

Hearing Care Within Diabetes Care: Strategies for Direct Inclusion

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An estimated 38 million Americans have hearing loss, affecting their function and ability to communicate in everyday activities, with prevalence increasing with each decade of life (1). Hearing loss, especially unmanaged hearing loss, is associated with many negative outcomes, including falls (2,3), dementia (4), social isolation or loneliness (5), and increased health care utilization (6,7). Management of hearing loss, traditionally with hearing aids and rehabilitation strategies to facilitate improved listening environments, is remarkably effective in augmenting impaired hearing function, supporting quality of life, and preventing adverse health outcomes (8-11). However, hearing loss remains underdiagnosed and undermanaged (12,13). Despite the growing understanding of the role of hearing loss across health and function, hearing health has not commonly been considered in primary care or specialty practices as part of the clinical care workflow and best practice recommendations, including for diabetes care (14).

The association between hearing loss and diabetes has been recognized for decades, although the mechanism behind the association remains unclear (15–23). Whether the hearing loss is caused by biological processes (vascular or neuropathic) or is a secondary consequence of diabetes treatment, attention to hearing as part of comprehensive diabetes care is foundational for greater quality care and to promote health and function. Yet, hearing is not routinely evaluated or integrated as part of best practice care for people with diabetes (24). Our objective is to highlight missed opportunities for more holistic care for people with diabetes, and particularly for the growing population of older adults with diabetes who are experiencing hearing loss, by incorporating hearing assessment and intervention directly into diabetes care plans. We first provide a description of hearing loss and its impact on health and function. Then, we discuss the epidemiology and existing evidence for the association between diabetes and hearing loss. Finally, we offer actionable recommendations for the inclusion of hearing health in diabetes care.

Overview of Hearing Loss

No longer considered a benign consequence of aging, hearing loss is increasingly identified as a risk factor for many negative health outcomes across the life course. This underdiagnosed and generally progressive condition limits the ability to effectively communicate and engage with surroundings (25). For many, life with hearing loss becomes quiet not only because of the decreased integrity and volume of incoming sounds, but also because of impaired clarity or understanding of auditory stimuli. Increasing evidence suggests that unmanaged hearing loss impedes diabetes management and predisposes individuals to poor health outcomes such as falls, cognitive impairment/dementia, social isolation or loneliness, and depression (25,26). The American Diabetes Association's (ADA's) Standards of Care in Diabetes (27) places person-centered goals and collaborative care as foundational pillars of diabetes management. Nearly all of these care and treatment recommendations for collaborative care are contingent upon the ability to effectively hear, engage in the treatment process, and understand the care plan and recommendations.

Yet, hearing loss remains underdiagnosed, and management strategies are underutilized (25). Despite robust evidence on the prevalence of hearing loss and its detrimental effects, universal screening for hearing loss is not currently recommended for asymptomatic adults (28,29). This means the hearing care process for adults is currently also entirely patient driven. Without hearing screening guidelines and processes in clinical practice, individuals serve as their own advocates for access to hearing evaluation and treatment. Because the hearing loss process is often gradual, many individuals are not aware of their declining hearing until they experience a

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significant impact on communication. Furthermore, the changing landscape of hearing care and device availability over the past decade has left gaps in how individuals and families may orient to the hearing care process (30). Health care professionals (HCPs) working with people with conditions that place them at increased risk for hearing loss, such as diabetes, have an opportunity to fill this gap and help to address these needs, resulting in higher-quality care overall.

The cost of undiagnosed and untreated hearing loss is high. Compared with people with managed hearing loss, those with untreated hearing loss incur 46% higher total health care costs (\$22,434 higher) over a 10-year period (7). Those with unmanaged hearing loss are also more likely to experience hospitalizations and readmissions (7,31,32). For people with diabetes, hearing loss additionally hinders key aspects of safe diabetes management. For example, continuous glucose monitoring (CGM) systems are an essential part of the diabetes treatment plan and rely on audible alerts to prompt timely treatment of dangerous glycemic events (33).

Although there is no cure for hearing loss, there are effective intervention options that provide tools (i.e., hearing aids or other devices) and strategies (i.e., communication tips and lifestyle changes) to help people "fill in" missed auditory information. Because the auditory system remains damaged, a large focus of rehabilitation is on guiding individuals in acclimatizing to using augmented sound to fill in what they have been missing. These rehabilitation options, when aligned with patient goals and values, are highly effective in maintaining the function of individuals affected by hearing loss. Connecting people with diabetes who have hearing concerns to hearing health can facilitate easier communication, greater quality of life, more proactive involvement in health care plans and decisions, and overall person-centered care.

Epidemiology of Hearing Loss

Nearly 460 million people worldwide are living with diabetes (34), 466 million have clinically meaningful hearing loss (35), and many more remain at risk for both conditions. From a population perspective, the greatest risk factor for hearing loss is age; roughly two-thirds of individuals >70 years of age have measured hearing loss (32). Although the overall prevalence of hearing loss is increasing because of the aging population, the age-specific prevalence appears to be decreasing by $\sim 2\%$ since the past decade, likely because of improved health care and resulting health and emphasis

on prevention of known risk factors for hearing loss (36).

The prevalence of hearing loss overall varies by selfreport versus objectively measured hearing and additional demographic factors. Hearing loss is more common among males, likely related to behavioral and lifestyle factors, with slight evidence for a protective effect of estrogen among women. Hearing loss is also more common among non-Hispanic White or Hispanic adults compared with Black adults (13,32,35,37). Chronic disease-related risk factors for hearing loss include hypertension and cardiovascular disease (35). Differences in the accuracy of self-reported hearing ability are observed by demographics. Older individuals, those with a low poverty index ratio, and those with lower education levels are more likely to underestimate their hearing loss (37,38). Coincidentally, those <70 years of age, those with higher income and education and for non-Hispanic Black individuals are more likely to overestimate hearing ability and believe hearing is worse than audiometric testing suggests (37, 38).

People with diabetes (18,19) have a nearly two times greater risk of hearing loss than those without diabetes, with some excess risk observed even in those with prediabetes (18). Both type 1 and type 2 diabetes have been associated with hearing loss. The risk of hearing loss increases progressively with A1C levels >5% (18,19), although none of the glycemic management clinical trials have examined the effects of lowering A1C on risks of incident or progressive hearing loss. A 2915 cohort study suggested that people with an A1C >8% had a roughly 8% higher risk for hearing loss than those with an A1C <8% (hazard ratio 1.08, 95% CI 1.02–1.14) (39). The association between diabetes (40) or A1C (19) and hearing loss might be stronger in younger adults with diabetes than in older adults with diabetes (23). This observed difference is likely the result of stronger cumulative effects of age and age-related hearing loss, noise exposure, lifestyle factors, and other chronic conditions, which obscure the diabetes relationship.

Pathogenesis of Hearing Loss in Diabetes

The observed association between diabetes and hearing loss likely has both direct and indirect causes (Figure 1) (18,27,40–44). Additional risk factors for hearing loss among people with diabetes include smoking, alcohol consumption, high triglycerides, chronic kidney disease, and low-income level (45). The presence of insulin receptors, glucose transporters, and insulin signaling components within the structures of the auditory system, such as



FIGURE 1 Pathogenesis of hearing loss in diabetes.

the stria vascularis and the spiral ligament of the cochlea (also known as the "organ of hearing"), means that impairment in glucose utilization among those affected by diabetes may result in impaired functioning of these auditory structures essential for maintaining auditory signal integrity (42,43). Additionally, mitochondrial dysfunction and glucotoxicity from hyperglycemia may disrupt function in organ systems that have high mitochondrial density or are dependent on high energy consumption, such as the marginal cells of the basal cell membrane of the cochlea. Finally, changes in microvascular structure resulting from diabetes and hyperglycemia may ultimately affect the inner ear structures, which are dependent on a rich microvascular network to maintain the endocochlear potential across membranes (41,42). This maintenance enables hair cells of the cochlea to respond to incoming auditory input, allowing effective transmission of the auditory signal to the auditory nerve.

Common co-occurring complications and comorbidities of diabetes indirectly increase the risk for hearing loss (40,43). More than 200 medications are known to be ototoxic when prescribed in certain manners or conditions. The most commonly reported ototoxic drugs include loop diuretics (which are frequently used by people with diabetes for hypertension management), quinine, chemotherapeutics (i.e., cisplatin and carboplatin), ethacrynic acid, nonsteroidal anti-inflammatory drugs, salicylates (including aspirin), and aminoglycosides antibiotics (e.g., gentamicin, neomycin, vancomycin, and streptomycin) (46-48). Although, to our knowledge, none of the glucose-lowering medications list hearing loss as a side effect, up to 26% of diabetes medications have potential ototoxic effects via reported adverse events, with ear congestion or pounding in the ears being the most common adverse events related to the auditory system (49). Because these are reported adverse events but not findings of clinical hearing evaluations per se, the etiology of reported ear congestion cannot be determined, including whether it represents a hearing shift manifesting as perceived congestion or is related to eustachian tube dysfunction or other issues (49). Whether use of these medications should be avoided, if clinically appropriate, in individuals at high risk for hearing loss or auditory nerve pathology is unknown, but caution may be warranted (42,43,49). Additionally, people with diabetes have a heightened risk of other health conditions, most notably vascular disease. Apart from vascular-related changes that might subsequently manifest in the inner ear, chronic aspirin use, commonly recommended as a vascular disease prevention measure, has been found to have ototoxic properties, especially with prolonged use (18,43,46-48).

Observational studies suggest that improving glucose management may reduce the risk for hearing loss

(18,19). However, longitudinal data are needed to assess whether lowering A1C reverses the observed effect on hearing or tinnitus once hearing loss is present. To our knowledge, none of the treat-to-target trials in type 1 diabetes (the Diabetes Control and Complications Trial) (50) or type 2 diabetes (ACCORD [Action to Control Cardiovascular Risk in Diabetes] (51) ADVANCE [Action in Diabetes and Vascular Disease: Preterax and Diamicron MR Controlled Evaluation] (52), and VADT [Veterans Affairs Diabetes Trial]) (53) examined the effects of glucose-lowering on hearing health.

Hearing Health Within Diabetes Care

Poor hearing ability and unmanaged hearing loss are negatively associated with patient-HCP communication and satisfaction with care (54,55). The ability to effectively communicate is instrumental, not just for quality of life and engagement, but also for effective medical information exchange, HCP-patient partnerships, and implementation of care recommendations. Individuals who are more engaged with HCPs during medical decisionmaking, which requires the ability to appropriately hear and understand the conversation, with or without additional accommodations, have been found to more effectively engage in self-care or self-management and implement medical recommendations (56,57). Individuals with hearing loss may also need alternative or complementary modes of communication, including providing detailed written treatment and dosing instructions and using the teach-back method to ensure adequate hearing and comprehension of treatment recommendations. Hearing loss, even managed hearing loss, can often require greater cognitive effort for effective listening and understanding during conversations when complex or unfamiliar terms are used, even in quiet listening environments (58,59). This increased effort taxes memory and attention and increases listening fatigue-factors that may limit retention of medical information discussed without additional supports.

The World Health Organization's 2021 World Report on Hearing (35) considers diabetes among the list of chronic diseases co-occurring with hearing loss, which warrants regular monitoring of people with diabetes for early identification of changes in hearing. The ADA's Standards of Care (27) recommend screening people with diabetes for hearing disability at the initial diabetesrelated visit and yearly thereafter, with referrals to audiology as appropriate and support use of assisted listening devices during visits as needed. The Endocrine Society similarly recommends assessing hearing in older adults with diabetes (60). Despite these recommendations, there is little systematic attention to hearing as part of routine clinical care in general practice and minimal guidance on how to incorporate hearing health into diabetes care (24,27). Below we include recommendations for integrating hearing health into diabetes care.

Hearing Assessment in Clinical Practice

Reimagining diabetes care workflows to include hearing health can improve the overall quality of diabetes care and enrich the quality of life of those affected by diabetes in alignment with the 4Ms framework to address person-specific issues outlined by the ADA (27). The 4Ms were created as part of the Age Friendly Healthcare Initiative, supporting reliable implementation of four evidence-based pillars of high-quality health care: what **m**atters (i.e., knowing and aligning care with individuals' health goals or preferences), **m**edication (i.e., using age-friendly medications that do not interfere with the other components of the 4Ms), **m**entation (i.e., preventing, identifying, treating, and managing mental health concerns), and **m**obility (i.e., supporting safe movement to maintain function and do what matters) (61).

Although hearing impairment is directly linked to the mobility component of the 4Ms in the ADA's 2025 Standards of Care, it is indirectly linked to all components, as described throughout this text. The first step is to evaluate for known or possible hearing loss, either through diagnoses review or self-reported concerns (Figure 2). The goal of this initial step is to ensure that communication plans for patients during their visit incorporate their personal hearing needs or communication preferences (27). Care teams may ask whether there is known hearing loss or attend to co-occurring diagnoses for awareness of hearing loss before conversing during medical visits to remove ownership of effective communication solely by patients and support accommodations for communication.

In-office accommodations might include increased use of or expanded written summaries of the appointment to augment oral communication, using a Pocketalker (i.e., personal sound amplifier) or other assistive listening device to reduce listening effort, or ensuring that all communication with patients or families is done in a face-to-face manner. Communication for those with hearing loss does not necessarily need to be louder, but should include slower conversation with clear articulation. For those with significant hearing loss, telephone communication may limit effective information



FIGURE 2 Strategies to incorporate hearing in diabetes care.

exchange. Individuals may prefer different communication modalities for care planning or decision-making such as patient portal messaging or e-mail, which remove dependence on hearing.

In reality, many of these recommendations for communication can benefit all patients-not just those with hearing difficulties. However, if no known hearing loss is evident, HCPs may inquire at routine evaluations about self-reported hearing concerns or changes in hearing. HCPs might also ask about any noticed declines in the ability to hear in crowded spaces, decreased understanding while talking on the phone or watching television, a feeling of fullness in the ears, or a ringing or buzzing in the ears (i.e., tinnitus). Prior work suggests asking the question, "Which statement best describes your hearing (without a hearing aid or other listening devices)? Would you say your hearing is excellent, good, that you have a little trouble, moderate trouble, a lot of trouble, or are you deaf?" This approach has been found to be 71% accurate in identifying meaningful hearing loss (when classifying hearing loss as any responses other than excellent or good hearing), with some differences by demographic characteristics, as described above (38).

If hearing concerns or bothersome tinnitus are identified, individuals should be referred to an audiologist for an initial diagnostic evaluation and hearing health education (i.e., device options and communication strategies). For individuals with Medicare insurance, an audiological evaluation is a covered health benefit with referral. Medicare currently does not include coverage for hearing devices or rehabilitative services, but many Medicare Advantage plans have at least some coverage for hearing devices. For pediatric patients with private insurance or Medicaid, an audiological evaluation is generally a covered benefit with referral, and additional rehabilitation and management benefits are dependent on insurance.

HCPs may identify local audiologists through local health systems or through the American Academy of Audiology website's Find an Audiologist feature. Certain auditory system concerns may warrant ear, nose, and throat (ENT) and audiology evaluation. Patients may be referred to an ENT and audiologist for concerns related to aural fullness, vertigo, balance, or pulsatile tinnitus, among other concerns.

Over-the-Counter Hearing Device Considerations

In 2022, over-the-counter (OTC) hearing devices entered the hearing care market (30), creating a monumental shift in how individuals may become oriented to the hearing health landscape. This new class of device was intended to expand accessibility as a direct-toconsumer option at a lower price point compared with traditional hearing aids obtained through a hearing care professional. OTC devices are now available via retail stores and online for adults with no more than moderate hearing loss (i.e., minimal challenges communicating in a quiet environment). More than 2 years after the introduction of OTC devices, their share of the hearing device market remains low, however, these products do provide individuals with more options for hearing accessibility. OTC devices may be an excellent option for some individuals with hearing loss, particularly those with greater health literacy who can navigate the process (i.e., complete independent hearing evaluations, determine how to obtain a device, and program the device or make use of online programming supports) (62–64).

The primary concern about OTC options expressed by some from a hearing health care perspective are bestpractice care considerations that may inhibit some patients from reaching their communication goals with OTC devices but may have little to no impact on others.

First, OTC devices are just that—devices. Unless provided through an audiologist's clinic (many audiologists now offer OTC devices), the OTC pathway often does not come with the additional counseling, education, and other rehabilitation tools. Such additional services are essential for many, but not all, individuals to understand that hearing devices are tools to enhance exposure to auditory stimuli that may otherwise be missed, but they do not repair an impaired auditory system.

Second, because of regulatory requirements, OTC devices must enhance auditory ability (65), but the sophistication of the technology varies, as does the price point. Many OTC devices are available at a lower cost and therefore more affordable for people for whom the expense of traditional hearing aids is a barrier to care; however, not all OTC devices are less expensive. As with many industries, the sophistication of what a specific device offers aligns with its initial cost. This fact is recognized by many who can be successful OTC users, but not by everyone. There is some concern that individuals who are dissatisfied with an OTC device will also assume that traditional hearing aids are also ineffective and not pursue alternative means to support communication. Importantly, audiologists, and some of the resources included here, can fill gaps in rehabilitation support that are not generally offered through OTC purchases, depending on the device manufacturer.

The OTC market and hearing health landscape continue to evolve. At conception, OTC devices were envisioned to serve as an entry point for many individuals with hearing loss who were either unsure of their hearing aid readiness or for whom cost presented a barrier. The intention was that, once more significant hearing loss or impairment of daily function and activities from hearing occurred, individuals would then seek traditional hearing care. With the end goal of improving health and function for those with hearing loss, time will tell how the availability of OTC devices influences the affordability and accessibility of hearing care.

Screening in Clinical Practice

Importantly, support for hearing monitoring can be integrated within the existing care process (27). Recommendations for baseline hearing evaluations or regular monitoring (every 1–2 years for most adults) allow patients and families to understand their current hearing ability and hearing management options, if a loss is detected. A referral to hearing health (i.e., an audiologist for hearing or tinnitus concerns or an ENT specialist for other ear-related concerns) is a simple way to initiate hearing care. Although coverage for hearing management options may vary, hearing health education and counseling on communication strategies alone can, to an extent, offset hearing loss and leave patients more informed and engaged in care decisions.

Simple, validated hearing screening tools are now available via smartphone devices (e.g., iOS Easy Hearing Test and or Android Hearing Test), publicly available apps compatible with Apple device technology (e.g., Know your Hearing Number) (66), or a simple portable device (e.g., HearX) (67,68). Many of these screeners can be completed in 2–3 minutes. When used with headphones in a quiet environment, these screening tools can expand initial access to hearing loss awareness that might also provide greater education on hearing health and inform potential next steps. Patients might be able to complete a screener or answer questions about hearing concerns in the clinic or while waiting in an exam room, or they may be provided resources to complete a hearing screening at home with information on referral and next steps.

Hearing Care Interventions

Gaining a baseline understanding of hearing levels and monitoring for changes enables direct consideration of hearing in clinical care decision-making. For example, potential effects on the auditory system should be considered when selecting diabetes management strategies. Although medications with known ototoxic effects should not be avoided if their benefits outweigh the potential harm, potential medication effects on hearing should be noted as part of shared decision-making about the optimal choice of glucose-lowering therapy. Hearing loss additionally suggests that audible CGM alerts may not be a viable strategy to help patients at risk for hypoglycemia, and particularly those with impaired awareness of hypoglycemia, detect and treat their hypoglycemic events. Instead, vibratory CGM alerts or other means of notification should be pursued. Consideration of patients' comorbid conditions might enable increased consideration of the risk for hearing loss and personal communication needs.

Conclusion

Evidence overwhelmingly suggests that diabetes increases patients' risk for hearing loss, and the ADA now recommends hearing screening and incorporation of hearing health to support higher quality diabetes care. These efforts might include increasing awareness of hearing and communication needs to support shared clinical decision-making, hearing monitoring and options for hearing screening, referral for audiology evaluation and support for monitoring, and consideration of the influence of diabetes management decisions on hearing health to review with patients. By outlining strategies to incorporate hearing health into diabetes care, we provide a framework to support this additional step toward person-centered care, incorporating patient preferences or needs into the decision-making process.

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AUTHOR CONTRIBUTIONS

D.S.P. researched, wrote, and edited the manuscript. R.G.M. contributed to the overall discussion and reviewed and edited the manuscript. D.S.P. is the guarantor of this work and, as such, takes responsibility for the accuracy of data included and the perspective presented in this article.

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