING CARE WORKFORCE

Beyond the basic communication strategies described above, which can be implemented immediately by any individual caring for older adults, there are multiple points of entry for professional evaluation and screening for hearing loss. The following section will discuss the roles of audiologists, hearing aid specialists, and otolaryngologists in delivering hearing health care.

Audiologists diagnose and assess disorders of the hearing and balance systems of children and adults. Audiologists select, fit, and dispense amplification systems such as hearing aids and related devices; program cochlear implants; and provide instruction, rehabilitation, and counseling services to enhance human communication. A graduate (doctorate or master's) degree is required for practice.

Hearing aid specialists assess hearing and select, fit, and dispense hearing aids and related devices. They provide instruction and counseling in the use and care of hearing aids and related devices to enhance human communication. Licensure requirements for hearing aid specialists vary by state.

Otolaryngologists (ear, nose, and throat physicians) perform a complete medical history and physical examination of the head and neck. They also perform and supervise hearing and balance testing, which leads to the medical diagnosis, treatment, and rehabilitation of diseases of the hearing and balance systems in children and adults. This may include prescribing medications and performing surgery, including implanting cochlear implants. A medical degree (MD or DO) is required and at least 5 years of post-doctoral residency training in otolaryngology—head and neck surgery.

Comprehensive hearing rehabilitation and treatment provided by a licensed hearing healthcare professional should be comprised of a diagnostic assessment (including audiometry, speech-in-noise tests, otoscopy, etc.), communication needs assessment, education, instruction in hearing technologies, and rehabilitative counseling. While this approach serves as the gold standard treatment for hearing loss, the actual level of care provided may vary from provider to provider, often depending on the needs of the patient as well as the practice pattern and scope of practice of the provider as defined by the state.

Since 1977, the Food and Drug Administration (FDA) has specified that hearing aids sold in the U.S. require medical clearance by a physician, preferably an otolaryngologist. However, the FDA released non-binding guidance in 2016 stating it would no longer enforce that requirement for adults, though some states maintain the requirement that an adult must first sign a waiver if they choose to bypass medical clearance. Children still must obtain medical clearance before being fitted and dispensed a hearing aid.

The vast majority of older adults with age-related hearing loss arguably do not need to be seen by an otolaryngologist for evaluation unless there is an indication that implantable devices may be warranted or other medical indications exist. The American Academy of Otolaryngology—Head and Neck Surgery outlines 10 red flags of hearing loss that warrant specialist evaluation, which are based on expert consensus opinion. These incorporate the FDA hearing aid "red flags," for which a physician referral is required by law. Medical issues necessitating referral include, but are not limited to, pain, sudden onset of hearing loss, dizziness, deformity of the ear, unremitting tinnitus, ear drainage, asymmetric hearing loss, unexplained conductive hearing loss, or complex history (e.g., ear infections, noise exposure, autoimmune disorder, ototoxic medication use, otosclerosis).

HEARING TECHNOLOGIES

While hearing aids are the most common hearing technology used with hearing loss, there is a range of technologies that can be implemented to help individuals communicate and function optimally.

Hearing Aids

Hearing aids are medical devices regulated by the Food and Drug Administration and as such can only be sold through a licensed provider. Hearing aids are designed to be worn in or on the ear and are custom programmed and fit by a hearing professional. These devices as well as the associated programming and counseling provided by a hearing professional are considered the gold standard for optimal hearing rehabilitative care. One of the major concerns pertaining to hearing aids is cost, which is not covered by Medicare and rarely covered by other insurers. The average price of a pair of hearing aids generally ranges from $2,000–$6,000 which, in light of decreasing prices for other electronics, begs the question of why hearing aids remain so expensive.

One of the major factors is bundling of audiologic services and technology in which the costs for an audiologist's expertise and services (e.g., diagnostic testing, counseling, device fitting/programming) are bundled into the cost of the actual hearing aid.

Over-the-counter amplification devices

Over the past 10 years with the development of wearable consumer technologies, there has been a rapid growth of hearing-related technologies that can be purchased directly "over-the-counter" and are designed to be worn on or in the ear similar to a hearing aid. These devices are labeled for use by individuals with "normal hearing" but, in effect, are often intended to be used by individuals with hearing loss (but cannot be labelled as such given FDA regulations about what constitutes a hearing aid). These "Personal Sound Amplification Products (PSAPs)" are often sought out by individuals who

do not wish to go through conventional pathways to obtain a hearing aid or wish to obtain some sort of hearing assistance at a lower cost. The vast majority of these current unregulated products are of poor quality, particularly those sold at major drugstore chains and box stores. However, the growth of OTC hearing technologies is poised to explode exponentially in 2020. A recent federal law was passed in 2017 that mandates the FDA to create a new regulatory classification for OTC hearing aids that will provide explicit performance criteria to ensure safety and effectiveness. These regulations will go into effect in 2020 and will allow traditional consumer technology companies such as Apple, Samsung, and Bose to enter the market to sell OTC hearing aids directly to consumers.

Technologies for telephone use

The ability to effectively communicate with friends and family using the telephone remains a critical need for many older adults to remain socially engaged. Unfortunately, for those with hearing loss, hearing on the phone can be particularly challenging given that traditional landline phones only transmit sound across a limited frequency range leading to poorer quality sound.

An effective option is to use captioned telephones in which a specialized telephone provides both the voice signal as well as a real-time transcript of what the speaker is saying. These services which are termed "Internet Protocol Captioned Telephone Service (IP CTS)" allow an individual with hearing loss to speak and listen normally as on a regular call with the key difference being that the other speaker's voice is also transcribed onto the screen of the specialized phone by a combination of voice-recognition software and a human captioning agent that helps ensure accurate transcription. An example of this service is provided by CaptionCall (Figure 4) in which the company provides the installation of the phone, instruction in its use, and follow-up captioning service. The CaptionCall phone also offers customizable frequency amplification for improved audio quality, along with amplification if desired. The captioning service is fully covered by the federal government through a fund established under the Americans with Disabilities Act so there is no cost to the end user. In addition, the cost of the phone hardware is subsidized by CaptionCall for eligible candidates. To qualify for this covered technology and service, an individual needs to obtain a professional certification from a heath professional (e.g., audiologist, physician, hearing instrument specialist, etc.) that states the person has a hearing loss that necessitates the use of captions in order for them to use the phone effectively.

Figure 4 Example of a captioned telephone from CaptionCall.

Another option to improve communication on the telephone is to use internet-based videoconferencing or calling services (e.g., Skype, FaceTime) where the sound quality can be much better. Amplified telephones, which are often subsidized by state-level accessible telecommunications programs, can also be a helpful option.

Other technologies

Other technologies for situational hearing use include body-worn amplifiers and specific systems for TV watching. A body-worn amplifier (example provided above in *Addressing Hearing Loss*) can be helpful when individuals with hearing loss (particularly those with severe losses who have trouble communicating even in quiet) need situational help when communicating with others. TV listening systems wherein a transmitter attached to the TV sends the auditory signal directly to a pair of head-

phones can also be helpful, particularly in situations where there are multiple individuals watching TV with different listening needs.

NATIONAL INITIATIVES

The importance of hearing to older adults and public health has rapidly come to the national forefront over the last several years with growing scientific evidence of the impact that hearing loss can have on older adults and society. This awareness has directly led to "top down" national initiatives to reduce the barriers to obtaining hearing care for older adults. From 2015–2016, both the National Academies of Science, Engineering, and Medicine and the White House President's Council of Advisors on Science and Technology dedicated specific panels to look at this issue. These efforts led to consensus recommendations coming from both bodies about the future regulatory and policy changes that must be made to ensure broader awareness and action on hearing loss in older adults. One of the key recommendations to re-regulate hearing aids to allow for over-the-counter access has already been enacted by Congress as described above. Other recommendations pertaining to Medicare coverage of devices/services and other strategies are all being actively discussed and pursued. These initiatives signal a "sea of change" in our current national focus on hearing loss and the importance of addressing hearing loss in older adults to optimize the public health of our aging population.

CONCLUSIONS

Public health has evolved in the past century through three fundamental eras which characterize human society. At the beginning of the 20th century, for the first time in human history, we effectively conquered infectious diseases such as tuberculosis and smallpox which were previously the leading causes of morbidity and mortality for humans. Thereafter, over the course of the 20th century, we entered the era of chronic diseases (e.g., high blood pressure, cardiovascular disease, etc.), and in which we have made tremendous strides in mitigating through medications and other strategies. As we have entered the 21st century, we are now confronting the third era of public health which is to reduce the adverse effects of aging itself on human health. Namely as societies around the world are increasingly aging and individuals are living longer because of the control of infectious and chronic diseases, we now face the challenge of how to optimize the health of a generation of baby boomers who are living longer than ever. While some of these approaches are intuitive (exercise, diet), the importance of hearing and our ability to engage effectively with others and the auditory environment has rapidly emerged as a key factor that needs to be targeted to improve the lives of older adults around the world. National and international initiatives to push these changes forward and improve awareness and access are ongoing. While these initiatives move forward, there are already many options as detailed in this white paper through which to improve the lives of older adults with hearing loss.

REFERENCES

Aging America & Hearing Loss: Imperative of Improved Hearing Technologies: White House President's Council of Advisors on Science and Technology, October 2015

Hearing Health Care for Adults: Priorities for Improving Access and Affordability. National Academies Press. Washington, D.C. 2016.

IOM (Institute of Medicine) and NRC (National Research Council). Hearing loss and healthy aging: Workshop summary. Washington, D.C.: The National Academies Press; 2014.

Lin FR, Albert M. Hearing loss and dementia - who is listening? Aging Mental Health 2014;18(6):671-3.

Lin FR, Metter EJ, O'Brien RJ, Resnick SM, Zonderman AB, Ferrucci L. Hearing loss and incident dementia. Arch Neurol 2011;68(2):214-20.

Lin FR, Niparko JK, Ferrucci L. Hearing loss prevalence in the United States. Arch Intern Med 2011;171(20):1851-2.

Livingston G, Sommerlad A, Orgeta V, Costafreda SG, Huntley J, Ames D, et al. Dementia prevention, intervention, and care. Lancet 2017.

Hearing Care and Healthcare Providers

(Audiologists, Hearing Instrument Specialists, ENTs, Otolaryngologists, Physicians, Nurse Practitioners, Physician Assistants, Gerontologists, Geriatricians)
www.captioncall.com/provider

Professional Caregivers and Senior Living Professionals

(Nurses, Case Managers, Care Managers, Social Workers, Therapists, CNAs, Personal Aids, etc.)
www.captioncall.com/share

4215 S. Riverboat Rd., Salt Lake City, UT 84123
©2018 CaptionCall, LLC. All rights reserved. Patent information: www.captioncall.com/patents
CaptionCall, Life is Calling, SilkScroll, and the Spiral C mark are registered trademarks of CaptionCall, LLC.